

Asia Pacific Economic and Management Review

Editor-in-Chief:

Prof. Lakshman Sharma

University of Delhi, Indian

Associate Editor

Dr. Zijian Wu

Guangzhou Medical University, China

Copyright © 2025. ASIA PACIFIC SCIENCE PUBLICATIONS
COMPANY LIMITED. Complimentary Copy.



Asia Pacific Science Press

Asia Pacific Economic and Management Review

Asia Pacific Economic and Management Review (APEMR) is an international, peer-reviewed and open access journal which focuses on theoretical and applied studies of corporate and financial behavior. Aiming to promote the research in fields of business economics and management, it covers mainly but not limits to the following areas:

- Accounting and Financial Management
- Economics
- Political Economy
- Human Resource Management and Organizational Behavior
- Information Management
- International Business
- Strategy and Innovation
- Management Science and Operations Management
- Marketing and Retail
- Asset Evaluation
- Financial Theory and Practice
- Commercial Circulation
- International Trade
- E-commerce
- Logistics Management
- Business Administration

About Publisher:

Asia Pacific Science Press (APSP) is a swiftly expanding publisher of peer-reviewed and open-access journals, strategically located in Hong Kong. As a reliable and esteemed corporation, APSP is dedicated to promoting and serving a wide array of subject areas, ultimately contributing to the betterment of humanity. By disseminating knowledge to a global community of scholars, practitioners, researchers, and students, we strive to establish ourselves as the world's leading independent academic and professional publisher.

Submission instructions: You can submit your manuscript through the official website (www.apspublisher.com) or email (editor.apemr@apspublisher.com), All manuscripts will go through a rapid peer review and production, making the process of publishing simpler and more efficient.

Publisher Headquarter

Room 03, 7th Floor, Block B, Tuen Mun Industrial Centre, 2 New Ping Street, Tuen Mun, Hong Kong, China
Website : www.apspublisher.com
Email : info@apspublisher.com

Fujian Province Office, China

603-1, 6th Floor, Building B20, Chengyi North Street, Software Park, Jimei District, Xiamen City, Fujian Province, China
Website : <https://ojs.apspublisher.com/index.php/amit>
Email : amit@apspublisher.com

Table of Contents

- 1 Analysis of Online Reviews on Hanfu Based on Text Mining: A Case Study of JD.com**
XieWei
- 12 Research on Financial Analysis and Evaluation——A Case Study of Joyoung CO**
Chenyang Qi
- 19 Research on the Development Strategy of Commercial Bank Business Based on BCG Matrix
——Taking Bank A as an Example**
Chengzhong Gao
- 27 Research on ESG Strategies of Multinational Enterprises and Consumer Response Mechanisms
under the Wave of Green Consumption**
Huanhuan He
- 32 Legal Regulation of Egg Freezing for Single Women: The Game between Reproductive
Rights and Ethics**
Yuyang She
- 38 The Interlinked Impact of Supply Chain Trust on Logistics Efficiency and Business Growth
in a Borderless E-commerce Environment**
Qiu Chao, MOHAMAD IDRAKISYAH ABDULLAH
- 44 Evaluation on the Quality of Environmental Accounting Information Disclosure
——A Case Study of Huayang Shares**
Ruiru Deng
- 47 Research on the Impact of Digital Inclusive Finance on the Urban-Rural Income Gap ——
Panel Analysis Based on Province-Level Data in China**
Miaoxi Gu
- 57 Creating New Productivity: The Practice and Breakthrough of Liuzhou Intelligent Terminal
and Robot Industry Innovation Ecosystem**
Songxing He, Linhao Yang

- 69 **The Manipulative Mechanisms and Multifaceted Impacts of Dark Patterns in Social Platform: A Case Study of Xiaohongshu**
Xiaoyu Huang
- 75 **A Study on the Chinese Translation of European Automobile Brand Names from the Perspective of Skopos Theory**
Yuanhao Lin
- 83 **The Dilemma and Optimization Path of Performance Evaluation of Government Guided Funds**
Wanqing Xu
- 88 **The Impact of Media Reports on the Audit Quality of Listed Manufacturing Companies**
Qi Bai
- 99 **Research on the Current State of Supply Chain Finance - CiteSpace-based Analysis and Bibliometric analysis**
Shuijing Wang, Zheng He
- 113 **Research on Service Robot's Willingness to Use: Extended TAM Model**
Dapeng Xu
- 120 **Marketing Channel Planning Analysis and Recommendations for Anshan Nanguo Pears**
Xuyan Pu
- 123 **Detailed Analysis of the Anshan Nanguo Pear Market and Related Recommendations**
Zixuan Wang, Yahui Qian, Xinying Zhong, YaNuo Wang
- 126 **The Influence and Mechanism of ESG Peer Effect on Green Innovation of Heavy-Polluting Enterprises**
Mingyue Li, Xin Wang
- 138 **Research On the Impact of Data Assetization on Enterprise New Quality Productivity**
Zichen Wang
- 145 **Analysis on the Impact of Digital Finance on Carbon Emissions under the Background of "Double Carbon"**
Rong Liang
- 150 **Exploration of University Data Asset Management**
Hongfei Ding, Qin Liu

- 154 **Analysis of Online Reviews on Hanfu Based on Text Mining: A Case Study of JD.com**
Xie Wei
- 165 **Research on Basic Issues of State-owned Asset Management in Higher Education Institutions**
Jianqiang Wang
- 176 **Research on Labor Rights Protection Challenges and Countermeasures for Employees in Dujiangyan's Emerging Service Industries Amid the Digital Economy**
Jialu Chu
- 181 **Research on Encrypted Traffic Classification and Sparse Traffic Recognition Based on Feature Extraction and Deep Learning**
Qi Ruiya, Wang Junxi, Chen Chengyi, Yang Fangyu
- 188 **Study on Influencing Factors of College Students' Willingness to Return to Their Hometowns for Entrepreneurship under the Background of Rural Revitalization
—— Take the College Students in Shandong Universities in Yantai as an Example**
Tongxin Tan, Minqi Yan, Xiaoxuan Zhang, Ruijin Han, Meijia Liu
- 193 **Research on the Evaluation and Improvement Path of Human Settlements Satisfaction in Ecological Relocation Sites under the Yellow River Strategy—— Taking Liangshan County as an Example**
Jiayi Liu, Linhan Zhang, Lei Liu, Zhuohan Dong, Jingjing Zhou
- 200 **The Impact of Technological Innovation on Environmental Governance in the Logistics Industry**
Yanan Zheng, Panlong Sheng
- 209 **Research on the Efficiency Evaluation of Company A's Financial Shared Service Center**
Caiyu Song
- 219 **Unveiling the Gaze: Patriarchal Power and Female Resistance in Disgrace**
Xiaoyu Chen, Chuan Shi
- 228 **Tibetan Women's Identification with the Sense of Community for the Chinese Nation: A Case Study of Wind**
Xiaoyu Chen, Chuan Shi
- 234 **Home-Country Institutional Pressure and Foreign Divestment: Evidence from Developed-Country Multinationals in China**
Qihu Wang, Yue Gong, Yilan Gao

- 244 The Effect of Readability of Listed Company Prospectuses on IPO Breaks: Evidence from the Shanghai Stock Exchange in China**
Ruining Li, Jiangjiao Duan
- 261 Research on Marketing Strategy of Tea Wine Products of DJ Wine Industry**
Wei Wang
- 270 Bridging Structural Causal Inference and Machine Learning: The S-DIDML Estimator for Heterogeneous Treatment Effects**
Yile Yu, Anzhi Xu
- 286 A Concise Algorithm for Calculating the Number of Microstates in a Bose System**
Chuan Shi, Jun Wen
- 290 A Study on Ethnic Identity and National Identity in “Sui Feng Piao San”**
Chuan Shi, Xiaoyu Chen
- 295 Optimal Product Pricing and Recovery Strategies in a Two-period Model for Manufacturers with Core Classification and Trade-In-for-New/Reman Policies**
Zhe Wang, Peipei Cao, Fan Xu
- 315 Divergent Pathways of Artificial Intelligence Adoption in E-Commerce: A Multidimensional Comparative Analysis of China, the United States, and the European Union**
Fengyu Zhao
- 325 Analysis of China’s Local Government Debt Risk Causes and Resolution Pathways**
Jingjing Cui, Dongping Xiao
- 333 AI-Enhanced Traditional Crafts in Art Education: A Digital Approach to Revitalizing Chinese Tie-Dye in High School**
Ruimin Li
- 341 Research on the Decision-making of the Battery Swapping Supply Chain Considering Battery Standardization under the Battery Swapping Model**
Chao Li
- 352 Research on Tax Planning in Corporate Mergers and Acquisitions**
Dongyang Huang
- 358 Research on Cost Management Issues of Small and Medium-Sized Enterprises - A Case Study of Company H**
Wenjing Fan

- 366 **Research on Accounting Recognition of Enterprise Data Assets——Taking A Group as an Example**
Yifan Zhang
- 372 **Cost Control Analysis of Jingdong Logistics**
Haotian Zhao
- 380 **Research on Financial Performance Evaluation of Company W Based on Factor Analysis Method**
Haobin Li
- 388 **The Theoretical basis and literature Review of esg and Enterprise Performance**
Dong Fan
- 396 **Construction of an AI-supported Business Administration Course System in the Context of Digital Transformation**
Man Liu
- 403 **Theoretical Research on AIGC-Assisted Teaching in the Course of Introduction to Digital Media Art**
Wenju Gao
- 406 **Taking Agricultural Products as the Core Lever: An Analysis of the Mechanism by Which Northeast China's Digital Economy Catalyzes New Quality Productive Forces in Agriculture**
Xinci Zhang, Xiwen Zhang, Chuhan Wang, Qingshuo Yang
- 411 **Analysis of Enterprise Audit Failure Issues: A Case Study of Guangdong Rongtai's Audit**
Shiyuan Li
- 418 **A Study on Corporate Income Tax Planning Strategies: The Case of Alibaba Group**
Ping Wang
- 423 **The Empowering Effect of Digital Transformation on Corporate ESG Performance: A Case Study of the New Energy Industry**
Wenyi Sun
- 427 **Performance Analysis of Green Transformation in High Energy-Consuming Enterprises: A Case Study of Huaneng Power International, Inc.**
Xiaoyu Li
- 431 **Accounts Receivable Risk Control in Small and Medium-Sized Enterprises: A Case Study of Manufacturing Industry**
Min Yang

- 438 The Impact of Corporate Governance and Internal Control on Accounting Information Disclosure: Evidence from the Textile Industry**
Chenxi Cao
- 442 Do Environmentally Conscious Executives Truly Promote Corporate Green Technology Innovation?—From the Perspective of Governance Pressure and Signaling**
Yihang Tu
- 455 Promoting High-Quality Development of Shaanxi's Manufacturing Industry with Digital-Physical Integration as a New Feature**
Jiahui Zhao, Tieshan Wang, Tong Yang
- 463 A Study on the Relationship Between ESG Strategic Orientation and Corporate Green Innovation Performance**
Yixue Li, Xiaohong Wang, Meng Li
- 474 Research on Digitalization and High-Quality Economic Development of Shaanxi Province**
Ru Feng
- 480 Comparative Analysis of Investment Environments for Chinese Auto Parts Enterprises in Mexico and Southeast Asia and Different Development Strategies**
Xin Sun, Tieshan Wang
- 489 Construction of Performance Management System in the Context of Digital Transformation**
Yu Pang
- 495 How Local Government Policies Promote the Construction of Municipal Industry - Education Alliances—A Policy Text Study Based on Grounded Theory**
Wenwen Sun
- 506 How to Empower Green Technology Innovation of Private Enterprises by Environmental Protection Oriented Shareholders**
Zeyu Tian
- 520 The Impact of Financial Misallocation on Corporate ESG Performance**
Hongli Guo
- 540 A Study on the Theoretical Evolution, Practical Dilemmas, and Policy Innovations in Enhancing Rural Social Welfare**
Yuan Wei
- 547 Problems and Countermeasures of the Profit Model of Sanquan Food**
Tongtong Han

- 555 The Moderating Role of Consumer Digital Trust in the Relationship Between AI Anchors and the Intention to Purchase Agricultural Products**
Yingying Cai
- 562 The Development Status, Challenges and Countermeasures of Investment Banks in China**
Yongdong Xu
- 568 Clarifying Four Key Issues Regarding Letters of Credit: The Most Important International Payment Method**
Yongdong Xu
- 576 From Hamilton to Trump: Examining the Evolution, Logic and Resurgence of US Tariff Policy**
Yongdong Xu
- 582 Research on Risk Identification and Regulation of Binance from a Global Regulatory Perspective**
Xiayi Zhang, Jiawei Xi
- 587 Research on the Development of New-Quality Productive Forces Driven by the Low-Altitude Economy under the Coupling of Finance, Technology and Policy**
Junquan Ding
- 598 Digital Infrastructure Development Driving the Intelligent Transformation of Manufacturing: Technological Application Scenarios and Policy Optimization Strategies**
Liyu Ge, Keke Ning, Mengyi Zheng
- 607 Research on the Narrative Characteristics and Aesthetic Evolution of Micro-Series in Short-Video Platforms**
Haitao Cheng
- 613 Research on the Integration Path of Smart Wearable Technology in Jewelry Design**
Xianfa Zhang

Analysis of Online Reviews on Hanfu Based on Text Mining: A Case Study of JD.com

XieWei*

School of Management, Xi'an Polytechnic University, Xi'an, 71048, China

**Corresponding author: XieWei*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Hanfu is a component of China's excellent traditional culture, but there is relatively little research on consumer satisfaction with Hanfu products. This paper takes JD.com as an example to conduct statistical analysis on the brand information, price range distribution, and discount information of Hanfu products, and uses text mining methods to conduct sentiment analysis and social network analysis on product reviews. The research finds that consumers have a high recognition of brands, are willing to pay for the high-end pricing of Hanfu, and labels such as "reassuring purchase", "free shipping", and "JD Logistics" have a certain promoting effect on the sales of Hanfu. Consumers have a good overall perception of Hanfu, and when purchasing Hanfu online, they mainly focus on product quality, price, and other aspects. In the future, Hanfu brands should strictly control product quality and closely integrate Hanfu with Chinese traditional culture.

Keywords: Hanfu; Online Reviews; Text Mining; Social Network Analysis

Published: Aug 27, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.564>

1.Introduction

Hanfu embodies the beauty of inheritance and is a component of China's outstanding traditional culture^[1]. With the enhancement of China's comprehensive national strength and the strengthening of cultural confidence construction, contemporary young people have shown a significant emotional identification and belonging to traditional culture^[2]. In 2019, the transaction volume of Hanfu on the Taobao platform exceeded 2 billion yuan, and it is still growing at an average annual rate of 150%; although the consumer group is small, the growth rate is considerable. The number of Hanfu enthusiasts has reached 3.561 million, with a year-on-year growth of 74.4%^[3]. With the development of technology and the increase in residents' disposable income, online shopping has become the preferred shopping method for consumers, and the way consumers obtain product information has also changed from traditional word-of-mouth to online reviews. This paper takes the JD.com as an example to collect the sales feature information and product review data of Hanfu, analyzes the sales features of Hanfu and conducts text mining on product reviews, explores consumers' preferences for purchasing Hanfu and puts forward relevant suggestions, so as to help merchants better understand consumer needs and market conditions, and provide reference for the strategic decision-making of e-commerce enterprises. It has strong innovation and practical significance.

2.Research Overview

Hanfu, also known as Chinese traditional clothing or Huaifu, is the full name "Traditional Han Ethnic Clothing". It evolved

continuously in the areas where the Han ethnic group lived and gathered from the reign of Emperor Huangdi to the late Ming and early Qing dynasties, around the 17th century AD^[4]. Hanfu, as the representative clothing of the traditional clothing culture of the Chinese nation, vividly showcases the characteristics of Chinese culture and is an important carrier of Chinese culture. According to its form, Hanfu can be classified into four categories: “Shangfang”, “Shenyi”, “Paofu”, and “Ruanshen”. With the revival of traditional Chinese culture and the enhancement of cultural consciousness, Hanfu culture, as an important part of traditional Chinese clothing culture, has gradually attracted the attention and affection of young people. At the same time, the rapid development of Internet technology has provided new opportunities for the inheritance and innovation of traditional culture. The Internet has provided new ideas for the dissemination of Hanfu culture, and the promotion methods and marketing strategies of traditional clothing brands have changed due to the emergence of the Internet.

Hanfu in each dynasty has its own characteristics of the dynasty, but overall presents the style of “top garment and bottom dress” and “deep clothing”. Currently, the research on Hanfu mainly focuses on Hanfu culture. Wei Pengju (2021) believes that Hanfu is not an ordinary cultural industry, but a cultural industry with Chinese characteristics^[5]. Yang Xue et al. (2022) used Hanfu as the starting point and investigated the evolution of its style representations and the interaction relationship of its changes among young people to explore the cognitive and value changes of contemporary youth towards the “traditional” image^[6]. Jiang Na (2022) believes that Hanfu has become a cultural totem that people love, and with this strong cultural sentiment trend, China’s excellent traditional clothing culture thus has the opportunity to integrate into modernity and go global^[7]. Studies have shown that online product reviews have a significant impact on consumers’ purchase decisions^[8]. Therefore, many scholars analyze consumers’ online reviews to improve enterprise products and services and increase customer stickiness. Kang Lei and Zhang Yu (2024) used data from the Russian e-commerce platform Wildberries and applied text mining technology to analyze the online review content of products on the platform for sentiment analysis. Through the weight of consumer evaluation dimensions, the positive rate of emotions, and the degree of improvement needed, they obtained feedback information from clothing consumers^[9]. Qiu Dongyang and Yi Xian (2023) mined the online reviews of personal care and beauty products on Tmall during the Double Eleven period to explore consumer satisfaction before and after the event^[10]. Lin Weizhen et al. (2023) used 11,349 online review data from Amazon’s shopping website and used the LDA model to identify customer satisfaction dimensions, combined with machine learning algorithms to construct a satisfaction model. The results showed that consumers’ attention to products focused on functional attributes, service attributes, and quality attributes, etc., in 13 product dimensions of 7 comprehensive attributes^[11].

In conclusion, using online reviews to study consumer satisfaction is a current research hotspot. In recent years, research on Hanfu has also increased, but there is less research on the satisfaction of Hanfu products. Online reviews are the real feedback of consumers’ shopping experience. Digging out the consumer satisfaction from them is of great significance for promoting the development of Hanfu e-commerce. This paper analyzes the sales characteristics information and product review data of Hanfu on JD Mall through sentiment analysis, feature keywords, word cloud charts, and network visualization analysis, aiming to explore the impact of Hanfu online reviews on consumers’ purchase intentions on the new media platform.

3. Research Plan Design

3.1 Research Method

Text mining refers to data mining of unstructured text, such as sentiment analysis, word frequency analysis, and semantic network analysis, etc. This method has been widely applied by scholars at home and abroad in comment analysis^[12]. Compared with market research methods and expert interviews, text mining method can more conveniently and quickly identify consumers’ concerns and preferences, saving time, manpower and resources^[13].

3.2 Data Collection

JD Mall is the second largest e-commerce platform in China, with a large customer base. Its online comment module is comprehensive, detailed and convenient for consumers to read, and has strong representativeness^[14]. This paper uses the Octopus software to collect the Hanfu comment data of JD Mall, including basic information such as the brand, price and positive rate of the products. The data is up to May 1, 2024. Secondly, to understand the satisfaction and factors of concern of Hanfu product comments, the comments of the top five children’s Hanfu and adult Hanfu products with the highest number

of comments were obtained. A total of 3,058 comments for children's Hanfu and 1,384 comments for adult Hanfu were collected.

Part of the original comment data in Table 1

User	Comment
Yuyi***tears	The fabric and craftsmanship of the dress are excellent. It is comfortable and breathable to wear. It is made of chiffon fabric, with a lot of drape. The lining is made of cotton yarn fabric, and there are embroidery patterns. The style is simple and elegant... You can buy it with confidence.
u***d	A beautiful Hanfu dress. The actual product is very beautiful. The fabric is soft, comfortable, and skin-friendly, breathable. The waistline design is cinched, and there are flower embroideries. It looks great when worn. The pink color complements one's skin tone. I'm satisfied.
j***t	A very beautiful Hanfu skirt. It is made of chiffon fabric, soft and comfortable, breathable. It is just suitable for summer. The small bag it comes with is also very cute.
u***m	The style is very nice, the fabric is comfortable, the workmanship is good, it doesn't pinch the flesh, and it is safe to wear for children.
u***y	Finally, I bought a satisfactory dress. It exceeded expectations. I really like it. Everyone around me says it looks nice. The fabric is very comfortable, and the child is very happy.
Xixi***cai	The quality is quite good. The fabric is smooth and soft, not pinching the skin, and it is breathable and cool. My daughter looks very nice when wearing it. It is very beautiful when paired with the small bag.
c***a	The Hanfu skirt is so beautiful. My daughter loves it very much. Wearing it gives a feeling like a little fairy. The quality is very good, and the delivery is very efficient.
Wanxi***xi	A very beautiful piece of clothing. It looks beautiful when wearing it in spring and summer with the baby. A friend asked where I bought it, and I have recommended it.

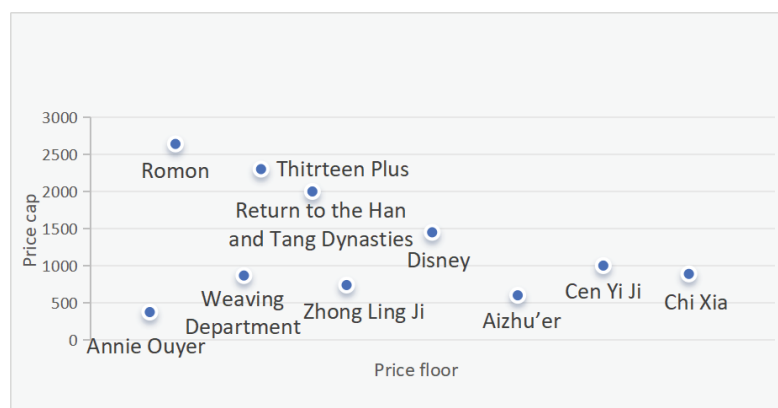
4. Sales Characteristics of Clothing

To understand the sales characteristics of Hanfu products on JD Mall, this article analyzes the data related to the brands, prices, and ratings of Hanfu products.

4.1 Brand Positioning of Hanfu

By conducting research on the Hanfu products on JD Mall, it was found that there are over 500 brands included, such as Return to Han and Tang, Zhiyeshi, San Yuyu, Anni Youyu, etc. This article selects ten Hanfu brands for analysis, and the price range distribution of each brand's Hanfu is shown in Figure 1. The price levels among the brands are clearly distinct. The lowest price of each brand's Hanfu is 0, and the highest price is the highest among Romon, San Yuyu, and Return to Han and Tang, all exceeding 2000 yuan; the highest price of the Disney brand is around 1500 yuan; and the prices of Zhiyeshi, Zhongling Ji, and Ai Zhu'er are all below 1000 yuan.

Figure 1 Price Positioning of Hanfu Brands



4.2 Product Price Range

Jingdong Mall has a total of 1.3 million sets of Hanfu. The price range distribution is from the Jingdong website. As shown in Table 1, the distribution of Hanfu in different price ranges is presented. Hanfu priced below 79 yuan accounts for 1,700 pieces, accounting for 0.1% of the total, and the proportion of users who like it is 9%; Hanfu priced between 79 and 197 yuan has the largest quantity, approximately 1.3 million pieces, accounting for 99.64%, and the proportion of users who like it reaches 30%; Hanfu priced between 197 and 349 yuan has 5,300 pieces, accounting for 0.4%, and the proportion of users who like it is 43%; Hanfu priced between 349 and 491 yuan has 1,100 pieces, accounting for 0.08%, and the proportion of users who like it is 12%; Hanfu priced between 491 and 2,038 yuan has 900 pieces, accounting for 0.06%, and the proportion of users who like it is 6%. The most numerous price range is not the one that users like the most. 99% of the products have only about 30% of users who like them. Thus, it can be seen that consumers recognize the higher price positioning of Hanfu. Compared to the price, they may pay more attention to product quality or other factors when making purchases.

Table 2 Price Distribution of Hanfu

Price range	Quantity (pieces)	Percentage (%)	Percentage of users who like it (%)
0-79	1700	0.1	9
79-197	1300000	99.64	30
197-349	5300	0.4	43
349-491	1100	0.08	12
491-2038	900	0.06	6

4.3 Product Discounts and Labels

Promotions such as discounts, gift vouchers, member prices, gift giveaways, and discounts are common forms of offers. Analyzing the top 200 best-selling products on JD Mall, it was found that the most common discount method used by merchants was the JD PLUS member price, with a discount of 40% off for every 300 yuan spent. The second most common discount was a 30% discount for every 200 yuan spent, followed by a 10% or 5% discount for every 100 yuan spent. Discounts mainly include a 9.5% discount for one item and a 90% discount for two items. The most common product labels were “Trust Purchase”, “Free Shipping”, and “JD Logistics”, followed by “Self-operated” and “New Products”, etc. These discount situations have a certain promoting effect on the sales of Hanfu. JD’s self-operated stores have a good reputation image, and “Trust Purchase” provides services such as shipping insurance or lightning refund. Flash sales promotions and discount promotions mean price discounts. Such labels can satisfy consumers’ desire for price discounts or reduce perceived risks to promote purchases.

5. Text Comment Analysis

To further explore the information contained in online comments about Hanfu and understand the evaluations and concerns of online consumers regarding Hanfu, this paper uses sentiment analysis to explore consumers’ satisfaction with existing Hanfu products, and uses word frequency analysis and social network analysis to explore consumers’ focus points.

5.1 Sentiment Analysis

With the improvement of social economy and culture, consumers’ fashion awareness has continuously increased, and their demand for clothing is no longer limited to the physical performance of practicality, but tends more towards emotional functions^[15]. Image perception has a processual and multi-dimensional characteristic. Analyzing the sentiment of comments from Hanfu consumers is a common method for evaluating the image of Hanfu. This paper conducts consumer sentiment analysis of Hanfu comments using ROST CM6.0.

First, sentiment analysis was conducted on children’s Hanfu (as shown in Table 3), and it was found that consumers had a relatively high level of positive emotions, with 2,781 comments, accounting for 90.94%; the proportion of intermediate emotions was relatively small, with 141 comments, accounting for 4.61%; the proportion of negative emotions was the

lowest, with 136 comments, accounting for 4.45%. It can be seen that consumers' overall perception of the image of children's Hanfu is relatively good.

Table 3 Analysis of Emotional Image of Children's Clothing and Hanfu

Emotional Type	Percentage (%)	Segment Type	Percentage (%)
Positive Emotion	90.94	General (0-10)	16.91
		Moderate (10-20)	21.78
		High (20 or above)	52.26
Intermediate Emotion	4.61	—	—
Negative Emotion	4.45	General (-10-0)	2.81
		Moderate (-20 to -10)	1.60
		High (-20 or below)	0.03

Secondly, an emotional analysis was conducted on adult Hanfu (as shown in Table 4), revealing that consumers had a relatively high level of positive emotions, with a total of 1194 comments, accounting for 86.27%; the proportion of moderate emotions was relatively low, with 132 comments, accounting for 9.54%; and the proportion of negative emotions was the lowest, with 58 comments, accounting for 4.19%. Consumers had a relatively favorable perception of the overall image of adult Hanfu, but their positive emotions were less compared to those of children's Hanfu, while the negative emotions were the same. Consumers were generally in a pleasant mood during the consumption process.

Table 4 Analysis of Emotional Image of Adult Hanfu

Emotional Type	Percentage (%)	Segment Type	Percentage (%)
Positive Emotion	86.27	General (0-10)	23.27
		Moderate (10-20)	25.43
		High (20 or above)	37.57
Intermediate Emotion	9.54	—	—
Negative Emotion	4.19	General (-10-0)	3.11
		Moderate (-20 to -10)	0.91
		High (-20 or below)	0.14

5.2 Feature Keyword Analysis

The frequent words mainly focus on two aspects: one is the overall perception of consumers' image, and the other is the material of Hanfu, the degree of liking, and the perception of consumers' consumption image. Through the frequency analysis of NVivo, the top 100 frequent words were selected for tabulation and summary.

By analyzing the 100 frequent words in Table 5, it can be seen that when consumers evaluate children's Hanfu online, they mainly focus on four parts: feeling, quality, price, and workmanship. The words that dominate are "like", "good", "nice", "beautiful", etc., which are words of praise. The frequency of mentioning "quality", "fabric", "suitable", "comfortable" is relatively high. The frequent words related to price are mainly descriptive words such as "affordable", "shopping", "worth it", "price", "cheap", etc. The words related to workmanship are mainly perception words such as "style", "workmanship", "fabric", "comfortable", etc. From the frequent words of these four parts, it can be seen that consumers' perception of the image of children's Hanfu leans towards the quality and price of the Hanfu.

Table 5 Summary of Frequent Words in Online Reviews of Children's Hanfu Clothing

Frequent Word	Frequency	Frequent Word	Frequency	Frequent Word	Frequency	Frequent Word	Frequency
Like	1658	Fabric	186	Hope	83	Guys	48
Quality	869	Dress	181	Fine	79	Physical	48
Very	698	Speed	181	Quite	78	Complete	47
Good	524	Size	173	Feel	77	Immediately	46
Baby	455	Soft	167	Must	76	Cousin	46
Affordable	410	Child	162	Product	72	Come in	46
Logistics	365	Cheap	160	Patient	72	Children	46
Child	353	Clothing Size	154	Say	71	Seller	45
Received	341	Color	151	Safe	66	Business	45
Nice	321	Recommend	148	JD	64	Style	44
Service	316	Not	141	Shop Owner	63	Always	43
Pretty	314	Express	132	Boss	63	Outside	43
Shopping	290	Packaging	130	Price	58	A lot	43
Attitude	280	In the Future	128	Material	58	Activity	43
Price	278	Positive Review	105	Doubt	58	Really	43
Next Time	268	Effect	104	Overall	55	Think of	42
Worthwhile	260	On Body	98	Whole Set	55	Imagine	42
Seller	248	Soft	98	One	53	Somewhat	41
Suitable	234	Continue	96	Consistent	53	Sure	40
Very Soon	221	Cosmetic Comfort	96	Attention	53	Standard	40
Purchase	216	Visit	91	Merchant	50	Truly	40
Delivery	206	Description	91	Fit	49	Introduction	39
Style	192	Overall	90	Colleague	49	Cheap	39
Workmanship	188	Compare	89	Happy	49	Just Now	39
Satisfied	187	Product	87	Have Something	49	Happy	39

A further analysis of the 100 frequently used words in the adult Hanfu reviews in Table 6 reveals that when consumers evaluate adult Hanfu online, their main focus is on four aspects: feeling, quality, price, and craftsmanship. Consumers' perception of the image of adult Hanfu leans towards quality and price, which is consistent with the preferences of consumers when purchasing clothes.

Table 6 Summary of Frequent Words in Online Reviews of Adult Hanfu Clothing

Frequent Word	Frequency	Frequent Word	Frequency	Frequent Word	Frequency	Frequent Word	Frequency
Good	417	Soft	66	Things	32	Girlfriend	19
Very good	402	Worth	60	Shop owner	32	Imagination	19
Quality	392	Comfortable	59	Clothes	31	Wife	19
Like	329	Shipment	58	Packaging	30	Height	19
Clothes	254	Dress	55	Express delivery	29	Style	19
Nice	238	Speed	54	Correct fit	28	Reliable	18
Fabric	210	Positive review	52	Description	28	Try on	18
Satisfied	189	Slightly	52	Just now	25	Five-star	16
Style	159	Fine	51	Next time	24	Merchant	16
Effect	154	Tactility	51	Some degree	24	Matching	16
Comfortable	154	Service	47	First time	24	Indeed	16
Workmanship	145	Images	46	High quality and low price	23	Happy	15
Received	141	Feeling	46	Material	22	Standard	15
Suitable	130	Attitude	44	Delicate	22	Unique	15
Beautiful	124	JD	43	Consistency	21	Now	15
Size	109	Recommendation	42	Child	21	Always	14
Wear	102	Design	42	Cloth	21	In the future	14
Shopping	90	Baby	41	New	21	Body type	14
Size	78	Friend	40	Generous	20	Weight	14
Price	77	Comparison	40	Already	20	Happy	14
Material	74	Trend	38	Details	20	Overall	14
Color	72	Touch	37	Body shape	20	Whole picture	14
Logistics	70	Superior	35	Suitable	20	Truly	14
Comfortable	69	Seller	34	A little bit	19	Know	14
Purchase	67	Practical	33	Daughter	19	Fine	14

5.3 Cognitive Image Analysis

Further cognitive image analysis was conducted using the NVivo software, generating a word cloud chart from the consumer cognitive comments. Visually, the consumers' perception of the consumption image of Hanfu was presented.

Figure 2 shows the cognitive image analysis word cloud chart of children's Hanfu. In this figure, the larger the font size, the higher the frequency of its appearance in the online evaluations of consumers. It can be clearly seen that the attention on "feeling" and "quality" is the highest, and various demands and feelings have been derived from these two focus points.

Figure 2 Word Cloud Chart for Analyzing the Cognitive Image of Children's Clothing Hanfu

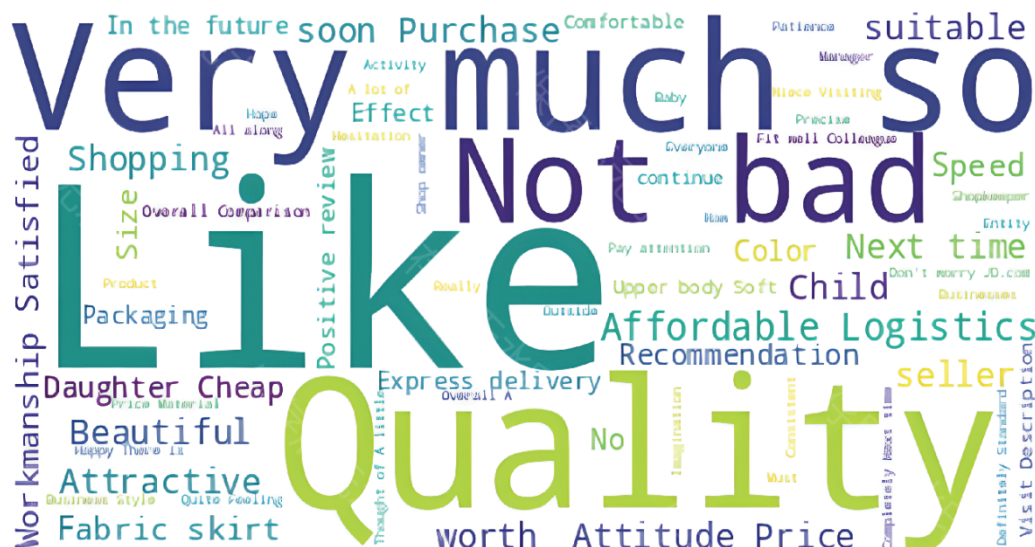


Figure 3 is a word cloud chart for the analysis of the cognitive image of adult Hanfu. It is clearly visible that the terms “quality”, “not bad”, and “like” have the highest attention levels, and these focus points have led to various demands and feelings.

Figure 3 Word Cloud Chart for Analyzing the Cognitive Image of Adult Hanfu

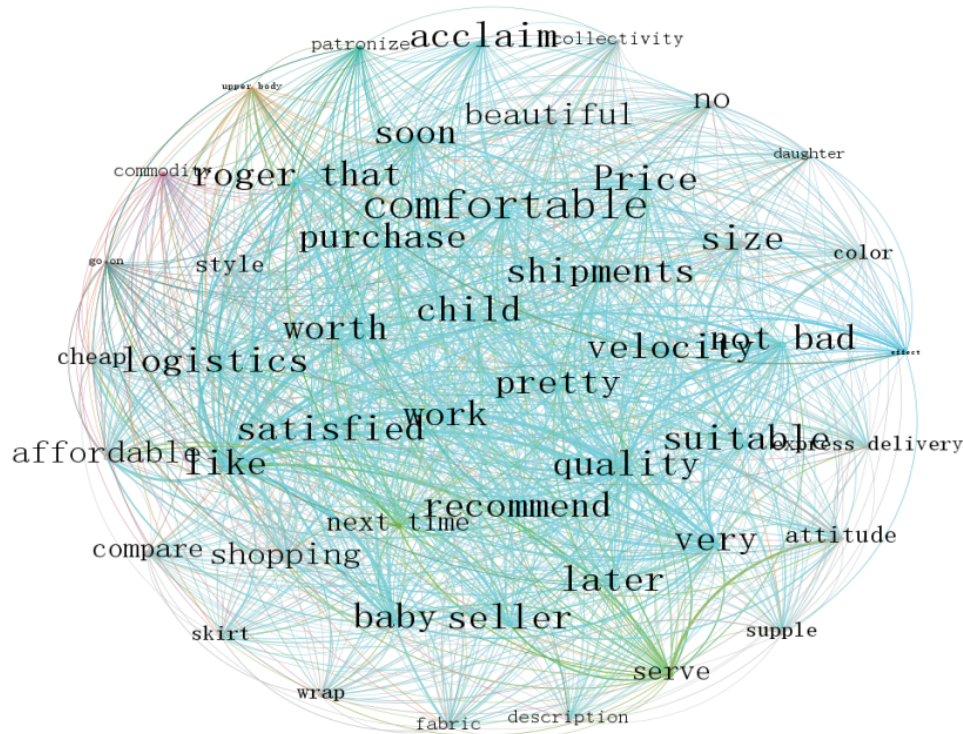


5.4 Semantic Network Analysis

Word frequency analysis can reflect the main characteristics of the sample data, but it cannot reflect the relationships between sample phrases and the structure of the sample. The construction of a semantic network can better reflect the correlation degree among high-frequency words. Therefore, based on the previous research, this paper uses Gephi to generate a semantic network diagram. The semantic network diagram is in a divergent shape. The more vocabulary connections there are, the closer the relationship is.

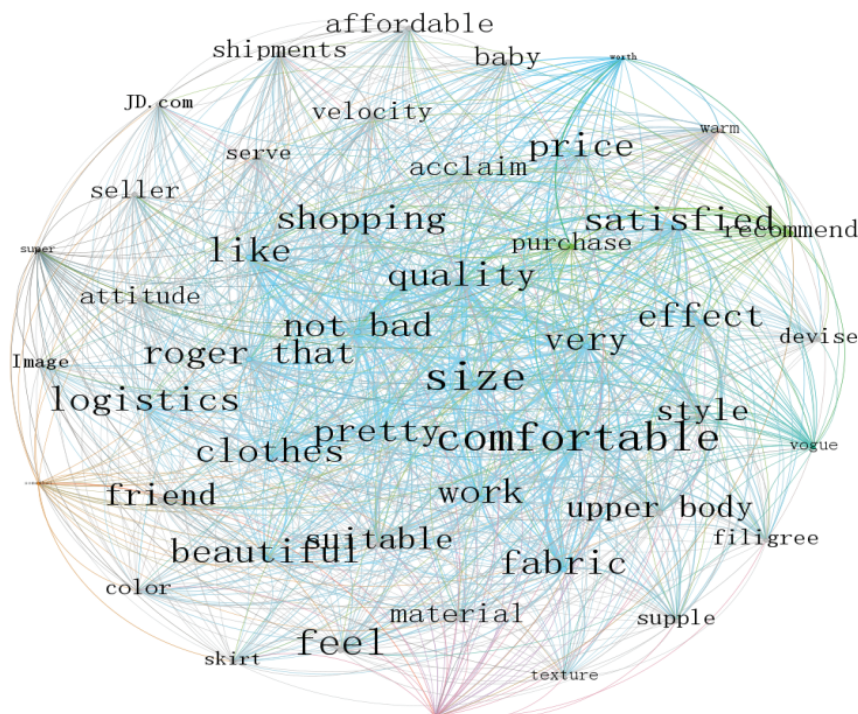
As shown in Figure 4, words such as “like”, “satisfied”, “quality”, and “recommend” are located at the core position of the graph. These words are the high-frequency words that appear frequently in online consumer reviews and are the first impression for children’s clothing and Hanfu. Consumers’ online reviews often start from these words. “Nice”, “logistics”, “workmanship”, “attitude”, and “delivery” are located at the secondary core of the graph. These keywords represent the basic cognitive needs of consumers for purchase intentions. The peripheral associated words of the graph further describe and explain the core words. Further analysis of the strength of the word associations in the graph reveals that the connection nodes around “like” and “price” are the most numerous.

Figure 4 Semantic Network Diagram of Children's Clothing Hanfu



As shown in Figure 5, words such as “not bad”, “quality”, and “comfortable” are located at the core of the graph. These words are frequently used in online consumer reviews and represent the first impression of adult Hanfu. Consumer online reviews often revolve around these words. Consumers’ main concerns are concentrated on aspects such as “style”, “logistics”, “attitude”, “quality”, “packaging”, “clothes”, “size”, “fabric”, “delivery”, “fit”, “affordability”, “workmanship”, “price”, “material”, “texture”, “JD.com”, etc. These key words reflect the basic needs of consumers for Hanfu.

Figure 5 Semantic Network Diagram of Adult Hanfu



6. Conclusions and Implications

The rise of Hanfu fashion has led to a significant increase in the transaction volume of Hanfu clothing. Many Hanfu merchants have seized the opportunity and stood out in this trading trend. However, related development issues have gradually emerged. This article takes JD Mall as an example to analyze the brands, prices, and product discounts of Hanfu, summarizes the online sales characteristics of Hanfu, and conducts social network analysis on online reviews of Hanfu products, summarizing the factors that consumers pay attention to. Based on this, four suggestions are proposed.

First, clarify the target audience group. For different audiences, corresponding marketing strategies can be formulated, such as the youth group, culture enthusiasts, history enthusiasts, etc. The focus of comments on children's Hanfu and adult Hanfu is different. In terms of price, Hanfu should be designed within the price range that consumers like. Different types of Hanfu should adopt different pricing strategies in terms of brand, material, positioning, etc. In the market competition, it is very important to distinguish from other brands.

Second, strictly control the quality of Hanfu. The words "quality", "material", "very", "comfortable" frequently appear in the comments. It can be seen that consumers are very satisfied with purchasing Hanfu. Consumers pay the most attention to the quality and fabric when purchasing Hanfu. Therefore, the brand should strictly control the quality of the product and obtain high satisfaction consumers through high-quality fabrics.

Third, update the styles of Hanfu in a timely manner. The words related to the design appearance appear frequently in the comments, such as "nice", "beautiful", "style", etc. Therefore, the brand should increase investment in Hanfu design, "nice" and "beautiful" are important reasons for consumers to purchase Hanfu and be satisfied with it.

Fourth, combine Hanfu with Chinese traditional culture closely. Hanfu brands can emphasize their unique cultural value through attention to design style, craftsmanship technology, etc., to create a unique brand image, making it have a unique and high-quality image in the consumers' minds, to attract those who are interested in traditional culture. It can be done through cultural exhibitions, theme activities, etc., to enable consumers to have a deeper understanding and experience of the cultural connotation represented by Hanfu.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Zhang, C., Dai, Q., Yao, X., et al. (2023). Research on design elements of Hanfu in the Ming Dynasty based on eye tracking technology. *Silk*, 60(09), 120–127.
- [2] Zhou, Y., & Zhu, H. (2024). Perspective on the "Hanfu Trend": Cultural value re-creation of Chinese cultural products from the perspective of symbolic consumption. *Academic Sea*, (03), 143–149.
- [3] Wu, M., Yang, L., Xie, Y., et al. (2020). Research on the development of Hanfu industry under the revival of traditional culture. *Cooperative Economy and Science & Technology*, (17), 36–38.
- [4] Han, X. (2012). Cultural reflection on the contemporary revival of Hanfu. *Journal of Art College of Inner Mongolia University*, 9(04), 38–45.
- [5] Wei, P. (2021). "Hanfu craze" from the perspective of cultural economics: The coincidence of ontological cultural consciousness and clothing industry segmentation. *People's Forum*, (27), 100–104.
- [6] Yang, X., Zhang, R., & Kong, L. (2022). "Reconstruction of tradition" and popularity: An investigation into the evolution logic of youth Hanfu culture. *Contemporary Youth Studies*, (02), 40–47.
- [7] Jiang, N. (2022). From cultural behavior to identity expression: The popularity and controversy of Hanfu culture from the perspective of "actor network theory". *Shanghai Culture*, (10), 94–103.
- [8] Huang, K., Zhang, J., Zhang, Z., et al. (2024). Research on the influence of consumer online evaluation intentions in the context of good reviews reward. *Jiangsu Business Review*, (11), 39–43.

- [9] Kang, L., & Zhang, Y. (2024). Consumption demand of Russian down jackets based on text mining. *Modern Textile Technology*, 32(08), 108–116.
- [10] Qiu, D., & Yi, X. (2023). Research on consumer satisfaction during the Double Eleven campaign – Based on text mining of Tmall's personal care and beauty products. *Journal of Chongqing University of Posts and Telecommunications (Social Science Edition)*, 35(02), 131–145.
- [11] Lin, W., Liu, H., Chen, Y., et al. (2023). Research on customer satisfaction based on online reviews – Taking health monitoring wearable products as an example. *Data Analysis and Knowledge Discovery*, 7(05), 145–154.
- [12] Liu, J., & Li, M. (2023). Online review analysis of silk blankets based on text mining – Taking JD Mall as an example. *Silk*, 60(08), 11–20.
- [13] Sun, B., Ao, C., Wang, J., et al. (2022). Research on satisfaction evaluation of ecotourism based on network text mining. *Operations Research and Management*, 31(12), 165–172.
- [14] Guo, L., & Li, J. (2022). The impact of consumer crisis perception risk on online review effects. *Journal of Northeastern University (Natural Science Edition)*, 43(11), 1662–1672.
- [15] Xiao, J. (2012). Analysis and construction of emotional factors in clothing brands. *Journal of Textile Research*, 33(10), 117–121.

Research on Financial Analysis and Evaluation——A Case Study of Joyoung CO

Chenyang Qi*

College of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710000, China

*Corresponding author: Chenyang Qi

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In recent years, due to the impact of the new crown pneumonia epidemic, the economic development of countries around the world has been slow or even stagnant, and the same is true for our country's economy. In recent years, due to the impact of the new crown pneumonia epidemic, the economic development of countries around the world has been slow or even stagnant, and the same is true for our country's economy. As far as the home appliance industry is concerned, the large-scale home appliance market has been significantly affected, and the market has generally shown a downward trend. However, with consumption upgrading, small home appliances characterized by "small but refined" are not the most popular products. However, with consumption upgrading, small home appliances characterized by "small but refined" are developing rapidly like a dark horse, showing a relatively tenacious vitality, and has developed into a new blue ocean in the home appliance market, with the market being characterized by "small but refined". However, with consumption upgrading, small home appliances characterized by "small but refined" are developing rapidly like a dark horse, showing a relatively tenacious vitality, and has developed into a new blue ocean in the home appliance market, driving a new wave of consumption in the field of home appliances. Co., Ltd. is a very representative enterprise in this industry. This paper will take home appliance company Joyoung Co., Ltd. as the research object, based on the company's 2020-2022 financial statement data, using relevant financial methods, from four dimensions of profitability, solvency, operating capacity, development capacity and other comprehensive analysis. This paper will take home appliance company Joyoung Co. as the research object, based on the company's 2020-2022 financial statement data, using relevant financial methods, from four dimensions of profitability, solvency, operating capacity, development capacity and other comprehensive From the perspective of financial analysis, finds the existing problems of Joyoung Company, summarizes the drawbacks and deficiencies in the operation process of the enterprise, and gives a comprehensive analysis of the company's financial statement. operation process of the enterprise, and gives some suggestions, hoping to provide some help for the development of the company, and also provide some reference for the healthy development of other companies in the same industry.

Keywords: Small Household Appliance; Joyoung Co., Ltd.; Financial Analysis

Published: Aug 27, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.570>

1.Introduction

With the improvement of residents' living standards and accelerated urbanization, China's demand for home appliances has

grown significantly, and the industry is booming^[1]. Consumption upgrading has led to the rapid popularization of small home appliances as a symbol of quality life, and a strong manufacturing base not only supports domestic demand, but also makes China an important global production base. Under the guidance of national policies, the home appliance industry is crucial to people's livelihood and economic stability. Technological advances and consumer demand upgrades drive products to intelligent, refined development, the rise of e-commerce channels to further expand the market^[2]. However, the industry is facing multiple challenges such as rising costs, intensifying competition, product homogenization and epidemic impact. The slowdown in real estate growth and disruptions in the global supply chain led to a significant decline in sales. Against this backdrop, financial analysis has become a key tool for companies to diagnose problems and seek breakthroughs^[3]. Domestic and international studies have provided theoretical support to cope with the challenges. Western financial analysis has a mature theoretical system, and domestic research has a late start but strong practicability^[4].

In this paper, Jiuyang is selected as a case study to carry out a multi-dimensional analysis, aiming to reveal the core problems of enterprises in the post epidemic era, put forward targeted solutions, and provide a model of financial analysis practice for the same industry.

2. Financial analysis of Jiuyang

With the help of relevant financial analysis methods, this part will take Jiuyang Company as the research object, and selected the financial statement data of the last three years to conduct an all-round financial analysis of Jiuyang Company.

2.1 Jiuyang Company Profile

Jiuyang was founded in July 2002 as Shandong Jiuyang Small Home Appliances Co. It is a company known for its soymilk machines and has diversified into various small home appliance fields, including cooking machines, and is committed to the innovation, production and marketing of various types of products. As a leading brand of national healthy life, the company has always been adhering to the strategic concept of “positioning the kitchen, upgrading the kitchen”, focusing on improving people's quality of life, and continuing to innovate and produce high-quality products in line with the national health needs, and work hard to bring convenience to the lives of customers.

2.2 Company operations

Table 3-1 Changes in Total Operating Income and Net Income of Jiuyang Corporation

Unit: million dollars

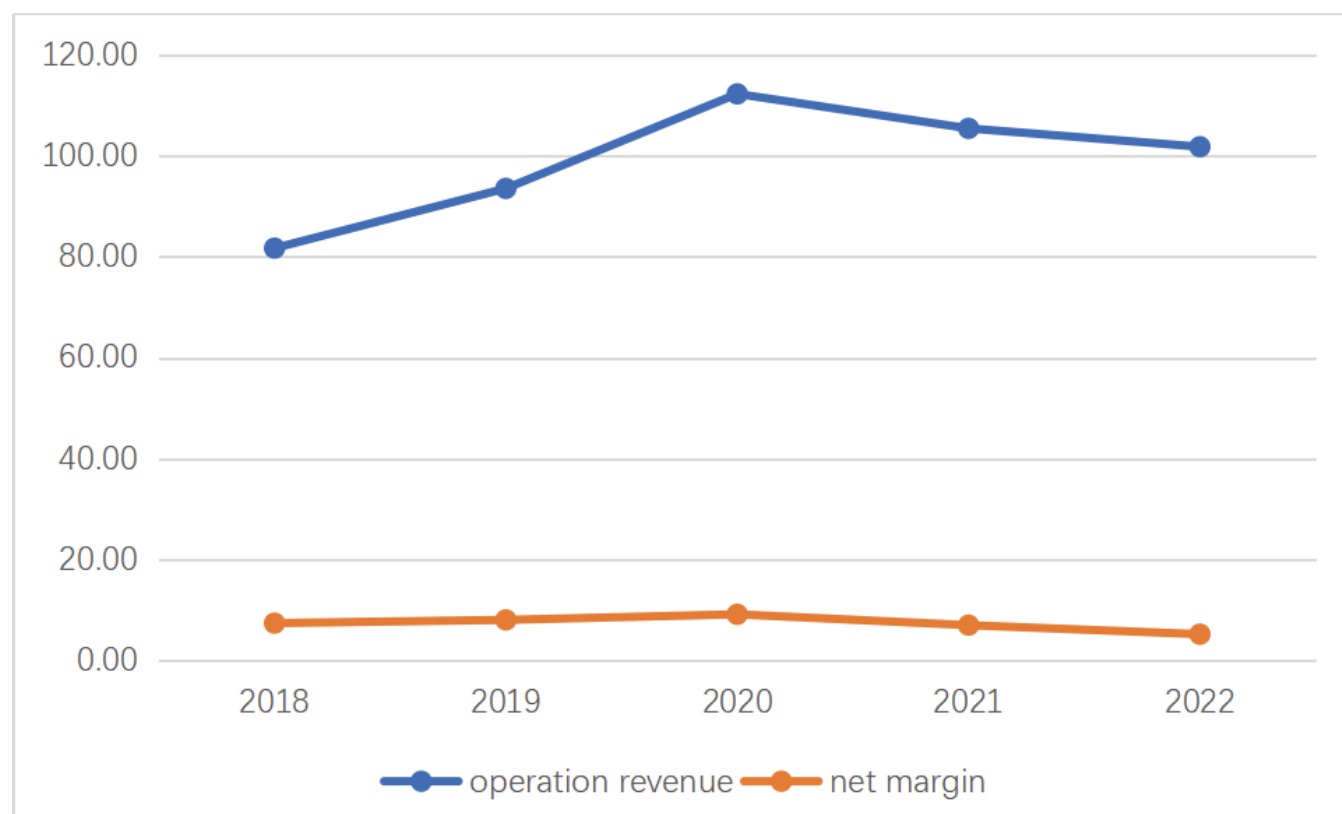
particular year	2018	2019	2020	2021	2022
total revenue	816,870.87	935,143.95	1,122,374.76	1,054,047.39	1,017,668.78
net profit	74,166.15	80,576.01	91,631.41	70,130.60	52,251.05

Data source: 2018-2022 Annual Reports of Jiuyang Corporation

According to the financial annual report of Jiuyang Company, the total operating revenue in 2022 decreased by 3.45% from 2021; total profit decreased by 26.20% from 2021; and net profit attributable to shareholders of the parent company decreased by 28.98% from 2021. Table 3-1 above summarizes the changes in Jiuyang's total operating income and net profit from 2018 to 2022.

From Table 3-1 and Figure 3-1 shows that during the period of 2018-2022, Jiuyang's total operating income and net profit showed a general trend of rising and then falling, and the operating income grew faster during the period of 2018-2020, mainly due to the transformation and upgrading of China's small household appliance industry is the “epitome” of China's manufacturing transformation and upgrading. And from 2020 to 2022 slow decline, mainly due to rising raw material prices, high production costs, the gradual recovery of the offline market, online market change accelerated, channel traffic fragmentation and other factors to the company's development has brought greater pressure and difficulties, resulting in a decline in the company's operating income. And the net profit compared to the operating income, the growth rate is slower, mainly due to the raw materials and other production costs rise, advertising investment and the various channels aspects of the cost of sales expenses such as the increase.

Figure 3-1 Trends of Total Operating Income and Net Income of Jiuyang Corporation, 2018-2022



2.3 Analysis of Jiuyang's Financial Capability Indicators

2.3.1 Profitability analysis

Profitability is the ability of a firm to make profits over a certain period of time, also known as the ability of the firm to increase its capital or capital appreciation, which is crucial for all stakeholders of the firm. And as the profitability of a firm increases, the return to shareholders also increases, which enhances the value and cash flow of the firm, as well as the ability of the firm to service its debt.

Table 3-2 Profitability Analysis of Jiuyang Corporation, 2020-2022

Unit: million dollars

Profitability indicators	2020	2021	2022
net operating profit margin	8.16%	6.65%	5.13%
Total asset turnover	1.35	1.19	1.31
return on total assets	12.80%	8.96%	7.48%
Return on shareholders' equity	29.25%	18.57%	13.81%

Source: Jiuyang Financial Statements

Table 3-2 can be analyzed to show that the net operating margin of the enterprise is in a declining state from 2020 to 2022, which indicates that the financial structure of the company is unreasonable, the profitability of the enterprise needs to be improved, and the development of the enterprise has encountered a bottleneck. The enterprise's total asset turnover ratio shows a small fluctuation state, and then from the two aspects of total asset return and shareholders' equity return, both of which show a downward trend year by year.

2.3.2 Debt service capacity analysis

Table 3-3 Solvency Analysis of Jiuyang Company 2020-2022

Unit: million dollars

Solvency indicators	2020	2021	2022
current ratio	1.52	1.56	1.34
Quick Freeze Ratio	1.14	1.17	1
cash ratio	0.41	0.48	0.43
gearing	53.12%	50.19%	52.98%

Source: Jiuyang Financial Statements

From the perspectives of current ratio, quick ratio and cash ratio, the overall trend of these three ratios from 2020 to 2022 shows a rising and then falling trend, which shows that the company's short-term solvency is not obvious. From a certain point of view, the enterprise cash ratio has a certain relationship with its financial elasticity and current liabilities repayment ability, that is, the higher the cash ratio, the higher its financial elasticity, the stronger the current liabilities repayment ability, but for an enterprise, the pursuit of improving the cash ratio is not good, the ratio is too high, it may produce excess funds, the opportunity cost of funds increases, the ability of cash profitability will be correspondingly low, the utilization of liquid assets and other related problems. Therefore, the enterprise should control the cash ratio within a certain limit is the optimal choice. From the perspective of gearing ratio, the change is not obvious in these three years, which shows that the company's long-term solvency is basically stable, of course, from the perspective of enterprise development, the gearing ratio should be reduced year by year, therefore, Jiuyang should also take measures to improve the competitiveness of the enterprise as well as the profitability^[2].

2.3.3 Operational capacity analysis

Table 3-4 Jiuyang Corporation Operating Capacity Analysis 2020-2022

Unit: million dollars

Indicators of operational capacity	2020	2021	2022
Inventory turnover	7.51	12.14	29.27
Accounts receivable turnover ratio	53.68	26.27	15.93
Fixed asset turnover	16.92	17.24	16.77
Current asset turnover ratio	1.75	1.53	1.78
Total asset turnover	1.35	1.19	1.31

Source: Jiuyang Financial Statements

From Table 3-4, it can be seen that the company's inventory turnover ratio has been in a steadily increasing trend from 2020 to 2022, which shows that the company is more capable in inventory management. The improvement of inventory turnover ratio can effectively reduce the level of capital utilization. Analyzing from the perspective of accounts receivable turnover, the speed of the company's receipt of payments is inversely proportional to the chance of bad debts, i.e., the faster the company receives payments, the less likely bad debts will occur. The company's accounts receivable turnover ratio peaks in 2020, indicating that the company has the strongest accounts receivable management in 2020. In 2020, the rate of collection also declines significantly, and liquidity then becomes weaker. Analyzing from the perspective of fixed asset turnover and current asset turnover, the company as a whole shows the trend of rising and then falling, and the overall change is not obvious. The higher the current asset turnover ratio, the faster the turnover of current assets, the higher the utilization rate. Analyzing from the perspective of total asset turnover ratio, the company as a whole shows the development trend of decreasing and then

increasing. The decline in total asset turnover ratio indicates that in the process of operation, the flow rate of many assets from input to output is low, the utilization rate of assets is not high, and the quality level of asset management is not high, while the company's total asset turnover ratio as a whole shows a slow fluctuation trend, which is enough to make the enterprise managers to raise the vigilance, and they should strengthen the management of the assets, in order to improve the efficiency of the utilization of the assets.

2.3.4 Development capacity analysis

Table 3-5 Jiuyang's Development Capability Analysis, 2020-2022

Unit: million dollars

Capacity development indicators	2020	2021	2022
Revenue growth rate	20.02%	-6.09%	-3.45%
Total asset growth rate	22.32%	-6.77%	-16.93%
rate of capital accumulation	12.03%	28.14%	-21.58%
profit growth rate	13.08%	-25.63%	-26.20%

Source: Jiuyang Financial Statements

According to Table 3-5, the company in the period of 2020-2022, the company's revenue growth rate as a whole showed a negative growth trend, indicating that the company through the creation of creative products, the effectiveness of the product is not clear, the product stagnation, the market development ability has significantly reduced. From the perspective of total asset growth rate to analyze, the company's total asset growth rate as a whole showed a negative growth trend, that is, the total amount of assets declined significantly, the size of the assets fell significantly in just a few years, indicating that the growth capacity of the enterprise is extremely weak. Analyzed from the perspective of capital accumulation rate, the overall fluctuation of the company's capital accumulation rate is more obvious, showing a trend of rising and then falling, indicating that the company has a strong expansion capacity, while its capital accumulation is unstable, indicating that its ability to sustained development needs to be improved. Analyzing from the perspective of profit growth rate, the overall profit growth rate shows the trend of increasing year by year, indicating that the company's profitability is weak and the market prospect is worrying.

3.Problems and Improvement Suggestions of Jiuyang Company

3.1 Problems

3.1.1 Reduced asset size and growth capacity

From Table 3-2, since 2020, Jiuyang's total assets have declined and the asset growth rate has been negative, which shows that the enterprise's asset scale is shrinking, not forming the advantages of scale operation, and the enterprise's growth ability is not good.

3.1.2 High proportion of current liabilities and increased operational risk

As shown in Table 3-2, in 2022, Jiuyang's current liabilities accounted for as high as 97.98% of the total liabilities, while the repayment period of current liabilities is short, in case of a shortage of funds, large short-term liabilities will be difficult to be repaid, and the company will face a greater financial risk, and the business operation will face great challenges.

3.1.3 Decreased operating profit and weakened profitability

From Table 3-2, since 2020, Jiuyang net operating profit margin, return on total assets, return on shareholders' equity and other indicators to examine the profitability of the value of a significant decrease in the enterprise can be seen in the lack of growth, analysis of the reasons can be found, the enterprise needs such as raw materials, labor and other costs of production have risen significantly, the increase in advertising investment and the cost of various channels and other significant increase in the cost of sales, the increase in market competition has led to a decrease in product sales, which ultimately led to a decline in product profitability. Increased competition in the market led to a decrease in product sales, which ultimately led to a

decline in product profitability. Moreover, the market situation in this industry shows that supply exceeds demand and has reached saturation. Therefore, the enterprise in reducing costs at the same time, transformation and upgrading without delay.

3.1.4 Unstable asset utilization and low level of asset management

Table 3-4 shows that between 2020 and 2020, the asset turnover ratio of Jiuyang Company first shows the development trend of decreasing and then increasing, and the overall view is unstable, which indicates that in the process of the operation of the enterprise, the flow rate of many assets from input to output is low, the utilization rate of the assets is not high, and the quality level of the management of the assets is not high, and this dynamic is enough to make the managers of the enterprise to raise vigilance, and the management of the assets should be strengthened in order to improve the utilization efficiency of assets.

3.1.5 Low turnover of accounts receivable and inadequate collection efforts

As shown in Table 3-4, the accounts receivable turnover rate of Jiuyang Company falls significantly from 53.68% in 2020 to 15.93% in 2022, and the slower the company receives the payment, the higher the probability of bad debts occurring. And the liquidity will become weaker with the decline in the speed of collection, so the management level of accounts receivable is crucial for a company, and the company should solve the problem of low accounts receivable turnover as soon as possible and improve the management level of accounts receivable ^[3].

3.2 Recommendations for improvement

3.2.1 Increase R&D investment to enhance product competitiveness

Increase the attention to such products, increase the capital investment in their research and development, and continuously launch new products with higher technological content and better product value to enhance the competitiveness of the relevant products and promote the enhancement of the economic benefits of enterprises ^[4].

3.2.2 Controlling operating costs and reducing business risks

Establish a cost and expense control system to refine and decompose costs; subdivide management expenses to reduce non-essential expenditures; and formulate scientific management expense standards to reduce costs.

3.2.3 Innovate and accelerate product transformation and upgrading

Continuously improve the competitiveness of ace products, stabilize the main business income brought by higher profit products, so that profits continue to improve. Adjust the development strategy, accelerate the transformation and upgrading, increase technological innovation ^[5], explore new blue ocean and increase the added value of products. Focusing and oriented on user needs, we continue to launch more products that meet the needs of consumers in the new era to satisfy the growing personalized needs of consumers.

3.2.4 Enhanced management of funds and fixed assets

Actively explore diversified financing channels to improve the efficiency of capital utilization, strengthen the management of accounts receivable to reduce the enterprise's capital consumption, and strengthen the all-round management of fixed assets. Comprehensively optimize the above links to promote the improvement and accelerated development of the supply chain.

3.2.5 Improve accounts receivable management

In formulating credit policies, it is necessary to accurately assess customer creditworthiness and weigh credit costs and credit risks; establish collection mechanisms with flexibility and efficiency to ensure timely collection of accounts; commit to reducing and preventing the occurrence of bad and doubtful debts by conducting in-depth analysis of the aging of accounts receivable; the enterprise must follow the principle of soundness, anticipate possible losses from bad debts, and proactively establish an appropriate reserve system; raising the risk awareness of leaders and strengthening the leadership responsibility for receivables are also important measures to improve the management of receivables.

4. Conclusions and outlook

This paper takes Jiuyang Company as the research object and draws the following conclusions by summarizing and analyzing the relevant financial data of the company from 2020 to 2022:

Firstly, a company with even better performance in the past is bound to go downhill in the end if it does not think of making progress and strive to innovate and improve itself in terms of technology, market and management. This can be fully illustrated by analyzing the financial status of Jiuyang in recent years, although the development of Jiuyang has not yet

reached this point of decline.

Secondly, the rising cost of raw materials and rising management costs are inevitable problems in the process of enterprise development, enterprises must rely on technological progress, management level improvement, efficiency enhancement and other ways to solve them.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Shan, Y. (2020). Profitability analysis of small household appliance enterprises in China—Taking Jiuyang Joint Stock Company as an example. *Modern Business*, (08), 99–100.
- [2] Fu, Z. (2021). Research on the evaluation of profitability of Jiuyang Stock (Master's thesis). Northeast Agricultural University.
- [3] Chen, Y. (2023). Optimization research on marketing strategy of Xiaoxiong Electric Appliance Company (Master's thesis). East China Normal University.
- [4] Zhou, C. (2020). Comparative analysis of financial performance, financial policy and financial strategy of Supra and Jiuyang shares (Master's thesis). Xiamen University.

Research on the Development Strategy of Commercial Bank Business Based on BCG Matrix—Taking Bank A as an Example

Chengzhong Gao*

Gansu University of Political Science and Law, Business School, Lanzhou, Gansu, 730000, China

*Corresponding author: Chengzhong Gao

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Based on public annual reports and financial statistics from the People's Bank of China, this study employs an adjusted BCG Matrix analysis to conduct an in-depth analysis of the main business operations of Bank A. The study finds that its business mainly falls within high-growth, low-market-share categories, lacking significant competitive advantages, with issues like insufficient market competitiveness, challenges in risk management, and ineffective policy implementation. Recommendations include enhancing market competitiveness by innovating financial products and personalized services, optimizing the customer relationship management system, and mitigating price disadvantages through market segmentation; strengthening risk management by introducing advanced risk management tools, optimizing business structure allocation, establishing risk mitigation mechanisms, and enhancing the risk management committee's structure and team expertise; optimizing policy execution by adjusting internal incentive mechanisms, improving performance assessments for policy-related businesses, conducting regular internal training, and developing internal promotional materials, while also refining loan distribution channels to enhance cooperation with small and micro enterprises and individual business owners.

Keywords: Commercial Bank; BCG Matrix; Business Development Strategy

Published: Aug 27, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.569>

1.Introduction

Commercial banks play a key role in promoting the adjustment of the national economic structure and driving the development of the real economy. Currently, the global economy is complex and ever-changing, with intensified international competition, while China's economy has entered a new "dual circulation" development pattern. Under this framework, as the main goal of expanding the domestic financial market has been established, competition among commercial banks in China is expected to become increasingly fierce^[1]. Business development strategy, being a crucial factor influencing competition, also presents some new challenges in the new context.

At present, the digital transformation of Chinese state-owned commercial banks has made significant progress^[2]. With the gradual refinement of digital transformation in financial institutions, there have been considerable changes in the business development and transformation of commercial banks compared to before, particularly in the impact on the proportion of different business segments. The overall business structure has seen notable differences from the past^[3]. However, in practice, many business segments have not evolved in tandem with digital transformation, leading to issues such as delays in business structure adjustments. By analyzing the latest business data, it is possible to uncover deeper problems in the current business development strategies of commercial banks and address them accordingly.

On this basis, risk management, as an important part of the development strategy of commercial banks, must not be overlooked in any environment or phase. In the process of digital transformation, risk factors have the most critical impact on the overall development of commercial banks, and issues related to risk management in business development significantly influence the bank's overall performance^[4]. When studying business development strategies, we must pay close attention to risk issues, using risk management as a guiding principle for proposing optimizations and solutions.

In addition, the strategic formulation of Chinese commercial banks has unique characteristics compared to their foreign counterparts. The strategic vision and objectives of Chinese commercial banks tend to be more macro-oriented^[5], with strategies generally based on the specific characteristics of domestic industrial structure and financing needs, aiming to serve the real economy and contribute to national development^[6]. Conducting case studies on specific banks can help reveal issues brought by homogeneous competition, thereby providing valuable insights for other financial institutions in the industry and achieving policy objectives that promote economic development.

Based on the widespread issues currently existing in commercial banking business development, this paper takes Bank A as an example, compiling data on business development from its annual report, along with data from its main competitors and industry-related statistics as a basis for research. Data analysis uses the BCG Matrix, a classic strategic analysis tool, which has been optimized for this study to analyze Bank A's business development status and identify existing problems. Finally, combined with industry characteristics and guided by risk management, relevant optimization strategies are proposed.

2.Review of Relevant Theories

The BCG Matrix, also known as the market share matrix or the growth-share matrix, is a strategic management tool used for analyzing a company's portfolio of products or services. This matrix was developed by the Boston Consulting Group in the 1970s to help companies identify the market potential of their products or services and assess their relative market position^[7]. In recent years, the BCG Matrix has been applied in various fields, including dynamic analysis of strategic positions^[8], studies on changing patterns and driving mechanisms^[9], strategic evolution processes in enterprises^[10], performances and potentials in different market segments^[11], and the impact of macroeconomics on banking costs and efficiency^[12]. There have also been studies that combine the BCG Matrix with other theories to explore strategic decision-making methods^[13] and further analyze the influence of market share dimensions on company performance^[14]. These studies have enriched the theoretical foundation of the BCG Matrix, providing valuable references for strategic planning and market competition analysis.

The analysis of the current business development of commercial banks using the BCG Matrix allows for a clear understanding of the specific issues with their products, enabling the formulation of more informed decisions to address these problems and optimize their business development strategies.

3.Selection and Adjustment of Matrix Indicators

3.1 Selection of Relevant Indicators

As a commercial bank, Bank A currently has three main businesses: deposit business, loan business, and intermediary business. By utilizing these three primary indicators and their corresponding sub-indicators as the analytical foundation, it is possible to identify and reflect the underlying issues within the bank.

3.2 Processing of Relevant Indicators

For market share, the corresponding data of the largest competitor in the industry is used to calculate the relative market share. The basic formula is as follows:

$$\text{Relative Market Share of a Product} = \frac{\text{Market Share of the Product (Bank A)}}{\text{Market Share of the Product (Largest Competitor)}}$$

Due to the nature of the industry, the core value of banking competition is often directly reflected through balances. These balances are not only a direct reflection of a bank's business achievements but also a fundamental measure of business scale. After incorporating the concept of market share, the market share of a banking product is the ratio of its balance to the total market volume, with the same approach applied to the market share of competitors. By canceling out the common factor of

total market volume, the adjusted formula for relative market share is:

$$\text{Relative Market Share of a Product} = \frac{\text{Balance of the Product}}{\text{Balance of the Product (Largest Competitor)}}$$

For market growth rate, data from 2023 and 2022 of Bank A were used, with the basic formula as follows:

$$\text{Market Growth Rate of a Product} = \frac{\text{Current Year Balance} - \text{Previous Year Balance}}{\text{Previous Year Balance}} \times 100\%$$

In the BCG Matrix, the market growth rate is evaluated against the industry average growth rate for the year, which is used as the benchmark. Since the average growth rates differ across various business segments, to make the comparison more intuitive, the difference between the product growth rate and the industry average growth rate is taken, and 10% is used as a common benchmark line. The final adjusted growth rate is calculated by adding 10% to the difference. The formula for adjusted growth rate is as follows:

$$\text{Adjusted Growth Rate} = \text{Product Growth Rate} - \text{Industry Average Growth Rate} + 10\%$$

3.3 Data for Relevant Indicators

The specific data for the indicators come from the annual reports of listed companies, while the industry average growth rates are derived from the 2023 financial statistics report by the People's Bank of China. Specific data is shown in Table 3-1.

Table 3-1 Relevant Indicator Data

Business Indicator	2023balance (Trillion CNY)	2022balance (Trillion CNY)	Competitor 2023 Balance (Trillion CNY)	Market Growth Rate	Industry Average Growth Rate
Deposit Business	28.9	28.2	31.1	16.59%	9.60%
Loan Business	22.6	19.8	25	14.52%	10.10%
Intermediary Business	0.0801	0.0813	0.1193	-1.46%	-8.10%
Corporate Loans	12.8	10.7	16.1	19.63%	12.70%
Short-term Corporate Loans	3.3	3.1	3.7	6.45%	8.20%
Medium-to-long-term Corporate Loans	9.5	7.6	12.4	25.00%	15.70%
Personal Loans	8.6	7.5	8.7	14.67%	5.70%
Personal Housing Loans	5.2	5.3	6.3	-1.89%	-1.60%
Personal Consumption Loans	0.3	0.2	0.3	50.00%	9.40%
Personal Business Loans	0.7	0.6	1.3	16.67%	17.20%
Credit Card Loans	0.7	0.6	0.68	16.67%	2.35%

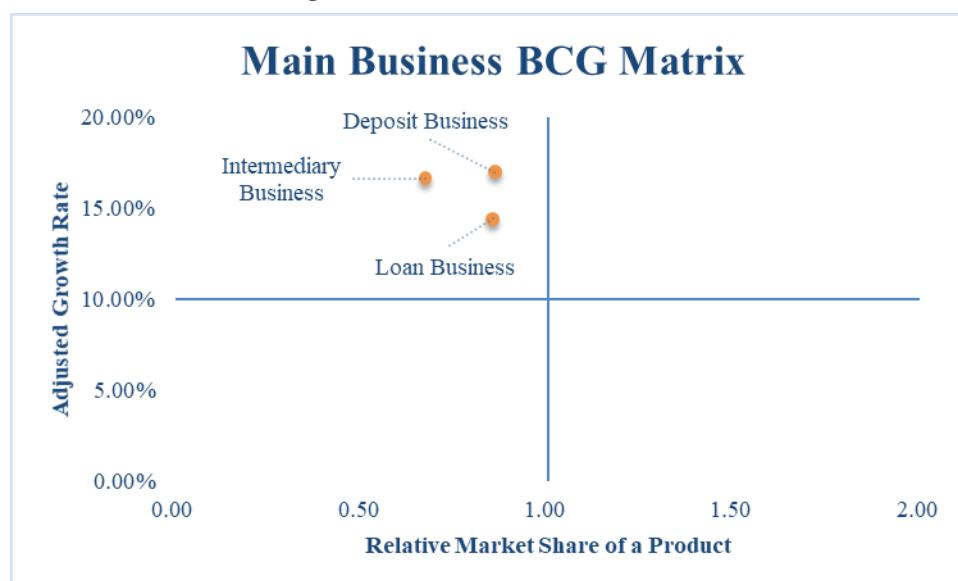
Source: Listed company annual reports, financial statistics report by the People's Bank of China

4.BCG Matrix Analysis of Bank A's Business

4.1 Analysis of Main Business Segments

Based on the annual report data of Bank A, the adjusted matrix is shown in Figure 4-1.

Figure 4-1 Main Business BCG Matrix

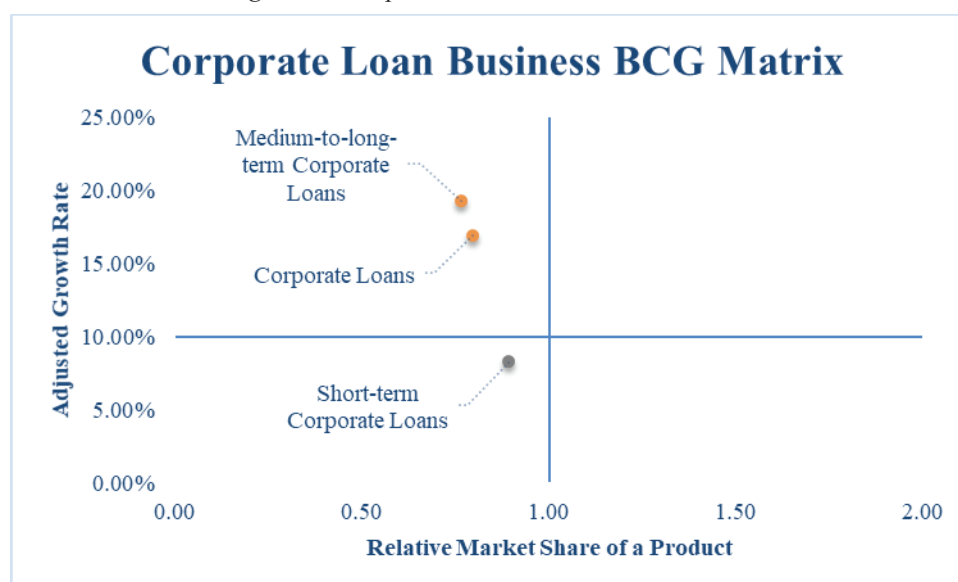


From Figure 4-1, it can be observed that both Bank A's deposit and loan businesses belong to the high-growth, low-market-share quadrant, with deposit business showing relatively high growth. Although the growth rate of intermediary business was negative, due to factors such as capital market volatility in 2023, fee reform, and the “one rate for all” initiative in the insurance industry, the overall intermediary business income of the banking industry dropped significantly. Compared to peers, Bank A's intermediary business income was above the industry average growth rate, placing it in the high-growth quadrant after adjustments.

4.2 Analysis of Corporate Finance Business

Further analysis of loan business divides it into corporate business and personal business. The BCG Matrix for corporate loan business after adjustment is shown in Figure 4-2.

Figure 4-2 Corporate Loan Business BCG Matrix

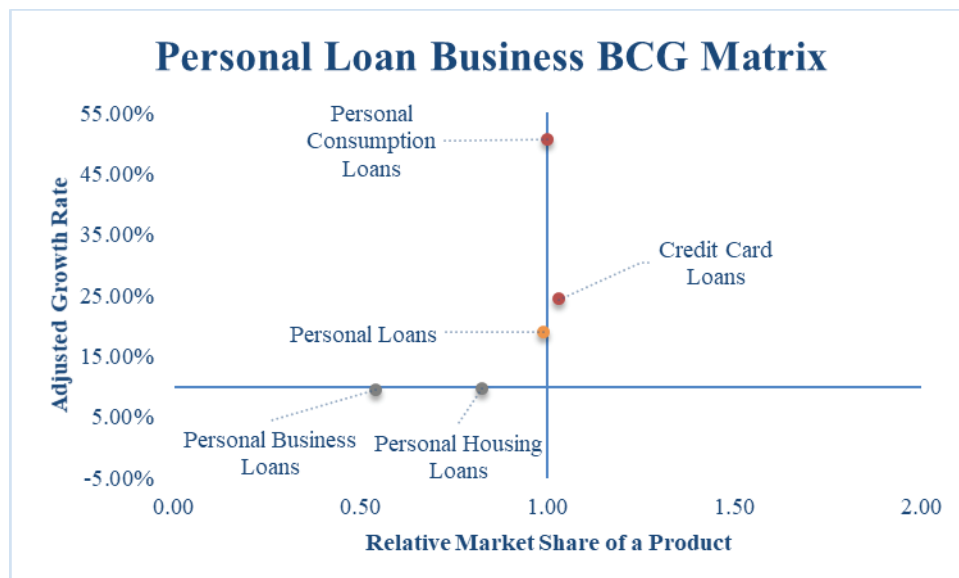


From Figure 4-2, it is evident that the total corporate loan business of Bank A has a relatively high growth rate, but its relative market share compared to its main competitor is low. Further segmentation shows that although medium-to-long-term corporate loans have a high growth rate, short-term corporate loans are in the quadrant of both low growth and low market share, indicating insufficient market competitiveness. However, compared to short-term loans, medium-to-long-term loans carry higher risks, impacting overall bank risk management significantly. This is a common issue in the industry, but it requires attention, and the overall structure of corporate loans needs appropriate optimization.

4.3 Analysis of Personal Finance Business

In 2023, the total personal loan amount for Bank A was 8.6 trillion CNY. The adjusted BCG Matrix for personal loans is shown in Figure 4-3.

Figure 4-3 Personal Loan Business BCG Matrix

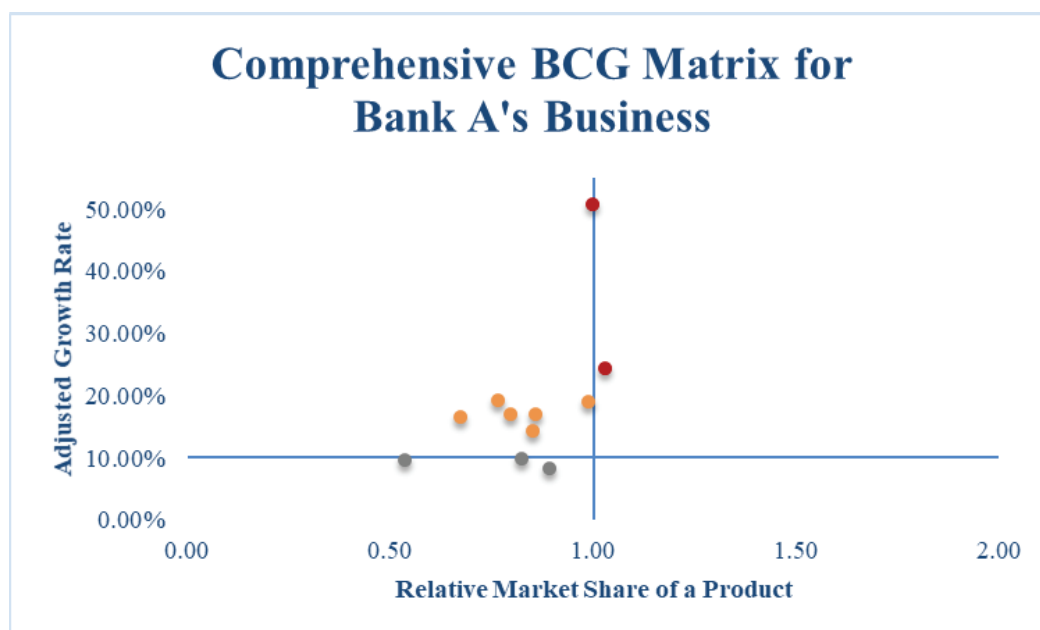


From Figure 4-3, it can be seen that Bank A's overall personal loan business has a market share close to 1 compared to its main competitor, indicating no significant competitive advantage. After further segmentation, the credit card business stands out in the high-growth, high-market-share quadrant, remaining in the "Star" category despite the strengthening of regulatory requirements and increased management of credit card business in recent years, suggesting a successful strategic approach for the credit card business. Due to industry factors, the largest component of personal loans, personal housing loans, is in the quadrant of both low growth and low market share. Personal business loans are also in this quadrant, indicating underperformance relative to peers, particularly in promoting economic development—a significant issue in light of the broader economic policy aims. Meanwhile, Bank A's personal consumption loan business showed significant growth in 2023, indicating a favorable trend due to recent strategic shifts.

4.4 Comprehensive Analysis and Summary of Problems

The comprehensive BCG Matrix for Bank A's overall business is shown in Figure 4-4.

Figure 4-4 Comprehensive BCG Matrix for Bank A's Business



From Figure 4-4, the business development is competitive, it lacks absolute competitive advantage. Based on all the matrix analysis results, Bank A's current business faces the following issues: firstly, market competitiveness is insufficient, as shown by lower relative market shares for deposits, loans, and intermediary businesses compared to the industry leader. Secondly, challenges in risk management are notable, particularly concerning the structure of corporate and personal loans under the current economic environment, as well as the sharp decline in intermediary business income that has weakened its risk-hedging role. Finally, Bank A's personal business loan performance lags behind peers, failing to effectively channel funds into the real economy, thereby undermining the effectiveness of national economic policies and posing a risk of regulatory penalties.

5. Conclusions and Recommendations

From the adjusted BCG Matrix, it can be observed that Bank A's overall business in 2023 lacked competitive advantages. Most of the business indicators, compared to peers, were located in the high-growth, low-market-share quadrant, with only a few indicators showing relatively high market share. Further analysis of industry factors and policy backgrounds reveals that Bank A has three major problems: insufficient market competitiveness, challenges in risk management, and poor effectiveness in supporting policy implementation. To solve these problems, this paper provides targeted recommendations as follows:

5.1 Enhance Market Competitiveness and Promote Differentiated Advantages

The competitiveness problem of Bank A mainly lies in serious product homogeneity, lack of innovation, and uniqueness. To enhance differentiated advantages, the following strategies can be adopted:

5.1.1 Innovate Financial Products and Launch Deeply Customized Services

To implement digital transformation effectively, Bank A can leverage big data and artificial intelligence technologies to develop customized financial products for different customer groups, such as high-AUM customers, small and micro enterprises, and rural customers, thereby avoiding product homogeneity. The bank should clarify its market positioning in serving agriculture and inclusive finance, retain its existing customer base, introduce savings and wealth management products targeting different age groups, develop loan solutions for small technology enterprises, and continuously create green finance products by referencing domestic and international achievements.

5.1.2 Optimize the Customer Relationship Management System and Enhance Customer Experience Using Financial Technology

Bank A should continuously improve its customer relationship management system. By conducting precise customer data analysis, it can identify high-value customers and provide exclusive VIP services to enhance customer satisfaction and loyalty. The bank should also optimize existing digital tools to improve customer interactions with front-end devices and software such as smart counters, mobile banking apps, and smart customer service, enhancing service efficiency and customer experience. This will increase customer stickiness and reduce the likelihood of customers switching to other banks due to service issues.

5.1.3 Reduce Pricing Disadvantages Through Market Segmentation and Offer Value-Added Services

Bank A can adopt a refined market strategy by further segmenting existing customer groups in cities, rural areas, and businesses based on factors like occupation, residence, and hobbies. This approach allows the bank to meet the specific needs of different groups beyond basic products and services, thereby reducing pricing disadvantages. For example, in the rural market, it could offer differentiated loan repayment terms based on product cycles for agricultural enterprises producing different products, while in urban areas, it could provide specific financing solutions for different occupational groups. By avoiding direct price competition with competitors, Bank A could build a differentiated advantage, reducing customer attrition caused by price differences.

5.2 Strengthen Risk Management to Address Environmental Challenges

Bank A's risk management faces significant challenges under conditions of heightened market volatility, exposure of real estate and local government debt risks, and changes in supply-demand relationships. To address these risks effectively, Bank A can take the following measures:

5.2.1 Introduce Advanced Risk Management Systems and Tools

Bank A can introduce advanced AI-based risk management systems and tools, utilizing a Multi-Layer Multi-View Stacking (MLMVS) method to enhance the identification of actual default loans [15]. It can also use heterogeneous deep forest models (Heter-DF) to establish customer credit scoring [16], or adopt new frameworks to manage market risk in trading accounts to monitor the risk status of loan portfolios in real-time [17]. Additionally, the bank can perform intraday liquidity monitoring, scenario analysis, and stress testing, assessing risks in extreme scenarios such as reputational crises, real-time gross settlement payment system interruptions, increased deposit outflows, and bank runs [18]. Through these advanced tools, monitoring in high-risk fields such as real estate and local government debt can be strengthened to ensure timely risk warnings.

5.2.2 Optimize Business Structure Allocation and Establish Risk Mitigation Mechanisms

Bank A needs to optimize its business structure allocation, adjusting the ratio between medium-to-long-term and short-term loans in corporate finance to reduce overreliance on high-risk areas like real estate and local government debt. As regulatory reforms are implemented, the income from intermediary business (fees and commissions) is expected to decrease significantly in the coming years, affecting the bank's overall risk management. Therefore, Bank A should take measures to mitigate the indirect impact of declining intermediary business income on risk and make strategic adjustments to prevent negative compound effects when combined with other issues. On top of addressing these problems, Bank A can introduce risk-sharing mechanisms from a broader perspective, cooperating with the government or third-party guarantee institutions to share exposure in high-risk fields, further enhancing its overall resilience to risk.

5.2.3 Adjust Risk Committee Structure and Strengthen the Professional Competence of the Risk Management Team

The risk management committee structure of Bank A may have overlapping functions, with two committees possibly covering similar responsibilities without clear differentiation. To streamline operations, Bank A could integrate the "Risk Management and Internal Control Committee" with the "Loan Review Committee" to form a unified "Risk Management Committee," while separating internal control and compliance functions to establish a dedicated "Internal Control and Compliance Committee." Concurrently, by attracting high-level risk management talent or collaborating with fintech companies, Bank A can enhance the risk identification and management capabilities of its internal team. Regular training programs should also be conducted to ensure that employees are equipped with the skills necessary to navigate complex market environments.

5.3 Optimize Policy Execution to Improve Policy Implementation Effectiveness

In terms of promoting policy execution, Bank A faces both internal and external challenges that impact the effectiveness of policy implementation, hindering the bank's ability to fully fulfill its role in inclusive finance. The following specific measures can be taken to enhance the effectiveness of policy execution:

5.3.1 Optimize Internal Incentive Mechanisms and Strengthen Performance Assessment for Policy-Oriented Business

To address the lack of motivation for executing policy-oriented business at the grassroots level, Bank A should optimize the performance assessment system and implement assessment metrics for policy-related business. Establishing a reward mechanism linked to policy-oriented business could encourage grassroots departments to be more proactive in executing tasks related to inclusive finance. Additionally, an innovation reward mechanism could be established to encourage departments to innovate methods of business development while promoting policy implementation.

5.3.2 Conduct Regular Internal Training and Develop Internal Policy Manuals

Bank A can ensure a thorough understanding of national policies and bank strategies among grassroots employees by conducting regular training programs. Employees should understand the rationale behind serving agriculture and inclusive finance, thus enhancing compliance and effectiveness in policy-oriented business execution. Internal policy manuals and case studies should also be developed to help employees apply policy requirements in complex business scenarios, allowing grassroots branches in less developed areas to learn from best practices in more advanced regions.

5.3.3 Improve the Channels for Issuing Business Loans and Strengthen Connections with Small and Micro Enterprises

Bank A needs to implement improvements in the quality and effectiveness of digital operations, simplifying the loan

application process through its existing digital service system and improving the channels for issuing business loans to enhance the efficiency and coverage of policy implementation. To enhance the effects of policy implementation, Bank A should increase its support for small and micro enterprises and individual business owners by organizing activities such as “Financial Policy Support for Rural Revitalization” and providing exclusive financing products to help these groups better understand and benefit from policy incentives.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Wang, X. (2022). Exploration of banks under the new dual circulation development pattern. *China Finance*, (15), 50–51.
- [2] Xing, T., & Su, Y. (2024). Differences and dynamic distribution in the digital transformation development of China’s four types of commercial banks. *Economic Issues*, (05), 43–51.
- [3] Jia, Y., Lv, J., & Guo, P. (2024). Digital transformation of banks, business structure, and operational stability. *Financial Theory and Practice*, (03), 51–62.
- [4] Sachentu, Taoketao, & Hasmuqier. (2023). Research on transformation and innovation strategies of commercial banks under complex system situations—A configuration effect analysis based on 130 banks. *Scientific Decision*, (10), 193–204.
- [5] Cai, P., Zhou, B., Li, L., et al. (2020). Comparative study on development strategies of major commercial banks at home and abroad and its implications. *New Finance*, (11), 27–32.
- [6] Wang, Y., & Gu, H. (2023). The theory and practice of “going out” of Chinese commercial banks in the process of Chinese-style modernization—From the perspective of new structural economics. *Learning and Exploration*, (04), 128–137.
- [7] Yuan, B., & Lv, H. (2012). Extended research on the application of the BCG matrix. *Business and Management*, (06), 85–89.
- [8] Akyar, D. A., Celik, M. S., & Ceylan, B. O. (2024). Global terminal operators: A competitive strategic position analysis. *Maritime Policy & Management*, 51(6), 1210–1228.
- [9] Cai, Z., Zhao, S., & Huang, M. (2023). Evolution model mechanism and performance of urban park green areas in the Grand Canal of China. *Land*, 13(1), 42.
- [10] Xiao, S., & Sun, B. (2023). How has the inter-city corporate network spatio-temporally evolved in China? Evidence from Chinese investment in newly established enterprises from 1980–2017. *Land*, 12(1), 204.
- [11] Ha, J., Yu, C., & Hwang, Y. (2021). Analyzing the impact of relative push and pull factors on inbound medical tourism in South Korea: Focused on BCG matrix applied segment group characteristics. *Asia Pacific Journal of Tourism Research*, 26(7), 768–779.
- [12] Chen, X., & Lu, C. C. (2021). The impact of macroeconomic factors on bank efficiency: Evidence from the Chinese city banks. *The North American Journal of Economics and Finance*, 55, 101294.
- [13] Özemre, M., & Kabadurmus, O. (2020). A big data analytics-based methodology for strategic decision making. *Journal of Enterprise Information Management*, 33(6), 1467–1490.

Research on ESG Strategies of Multinational Enterprises and Consumer Response Mechanisms under the Wave of Green Consumption

Huanhuan He*

School of Business Media, Lanzhou University of Finance and Economics, Lanzhou, Gansu, 730100, China

**Corresponding author: Huanhuan He*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Driven by the dual factors of the escalating global climate crisis and the awakening of consumers' environmental awareness, green consumption has evolved from a marginal issue to the core logic of global business. As major participants in economic globalization, the formulation and implementation of ESG (Environmental, Social, and Governance) strategies by multinational enterprises are not only related to their sustainable development but also directly affect consumer trust and market competitiveness. This paper takes Yum China as a typical case to analyze the core framework of its ESG strategy, the internal logic of consumer responses, and the interaction mechanism. The study finds that multinational enterprises need to adopt a three-stage response mechanism of “strategic positioning–value transmission–ecological co-construction” to transform ESG goals into consumer-perceivable value, thereby building competitive advantages in the wave of green consumption.

Keywords: Green Consumption; ESG Strategy; Multinational Enterprises; Consumer Response; Yum China

Published: Aug 28, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.571>

Introduction

The rise of green consumption is the result of the combined effects of policy coercion, endogenous market dynamics, and technological innovation. At the policy level, more than 130 countries worldwide have put forward “zero-carbon” or “carbon neutrality” goals. Policy frameworks such as the EU’s Green Deal, the U.S. Inflation Reduction Act, and China’s “dual-carbon” strategy have upgraded sustainable development from a voluntary corporate behavior to a statutory responsibility. At the market level, consumers’ environmental awareness has significantly improved: data from Bain & Company shows that in 2023, 75% of global consumers listed “sustainability” as one of the top three criteria for shopping decisions, with this proportion reaching 89% among the Generation Z (born between 1995–2009). At the technological level, the application of technologies such as blockchain and artificial intelligence has greatly improved supply chain transparency. Consumers can obtain lifecycle environmental data of products by scanning codes, further promoting the transformation of green consumption from an idea to practice.

As the core subjects of global resource allocation, the ESG performance of multinational enterprises directly affects the process of global sustainable development. On the one hand, multinational enterprises control 60% of global industrial output value and 70% of international trade, and their technological, capital, and market influence make them key promoters of

green transformation. On the other hand, multinational enterprises face a complex global operating environment and need to balance policy differences, cultural conflicts, and stakeholder demands in different countries and regions. Therefore, the ESG strategies of multinational enterprises must have both a global perspective and local adaptability, not only complying with international standards but also responding to the core concerns of local consumers.

1.The Core Framework of Yum China’s ESG Strategy

1.1 Environmental Strategy: Full-Chain Management from Low-Carbon Operations to Ecological Restoration

As a leading enterprise in the catering industry, Yum China’s environmental strategy covers the entire life cycle from raw material procurement to end consumption. In terms of energy management, Yum China realizes green power supply for restaurants through distributed photovoltaic power generation projects. In 2023, the company used approximately 8,000 megawatt-hours of renewable energy, avoiding 4,500 tons of greenhouse gas emissions, and over 70 restaurants achieved 100% green power supply. In packaging management, Yum China implements the “Reduction–Circulation–Substitution” strategy: in 2023, it saved about 30,000 tons of packaging materials, 95% of KFC restaurants established a coffee grounds collection and transportation network, and 30% of paper packaging obtained Forest Stewardship Council (FSC) certification. In addition, the company reduces food waste through the “Food Station” project, donating surplus food within the shelf life to community residents, sanitation workers, and other groups. By 2023, it has covered more than 100 cities and over 580 restaurants, benefiting more than 40,000 people.

1.2 Social Strategy: From Stakeholder Balance to Social Value Co-Creation

Yum China’s social strategy focuses on employee rights, community participation, and supply chain responsibility. In terms of employee rights, the company has been rated as “China’s Best Employer” for six consecutive years, providing family medical insurance, accident insurance, and other benefits, and establishing “Angel Restaurants” to provide equal employment opportunities for disabled young people. By 2023, Yum China has opened 36 “Angel Restaurants” in 32 cities. During the Hangzhou Asian Games, the angel employee team provided services for athletes and staff. In terms of community participation, Yum China supports rural children’s nutrition improvement through the “Donate One Yuan” project, raising a total of over 260 million yuan in donations and equipping more than 1,480 schools with modern kitchen equipment. In terms of supply chain responsibility, the company has established “Sustainable Agricultural Standards” covering a variety of agricultural products, and has purchased palm oil certified by the Roundtable on Sustainable Palm Oil (RSPO) for six consecutive years.

1.3 Governance Strategy: Institutional Upgrading from Compliance Management to Strategic Leadership

Yum China’s governance strategy takes the board of directors as the core and builds a three-level management system of “Strategy–Execution–Supervision”. The board of directors has a Sustainable Development Committee, which is responsible for formulating the ESG strategic framework; the operation department decomposes ESG goals into specific KPIs, such as the proportion of green power used in restaurants and the amount of packaging materials saved; the audit department ensures data transparency through third-party certification. For example, the company releases an annual “Sustainable Development Report”, disclosing key indicators such as carbon emissions, packaging management, and community contributions, and accepts audits from internationally authoritative institutions (such as SGS). In addition, Yum China links executive compensation to ESG goals. If the annual emission reduction target is not met, the bonuses of relevant responsible persons will be deducted by 20%.

2.The Internal Logic and Behavior Patterns of Consumer Response

2.1 Driving Factors of Consumer Response: From Rational Choice to Emotional Identity

Consumers’ response to Yum China’s ESG strategy is the result of the joint action of rational calculation and emotional identity. At the rational level, consumers evaluate the environmental cost of products through information such as carbon labels and sustainable certifications ^[1]. For example, Yum China marks “zero-carbon” products (such as oat latte) on

restaurant menus, and consumers can obtain product carbon footprint data by scanning codes. At the emotional level, consumers regard purchasing behavior as an expression of values. A survey by Southern Metropolis Daily shows that 62% of consumers obtain ESG information through social media, and 48% use corporate ESG reports as a basis for purchasing decisions. Yum China conveys environmental protection and public welfare concepts through projects such as “Food Station” and “Angel Restaurant”, attracting a large number of young consumers.

2.2 Behavior Patterns of Consumer Response: From Individual Action to Collective Advocacy

Consumer response shows an upgrading trend from individual purchase to collective action. At the individual level, consumers reduce their personal environmental footprint by choosing green products^[2]. For example, Yum China’s “Recyclable Dinner Plate” project reduces plastic usage per meal by 80%, and after the project was launched, the sales of related products increased by 30% year-on-year. At the collective level, consumers launch boycotts through social media to force enterprises to improve ESG practices. In 2022, an international fast-food brand was exposed on Weibo for using non-degradable packaging materials, triggering a consumer petition, which eventually prompted the brand to promise to achieve 100% degradable packaging by 2025. Yum China guides consumers to participate in public welfare through the “One-Day Station Master” program (where brand spokespersons act as volunteers to distribute surplus food), enhancing brand loyalty.

3. Interaction Mechanism between Yum China’s ESG Strategy and Consumer Response

3.1 Strategic Positioning: Translating ESG Goals into Consumer Value

In the surging wave of green consumption, consumers’ expectations of enterprises have extended beyond products or services themselves, with growing attention to corporate performance in environmental, social, and governance (ESG) aspects^[3]. Yum China keenly perceives this market trend and, through a precise and innovative “scenario-based positioning” strategy, skillfully connects ESG goals with consumers’ diverse needs, successfully transforming abstract ESG concepts into tangible, participatory consumption experiences.

Targeting young consumers—a vibrant group passionate about environmental protection—Yum China keenly captured their pursuit of fashion, health, and environmental concepts, innovatively launching the “Zero-Carbon Meal Set”. This set is not merely a combination of food but deeply integrates low-carbon concepts. In ingredient selection, priority is given to local, seasonal organic ingredients to reduce carbon emissions from long-distance transportation and cold storage; energy-efficient equipment and technologies are adopted during cooking to lower energy consumption; even packaging uses degradable and recyclable eco-friendly materials to minimize environmental impact. Meanwhile, to align with young consumers’ fashion-conscious psychology, Yum China invested heavily in the presentation and promotion of the meal set. Stylish packaging designs, creative posters, and interactive marketing on social media quickly made the “Zero-Carbon Meal Set” a “viral” product among young consumers^[4]. For example, on social platforms, Yum China launched the “Zero-Carbon Life Challenge”, encouraging young consumers to share photos and experiences of choosing the meal set with attractive prizes. The campaign attracted massive participation, boosting both visibility and reputation of the set while letting consumers feel their contribution to environmental protection. Statistics show that in 2023, “Zero-Carbon Meal Set” sales accounted for 15% of KFC China’s total revenue, with Generation Z comprising 60% of buyers—testament to the strategy’s success.

For family consumers, Yum China focused on parent-child interaction and environmental education, launching “Parent-Child Eco-Classrooms”. In these classrooms, children and parents learn waste sorting and resource recycling through engaging games. Activities like waste sorting competitions (matching garbage cards to bin models) and eco-friendly crafts (using recycled materials) foster environmental awareness and creativity in children. Beyond providing quality family time, these activities deepen parents’ understanding of Yum China’s ESG practices, enhancing brand recognition and loyalty. This family-oriented education model not only cultivates environmental awareness in the next generation but also earns Yum China strong social praise.

3.2 Value Transmission: Building Transparent and Trustworthy Communication Channels

In an era of information overload, consumers often approach corporate messages with caution and skepticism. To earn trust in its ESG strategies, Yum China leveraged digital technologies to build transparent communication channels, delivering

comprehensive, accurate, and timely ESG information. The company developed an innovative “Carbon Footprint Calculator”. Diners input their food and drink choices to instantly obtain the carbon emission reduction of their meal. Backed by scientific algorithms and detailed data, the calculator considers emissions from ingredient cultivation, transportation, processing, and restaurant energy use, providing reliable information. This tool helps consumers visualize their environmental impact, encouraging greener choices. For instance, seeing the emission reduction from a “Zero-Carbon Meal Set” strengthens consumers’ recognition of Yum China’s ESG efforts.

Blockchain technology ensures supply chain traceability. Using its decentralized and tamper-proof ledger, Yum China enables full traceability of ingredients from origin to restaurant. Scanning a QR code reveals details such as origin, farming methods, transportation temperature control, and processing hygiene standards. This transparency reassures consumers about food safety and demonstrates Yum China’s commitment to sustainability. For example, KFC customers can check a chicken’s farm origin, eco-friendly breeding practices, and transportation conditions—boosting trust in product quality and the brand.

3.3 Ecological Co-construction: Collaborating with Stakeholders to Expand Influence

ESG implementation is a systemic project requiring collaboration among enterprises, governments, NGOs, and consumers. Yum China recognized this, creating a four-party ESG ecosystem (“enterprise–government–NGO–consumer”) to elevate ESG from individual efforts to systemic change, maximizing stakeholder benefits and achieving sustainable win–win development. In cooperation with local governments, Yum China actively promotes “Green Restaurant” certification. It upgrades restaurants to meet government standards—adopting energy-saving equipment, optimizing energy management, and using green packaging. Certified restaurants receive tax incentives and policy support, reducing operational costs while enhancing environmental reputation and competitiveness^[5]. Joint public awareness campaigns, such as “Green Dining Week” with city governments (featuring eco-exhibitions and materials), encourage consumers to choose green restaurants.

Partnerships with NGOs like WWF provide technical expertise and resources for sustainable agriculture projects. Yum China and WWF train farmers in eco-friendly cultivation, reducing fertilizer and pesticide use to protect soil and water. This improves produce quality, increases farmers’ income, and promotes rural sustainability. Yum China also integrates sustainable agriculture into supply chain management, prioritizing certified ingredients to drive green transformation across the supply chain.

To engage consumers, Yum China created a “Public Welfare Points System” rewarding eco-actions. Points earned through participating in restaurant green activities, choosing eco-meals, or sorting waste can be redeemed for coupons, gifts, or donated to charity. This incentive mechanism motivates consumers to contribute to environmental protection. For example, in 2023, Yum China and suppliers reduced packaging by 12,000 tons—equivalent to protecting 2,000 hectares of forest. This achievement, supported by consumer participation, showcases the ecosystem’s vitality. Through such collaboration, Yum China embeds ESG into societal development, fostering collective participation in sustainability.

4. Conclusion

In the wave of green consumption, a two-way interaction has formed between multinational enterprises’ ESG strategies and consumer responses: enterprises meet consumers’ environmental demands through ESG practices, while consumers drive enterprises to upgrade ESG strategies through purchasing behavior and collective actions. The case of Yum China shows that multinational enterprises need to deepen practices in three key areas: technology-driven innovation (using blockchain, AI, and other technologies to enhance supply chain transparency and consumer participation), cultural integration (respecting value differences across markets and customizing ESG strategies and communication approaches), and long-term commitment (integrating ESG into core corporate strategies to avoid “greenwashing” risks).

It is important to note that green consumption is not merely a business trend but an inevitable choice for humanity to address the climate crisis. As key players in global sustainable development, multinational enterprises must foster positive interactions between ESG strategies and consumer responses, collectively building a low-carbon, inclusive, and resilient future economic system.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Fang, F. (2022). A study on the impact of retailers' low-carbon behavior on consumer responses [Master's thesis, Dongbei University of Finance and Economics].
- [2] Wang, Q. (2025). Research on the optimization of corporate ESG marketing strategies in the context of green consumption trends—A case study of Gujing Gongjiu. *Time-Honored Brand Marketing*, (11), 13–15.
- [3] Fang, L. (2025). The generative logic and governance practice of green consumption concepts in the new era. *Journal of Social Sciences of Harbin Normal University*, 16(03), 39–45.
- [4] Xin, Y. (2025). An analysis of the impact and promoting role of green consumption concepts on green economic development. *Modern Business Research*, (06), 7–9.
- [5] Huang, P. (2024). A study on the economic consequences of Proya's ESG practices [Master's thesis, Guangxi University].

Legal Regulation of Egg Freezing for Single Women: The Game between Reproductive Rights and Ethics

Yuyang She*

School of Humanities and Law, North China University of Technology, Beijing, 100144, China

**Corresponding author: Yuyang She*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: With the development of assisted reproductive technology, the issue of single women freezing eggs has sparked widespread controversy between reproductive rights and ethics. The verdict of China's first "single woman egg freezing case" highlights the current legal restrictions on single women's egg freezing, and also leaves room for future policy adjustments. As a fundamental human right, the right to reproduction should be attributed to personality rights rather than identity rights. The demand of single women for egg freezing conflicts with traditional ethical concepts, mainly revolving around issues such as intergenerational equality, the weakening of traditional family values, and possible illegal transactions. This article discusses ethical controversies and proposes legal regulatory pathways, calling on society to provide space for diversified reproductive choices while respecting traditional ethics.

Keywords: Egg Freezing for Single Women; Reproductive Rights; Personality Rights; Ethical Conflict; Legal Regulation; Assisted Reproductive Technology

Published: Aug 28, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.572>

1.Proposal of the problem

In August 2024, the second instance verdict was delivered in China's first "single female egg freezing case". The five-year-long dispute over the right to "egg freezing" (egg cryopreservation) ultimately ended with Ms. Xu losing the case. In 2018, Ms. Xu, the party involved, went to the Beijing Obstetrics and Gynecology Hospital affiliated to Capital Medical University to consult about "egg freezing" in order to protect her fertility. However, she was rejected due to her unmarried and single status. Subsequently, Ms. Xu filed a lawsuit against the hospital on the grounds that it had infringed upon her personality rights. This case, as the first "single female egg freezing case" nationwide, attracted widespread social attention. Although the second instance verdict upheld the original judgment, the statement in the judgment that "with the further adjustment of China's fertility policy, relevant medical and health laws, regulations, rules, diagnostic and treatment norms, and medical ethics norms may also undergo corresponding changes. Once conditions are ripe, both parties can resolve corresponding disputes separately" left open the possibility for the future development trend of "egg freezing" for single women.

With the changes in social life, assisted reproductive technologies represented by "egg freezing" have entered the public eye. Currently, China only allows the use of assisted reproductive technologies for medical reasons. In response to this situation, Ruan Xiangyan, Wang Shuming, and other NPC representatives and committee members have put forward suggestions to encourage the opening of oocyte cryopreservation to single women. "Egg freezing" is a way for single women to exercise

their reproductive rights. Discussing whether single women have the right to freeze their eggs is essentially discussing whether single women enjoy reproductive rights and the exercise of reproductive rights. Behind it lies the conflict and game between reproductive rights and traditional ethics(Fang Xing, 2020).

2.Analysis of the attribute of reproductive rights

It has been widely acknowledged in academia that reproductive rights are fundamental human rights. Scholars no longer adhere strictly to the distinction between public and private matters in their research, but rather tend to explore reproductive rights within the realm of private law, specifically focusing on the debate between personality rights and identity rights. This is also the primary reason why the law has been unable to clearly define the nature of reproductive rights. In light of this, this article will examine the attribution of reproductive rights from a private law perspective(Wang Ruonan, 2024).

Personality rights refer to the rights that take the inherent personal interests of the subject as the object, with the goal of maintaining and realizing personality equality, dignity, and personal freedom(Wang Liming, 2012). They possess core characteristics such as inherent nature, specificity, universality, legality, and non-property. Among them, inherent nature serves as a key distinguishing mark of personality rights from other rights, indicating that this right coexists with the subject, exists objectively without relying on the subject's will, and is usually non-transferable, non-inheritable, or non-renounceable. Exploring the attributes of reproductive rights, the inherent nature characteristic provides an important analytical perspective. Tracing back to its origin, "reproduction" as the natural foundation for human life and social continuation, its rights are inherently inseparable from the individual, an inevitable extension of personality dignity and life freedom, and are significantly embodied within the scope of personality rights.

Personal interests refer to various interests necessary for the natural and social survival of civil subjects. Reproductive interests encompass individual physiological needs and reproductive aspirations, which are inseparable from basic human survival needs and social life. Therefore, reproductive interests should be included in the category of personal interests(Wei Zhenying, 2017).

On the other hand, identity rights refer to rights derived from specific identity relationships (such as marriage and kinship), with the core lying in the legal interests enjoyed by the rights holder based on a specific identity. Although there are views advocating that reproductive rights belong to identity rights, meaning that only those in marital relationships can enjoy them, this view ostensibly grants reproductive equality to both sexes, in reality, due to the relativity of rights and obligations, it can easily transform into a compulsory burden on married women in practice. This position clearly violates existing legal provisions, such as Article 51 of the Law of the People's Republic of China on the Protection of Women's Rights and Interests, which clearly states that "women have the right to bear children in accordance with relevant national regulations and also have the freedom not to bear children," and Article 9 of the Supreme People's Court's Interpretation on Several Issues Concerning the Application of the Marriage Law of the People's Republic of China (III), which establishes that "the people's court shall not support a claim for damages by a husband who alleges that his wife's unauthorized termination of pregnancy infringes upon his reproductive rights." These provisions embody the spirit of protecting women's reproductive autonomy. The viewpoint of closely tying reproductive rights to the identity rights of marriage has deep historical and ethical roots, deeply influenced by traditional family structures and Confucian views on chastity. Historically, due to limitations in medical technology, reproduction had to be achieved through sexual activity, thus naturally linking it to the institution of marriage. However, with the spread of feminist thought, the elevation of women's social status, increasingly open and diverse social lifestyles, and breakthrough developments in assisted reproductive technology, reproductive behavior can now be separated from sexual activity, and its identity bond with marriage is no longer inevitable. At the same time, China's legal policies also recognize the legal status of children born out of wedlock (such as Article 1071 of the Civil Code), demonstrating a clear trend of gradually "loosening the ties" between reproduction and marriage.

3.Ethical conflicts surrounding egg freezing for single women

After clarifying the personality right attribute of reproductive rights, the conflicts between it and traditional ethics are mainly manifested in the following aspects. Scholars who oppose egg freezing for single women mainly hold arguments such as it

being inconsistent with intergenerational equality, undermining traditional marriage and family values, and affecting social order.

3.1 A rebuttal to the claim that “egg freezing for single women leads to a weakening of traditional family values”

Traditional family values are closely intertwined with the institution of marriage. In ancient society, traditional familism was founded upon the institution of marriage. Marriage was regarded as the sole legitimate way to form a family, and it was constrained by social ethical and moral norms such as rituals. As a means of expanding the kinship and lineage structure of the family, “carrying on the family lineage” is closely tied to traditional marital relationships and is often seen as the primary significance of entering into marriage (Yu Zhiqiang, 2024). However, profound societal changes, technological and cultural advancements, the influence of Western ideologies, and the diversification of values and lifestyles have collectively driven fundamental changes in traditional family relationships and values in China. Taking intergenerational relationships as an example, the “feedback model” described by Fei Xiaotong (1983), which refers to bidirectional nurturing and support between generations, has shown a significant trend of “gratitude flowing downwards.” The purpose of modern individuals raising children has increasingly shifted from obtaining “old-age security” to pursuing emotional experiences and establishing emotional connections and intimate relationships. This evolution in intergenerational relationships and fertility beliefs means that reproductive behavior has gradually weakened its core function of simply continuing the lineage, and has instead placed greater emphasis on emotional satisfaction among family members, with the core of family formation falling on individual emotional needs and prioritizing autonomous choices. It is this modernization transformation of family values, driven by overall societal changes, that constitutes the social foundation and conceptual background for single women seeking the right to freeze their eggs. Therefore, the behavior of single women freezing their eggs is essentially a product and manifestation of the new family values under the aforementioned profound societal changes, rather than a reason for the indifference of traditional family values. Although single women constructing single-parent families through assisted reproductive technology differs from the traditional two-parent nuclear family model, this is precisely a testament to the diversification and increased inclusiveness of family values as they evolve with the times, reflecting society’s respect for individual reproductive self-determination and the diversity of ways to construct families. Blaming the changes in traditional family values on single women’s demand for egg freezing ignores the fundamental driving force of societal changes, which is actually a reversal of cause and effect.

3.2 Refutation of the claim that “egg freezing for single women is inconsistent with intergenerational equality”

Some opposing views argue that allowing single women to freeze their eggs to realize their reproductive rights sacrifices the rights that the next generation should enjoy (mainly referring to the so-called “two-parent upbringing” rights and the right to know the biological father), in order to meet the needs of the current generation, thus violating the principle of intergenerational equality (Tang Qing, 2015). The main argument is that “egg freezing” gives women control over reproductive rights, which may lead to a large number of women choosing to raise their children alone. The exercise of reproductive rights affects the offspring’s right to enjoy “two-parent upbringing” and deprives them of the right to know the biological father (Fang Xing, 2020).

This accusation has fundamental flaws on a legal basis. The principle of intergenerational equality focuses on the obligations that present generations have towards future generations. However, the discussion about the infringement of “rights” of future generations by egg freezing behavior is based on the premise of treating potential future generations that do not yet exist as current rights holders, which lacks legal basis. Although frozen eggs, as isolated cells, exhibit certain personality attributes, they are not legal subjects. The enjoyment of rights is based on the qualification of rights holders. Chinese law recognizes sperm and egg cells as special objects with personality attributes, but they still belong to the category of objects and are not rights holders themselves. Therefore, claiming that egg freezing behavior infringes the so-called “rights” of future individuals that do not yet exist is actually a misunderstanding of the qualification of rights holders, and the discussion itself lacks legal foundation.

Secondly, even when discussing the welfare of future generations at the hypothetical level, the opposing argument is difficult to sustain. According to the 2023 report of the United Nations Children's Fund, there is no significant difference in the incidence of psychological issues between children from single-parent families and those from two-parent families, which proves that the "two-parent upbringing" model itself is neither a necessary nor a sufficient condition for safeguarding the mental health of future generations. In terms of value measurement in conflicts of rights or interests, women's reproductive self-determination should take precedence. Furthermore, regarding the issue of rights over eggs, discussions can be conducted with reference to the legal status of embryos and fetuses: although Chinese law grants specific interest protection to fetuses in areas such as inheritance, it does not recognize them as full civil subjects; more importantly, laws such as the "Law on the Protection of Women's Rights and Interests" clearly state that when the potential life interests of a fetus conflict with an important component of women's reproductive rights, namely the right to abortion, the latter should be protected first. If it is believed that the vague interests of non-existent potential future generations can override the existing reproductive self-determination rights of women, logically, it would lead to a fundamental denial of the current abortion rights system, which is clearly contrary to legal practice and mainstream values.

Restricting the reproductive rights of single women on the grounds of protecting the well-being of future generations would lead to absurd and unequal consequences. Opponents are concerned that a single-parent family environment may be detrimental to children. However, the realities of divorce, absentee fathers, abandonment, domestic violence, and other phenomena indicate that the "two-parent upbringing" structure itself does not guarantee an ideal nurturing environment. If the restriction of reproductive rights is purely based on optimizing the conditions for children's growth, then logically, all family planners (including couples) should undergo rigorous psychological, economic, personality, and other "qualification" assessments, and only "qualified" individuals should be allowed to reproduce. This is not only impractical in practice, but also fundamentally violates the principle of reproductive freedom and the spirit of equality before the law, constituting discriminatory restrictions against the single women community.

In summary, allowing single women to freeze their eggs does not infringe upon any identifiable or legally protected rights or core interests of future generations. The accusation of "not adhering to intergenerational equality" lacks a solid legal foundation and is difficult to justify from the perspectives of value measurement and practical considerations.

3.3 Refutation of "triggering illegal transactions and disrupting social order"

Opposing views are concerned that liberalizing egg freezing for single women will encourage illegal transactions such as surrogacy and disrupt social order. In response, the following analysis is needed: Firstly, liberalizing egg freezing for single women is not the fundamental cause of illegal transactions such as surrogacy. The existence and spread of illegal transactions stem from loopholes in the regulatory system and deficiencies in law enforcement effectiveness, rather than the means of realizing reproductive rights for specific groups. A powerful counter-evidence is that under the current policy prohibiting egg freezing for single women, the phenomenon of commercialized egg freezing and the black market for surrogacy still exists. This not only forces some single women to seek services abroad, bearing high economic costs and health risks, but also highlights that the ban cannot effectively eliminate the illegal market, but rather exacerbates the governance dilemma. Therefore, the core of the issue lies in constructing a scientific and rigorous regulatory framework to prevent and combat illegal transactions, rather than depriving single women of their legitimate right to preserve their fertility.

Banning single women from freezing their eggs on the grounds that it may lead to illegal transactions constitutes a violation of the principle of equality. Articles 33 and 48 of China's Constitution establish the principle of equality between men and women. Current regulations such as the "Regulations on the Administration of Human Assisted Reproductive Technology" and the "Regulations on the Administration of Human Sperm Banks" allow men to preserve their fertility through frozen sperm, but restrict single women from exercising the same rights, constituting discriminatory treatment based on gender. It is unreasonable to deprive women of equal opportunities for fertility protection as men solely due to their physiological characteristics and society's improper association of egg freezing with pregnancy substitution (surrogacy).

In addition, this prohibition measure seriously violates the principle of proportionality. Egg freezing and surrogacy have essential differences in technical attributes and legal nature, and there is no necessary causal connection between the two.

Forcing the binding of egg freezing rights and surrogacy risks and implementing a ban based on this: firstly, it is not appropriate, as illegal surrogacy still exists under the current ban, proving that it is not an effective preventive measure; secondly, it is not necessary, as there are alternative solutions with less restriction on rights, such as strengthening supervision and accurately cracking down on illegal surrogacy; thirdly, it is not balanced, as the comprehensive ban on egg freezing causes serious damage to the reproductive rights of single women, which is clearly unbalanced compared to its uncertain and weak social order protection goals, and does not meet the basic requirements of administrative rule of law.

4.The practical regulatory path for single women to freeze their eggs

4.1 Legislative guarantee

Currently, the relevant provisions of the personality rights section in China's Civil Code have not yet explicitly included reproductive rights within the scope of specific personality rights. Given the significant controversy in society regarding the nature of reproductive rights, especially whether they belong to personality rights, it is not appropriate for legislation to adopt an evasive attitude towards this issue. Instead, it should clearly affirm the personality rights attribute of reproductive rights, providing a clear basis for claims when civil subjects encounter disputes over infringement of reproductive rights.

The existing regulations on egg freezing in China are scattered throughout various departmental regulations such as the "Administrative Measures for Human Assisted Reproductive Technology," the "Administrative Measures for Human Sperm Banks," and the "Standards for Human Assisted Reproductive Technology," all of which have a relatively low legal effect level. It is necessary to systematically revise and integrate these regulations, and specifically add provisions specifically targeting egg freezing for single women. Specifically, emphasis should be placed on the following: First, defining the scope of applicable subjects to ensure that single women are not treated differently based on their marital and reproductive status; second, clarifying the legal attributes of frozen eggs, such as whether they belong to property rights, personality rights derivative interests, or special objects, and detailing the rights women enjoy in various stages of egg extraction, storage, use, and destruction; third, regulating the rules for the use of frozen eggs, ensuring the informed consent rights of spouses when married women undergo egg retrieval, and obtaining the informed consent of the spouse again when thawing eggs for in vitro fertilization and other procedures.

In judicial practice, when courts hear cases involving egg freezing for single women, they tend to make judgments based on contractual relationships, avoiding direct judgments on the legitimacy of the egg freezing behavior itself. After the introduction of relevant legal norms in the future, judicial judgments should shift to examining such disputes from the perspective of tort liability, interpreting the law through typical cases, and fostering public consensus on the protection of women's reproductive rights.

4.2 Establish and improve supporting systems

Firstly, establish an evaluation and review mechanism before egg freezing. Construct a comprehensive medical evaluation system before egg freezing to ensure that applicants meet health conditions to reduce medical risks. Medical institutions have the obligation to truthfully inform applicants of their physical conditions and recommend appropriate assisted reproductive programs, safeguarding their right to know. At the same time, psychological assessments should be conducted on applicants to ensure that they fully understand the significance, potential risks, and subsequent issues of egg freezing, and provide necessary psychological counseling services to assist them in making rational decisions. For married applicants, their spouses' right to know should be guaranteed during this stage.

Secondly, standardize the technical operations and supervision of the egg freezing process. Establish unified and safe technical operation standards for egg collection, freezing, preservation, and thawing. Strengthen the qualification review and daily supervision of egg freezing institutions to ensure that they possess the corresponding technical capabilities and equipment conditions, and severely crack down on institutions that illegally engage in related businesses. In addition, establish a specialized ethics committee to conduct pre-review of egg freezing applications, and evaluate the legitimacy of the egg freezing behavior, the applicant's health status, and the usage plan after egg freezing based on medical ethics and social moral standards.

Finally, refine the rules for the preservation, use, and disposal of frozen eggs. In terms of preservation management, it is

necessary to clearly stipulate the preservation period, fee standards, and renewal rules to safeguard the right to know and the right to choose of women who freeze their eggs. Referring to the management model of human sperm banks, establish a safe and traceable egg information management system to prevent the risk of inbreeding. In terms of use, women who freeze their eggs must comply with laws, regulations, and ethical norms when using the eggs, and clarify the conditions and procedures for use. When married women use frozen eggs, their spouses' right to know and consent should be guaranteed. Single women, on the other hand, enjoy the autonomy to decide on the use of eggs. In terms of disposal, formulate clear rules for the destruction of eggs, specifying the triggering conditions for destruction, such as the expiration of the preservation period or the active application of the right holder, to ensure the transparency and legality of the destruction process.

5. Conclusion

The issue of egg freezing for single women is not only a legal and ethical dilemma, but also a clash between social perceptions and technological advancements. With the gradual clarification of reproductive rights and the standardization of egg freezing technology, the reproductive autonomy of single women is expected to be more fully safeguarded. In the future, through legislative improvements, institutional development, and ethical guidance, we can open up broader space for diversified reproductive choices while respecting tradition, achieving a balance between reproductive rights and ethics.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Wang, R. N. (2024, March 18). Research on the reproductive rights of single women. Heilongjiang University.
- [2] Wang, L. M. (2012). Research on the Law of Personality Rights (2nd ed.). China Renmin University Press.
- [3] Wei, Z. Y. (2017). Civil Law. Peking University Press.
- [4] Yu, Z. Q. (2024). Modernization Practices of Chinese Family Transformation and Its State Shaping. Social Science Research, 5.
- [5] Fei, X. T. (1983). The Issue of Elderly Support in the Changes of Family Structure - A Re-examination of the Changes in Chinese Family Structure. Journal of Peking University (Philosophy and Social Sciences Edition), 3.
- [6] Li, Y. N., & Jiao, Y. L. (n.d.). "Cold Thoughts" under the "Hot Demands" of Single Women's Reproductive Rights.
- [7] Fang, X. (2020, December). An Analysis of Improving the Regulation of "Egg Freezing" for Single Women - From the Perspective of the Game between Traditional Ethics and Autonomous Decision-making Right in Childbearing. Medicine and Philosophy.
- [8] Tang, Q. (n.d.). Single Women's Reproductive Rights and Intergenerational Equality: A Comment on the Irrationality of Paragraph 2, Article 30 of the "Regulations on Population and Family Planning of Jilin Province".

The Interlinked Impact of Supply Chain Trust on Logistics Efficiency and Business Growth in a Borderless E-commerce Environment

Qiu Chao^{1*}, MOHAMAD IDRAKISYAH ABDULLAH²

1.City University Malaysia (City U), Petaling Jaya, Selangor, 46100, Malaysia

2.City Graduate School, City University Malaysia (City U), Petaling Jaya, Selangor, 46100, Malaysia

*Corresponding author: Qiu Chao, qiuchao951103@163.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: The proliferation of borderless e-commerce has fundamentally reshaped global commerce, offering unprecedented opportunities for businesses to reach international markets. However, this expansion is accompanied by significant operational complexities within global supply chains, including profound information asymmetry, deep-seated cultural barriers, divergent and often conflicting regulatory landscapes, and heightened risks of disruption from geopolitical and economic volatility. These challenges create a high-friction environment that can severely impede logistics efficiency and, consequently, constrain business growth. This paper posits that supply chain trust—a multidimensional construct encompassing competence, integrity, and relational dimensions—is the critical, yet often underestimated, catalyst that mitigates these complexities. We argue that trust is not merely a desirable relational attribute but a strategic, intangible asset that initiates a powerful, synergistic feedback loop. By fostering transparent, timely, and accurate information sharing, trust dismantles the silos that lead to operational inefficiencies. It facilitates deep process integration and enhances the operational flexibility required to navigate unforeseen disruptions. Consequently, high levels of trust directly improve key logistics performance indicators such as a reduction in order cycle time, lower inventory carrying costs, and enhanced delivery accuracy. This enhanced logistics efficiency, in turn, becomes a primary and sustainable driver of business growth by vastly improving customer satisfaction and loyalty, enabling successful and less risky market expansion, and increasing overall profitability. Furthermore, the resulting business growth reinforces and deepens inter-firm trust, creating a virtuous cycle of continuous improvement and a formidable, relationship-based sustainable competitive advantage. Through a detailed conceptual analysis supported by illustrative data, this paper explores the intricate mechanisms of this(interlinked impact), demonstrating how a deliberate, strategic focus on building and maintaining trust is essential for any enterprise aiming to thrive in the dynamic and challenging environment of borderless e-commerce.

Keywords: Borderless E-commerce; Supply Chain Management; Supply Chain Trust; Logistics Efficiency; Business Growth; Globalization; Information Sharing

Published: Aug 28, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.573>

1.Introduction

The digital revolution has dismantled geographical barriers, giving rise to a vibrant and rapidly expanding borderless

e-commerce ecosystem. Consumers can now purchase goods from anywhere in the world with a simple click, and businesses, from small-scale artisans to multinational corporations, have access to a global customer base previously unimaginable^[1]. This paradigm shift has created immense opportunities for growth, but it has simultaneously exposed the profound vulnerabilities and complexities inherent in managing global supply chains^[2]. The journey of a product from a manufacturer in one country to a consumer in another involves a fragmented and often opaque network of actors—suppliers, component manufacturers^[3], third-party logistics (3PL) providers, freight forwarders, customs brokers, and last-mile delivery services—each operating within different legal, cultural, and economic contexts^[4]. This fragmentation breeds uncertainty, chronic information asymmetry, and a high potential for operational friction. This friction is not a minor inconvenience; it manifests as costly shipping delays, lost or damaged inventory^[5], intractable customs disputes, and ultimately, a poor and brand-damaging customer experience. While technological solutions like real-time tracking systems, IoT sensors, and digital trade platforms offer partial remedies by improving visibility^[6], they cannot fully address the underlying human and relational challenges. Technology can report a problem, but it cannot, by itself, foster the collaborative spirit needed to solve it. This paper asserts that supply chain trust is the fundamental enabler that transforms a fragmented and transactional network into a cohesive^[7], resilient, and collaborative one. It acts as the essential lubricant that reduces this friction, mitigates both perceived and actual risk, and unlocks the full potential of a global supply chain^[8]. We argue that trust initiates a powerful positive feedback loop: its presence significantly enhances logistics efficiency, and this improved efficiency is a direct and potent catalyst for sustainable business growth^[9], which in turn strengthens and deepens the foundations of trust for future collaboration and innovation^[10].

2. The Theoretical Framework of Supply Chain Trust in a Global Context

Supply chain trust can be defined as the confident expectation that a partner in the supply chain will fulfill its obligations, act with integrity, and possess the necessary capabilities to perform its role effectively, even in the face of uncertainty or unforeseen events. It is a multidimensional construct, primarily comprising three core, interdependent components. First, competence trust refers to the belief in a partner's skills, technological capabilities, operational processes, and specialized knowledge to execute its logistical functions reliably and efficiently. For instance, an e-commerce firm selling high-value electronics must trust that its 3PL provider has not only the physical security but also the sophisticated systems and expertise to manage complex international customs documentation for such products, ensuring compliance and avoiding costly seizures. Second, integrity trust is the belief that a partner is honest, reliable, and will adhere to its commitments, both explicit and implicit. It is the assurance that a supplier will not substitute inferior raw materials to cut costs, or that a logistics partner will provide transparent, accurate billing without hidden fees. This dimension is about predictability and moral character, forming the bedrock of any business relationship. Third, relational trust is a more profound, affective form of trust built over time through repeated positive interactions, demonstrated mutual respect, and the development of a sense of shared goals and identity. This dimension fosters a willingness to be vulnerable, to go beyond the formal terms of a contract to support a partner in a crisis, such as expediting a shipment at their own cost to help meet a critical customer deadline. In the anonymous and physically distant environment of borderless e-commerce, these dimensions of trust become critically important. The absence of face-to-face interactions and the heavy reliance on digital communication amplify the risks of misinterpretation, conflict, and opportunism. Furthermore, differing legal frameworks can make international contract enforcement prohibitively costly and time-consuming, making trust a far more efficient and effective governance mechanism. Trust effectively reduces perceived risk and lowers tangible transaction costs by minimizing the need for extensive background checks, constant monitoring, complex and restrictive contingency clauses in contracts, and other costly control mechanisms. It creates a collaborative atmosphere where partners are more inclined to share sensitive information, invest in relationship-specific assets (like specialized equipment), and engage in joint, proactive problem-solving, thereby laying the essential groundwork for superior and sustainable operational performance.

3. The Direct Impact of Trust on Logistics Efficiency

The cultivation of supply chain trust is not an abstract corporate value; it translates directly and powerfully into tangible,

measurable improvements in logistics efficiency. The primary mechanism through which this occurs is the promotion of transparent, timely, and high-quality information sharing. In a low-trust environment, partners are often hesitant to share critical data regarding inventory levels, production capacity, demand forecasts, or promotional plans, fearing that such information could be used opportunistically by the other party to negotiate better terms or gain a competitive advantage. This strategic withholding of information leads to the well-documented “bullwhip effect,” where small fluctuations in end-consumer demand are amplified into massive swings in orders as one moves up the supply chain, resulting in excessive inventory, costly stockouts, and wildly inefficient resource allocation. Conversely, a high-trust environment encourages open and proactive communication. Partners willingly share real-time data through integrated systems, knowing it will be used for mutual benefit to optimize the entire chain. This level of transparency enables far more accurate demand planning, synchronized production schedules, and optimized inventory management across the entire network, significantly reducing capital tied up in inventory and improving product availability. Furthermore, trust is an absolute prerequisite for deep process integration. It empowers partners to move beyond simple, arm’s-length transactions and co-develop tightly integrated logistics solutions. This can involve investing in shared IT platforms, such as a unified Warehouse Management System (WMS) or Transportation Management System (TMS), which provide end-to-end visibility and streamline operations from order placement to final delivery. A powerful example is collaborative practices like coordinated customs clearance. In a high-trust relationship, a seller can grant its customs broker direct access to its order system, allowing the broker to pre-file documentation accurately and electronically the moment an order is confirmed. This can reduce customs clearance time from days to mere hours, a feat impossible without the confidence that all parties will act in good faith. The resulting efficiency gains are substantial and multifaceted, leading to shorter order cycle times, higher order fulfillment accuracy, fewer shipping errors, and lower overall operational costs.

Table 1: Impact of Trust Levels on Key Logistics Performance Indicators (KPIs)

Performance Indicator	Low-Trust Scenario (Transactional)	High-Trust Scenario (Relational)	Percentage Improvement
Average Order Cycle Time (Days)	25	15	40.0%
Inventory Holding Costs (% of Value)	8.5%	4.0%	52.9%
Order Fulfillment Accuracy	95.0%	99.5%	4.7%
Customs Clearance Time (Hours)	72	24	66.7%
Expedited Shipping Costs (% of Total)	15%	5%	66.7%

As illustrated in Table 1, the contrast between low-trust and high-trust supply chains is stark. In a high-trust scenario, the willingness to share information and integrate processes leads to a 40% reduction in average order cycle time, from 25 days to just 15. This is a transformative improvement that directly impacts customer satisfaction. The dramatic reduction in inventory holding costs (by over 50%) and customs clearance time (by two-thirds) further underscores how trust removes operational friction and costly buffers, directly cutting waste and improving the velocity of goods and capital across international borders. The reduction in expedited shipping costs is particularly telling, as it indicates a shift from reactive problem-fixing to proactive, smooth-flowing operations.

4.The Causal Link from Logistics Efficiency to Business Growth

Enhanced logistics efficiency is not merely an internal operational achievement; it is a powerful and direct engine for business growth in the hyper-competitive landscape of borderless e-commerce. The most immediate and impactful benefit is a significant and visible improvement in the customer experience. Today’s global consumers have high and ever-increasing expectations: they demand fast, reliable, and transparent delivery, regardless of the product’s origin. When a business, powered by an efficient and trust-based supply chain, can consistently meet or exceed these expectations, it builds profound customer satisfaction and loyalty. A customer who receives their international order quickly, with proactive and accurate

tracking updates, and in perfect condition, is far more likely to make repeat purchases and become a vocal brand advocate. This increase in customer lifetime value and positive word-of-mouth is a direct driver of organic, profitable revenue growth. Beyond retaining existing customers, logistics efficiency is the fundamental enabler of strategic, confident market expansion. The perceived risk and prohibitive cost of entering a new international market are major deterrents for many e-commerce businesses. An efficient and reliable logistics network de-risks this entire process. When a company is confident that it can deliver its products to customers in a new country cost-effectively and within a competitive timeframe, the barriers to entry are significantly lowered. This allows businesses to scale their operations, tap into new revenue streams, and build a truly global brand presence with less upfront capital risk. Finally, the significant cost savings generated by logistics efficiency directly fuel profitability and further growth. Reduced inventory costs, lower transportation expenses, the elimination of customs penalties, and fewer costs associated with handling returns or customer complaints free up substantial capital. This capital can then be strategically reinvested into other growth-oriented activities, such as targeted digital marketing campaigns, product innovation, or technology upgrades, further accelerating the company's growth trajectory in a compounding fashion.

Table 2: Correlation Between Logistics Efficiency and Business Growth Metrics

Logistics Efficiency KPI	Corresponding Business Growth Metric	Correlation Coefficient (Hypothetical)	Implication
Reduced Order Cycle Time	Customer Retention Rate	+0.78	Faster delivery is a key driver of customer satisfaction, which directly leads to higher loyalty and repeat purchases.
Lower Overall Logistics Cost	Annual Revenue Growth	+0.65	Cost savings are not just a boost to the bottom line; they represent capital that can be reinvested to fuel marketing and expansion.
Increased Fulfillment Accuracy	Rate of Return/Complaints	-0.85	A very strong negative correlation shows that getting orders right the first time is critical for a positive customer experience and avoiding costly reverse logistics.
New Market Delivery Success	New Market Penetration Rate	+0.81	This highlights that logistics is not a back-office function but a strategic capability; reliable delivery is a prerequisite for successfully launching in new regions.

Table 2 provides a conceptual illustration of this strong positive relationship. The high positive correlation between metrics like reduced order cycle time and customer retention rate (+0.78) highlights the direct link between operational performance and customer loyalty. Similarly, the ability to successfully deliver to new markets is almost perfectly correlated with the penetration rate in those markets (+0.81), demonstrating that logistics is not just a support function but a strategic spearhead for international expansion. The strength of these correlations underscores that investments in the supply chain are, in fact, investments in growth.

5. The Synergistic Feedback Loop: A Virtuous Cycle of Trust and Growth

The relationship between trust, efficiency, and growth is not a linear, one-way path; it is a dynamic, cyclical, and self-reinforcing system. While trust initially drives logistics efficiency, which in turn fuels business growth, the resulting growth serves to deepen, validate, and institutionalize the initial trust, creating a powerful synergistic feedback loop. As an e-commerce business grows and its order volume increases, its supply chain partners are presented with more frequent and higher-stakes opportunities to demonstrate their reliability and competence. Each successfully fulfilled large order, each smoothly handled complex customs clearance for a new product line, and each proactively resolved disruption (like a port strike or weather delay) acts as a powerful positive reinforcement. This continuous validation strengthens the relational bonds and integrity trust between the firms, transforming a tentative partnership into a robust, deeply-entrenched long-term alliance. A growing business also generates more capital and data, which can be reinvested to enhance its own capabilities and those of its partners. For example, it might co-invest with its 3PL in a more advanced order management system or a regional distribution

center closer to a new target market. These joint investments are potent signals of long-term commitment, increasing each company's competence and making them more valuable and trustworthy partners to each other. This virtuous cycle creates a formidable competitive advantage that is exceptionally difficult for rivals to replicate, as it is built on a foundation of unique, relationship-based, and intangible assets. A company trapped in a low-trust, transactional cycle will constantly struggle with operational inefficiencies, high friction costs, and reactive firefighting, severely limiting its ability to grow and innovate. In contrast, a firm that successfully initiates and nurtures the virtuous cycle of trust will find its path to growth becomes progressively smoother and more profitable, as its efficient, collaborative supply chain becomes a key strategic differentiator in the global marketplace.

Table 3: Case Study Simulation: Trust and Growth Trajectory of an E-commerce Firm (Year 1-5)

Year	Supply Chain Trust Index (1-10)	Avg. Order Cycle Time (Days)	Annual Revenue (USD)	Key Initiative
1	5.0	24	\$1,000,000	Initial partner vetting and standard contracts
2	6.5	20	\$1,800,000	Implemented shared data portal for forecast visibility
3	7.5	17	\$3,500,000	Joint process optimization project for customs
4	8.5	15	\$7,000,000	Co-investment in a shared regional warehouse
5	9.0	14	\$12,000,000	Long-term strategic alliance with integrated planning

Table 3 simulates this trajectory. In Year 1, the firm operates with a moderate level of trust, relying on standard contracts and achieving baseline performance. By investing in a trust-building initiative like a shared data portal in Year 2, they improve visibility, which raises the trust index to 6.5, cuts cycle time, and boosts revenue. The success of this initiative paves the way for a more involved joint project in Year 3. The subsequent success and revenue growth justify a significant co-investment in Year 4, which solidifies the partnership, raises the trust index to 8.5, and leads to exponential growth. By Year 5, the relationship has evolved into a strategic alliance, a testament to the power of the virtuous cycle.

Table 4: Comparative Analysis of Supply Chain Strategies: Transactional vs. Relational

Feature	Transactional Approach (Low-Trust)	Relational Approach (High-Trust)
Primary Focus	Cost minimization per transaction	Total value, risk reduction, and long-term capability
Communication	Formal, infrequent, reactive, often via escalations	Open, frequent, proactive, multi-level communication
Information Sharing	Minimal, guarded, strategic withholding	Extensive, transparent, real-time, and collaborative
Problem Solving	Blame-oriented, adversarial, seeks compensation	Collaborative, joint effort, root-cause analysis
Resilience to Disruption	Low, brittle, single point of failure	High, flexible, adaptive network response
Long-Term Outcome	Stagnant growth, high friction, constant partner turnover	Sustainable growth, high efficiency, long-term partnerships

Finally, Table 4 summarizes the fundamental philosophical and operational differences between a transactional strategy rooted in low trust and a relational strategy built on high trust. The transactional approach, while seemingly focused on short-term cost savings, ultimately leads to a brittle, inefficient, and high-stress supply chain that cannot support long-term growth. The relational approach, by prioritizing trust as a strategic investment, builds a resilient, flexible, and efficient network that becomes a sustainable and ever-improving source of competitive advantage.

6. Conclusion

In the complex, dynamic, and often turbulent environment of borderless e-commerce, the strategic importance of supply chain

trust cannot be overstated. This paper has argued and demonstrated that trust is far more than a “soft” relational concept; it is a hard strategic asset that serves as the primary catalyst for a virtuous cycle of operational efficiency and business growth. The core findings indicate a clear and compelling causal pathway: the establishment of competence, integrity, and relational trust among supply chain partners directly mitigates the inherent risks and frictions of global logistics. It fosters the transparent information sharing and deep process integration necessary to achieve significant, quantifiable gains in logistics efficiency, including reduced cycle times, lower system-wide costs, and greater delivery accuracy and reliability. This enhanced operational performance, in turn, directly and powerfully fuels business growth by delivering a superior customer experience that builds lasting loyalty and by enabling confident, cost-effective, and successful expansion into new international markets. Crucially, this process is cyclical. The success, profitability, and growth derived from this efficiency reinforce the initial trust, encouraging deeper collaboration and further joint investment in the partnership, creating a powerful feedback loop that drives sustainable competitive advantage that is difficult for competitors to emulate. For managers and leaders of e-commerce firms, the implication is clear: building and nurturing trust within the supply chain must be a conscious, deliberate, and continuous strategic priority. This requires a fundamental shift away from a purely cost-based, transactional view of partner relationships and instead focusing on long-term value creation through careful partner selection, fostering open communication channels, establishing shared goals and metrics, and demonstrating a willingness for mutual investment. Future research should aim to empirically validate and quantify the models presented here using real-world, longitudinal data from diverse e-commerce sectors. Further investigation into the role of emerging technologies like blockchain in institutionalizing and scaling trust, and comparative studies on how trust-building mechanisms must adapt across different cultural contexts, would also provide invaluable insights for the next generation of global business leaders.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Du, G., & Li, W. (2025). Corrigendum to “Does innovative city building promote green logistics efficiency? Evidence from a quasi-natural experiment with 285 cities” [Energy Economics, 114, October 2022, 106320]. Energy Economics, 148, 108685.
- [2] Li, Y., & Guangwen, Z. (2025). Balancing innovation and accountability: AI’s transformative influence on logistics in G20 nations. Humanities and Social Sciences Communications, 12(1), 750.
- [3] Anonymous. (2025). Menzies partners with HaulageHub to slash empty running losses. Commercial Motor, 236(6154), 6.
- [4] Zhang, D., Fu, M., & Zhang, S. (2025). Research on improving logistics efficiency in international trade between China and Kazakhstan. Forum on Research and Innovation Management, 3(5). (No page numbers provided)
- [5] Zheng, D., & Wang, T. (2025). Supply chain resilience, logistics efficiency, and enterprise competitiveness. Finance Research Letters, 79, 107335.
- [6] Radiant Logistics announces growth initiative opening new brokerage operation in Overland Park, Kansas. (2023). M2 Presswire. (No volume/issue/page info available)
- [7] Musrat, N., Khalid, Z., Shiraz, K., et al. (2023). Economic growth and carbon emissions in Pakistan: The effects of China's logistics industry. Environmental Science and Pollution Research International, 30(18), 53778–53795.
- [8] Jinshun, W. (2022). A study of the nonlinear dynamic interrelationship between CO₂ emissions and logistics sector output growth. Frontiers in Environmental Science. (No volume/issue/page info provided)
- [9] Xiaole, W., & Feng, D. (2022). The dynamic relationships among growth in the logistics industry, energy consumption, and carbon emission: Recent evidence from China. Journal of Petroleum Exploration and Production Technology, 13(1), 487–502.
- [10] Ning, L. (2022). Study on the relationship between logistics industry development and economic growth in Mianyang City. Academic Journal of Business & Management, 4(7). (No page numbers provided)

Evaluation on the Quality of Environmental Accounting Information Disclosure

——A Case Study of Huayang Shares

Ruiru Deng*

College of Management, Xi'an Polytechnic University, Xi'an, Shanxi 710000, China

*Corresponding author: Ruiru Deng

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This paper systematically analyzes the environmental accounting information disclosure practices of Huayang Shares (600348.SH) from 2019 to 2023, based on a constructed evaluation system for the coal industry, focusing on three dimensions: disclosure methods, content completeness, and quality grading. The study finds that Huayang Shares performs well in disclosure standardization and environmental liability measurement but shows significant deficiencies in the completeness of carbon emission data and the comparability of environmental performance. Through quantitative scoring and industry comparisons, recommendations such as optimizing disclosure structures and adopting blockchain certification technology are proposed, providing practical references for environmental information disclosure in the coal industry.

Keywords: Environmental Accounting; Information Disclosure; Coal Enterprises; Huayang Shares

Published: Aug 28, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.574>

1. Construction of the Environmental Accounting Information Disclosure Quality Evaluation System

This study combines content analysis and quantitative scoring methods to establish an evaluation system tailored to the coal industry. Referencing the Global Reporting Initiative (GRI) Standards and China's Measures for the Disclosure of Environmental Information, the system divides the evaluation into five primary indicators and 28 secondary indicators, with a total score of 50 points. Quality levels are classified based on score ranges. Key components of the evaluation system (excerpted) are shown in Table 1

2. Evaluation of the Quality of Environmental Accounting Information Disclosure by Huayang Shares

2.1 Methods of Environmental Accounting Information Disclosure by Huayang Shares

Huayang Shares primarily discloses environmental accounting information through annual reports, social responsibility reports, and government regulatory platforms. Environmental management measures, pollutant data, and environmental protection investments (e.g., CNY 270 million in technical upgrades in 2023) are scattered across sections like "Board of Directors Report" and "Significant Events." Since 2021, the company has issued standalone social responsibility reports, but environmental information accounts for only 10% of the content, predominantly qualitative (e.g., "strengthening ecological restoration").^[1] Data such as emission permits and monitoring results are published on Shanxi Province's Corporate

Table 1 Evaluation system of environmental accounting information disclosure quality

Primary indicators	Secondary indicators	Code of points
Environmental management disclosure	Environmental policy and objectives	Clear carbon reduction targets (such as the 14th Five-Year Plan) are worth 2 points, otherwise 0 points
	Environmental management structure	A full-time environmental protection department is awarded 1 point, and the disclosure of departmental responsibilities is awarded 1 point
	Environmental training	1 point is awarded for environmental training of employees each year, and 1 point is awarded for public training records
Environmental compliance disclosure	Implementation of emission permits	3 points will be awarded for disclosing the validity of the emission permit and pollutant data, and 1 point will be deducted for missing key data (such as SO ₂ concentration)
	Environmental penalty record	No penalty record gets 2 points, disclosure of corrective actions adds 1 point
Environmental liability disclosure	Ecological restoration fund is set aside	4 points will be deducted for full provision in accordance with the Measures for the Administration of Mine Geological Environment Management and Restoration Fund, and 2 points will be added for disclosure of fund use details
	Carbon liability	Quantitative disclosure of the cost of compliance with carbon emissions (such as the carbon quota gap) is worth 3 points
Environmental performance disclosure	Carbon emissions data	Full disclosure of Scope 1 & 2 emissions gets 4 points, and only scope 1 gets 2 points
	Resource recycling rate	Disclosure of comprehensive utilization rate of coal gangue and mine water (e.g.>80%) gets 3 points
Information disclosure carrier	Completeness of the annual report environment chapter	The independent “environment and social responsibility” chapter gets 2 points, and the decentralized disclosure gets 1 point
	Third party certification	The environmental data is certified by accounting firms/industries associations for 2 points

Environmental Credit Evaluation System (rated Grade B in 2023).^[2] However, Huayang Shares lacks a dedicated Environmental Accounting Report, forcing stakeholders to extract key data from disparate documents (e.g., carbon emissions in annual reports, ecological restoration fund details in social responsibility reports). The company’s investor relations webpage also lacks an environmental information column, failing to meet the Guidelines for Environmental Information Disclosure by Listed Companies requirements for accessibility.

2.2 Content of Environmental Accounting Information Disclosure by Huayang Shares

Huayang Shares has shown progressive improvement in environmental management disclosure. Analysis of public records from 2018 to 2023 reveals that the company has established a systematic environmental policy framework with clear targets, integrating environmental protection into its long-term strategy.^[3] Notably, its *14th Five-Year Environmental Protection Plan* sets a 5% reduction goal for energy consumption per ton of coal (achieving 3.2% in 2023). In 2022, Huayang Shares formed a Carbon Neutrality Leadership Group under the general manager’s oversight, refining management processes thereafter. These measures reflect the company’s commitment to environmental governance.

In environmental liability disclosure, Huayang Shares demonstrates proactive efforts, particularly in identifying and measuring liabilities.^[4] For five consecutive years, the company accrued ecological restoration funds at CNY 5 per ton of coal, reaching a balance of CNY 1.27 billion in 2023. This underscores its accountability and management capability. However, inconsistencies persist in disclosing liability fluctuations, financial impacts, and mitigation measures, potentially obscuring a comprehensive understanding of its environmental liability management.

Compliance disclosure remains an area for improvement. In 2021, Huayang Shares incurred a CNY 350,000 penalty for improper solid waste disposal but only briefly noted “rectifications completed” in its annual report without detailing actions or outcomes.^[5] This highlights transparency gaps in reporting environmental violations. Enhancing disclosure mechanisms for environmental liabilities would improve stakeholder access to reliable information and align environmental and financial reporting standards.

Performance disclosure and reporting formats also lag. While annual environmental targets are set, progress updates are inconsistent. For example, the company reports a 76% comprehensive utilization rate for coal gangue but omits compliance details for the remaining 24%. Disclosures are fragmented across four annual report sections, complicating data retrieval, and social responsibility reports lack third-party verification.

Overall, Huayang Shares has advanced in environmental management and liability disclosure but must bolster completeness, continuity, and depth to strengthen transparency and credibility.

2.3 Quality Grading of Environmental Accounting Information Disclosure by Huayang Shares

From 2018 to 2022, Huayang Shares' disclosure quality exhibited fluctuations but trended upward, ranking above the industry median. The company maintained consistency in core areas like environmental liability and compliance disclosure, reflecting sustained focus. However, performance disclosure and reporting formats scored unevenly across years, indicating unresolved challenges. A critical gap is the absence of standardized operating procedures (e.g., for underground dust control), suggesting inadequate evaluation and communication of environmental governance outcomes.

3. Conclusions and Recommendations

3.1 Conclusions

Huayang Shares' overall environmental accounting disclosure quality requires improvement. Systemic shortcomings in completeness, accuracy, and timeliness are evident, particularly in quantifying environmental liabilities, carbon emissions, and performance metrics compared to industry leaders.

Internal governance flaws, such as unclear responsibilities and disjointed workflows, hinder progress. Externally, weak regulatory oversight and limited media scrutiny reduce accountability. Infrequent inspections and minimal penalties fail to deter non-compliance, while sparse expert analysis diminishes public scrutiny.

3.2 Recommendations

To enhance environmental accounting disclosure quality, it is recommended to deepen environmental awareness by integrating green development into corporate culture through comprehensive employee training; standardize disclosure frameworks by adopting uniform formats and metrics (e.g., GRI Standards) to improve comparability and transparency; strengthen regulatory enforcement through increased inspection frequency and stricter penalties for non-compliance; improve data quality by implementing robust internal controls and third-party audits to ensure reliability; and promote technological innovation by investing in R&D for pollution reduction and resource efficiency. These measures collectively aim to elevate the accuracy, consistency, and credibility of environmental disclosures while fostering sustainable corporate practices.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Zhao, H. (2020). Research on environmental information disclosure of listed companies in China—A case study of the paper industry. *Friends of Accounting*, (23), 71–75.
- [2] You, X. Q. (2019). Improving environmental disclosure quality in polluting firms—Lessons from the Huifeng pollution incident. *Friends of Accounting*, (15), 80–85.
- [3] Liu, H. (2019). Corporate environmental disclosure mechanisms from a social responsibility perspective. *Journal of Commercial Economics*, (21), 111–113.
- [4] Yuan, Z. Y. (2023). Challenges and solutions in corporate social responsibility disclosure. *Times Economy and Trade*, (7), 108–110.
- [5] Xu, W., & Jiang, Y. (2023). Environmental accounting disclosure under dual-carbon goals. *Finance and Finance*, (1), 7–14.

Research on the Impact of Digital Inclusive Finance on the Urban-Rural Income Gap ——Panel Analysis Based on Province-Level Data in China

Miaoxi Gu*

School of Digital Economics, Sichuan University Jinjiang College; Meishan, Sichuan, 620860, China

*Corresponding author: Miaoxi Gu, miaoxi.music@163.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: With the rise of digital technology, digital inclusive finance has emerged as a game-changing innovation in modern finance. It's been instrumental in making financial services more accessible and convenient, reshaping income distribution patterns and fueling economic growth. This paper delves into the urban-rural income disparity stemming from financial exclusion, examining the impact of digital inclusive finance on this gap. Using panel data from 31 provinces and the latest Peking University digital financial inclusion index, we conducted empirical analyses to explore the overall and threshold effects. Our findings clearly indicate that the expansion of digital inclusive finance in China is significantly bridging the urban-rural income gap. Furthermore, our research reveals that the convergence effect of digital inclusive finance on the urban-rural income gap is contingent on thresholds related to economic development and urbanization. Finally, we propose actionable policy recommendations to foster the robust development of digital inclusive finance and promote urban-rural integration.

keywords: Digital Inclusive Finance; Urban-Rural Income Gap; Threshold Effect

Published: Sept 4, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.575>

1.Introduction

For years, the urban-rural income divide in developing nations has been a topic of significant discussion. Overcoming internal hurdles and sourcing funds has proven to be a tough row to hoe, resulting in substantial financial strain for folks living in rural areas. The stark differences in terms of wealth, income levels, and access to financial services have led to a noticeable trend of financial exclusion and a dearth of available financial products. China, as the globe's most populous developing nation, and its enduring urban-rural economic divide, continue to cast a spotlight on this issue ^[1]. The United Nations introduced the concept of inclusive finance in 2005, framing it as a revolutionary finance model aimed at boosting service coverage, broadening financial reach, and achieving inclusive financial access. Following the G20 summit in 2016, the digital finance inclusivity agenda was brought to the fore, marking a fresh trajectory for inclusive finance. This is where the fusion of traditional banking and digital tech comes into play. Now, how does this digital finance inclusivity really tackle the urban-rural income chasm? What's the ins and outs of its impact? Understanding these queries is vital for driving development in impoverished regions and bridging the urban-rural income divide. In the earlier years, most researchers have focused on the relationship between inclusive finance and the urban-rural income gap, but have seldom mentioned digital inclusive

finance. For example, some of them pointed out that the advancement of regional inclusive finance is likely to boost resident income and soothe the problem of income distribution inequality^[2]. Besides, inclusive finance helps alleviate mass poverty by increasing people's income in rural areas and relieve the imbalance of urban-rural development^[3,4]. What's more, the improvement in the availability of financial services exerts an obvious impact on resident income^[5]. Inclusive finance made it possible for all residents to contribute to economy growth and benefit from it by lowering the threshold of financial services, which narrow down the urban-rural income gap^[6-10]. However, in recent years, researchers noticed that the application of digital technology in finance has brought about a variety of interesting and desiring results including mitigating financial risk^[11] and facilitating the inclusive growth of economy^[12]. Digital technology gave birth to the innovations of online payment channels for non-financial institutions which enabled low income residents to benefit from financial services and products that were out of touch before^[13]. Thus, the inclusiveness of traditional finance is greatly enhanced^[14]. In the meantime, we can see other opportunities inclusive finance provided as regards a larger variety of job options and the possibility of investment return for rural residents^[15,16]. To sum up, digital inclusive finance reduces the risk of severe poverty for rural families and thus precluded the urban-rural income gap from going further^[17]. On that basis, there has been a consensus that by extending the traditional function of inclusive finance, digital inclusive finance will be able to reduce trade costs and lower the threshold of financial service to a whole new level^[18-20]. It contributed to the economic development of vast rural areas and plays a vital role in shortening the urban-rural income gap^[21,22].

While there's been a wealth of insights into how inclusive digital finance is impacting the urban-rural income divide, the bulk of existing research has zoomed in on the straightforward, linear influence of digital finance on income disparities between cities and countryside. However, the more intricate, nonlinear dynamics have largely been overlooked and definitely warrant a deeper dive. To this end, we've leveraged a dataset of 31 provincial-level panels and the digital inclusive finance index compiled by Peking University. Employing statistical models like the panel fixed effect model and threshold model, we've delved into the convergence impact of digital finance on both urban and rural incomes. Moreover, we've touched on the likelihood of a non-linear relationship between digital finance and the income gap between cities and the countryside.

Our article has the following marginal contributions: for one thing, the previous literature mainly focuses on the relationship between economic changes, financial development and urban-rural income differences, but ignores the impact of digital inclusive finance, which is increasingly emerging with the progress of mobile Internet. From the perspective of digital inclusive financial services, this paper analyzes its impact on the urban-rural income gap. For another thing, the current researches mainly focused on the linear effect that digital inclusive finance imposed on urban-rural income gap. However, the nonlinear effects seem to be more complicated and call for more attention. Thus, we further discussed the possibility of a nonlinear relation between digital inclusive finance and the urban-rural income gap.

The rest of the paper is organized as follows: Section 2 conducts theoretical analyses and clarifies our testable hypotheses; Section 3 is data sources and variable description; Section 4 conducts empirical analyses including panel fixed effect, and threshold effect; Section 5 is conclusions and recommendations.

2. Theoretical analysis and research hypotheses

Digital inclusive finance overcomes geographical and temporal constraints, reducing financial exclusion^[23]. China's urban-rural economic gap has persisted for decades, exacerbated by early industrial policies that concentrated resources like labor, capital, and infrastructure in cities^[24,25]. Limited education and information further restricted rural access to financial services, prompting institutions to withdraw from remote areas and deepen financial exclusion^[26]. By leveraging internet technologies, digital inclusive finance expands rural financial access via mobile networks, lowering operational costs and broadening service coverage^[27]. Big data enables precise credit assessments, reduces information asymmetry, and helps match rural residents with suitable financial products, cutting risk management costs while meeting diverse needs^[28]. Thus, digital inclusive finance plays a vital role in equitable financial resource allocation^[29] and narrowing the urban-rural income gap, supporting our first hypothesis (H1).

H1: The development of digital inclusive finance helps shrink the urban-rural income gap.

Moreover, the advancement of digital inclusive finance plays a pivotal role in strengthening financial infrastructure

and fostering a robust financial ecosystem. Residents in remote rural areas, where infrastructure has traditionally been lacking, now enjoy expanded access to diverse financial services^[30]. That said, given the disparities in regional economic development, uneven policy implementation, and lingering skepticism toward modern internet-based solutions, the impact of digital inclusive finance is likely to vary significantly across different regions. Additionally, since digital finance relies heavily on technology, its effectiveness hinges on users' familiarity with digital tools. In China, rural populations generally have lower educational attainment compared to their urban counterparts^[31]. Consequently, the adoption and success of digital inclusive finance in underdeveloped regions may fall short of outcomes seen in more prosperous areas. This observation leads us to the second hypothesis of this study—H2.

H2: There might be a nonlinear threshold effect in the impact that digital inclusive finance has on urban-rural income gap

3.Data sources and Variable description

We chose the panel data from China's 31 provinces as the main source in this article (the data of Hong Kong, Macao and Taiwan is not included temporarily). All indicator data were selected from "China Statistical Yearbook" each year and "The report of digital inclusive finance index from Peking University"(the third issue).The dependent variable, core independent variable and control variable are chosen as follows:

3.1. Dependent variable: Urban-rural income gap (theil)

Three key approaches measure urban-rural income inequality: the Gini index, urban-rural income ratio, and Theil index. While the Gini index assesses overall inequality, the income ratio ignores demographic factors crucial to China's urban-rural divide. The Theil index, however, accounts for population shifts and income fluctuations across wealth groups, making it our preferred method for this analysis^[35].

3.1 The formula of Theil Index is as follows:

$$\text{theil}_{i,t} = \sum_{j=1}^2 \left(\frac{Y_{ij,t}}{Y_{i,t}} \right) \ln \left(\frac{Y_{ij,t}}{Y_{i,t}} / \frac{X_{ij,t}}{X_{i,t}} \right)$$

$\text{theil}_{i,t}$ stands for the Thiel index of province i during t time, $j=1$ represents urban areas and $j=2$ represents rural areas. $Y_{ij,t}$ stands for the urban/rural per capita disposable income of province i during t time. $Y_{i,t}$ stands for the overall per capita disposable income of province i during t time. $X_{ij,t}$ stands for the urban/rural population of province i during t time. $X_{i,t}$ stands for the overall population of province i during t time.

3.2 Core independent variable: Digital Financial Inclusion Index of China(Indifit)

This study employs the Peking University Digital Financial Inclusion Index of China (PKU-DFIIC), spanning 2010–2020, as its key independent variable. Developed collaboratively by Peking University's Institute of Digital Finance and Ant Group, the index measures coverage breadth, usage depth (including payment, credit, insurance, investment, and money funds), and digitization level. Using provincial-level aggregate data sourced primarily from Ant Group, the analysis applies logarithmic transformation to the financial inclusion index^[36].

3.3 Control variables

(1) Level of economic development($\ln \text{rgdp}$). Economic development significantly influences urban and rural income distribution. Higher development levels enhance rural productivity through better resource allocation and factor mobility, boosting resident incomes. Per capita GDP, log-transformed for analysis, serves as the development measure^[37].

(2) Urbanization rate(urban). Urbanization drives the shift of rural populations to cities. A higher urbanization rate reflects not only the absorption of surplus rural labor but also improved productivity, often raising rural wages. This study measures urbanization as the urban population's share of the total population.^[38]

(3) Regional education level($\ln \text{edu}$). Higher regional education levels enhance rural human capital investment, narrowing the urban-rural income gap. College enrollment per 100,000 people measures education levels, with logarithmic transformation applied to this data^[39].

(4) Government expenditure(gov). Government spending helps balance regional economic growth and urban-rural income distribution. This study measures it using local budget expenditure as a percentage of regional GDP^[40].

(5) Regional financial development level(fina). Regional financial development is crucial to assess. The financial sector's

value-added proportion to GDP effectively indicates its development level^[39].

(6) The level of industrial structure(is). The primary, secondary, and tertiary sectors differ in productivity and GDP contributions. Consequently, shifts in a nation's industrial structure alter labor force dynamics, affecting urban-rural income disparities^[42]. We measure industrial structure by the combined secondary and tertiary sectors' share of GDP.

(7) The registered urban unemployment rate(unem). We obtained this date directly from China Statistical Yearbook^[42].

(8) Opening up level(imex). China's economic growth, particularly the opening degree, significantly impacts the urban-rural income gap, alongside the enduring dual economic structure and other inherent factors. The ratio of imports and exports to GDP serves as a measure of this openness^[43].

(9) Regional innovation level(lnpa). Patent approvals gauge regional innovation, with logarithmic transformation applied to the data^[45,46].

3.4 the descriptive statistics of variables

Table 1 shows the descriptive statistics of the main variables.

Table1 Descriptive statistics of main variables

Variable	Obs	Mean	Std.Dev.	Min	Median	Max
<i>theil</i>	310	1.561	0.637	0.719	1.427	4.877
<i>Indifit</i>	310	5.212	0.677	2.786	5.410	6.068
<i>lnrgdp</i>	310	10.779	0.440	9.682	10.734	12.009
<i>urban</i>	310	0.580	0.131	0.227	0.570	0.896
<i>lnedu</i>	310	7.823	0.292	6.987	7.793	8.633
<i>gov</i>	310	0.297	0.210	0.120	0.238	1.354
<i>fin</i>	310	0.071	0.030	0.026	0.067	0.196
<i>is</i>	310	0.902	0.052	0.742	0.902	0.997
<i>unem</i>	310	3.242	0.638	1.200	3.300	4.600
<i>imex</i>	310	0.292	0.491	0.007	0.145	7.010
<i>lnpa</i>	310	9.964	1.620	4.796	10.120	13.473

The Theil Index averages 1.561, ranging from 0.719 to 4.877, reflecting significant urban-rural income disparities. Similarly, China's Digital Financial Inclusion Index averages 5.212, with values between 2.786 and 6.068, highlighting further inequality. Regional economic imbalances also lead to notable variations in control variables.

4. Empirical analysis

4.1 The panel overall effect test of the influence that digital inclusive finance exerts on urban-rural income gap

4.1.1 Model settings

We set the panel data linear regression model as:

$$\text{theil}_{it} = \beta_1 \text{Indifit}_{it} + \beta_i X_{it} + \delta Z_i + \mu_i + \lambda_t + \epsilon_{it} \quad (1)$$

Among them, *i* stands for provinces. *t* stands for a certain year. theil_{it} stands for the index of province *i* in year *t*. Indifit_{it} is the logarithm of the digital inclusive finance index of province *i* in year *t*. X_{it} is supposed to mean other control variables that affect urban-rural areas. Z_i here stands for the unobservable individual effects that don't change over time and μ_i stands for the intercept of individual heterogeneity. λ_t is the individual-invariant but time-varying variable, which is the time effects of different individuals, ϵ_{it} is the idiosyncratic error that changes over time and individuals.

4.1.2 The methods and results of panel regression on that basis

This study employs Theil index (dependent variable) and digital inclusive finance index (independent variable) to assess digital finance's impact on the urban-rural income gap. Stata 17 was used to perform pooled regression, random effects, and one-way/two-way fixed effects analyses, with results presented in Table 2. The following test procedures were implemented:

First of all, we conducted a pooled regression as our reference frame. The disturbances of the same individual in different years inclined to present autocorrelation. Taking consideration of the within autocorrelation of the disturbances, we adopt cluster robust standard errors in our pool regression estimate.

Secondly, the disparity of different provinces may bring about some missing variables that do not change over time, which ends up with inconsistency in pooled regression. We therefore decided to adopt fixed effect model. Successively adopting within estimator method and Least Square Dummy Variable (or LSDV, for short) method to estimate individual fixed effect model, we found that the coefficients of dummy variables in different provinces are quite significant, which denies the null hypothesis that individual effect does not exist. This means we have to give up pooled regression.

Moreover, we added time effect into the fixed effect model to cover factors that change over time while staying fixed among different provinces, which is Two-way fixed effects model. Here we put in Annual dummy variables to estimate two-way fixed effects model and the result shows that the coefficients of dummy variables in some years are significant. Next, we tested the joint significance of the dummy variables throughout all the years and a P value approaching zero came into sight. Thus, the null hypothesis that there is no time fixed effect must be rejected and it's wise to adopt two-way fixed effects model. Finally, we decided to make good use of Hausman Test to make a choice between fixed effects and random effects model. As is known to all that the traditional Hausman Test does not work properly in heteroscedasticity situation, we adopt the unofficial "xtoverid" order in Stata17 to conduct robust Hausman Test. The P value derived from this result approach to zero, which gave us a strong urge to reject the null hypothesis that the random effects model fits here. To sum up, the two-way fixed effects model should be our final choice.

Table2 Regression results for model (1)

	(1)	(2)	(3)	(4)
	Pooled regression	Radom effect	Individual fixed effect	Two-way fixed effect
<i>lndifit</i>	-0.105*** (0.0311)	-0.0532*** (0.0146)	-0.0347** (0.0149)	-0.264** (0.127)
<i>lnrgdp</i>	0.127 (0.110)	0.108 (0.123)	0.129 (0.164)	-0.849** (0.325)
<i>urban</i>	-5.460*** (0.556)	-4.170*** (0.527)	-3.509*** (0.774)	-4.237*** (0.637)
<i>lnedu</i>	0.230 (0.185)	0.0526 (0.234)	-0.114 (0.322)	-0.0199 (0.318)
<i>gov</i>	1.165*** (0.181)	0.989*** (0.212)	0.793* (0.467)	-0.410 (0.445)
<i>fin</i>	5.888*** (1.572)	1.459 (1.114)	0.261 (1.467)	-2.569* (1.364)
<i>is</i>	0.916** (0.446)	1.512* (0.820)	0.828 (1.341)	1.173* (0.629)
<i>unem</i>	0.0438 (0.0337)	-0.0100 (0.0256)	-0.00424 (0.0286)	-0.0361 (0.0250)
<i>imex</i>	0.0817** (0.0388)	0.0127 (0.0102)	0.00551 (0.0112)	0.00217 (0.00737)
<i>lnpa</i>	0.0514* (0.0264)	-0.0154 (0.0423)	-0.0397 (0.0650)	-0.0876 (0.0559)
<i>_cons</i>	-0.158 (1.702)	1.107 (1.836)	2.686 (2.281)	14.06*** (2.799)
<i>N</i>	310	310	310	310
<i>R</i> ²	0.923		0.724	0.857

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

4.1.3 The Analysis of empirical results

The two-way fixed effects model reveals a significant coefficient β_1 of -0.264 ($p < 0.05$), indicating that a 1% rise in digital inclusive finance reduces the Theil index by 0.264%. This is likely due to digital inclusive finance's inclusive, poverty reduction, and growth effects, optimizing the rural environment and raising marginal output elasticity^[48]. Additionally, China's targeted poverty alleviation policies boost rural economic potential, increasing rural incomes.

Control variables reveal that per capita GDP, urbanization, and regional financing development significantly reduced the urban-rural income gap, with coefficients of -0.849 (5%), -4.237 (1%), and -2.569 (10%). In contrast, regional education, government expenditure, urban unemployment, and innovation had weakly negative but insignificant effects. Industrial structure and trade openness showed significantly positive coefficients, likely because secondary/tertiary industries and trade activities disproportionately benefit urban areas, widening the income gap.

The above can verify H1.

4.2 The threshold effect test of how digital inclusive finance impacting urban-rural income gap

4.2.1 Model settings

Digital inclusive finance's impact on the urban-rural income gap is contingent on a country's economic development and urbanization. Therefore, threshold models are constructed using per capita GDP and urbanization rate to analyze this nonlinear relationship.

$$\begin{aligned} \text{Theil}_{it} = & \theta_0 + \theta_{11} \text{Indift}_{it} \cdot I(\text{urban}_{it} \leq \gamma_1) + \theta_{12} \ln(\text{dift}_{it}) \cdot I(\gamma_1 < \text{urban}_{it} \\ & \leq \gamma_2) + \dots + \theta_{1n} \ln(\text{dift}_{it}) \cdot I(\text{urban}_{it} > \gamma_n) + \theta_i X_{it} + \epsilon_{it} \end{aligned} \quad (2)$$

$$\begin{aligned} \text{Theil}_{it} = & \theta_0 + \theta_{11} \text{Indift}_{it} \cdot I(\lnrgdp_{it} \leq \gamma_1) + \theta_{12} \text{Indift}_{it} \cdot I(\gamma_1 < \lnrgdp_{it} \\ & \leq \gamma_2) + \dots + \theta_{1n} \text{Indift}_{it} \cdot I(\lnrgdp_{it} > \gamma_n) + \theta_i X_{it} + \epsilon_{it} \end{aligned} \quad (3)$$

i represents individuals and t stands for time. Theil represent urban-rural income gap and is also the dependent variable here. Indift is digital inclusive finance which plays the role of core independent variable. Urban and \lnrgdp is adopted as the threshold variables. $I(\cdot)$ is the indicator function whose value is 1 if the conditions in the bracket are meet, otherwise the value of this function is 0. X_{it} is the set of control variables and $\gamma_1, \gamma_2, \dots, \gamma_n$ are the threshold value of n different levels.

4.2.2 Threshold effect test and Threshold parameter estimation

We have conducted single threshold, double threshold and triple threshold tests using urbanization rate and per capita GDP. Here is the result from Stata17.

Table 3 Self sampling threshold effect test

Threshold variables	Number of thresholds	F value	P value	Bs times	critical value		
					10%	5%	1%
urbanization rate (urban)	single	108.39**	0.0167	300	49.6690	68.2395	128.4596
	double	17.07	0.3733	300	102.7485	142.4191	188.2903
	triple	23.59	0.2233	300	77.3326	107.6272	142.2001
per capita GDP (lnrgdp)	single	60.42***	0.0000	300	29.6924	35.6094	51.0906
	double	32.69*	0.0800	300	29.4107	37.1350	56.6689
	triple	14.87	0.7667	300	47.8696	55.9120	70.9589

F value and P value are the results of 300 simulations by Bootstrap method. *, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively.

We can see from Table 3 that the estimate of urbanization rate passed the significance test in single threshold while it failed in double and triple threshold, thus urbanization rate fit single threshold model. The estimate of per capita GDP passed the significance test in both single and double threshold but failed in triple threshold, hence per capita GDP fit double threshold model. The results are displayed below:

Table 4 Threshold estimation results

Threshold variables	models	The threshold estimate	95% CI
urbanization rate (<i>urban</i>)	Single threshold	0.3147	[0.2747, 0.3324]
per capita GDP (<i>lnrgdp</i>)	Double threshold	10.0933	[10.0782, 10.0955]
		10.4145	[10.3672, 10.4147]

As is shown in Table 4, the estimate of urbanization rate in single threshold is 0.3147 and the estimate of per capita GDP in double threshold is 10.033 and 10.4145.

4.2.3 The regression of the threshold and analysis

We conducted panel threshold regression with model (2) and (3) and the results are displayed as bellow:

Table 5 Estimated results of the threshold regression

Variables	theil	
<i>Indifit-1</i> (<i>urban</i> ≤ 0.3147)	-0.163*** (0.0429)	
<i>Indifit-2</i> (<i>urban</i> > 0.3147)	-0.263*** (0.0416)	
<i>Indifit-1</i> (<i>lnrgdp</i> ≤ 10.0933)		-0.142*** (0.0442)
<i>Indifit-2</i> (10.0933 < <i>lnrgdp</i> ≤ 10.4145)		-0.201*** (0.0427)
<i>Indifit-3</i> (<i>lnrgdp</i> > 10.4145)		-0.219*** (0.0425)
Control variable	Yes	Yes
Cons	12.78*** (1.047)	10.72*** (1.113)
N	310	310
R ²	0.894	0.892

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 5 shows that digital inclusive finance significantly reduces the urban-rural income gap, with effects varying by economic development level. At per capita GDP below 10.0933, a 1% increase in digital finance narrows the gap by 0.142%. Between 10.0933 and 10.4145, the effect rises to 0.201%, and above 10.4145, it reaches 0.219%. This demonstrates that greater economic development enhances digital finance's impact, likely due to improved infrastructure, education, and financial access in rural areas. Lower development levels hinder these benefits due to limited resources, whereas advanced economies enable digital finance to more effectively reduce income disparities. The relationship is nonlinear, with infrastructure and education acting as key enablers.

Table 5 also shows that below the urbanization threshold of 0.3147, digital inclusive finance significantly reduces the urban-rural income gap by 0.163% per 1% increase (significant at 1%). Above this threshold, the effect strengthens to -0.263%. The greater coefficient suggests that higher urbanization enhances digital finance's impact on narrowing income disparities, likely due to increased rural employment and skill development opportunities^[47]. Consequently, income convergence accelerates with rising urbanization rates, confirming H2.

4.4 Robustness check

In order to test the reliability of these conclusions, we will apply upper and lower 1% winsorization to all variables and on that basis estimate all the models above once more with Stata17. According to the results of the regression we can see that no matter the positive and negative direction or the significance of the coefficient of digital inclusive finance remains unchanged,

and besides that, the threshold value did not alter significantly, which confirmed the robustness of the empirical results we have.

5. Research Conclusions and Policy Recommendations

From the perspective of the urban-rural disparity, we conducted empirical analyses on the overall impact, threshold impact, and mediating effect of digital inclusive finance on the urban-rural income disparity using panel data from 31 provinces and the Digital Inclusion Index provided by Peking University. Here's what we found: (1) The development of digital inclusive finance can significantly help reduce the urban-rural income gap. (2) There has been a threshold of economic development and urbanization level in the convergence effect that digital inclusive finance exerts on urban-rural income gap and it tends to be more and more significant as economy continues to grow and urbanization rate proceeds to soar.

Based on the above research findings, the following policy recommendations are proposed:

(1) To advance digital inclusive finance, we must broaden its reach, deepen its application, and enhance digitization. This involves upgrading digital financial infrastructure, integrating finance with technology, and reducing service costs. A diversified digital product system with lower barriers is crucial. The government should improve information transparency and regulation, especially in rural areas. Simultaneously, improving financial and internet literacy in rural populations will foster a better financial environment.

(2) Boost economic growth and urbanization by developing key industries, attracting investment, and fostering innovation, thus enabling wider access to digital inclusive finance. Integrate rural revitalization with urbanization by easing urban settlement restrictions for rural migrants, fostering urban-rural synergy. Prioritize modern agriculture and allocate resources to rural areas, accelerating integrated urban-rural development.

Funding

This work was supported by Sichuan University Jinjiang College 2023 Young Teachers' Scientific Research Fund Project (Fund project number: QNJJ-2023-B14)

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Li, M., Feng, S., & Xie, X. (2020). Heterogeneity effects of digital inclusive finance on urban-rural income gap. *Journal of Nanjing Agricultural University (Social Science Edition)*, 20, 132–145.
- [2] Sarma, M., & Pais, J. (2011). Financial inclusion and development. *Journal of International Development*, 23(5), 613–628.
- [3] Anand, S. K., & Chhikara, K. S. (2013). A theoretical and quantitative analysis of financial inclusion and economic growth. *Management and Labour Studies*, 38(1–2), 103–133.
- [4] Park, C. Y. (2015). Financial inclusion, poverty, and income inequality in developing Asia. *Social Science Electronic Publishing*, 20(5), 419–435.
- [5] Bruhn, M., & Love, I. (2014). The real impact of improved access to finance: Evidence from Mexico. *Journal of Finance*, 69(3).
- [6] Corrado, G., & Corrado, L. (2017). Inclusive finance for inclusive growth and development. *Current Opinion in Environmental Sustainability*, 2, 19–23.
- [7] Dai-Won, K., Jung-Suk, Y., & Hassan, M. K. (2018). Financial inclusion and economic growth in OIC countries. *Research in International Business and Finance*, 1, 1–14.
- [8] Fosu, A. K. (2016). Growth, inequality, and poverty reduction in developing countries: Recent global evidence. *Research in Economics*, 71(2), 306–336.
- [9] Kapoor, A. (2014). Financial inclusion and the future of the Indian economy. *Futures*, 56.
- [10] Menyelim, C., Babajide, A., Alexander, O., & Benjamin, E. (2021). Financial inclusion, income inequality and sustain-

- nable economic growth in sub-Saharan African countries. *Sustainability*, 13(4).
- [11] Bakhtiari, S. (2016). Microfinance and poverty reduction: Some international evidence. *International Business & Economics Research Journal*, 5(12), 34–42.
 - [12] Sutherland, W., & Jarrahi, M. H. (2018). The sharing economy and digital platforms: A review and research agenda. *International Journal of Information Management*, 43(12), 328–341.
 - [13] Nevvi, W., Idqan, F., & Teguh, S. I. (2018). Factors affecting consumer acceptance of digital financial inclusion: An anecdotal evidence from Bogor City. *Independent Journal of Management & Production*, 9(4), 1338–1338.
 - [14] Gomber, P., Koch, J. A., & Siering, M. (2017). Digital finance and FinTech: Current research and future research directions. *Journal of Business Economics*, 87(5), 537–580.
 - [15] Beck, T., Pamuk, H., Ramrattan, R., & Uras, B. R. (2018). Payment instruments, finance and development. *Journal of Development Economics*, 124(2), 223–243.
 - [16] Yadav, P., Davies, P. J., & Abdullah, S. (2018). Reforming capital subsidy scheme to finance energy transition for the below poverty line communities in rural India. *Energy for Sustainable Development*, 45, 11–27.
 - [17] Abor, J., Amidu, M., & Issahaku, A. (2018). Mobile telephony, financial inclusion and inclusive growth. *Journal of African Business*, 19(3), 430–453.
 - [18] Ouma, S. A., Odongo, T. M., & Were, M. (2017). Mobile financial services and financial inclusion: Is it a boon for savings mobilization? *Review of Development Finance*, 7(1), 29–35.
 - [19] Ozili, P. K. (2021). Digital finance, green finance and social finance: Is there a link? *Financial Internet Quarterly*, 17(01).
 - [20] Gabor, D., & Brooks, S. (2017). The digital revolution in financial inclusion: International development in the fintech era. *New Political Economy*, 22(4), 426–436.
 - [21] Ozili, P. K. (2018). Impact of digital finance on financial inclusion and stability. *Borsa Istanbul Review*, 18(4), 329–340.
 - [22] Sutherland, W., & Jarrahi, M. H. (2018). The sharing economy and digital platforms: A review and research agenda. *International Journal of Information Management*, 12, 328–341.
 - [23] Demir, A., Pesqué-Cela, V., Altunbas, Y., & Murinde, V. (2022). Fintech, financial inclusion and income inequality: A quantile regression approach. *European Journal of Finance*, 28, 86–107.
 - [24] Li, J., Gu, Y., & Zhang, C. (2015). Hukou-based stratification in urban China's segmented economy. *Chinese Sociological Review*, 47, 154–176.
 - [25] Guo, P., & Jia, X. (2009). The structure and reform of rural finance in China. *China Agricultural Economic Review*, 1, 212–226.
 - [26] Yu, N., & Wang, Y. (2021). Can digital inclusive finance narrow the Chinese urban–rural income gap? The perspective of the regional urban–rural income structure. *Sustainability*, 13, 6427.
 - [27] Arjunwadkar, P. Y. (2018). *FinTech: The technology driving disruption in the financial services industry*. Auerbach Publications.
 - [28] Nugraheni, N. (2020). Crowdfunding-based fiduciary warrant in providing capital loans for small and medium enterprises. *Hasanuddin Law Review*, 6, 224–231.
 - [29] Zy, A., Xue, G. A., Pg, A., & Tao, W. B. (2019). What drives entrepreneurship in digital economy? Evidence from China. *Economic Modelling*, 82, 66–73.
 - [30] Lashitew, A. A., van Tulder, R., & Liasse, Y. (2019). Mobile phones for financial inclusion: What explains the diffusion of mobile money innovations? *Research Policy*, 48, 1201–1215.
 - [31] Matthews, B. H. (2019). Hidden constraints to digital financial inclusion: The oral-literate divide. *Development in Practice*, 29, 1014–1028.
 - [32] Banerjee, A. V., & Newman, A. F. (1993). Occupational choice and the process of development. *Journal of Political Economy*, 101, 274–298.
 - [33] Peipei, L. S. L. (2019). Digital inclusive finance and the income gap between urban and rural areas. *Journal of Capital University of Economics and Business*, 1, 33–41.

- [34] Malladi, C. M., Soni, R. K., & Srinivasan, S. (2021). Digital financial inclusion: Next frontiers—Challenges and opportunities. *CSI Transactions on ICT*, 9, 127–134.
- [35] Bingqi, Z. (2020). Digital financial inclusion and urban–rural income gap in China: An empirical study based on panel threshold model. *Social Science Journal*, 1, 196–205.
- [36] Guo, F., Wang, J., Wang, F., Kong, T., Zhang, X., & Cheng, Z. (2020). Measuring China’s digital financial inclusion: Index compilation and spatial characteristics. *Quarterly Journal of Economics*, 19, 1401–1418.
- [37] Zhang, J., & Zhang, Y. (2021). The relationship between China’s income inequality and transport infrastructure, economic growth, and carbon emissions. *Growth and Change*, 52, 243–264.
- [38] Li, Y., Wang, X., Zhu, Q., & Zhao, H. (2014). Assessing the spatial and temporal differences in the impacts of factor allocation and urbanization on urban–rural income disparity in China, 2004–2010. *Habitat International*, 42, 76–82.
- [39] Ji, X., Wang, K., Xu, H., & Li, M. (2021). Has digital financial inclusion narrowed the urban-rural income gap: The role of entrepreneurship in China. *Sustainability*, 13, 8292.
- [40] Lu, M., & Chen, Z. (2004). Urbanization, urban-biased economic policies and urban-rural inequality. *Economic Research Journal*, 6, 50–58.
- [41] Ge, H., Li, B., Tang, D., Xu, H., & Boamah, V. (2022). Research on digital inclusive finance promoting the integration of rural three-industry. *International Journal of Environmental Research and Public Health*, 19, 3363.
- [42] Li, Z. Y., Tuerxun, M., Cao, J. H., Fan, M., & Yang, C. Y. (n.d.). Does inclusive finance improve income: A study in rural areas. *AIMS Mathematics*, 7(12), 20909–20929.
- [43] Burenmende. (2015). Research on influences of international trade on regional urban-rural income gap in China. In *Proceedings of 2015 International Conference on Education Technology, Management and Humanities Science (ETMHS 2015)* (pp. 601–604).
- [44] Neaime, S., & Gaysset, I. (2018). Financial inclusion and stability in MENA: Evidence from poverty and inequality. *Finance Research Letters*, 24, 230–237.
- [45] Park, C.-Y., & Mercado, R. (2018). Financial inclusion, poverty, and income inequality. *The Singapore Economic Review*, 63(1), 185–206.
- [46] Song, X. (2017). Empirical analysis of digital inclusive finance bridging the urban-rural residents’ income gap. *Finance and Economics*, 6, 14–25.
- [47] Wang, X., & He, G. (2020). Digital financial inclusion and farmers’ vulnerability to poverty: Evidence from rural China. *Sustainability*, 12, 1668.

Creating New Productivity: The Practice and Breakthrough of Liuzhou Intelligent Terminal and Robot Industry Innovation Ecosystem

Songxing He¹, Linhao Yang^{2*}

1.Liuzhou Institute of Science and Technology Information, Liuzhou, Guangxi Zhuang Autonomous Region, 545000, China

2.Guilin university of technology, Guilin, Guangxi Zhuang Autonomous Region, 541000, China

**Corresponding author: Linhao Yang, 3369168540@qq.com*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Under the background of accelerating the global scientific and technological revolution and industrial transformation, the intelligent terminal and robot industry has become a key field to measure the level of national scientific and technological innovation and manufacturing industry, and also an important starting point for cultivating new productivity. As the core city of Guangxi 's industry, Liuzhou is actively promoting the transformation and upgrading of industrial structure from traditional heavy industry to intelligent and digital, and focusing on building a modern industrial system with intelligent terminals and robot industry as the breakthrough point. Based on the theory of innovation ecosystem, this paper analyzes the construction path and practical effect of Liuzhou intelligent terminal and robot industry innovation ecosystem from three dimensions of supply end, organization end and demand end, and analyzes its progress in industrial linkage, digital empowerment, technical support and institutional guarantee. It points out that there are still development problems and puts forward corresponding solutions to help Liuzhou build an intelligent terminal and robot industry cluster with regional characteristics, and provide practical reference for Chinese modernization and high-quality development of local economy.

Keywords: New Quality Productivity; Intelligent Terminal; Robot Industry; Innovation Ecosystem

Published: Sept 4, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.551>

1.Introduction

Stimulated by the rapid growth of the global economy and the continuous innovation of science and technology, the robot industry and intelligent terminals have become the focus of competition among countries. They are included in the judgment index of a country's scientific and technological innovation ability and manufacturing level, and become an important direction for the future technological development of the world^[1]. In recent years, with the rapid progress of software and hardware technology, the product continues to be iteratively upgraded, the application scenarios and service models continue to expand, and the intelligent robot presents an increasingly strong market demand. China attaches great importance

to the development of the robot industry and lists it as a national strategic new industry. In the “14th Five-Year Plan for Robot Industry Development” it is clearly stated that China should become a new source of global robotics, a high-end manufacturing cluster and a new highland for integrated applications. At present, the overall development level of China’s robot industry has been steadily improved, the application scenarios have been significantly expanded, the localization process of core components has been accelerating, the advantages of collaborative robots, logistics robots, special robots and other products have been continuously enhanced, and a large number of innovative enterprises have emerged. Accelerating the technological revolution of intelligent terminal and robot industry is not only an important part of modern manufacturing industry, but also has great potential in improving production efficiency, reducing labor intensity and saving costs. As the industrial core city of Guangxi Zhuang Autonomous Region, Liuzhou City has long relied on traditional heavy industries such as steel, machinery and automobile manufacturing to develop its economy. It is facing the challenge of relatively single industrial structure and insufficient driving force for innovation and transformation. Under the dual requirements of the country’s transformation and upgrading of traditional manufacturing industries and the intelligence and digitization of global manufacturing industries, promoting the transformation of intelligent terminals and robot industries has become the only way for the innovative development of traditional industrial cities with industrial foundations. According to “The requirements of the 14th Five-Year Plan for Economic and Social Development of Liuzhou City “and the” Implementation Opinions of the Liuzhou Municipal Committee of the Communist Party of China on Implementing the Spirit of the Third Plenary Session of the 20th Central Committee of the Communist Party of China to Further Deepen the Reform and Promote the Practice of Chinese-style Modernization in Liuzhou”. Liuzhou should actively cultivate the intelligent terminal and robot industry as the fourth pillar industry, develop the new productivity system and mechanism according to local conditions, and build a “3 + 3 + X” modern industrial system. Through the “Implementation Opinions on Promoting the Development of Intelligent Terminal and Robot Industry in Liuzhou City”, it can be seen that the city has further clarified the development direction, path and measures of intelligent terminal and robot industry: intelligent terminal, focusing on the development of artificial intelligence network equipment, intelligent electrical equipment, drones and electric vertical take-off and landing aircraft, smart home, intelligent medical equipment, intelligent teaching equipment, etc. The robot industry focuses on the development of industrial robots, humanoid robots, service robots, logistics robots, inspection and maintenance robots, and robot integrated applications. In October 2024, the Liuzhou Municipal People’s Government held the ‘ Liuzhou Intelligent Terminal and Robot Industry Development Cooperation Conference’ and issued the ‘Nine Measures of Liuzhou City to Support the Development of Intelligent Terminal and Robot Industry (the first batch)’ (hereinafter referred to as the ‘Nine Measures’), which also clearly gave strong support to industrial development. However, there is still a gap between Liuzhou’s local industries and developed regions in terms of scale, innovation ability and industrial chain integrity. In order to enhance regional competitiveness, Liuzhou urgently needs to build an intelligent terminal and robot industry innovation ecosystem that adapts to the era of digital intelligence manufacturing.

2.The theoretical connotation of intelligent terminal and robot industry innovation ecosystem

The concept of innovation ecosystem came into being in the 1990 s^[2]. The American Competitiveness Commission defined the innovation ecosystem as an organic unity composed of social and economic systems, basic research, financial institutions, institutions of higher learning, science and technology, and human resources in the report “Innovating America-Challenge and Change. “ Through the transformation from the main body in the research innovation system to the dynamic interaction process between the research subjects and between the system and the environment, the evolution of the innovation analysis model is realized^[3]. The essence is that each innovation subject within the innovation ecosystem exerts its own heterogeneity to carry out collaborative innovation with other subjects, realizes value creation, and forms an interdependent and symbiotic evolution of the innovation ecosystem^[4] (Miller, Hankeke and Luo, 2002)^[4]. The network collaboration between different organizations and subjects breaks the traditional industry barriers and realizes the deep integration and sharing of multi-party resources^[5]. For the theoretical research of innovation ecosystem, most Chinese scholars refer to the foreign mainstream theories of open innovation proposed by Chesbrough et al^[6].and ecosystem collaboration proposed by Adner et al^[7]. Based on

this, based on the theory of business ecosystem, this paper defines the innovation ecosystem of intelligent terminal and robot industry as the system productivity of technological achievement transformation, industrial chain value-added and regional economic upgrading, which is composed of enterprises as the main body of innovation, based on the innovation environment, with technological innovation as the core driving force, through the coordination of supply side, organization side and demand side.

2.1 Supply side: technological innovation and change

The innovation ecosystem has three dimensions, namely, innovation subject, innovation resources and innovation environment^[8]. The fundamental connotation of the upgrading of the intelligent terminal and robot industry is innovation-driven, which is manifested as technological progress and industrial change on the supply side.

As far as the main body of innovation is concerned, enterprises are the most important investors in innovation. In 2016, the Central Committee of the Communist Party of China and the State Council issued the “Outline of the National Innovation-Driven Development Strategy” and formally proposed the implementation of the innovation-driven development strategy. In theory, the enterprise is the most important role in innovation activities. Under the condition of socialist market economy, enterprises, as the main body of market economy, directly participate in market competition. In order to meet the ever-changing product demand of customers, enterprises need to increase the production input of technological innovation and product innovation, and avoid fading out of market competition through long-term innovation. Therefore, it is the center of innovation resource integration and the output center of innovation achievements. From a practical point of view, the innovation subject of enterprises is irreplaceable in absolute position. General Secretary Xi Jinping pointed out when attending the deliberation of the Jiangsu Delegation at the Third Session of the 14th National People’s Congress: “To promote the integration of scientific and technological innovation and industrial innovation, we must build platforms, improve institutions and mechanisms, strengthen the principal role of enterprises in innovation, and ensure seamless integration between the innovation chain and the industrial chain. “To promote the deep integration of scientific and technological innovation and industrial innovation, the key is to strengthen the dominant position of enterprise scientific and technological innovation^[9]. Strengthening the dominant position of enterprises’s scientific and technological innovation is conducive to giving full play to the role of enterprises in the whole chain of innovation. General Secretary Xi Jinping proposed in the report of the 20th National Congress of the Party to “strengthen the main position of enterprise technology innovation and give full play to the leading and supporting role of technology-based backbone enterprises”. Liuzhou can build an innovation community around the main chain enterprises, which is “led by the main chain enterprises and coordinated by specialized, specialized and new small and medium-sized enterprises.” and give full play to the pioneering role of leading enterprises in science and technology. With the help of leading manufacturing enterprises such as Liugong and Wuling, Liuzhou can promote the independent innovation of the whole process and the whole industrial chain of enterprises, promote cross-border integration and innovation by means of technology penetration, and form a two-way synergy of “driven by the demand side and empowered by the supply side “ (Jacobides et al., 2018).

As far as innovation resources are concerned, the intelligent terminal and robot industry help the transformation and upgrading of traditional enterprises, opening up a new track of strategic emerging industries and future industrial development. Several industrial revolutions in history are marked by the technological innovation of a single industry, which in turn forms a radiation-driven effect on upstream and downstream industries^[10]. The intelligent terminal and robot industry injects youthful vitality into the allocation of production factors, further releasing the innovation vitality of traditional production factors such as labor and capital. The industry integrates modern science and technology, constructs the value co-creation mode of human resources and machine efficiency, effectively promotes the intelligent transformation of production, and helps enterprises to realize intelligent production. From the procurement of raw materials to the monitoring of production process to the quality control of finished products, every detail can be optimized by means of big data, artificial intelligence, Internet of things and other technologies. It not only helps workers to innovate their own knowledge structure, thinking mode and innovative methods, but also saves operating costs for enterprises. The remaining resources can be further invested in innovative research and development to create conditions for a new round of technological renewal.

As far as the innovation environment is concerned, technological progress and industrial transformation on the supply side are the trend of the times. In 2024, China's global innovation index ranked 11th, and the total amount of R & D investment in the whole society ranked second in the world. The number of high-tech enterprises has reached 463,000, and the number of global top 100 scientific and technological innovation clusters has reached 26, ranking first in the world^[11]. The Party Central Committee attaches great importance to and supports the development of intelligent terminals and robot industries. In recent years, it has successively promulgated the top-level design documents such as the "Guiding Opinions on the Innovative Development of Humanoid Robots," "Three-year Action Plan for Innovative Development of Metaspaces Industry (2023-2025)," "Robot+" Application Action Implementation Plan "to lay the tone of high-quality and rapid development, and escort the development of the industry. All localities have actively responded to the call of the state, and large and small enterprises have joined scientific research institutes, universities and other scientific research institutions to continue to promote the deep integration of industry, university and research. The scientific and technological innovation market has shown a good trend. Technological innovation competition has driven industrial change, and industrial change has pushed back technological progress, making China's innovation environment full of vitality.

2.2 Organization end: the center of enterprise operation and collaboration

The organizational side is the control center of the entire innovation ecology. Its main function is to rely on the cooperation between the main elements of enterprises, governments, research institutions, etc., and the allocation of various resources to complete the mutual transformation of technology, products, and markets. In this process, it plays an important role in the cooperation of material flow, information flow, and energy flow.

First of all, the organization needs the material flow to achieve accurate allocation of resources and ensure efficient production. In traditional industries, most of the resource allocation is done manually, depending on the manager's personal experience or intuitive judgment. This mode puts forward high requirements for the ability of managers, but due to the limitation of resource conditions, it is impossible to ensure that each decision of managers is correct, rational and timely. The scheduling of material resources often lags behind market changes, resulting in low production efficiency, inventory redundancy or shortage, which aggravates the waste of resources. However, in the modern innovation ecology, the resource allocation model at the organizational level has undergone fundamental changes. With the help of data intelligence and network collaboration to build a "digital twin" system, the organization end no longer relies solely on manual decision-making. Through means such as Internet of Things sensors, ERP systems, and cloud computing platforms, it can maximize the correct value of resources in an appropriate way, ensure the stable supply of raw materials and parts, and ensure the continuous operation of the production line. Optimize the inventory structure, reduce storage costs while ensuring sufficient inventory products to cope with market fluctuations, but also according to market forecasts to achieve capacity planning, reduce the probability of overcapacity and other issues.

Secondly, the organization side also needs to collect and process the information. At present, the organizational deconstruction of more and more digital transformation enterprises presents a flat design, which accelerates the information transmission and decision-making efficiency within the enterprise, and helps to improve the innovation synergy efficiency between alliance enterprises in the innovation network. These changes in communication and collaboration have benefited from the application of digital technology, which has strengthened data sharing and cross-border collaboration among technological innovation subjects, original innovation subjects and policy innovation subjects. In addition, with the help of information sharing and transmission of information flow, each innovation element can grasp the industry trend in time, understand the frontier dynamics of the industry, and clarify the next innovation direction according to the development prospect of the industry, so as to improve the competitiveness of the industry.

With the guarantee of material flow and information flow, energy flow is also needed to realize the green management of resources. General Secretary Xi Jinping pointed out to "accelerate the formation of new productive forces and enhance new development momentum. "With the help of energy flow, enterprises can reduce production energy consumption, optimize enterprise cost, promote digital, green and intelligent technological innovation, reshape enterprise production mode and development mode, actively respond to national policies, help enterprises seize development opportunities and enhance core

competitiveness. The application of automation equipment such as intelligent production system, intelligent control system and industrial robot reduces energy consumption while improving production efficiency and product quality. The construction of digital supply chain platform promotes the cooperation between upstream and downstream enterprises, improves the operation efficiency of industrial supply chain, and lays a solid foundation for the green and sustainable development of enterprises.

2.3 Demand side: the output and feedback hub of market demand and enterprise innovation

The demand side is the end point of the value realization of the innovation ecology^[12]. The direction of technology research and development should be closer to the market demand, driving product optimization and accelerating commercialization. Science and technology are not the product of the times, but should take the initiative to implement, give full play to its supporting role in high-quality development, and apply scientific and technological achievements to production and life. The market is the main consumer of enterprise science and technology innovation, so enterprises must pay attention to market demand when carrying out innovation. At present, the customer 's consumption demand mainly presents: the demand for commodity functions is diversified, the pace of consumption is accelerating, and the demand for derivative value is increasing. For example, in recent years, the new energy automobile industry has developed rapidly, the contradiction between new energy and old technology has become increasingly fierce, and consumers ' requirements for the long-term endurance of new energy vehicle terminal and the safety of lithium battery accidents have been continuously improved, forcing enterprises to achieve R & D breakthroughs in high-energy density batteries, AI energy-saving control and other fields, guiding enterprises to develop green and safe technologies, and promoting the virtuous cycle of " demand-driven supply, supply-created demand."

3. Analysis of the development status of Liuzhou intelligent terminal and robot industry innovation ecosystem

After the introduction of " Made in China 2025 " and "14th Five-Year " intelligent manufacturing planning, the research on intelligent industry has changed from theoretical discussion to actual regional and policy implementation, focusing on the ecological construction of intelligent industry in the Yangtze River Delta and Pearl River Delta, while relatively ignoring the industrial cities in the central and western regions. As an important industrial town in Guangxi, Liuzhou actively implements the spiritual requirements of the Party Central Committee, keeps up with the trend of the times, and vigorously develops the intelligent terminal and robot industry. In recent years, the ecological development of industrial innovation based on industrial linkage, digital empowerment, technical support and institutional guarantee has achieved remarkable results. This industry has become an important industry to support Liuzhou to achieve high-quality development, and has become one of the leading areas of China's advanced manufacturing industry. It has laid a solid foundation for further promoting the development of Liuzhou and Guangxi 's new industries.

3.1 Industrial linkage level: the cluster effect is beginning to appear, and the integration of industrial chain promotes upgrading

The world is at the intersection of the new technological revolution and the industrial revolution. With the continuous integration of informatization and industrialization, the intelligent industry represented by robot technology is booming, which has become an important symbol of technological innovation in the modern era. Liuzhou intelligent terminal and robot industry has begun to take shape. Relying on the development mechanism of complementary advantages between industries and continuous upgrading of industrial chain, the industrial development shows a large-scale growth trend. In the first half of 2024, Liuzhou has nearly 50 intelligent terminal and robot enterprises, with an output value of 6.15 billion yuan from January to September, an increase of 52.6 % year-on-year^[13]. The city's industrial robot stock is 8,000 units, and 134 intelligent manufacturing benchmarking enterprises, ranking first in the region, with a solid industrial foundation. Relying on the modern industrial system, Liuzhou combines the advantages of the intelligent industry with the traditional manufacturing industry, and learns from each other's strengths, so that the application of industrial robots blossoms. The traditional manufacturing industry represented by Shanghai General Motors Wuling Precision Manufacturing Factory and Dongfeng Liuqi Production Line applies robots to realize the upgrading of the manufacturing industry. Enterprises such as Youbixuan, Sike, Zhituo,

Sibichi and Qianjin have formed an aggregation effect on Liuzhou 's intelligent terminals and robot industry. Among them, Youbixuan Liuzhou Base has built a leading domestic production line of consumer robots, supplementing the gap in the regional high-end manufacturing industry chain^[14]. It presents an innovative trend of coordinated development of " intelligent empowerment-chain extension", promotes the construction of industrial chain resilience, and the development model of "intelligent empowerment-chain extension " also makes emerging industries and traditional industries Linkage, integration and symbiosis, providing a solid material foundation for the innovation ecosystem.

3.2 Digital empowerment level: wide application of wisdom and strong support of digital infrastructure

Digital economy empowerment is the core driving force for the development of Liuzhou intelligent terminal and robot industry. Digital infrastructure and intelligent scene application provide strong driving force for industrial development. At present, Liuzhou promotes " quality " with " intelligence ", promotes new industrialization, builds a modern manufacturing city, and promotes the high-quality development of intelligent terminals and robot industries. In terms of digital infrastructure, we will actively carry out the construction of information infrastructure such as the city's industrial and information Internet and 5G networks ; support and promote the digital transformation construction of intelligent terminal and robot industry ; promote the city to create smart application scenarios, covering smart government affairs, smart logistics, smart education and other fields ; a social intelligence ecosystem has been initially formed, which has set up a good test scenario and landing scenario for enterprises. Benefiting from the expansion of data exchanges between China and ASEAN countries under RCEP, the cross-border opening of cross-border e-commerce service model has led to the opening of cross-border optical cables, 5G pilots and other service areas in the city. Liuzhou adheres to the training of big data digital skills, vigorously cultivates local professional and technical talents, and makes up for the gap of high-end talents. The " hard infrastructure + soft ecology " linkage empowerment has an important impact on the output value growth of Liuzhou 's intelligent industry.

3.3 Technical support level: technological innovation is accelerated, and scientific research transformation is becoming more and more effective

Liuzhou intelligent terminal, robot industry technology support system is increasingly perfect, enterprises in the research and development of existing technology on the basis of the formation of industrialization, application of products. Local enterprises actively explore the practical path of promoting independent innovation ability through their own technology research and development. Some enterprises have launched a variety of competitive terminal products in the fields of consumer robots, industrial robots, intelligent controllers, service robots, and industrial automation equipment. The automatic cold rolling laser cutting system is used in Fangchenggang Base of Liugang Group, which realizes the application of complex scenes^[15]. The government relies on the integration of science and education innovation and industrial innovation to build a public technology service platform to enhance the core technology of enterprises through digitization and intelligence. At the same time, with reference to the cooperation experience of China-ASEAN, we encourage local enterprises and universities to work together to tackle key problems and cultivate technical talents. The Liuzhou Intelligent Terminal and Robot Industry Development Cooperation Conference, held in October 2024, invited many experts and scholars from the Chinese Academy of Engineering, the China Machinery Industry Federation, Tongji University and other units to actively plan and accelerate the transformation and upgrading of traditional industries, emerging industries, and future industries. Cultivate, build the intelligent terminal and robot industry into the fourth pillar industry, and accelerate the construction of a modern industrial system supported by advanced manufacturing.

3.4 Institutional guarantee level: the improvement of policy system

The stable development of the industry is inseparable from the support of policies. The guarantee of capital and talent strong support system is the support of Liuzhou industrial innovation ecosystem. It depends on the talent training system and the high-end talent introduction plan to improve the quality of human resources and solve the shortage of high-end talents in Liuzhou. The party committee and government of the autonomous region have vigorously promoted Liuzhou to create a new situation of " layout of new fields and development of new clusters. " The municipal party committee and municipal government have issued a landmark project plan around " development of new productivity, " promoted Liuzhou 's industrial intelligent manufacturing, intelligent networked equipment and robot application, and formed a linkage with China-ASEAN

system coordination, regional intellectual property protection collaborative network construction and technology transaction negotiation mechanism. Liuzhou enjoys the results of regional intellectual property collaborative protection and reduces the difficulty of technology transaction. The guarantee of funds depends on the participation and support of the government 's guiding investment cooperation fund, financial institutions and other aspects. Through appropriate measures such as increasing the interest rate of financial institutions, Liuzhou 's industry will continue to stabilize.

To sum up, Liuzhou has realized the positive role of new productivity in the high-quality development of the region, and is vigorously developing the intelligent terminal and robot industry. With the help of digital empowerment, it can stimulate the industrial kinetic energy, strengthen the collaborative linkage between upstream and downstream enterprises, build a strong material foundation, promote the innovation and development power of science and technology, and improve the system guarantee system. However, Liuzhou should strive to take the lead in the development of the global intelligent terminal robot industry, deeply integrate into the domestic and foreign circulation, give full play to its advantages, strengthen scientific research cooperation and regional coordination, and promote high-quality development to take on the situation.

4.Deconstruction of the development of Liuzhou intelligent terminal and robot industry innovation ecosystem

Compared with the traditional industrial base, Liuzhou 's industrial transformation has its particularity: Liuzhou used to be a traditional old industrial city known for its industry. On the basis of doing a good job in industry, Liuzhou has also actively developed new industries such as intelligent terminals and robots in recent years, and has achieved certain results. In 2024, the total output value will achieve explosive growth: from January to October, it will exceed 6 billion output value, an increase of more than 50 % year-on-year^[16]. However, there is no efficient allocation of innovation resources, insufficient deep participation of enterprises, inappropriate technical capabilities, ineffective convergence of policies and regulations, and insufficient industrial complementary effects. Problems still exist, which restrict the development of Liuzhou 's industrial innovation ecological vitality. This article will analyze from five aspects.

4.1 The allocation of innovative resources is unbalanced, and the synergy of science and technology industry is weak

Although Liuzhou has increased investment in intelligent terminals and robot industries, the uneven distribution of innovative resources has made it difficult for technology and industry to collaborate. There are many intelligent terminal and robot enterprises in Liuzhou, but the resources are concentrated in the hands of Liugong, Zhituo Technology and other enterprises^[17]. The lack of innovation resources in small and medium-sized enterprises leads to the problems of high R & D investment and unreasonable structure of R & D personnel among enterprises. The fundamental reason lies in the unbalanced distribution of scientific and technological resources: under the condition of limited resources, high-end talents and funds are inclined to large projects, the channels for project integration of resources are insufficient, and the construction of basic R & D and public service platforms is lagging behind; there is no efficient transfer and transformation system of scientific and technological achievements. Although the elements such as “ government-industry-university-research-application “ have been deeply integrated in Liuzhou, from the perspective of vertical innovation chain, a closed-loop innovation chain has not yet been formed ; from the perspective of the horizontal industrial chain, the cooperation between enterprises mostly stays in trade exchanges, production and R & D exchanges are few, and enterprises can not achieve technology exchange and joint R & D in various links ; the repeated allocation and inefficient utilization of resources coexist, the patent output rate is low, the achievement conversion rate is not high, the industrial technology upgrading is slow, the industrial cooperation innovation ability is insufficient, and the ecological function is not in place.

4.2 Enterprises to participate in the gradient differentiation, collaborative network linkage loose

The participation of enterprises in Liuzhou intelligent terminal and robot industry is quite different, and there is an obvious “ core-edge “ division of labor pattern, which is not conducive to the formation of collaborative network. On the one hand, leading enterprises rely on technology and policy guidance to innovate, and can directly apply new technologies, new processes and new tools to automated production lines. For example, Liugong excavator factory can realize 9 minutes off-line an excavator^[18]. However, most small and medium-sized enterprises still have a gap in the construction of innovation

ability, especially the narrow coverage and low level of technological innovation, and they do not have high-level innovation and R & D conditions. This is because the hardware facilities of small and medium-sized enterprises are relatively backward, the shortage of R & D equipment, the lack of high-level professional talents, the inability to support intelligent production and technology research and development, resulting in the fault of innovation chain, which in turn increases the development gap with leading enterprises. The resource sharing among large, medium and small enterprises is blocked, and intelligent technology is difficult to transmit to traditional industries. The weakening of synergy is not conducive to the agglomeration development of industrial clusters and the sustainable development of industrial ecology, and is not conducive to the improvement of Liuzhou 's overall industrial competitiveness.

4.3 The level of technical ability is very different, and the cooperation adaptation is difficult to connect

There is a large gap in technical capabilities between Liuzhou enterprises, and there are problems such as low adaptability in enterprise innovation cooperation, which makes it difficult to further extend the industrial chain. Some leading enterprises can realize the intelligentization of the whole process, but most enterprises are still in the initial stage. Due to the high degree of disparity in technical capabilities, there is a problem of standard adaptation: high-end standards cannot be connected to the existing systems of small and medium-sized enterprises, and there is a phenomenon of insufficient high-tech innovation and mismatched demand, resulting in sluggish development of the industrial chain and difficulty in upgrading the value chain. And Liuzhou enterprises do not master some core technologies such as artificial intelligence algorithms and high-end sensors, and there are certain technical shortcomings. In the “ Liuzhou New Generation of Artificial Intelligence and Real Economy Integration Development Plan (2020-2025)”, “ it is pointed out that Liuzhou is lagging behind the frontier technology in key technologies such as basic theory and core algorithms, and lacks advanced technology pre-research and strategic layout. Although Liuzhou has established an intelligent terminal and robot industry technology research institute, it lacks top artificial intelligence and robot researchers. The participation of colleges and universities in related fields is not high, and it has failed to form a leading innovation ecosystem. There is a certain deviation between local scientific research strength and industrial demand. The ability to tackle key core technologies such as basic algorithms and high-end sensors is weak, and it is urgent to achieve external supply through the introduction of high-end talents. In addition, Liuzhou still lacks a municipal computing center. The existing data room only operates on government data, and does not cover related aspects such as artificial intelligence and large models. It not only hinders the development of research and development work of local enterprises in Liuzhou, but also increases the cost of enterprise investment.

4.4 Absence of coordination of policies and regulations, institutional barriers barrier more

The lack of policy implementation and the difference of institutional norms cause institutional barriers, thus restricting the innovation vitality of enterprises. Since 2017, Liuzhou has set up government investment guidance fund, Liuzhou government innovation and venture capital guidance fund, “ONE-TWO-Five” project industry innovation guidance parent fund and other industrial development support policies to encourage industrial incubation and innovation development. However, due to the lack of legislative guarantee, the lack of convergence from top-level planning to grass-roots deployment, and the ambiguity of enterprise policies for different development stages, the effectiveness of policy implementation is not high. In the process of data circulation and intellectual property protection, the relevant rules are different. The horizontal and vertical management conflicts make the operating costs of enterprises higher and increase the operating risks faced by enterprises. It reduces its enthusiasm to join the industrial innovation ecosystem.

4.5 The complementary efficiency of the industry is not obvious, and the kinetic energy of collaborative innovation is lacking

The complementary potential of Liuzhou traditional industry and intelligent terminal robot industry is insufficient, and collaborative innovation lacks internal motivation. Although the two types of industries have integration space in structure, the synergy between the two is weak: traditional enterprises pay more attention to the investment and construction of hardware facilities, ignoring the improvement of soft capabilities such as data-driven, system integration and service innovation ; the development of emerging enterprises is fragmented, the overall scale is small, and the product line is relatively single, which is difficult to support full-chain collaboration and system integration. The connection between

upstream and downstream enterprises is low, and the cooperation between enterprises mostly stays at the level of basic material supply, lacking in-depth cooperation in the direction of technology co-research and market coordination.

5.The development path of Liuzhou intelligent terminal and robot industry innovation ecosystem

In view of the main problems existing in the innovation ecosystem of intelligent terminal and robot industry in Liuzhou, the following five solutions are proposed.

5.1 Continue to deepen the innovation ecology and build an open and shared innovation resource network

In-depth implementation of the market-oriented reform of science and technology reform demonstration enterprises to improve the quality, scientific and technological innovation ability to enhance the double mention “ project, and constantly stimulate the vitality of enterprise innovation and entrepreneurship. Strengthen the construction of cross-industry integration technology platform for chain main enterprises, jointly establish technology research and development institutions and test centers with universities, research institutes and small and medium-sized enterprises, diagnose enterprise problems according to the difficulties faced by enterprises, form targeted research reports and put forward optimization suggestions, and promote the construction of talent teams in colleges and universities while solving enterprise problems. We vigorously promote the “ intelligent cloud “ industrial Internet platform and supply chain digital twin system to achieve efficient use of resources and reduce waste with shared R & D data, production progress and logistics status, and to gather innovation elements and release innovation vitality on a larger scale. Guangxi Zhituo Technology Co., Ltd. can monitor the production of suppliers in real time after using Huawei Cloud IoT platform, and issue early warning. The accuracy of early warning is 92 %^[19]. Relying on the advantages of platform sharing, it greatly reduces the local computing cost of enterprises, which is conducive to rational allocation of resources, increase the efficiency of capital use, and promote industrial upgrading and development.

5.2 Deepen the collaborative innovation of large, medium and small enterprises, and strengthen the leading role of chain enterprises

For the problem of capacity differentiation between leading enterprises and small and medium-sized enterprises, while cultivating and developing chain enterprises such as Liugong and Zhituo Technology, we can encourage them to open their own technical interfaces and technical standards for special fields, drive the remaining small and medium-sized enterprises to focus on core components to carry out technical research and development work, and create a gradient industry development ecology. Solving the problem of differentiation does not mean that it is necessary to hinder the development of the main chain enterprises, but like the “ first rich drive after rich “ in economic development, the main chain enterprises develop themselves while driving the development of other enterprises. For example, the intelligent equipment of Qianjin in Liunan District has designed a welding automation production line for Saike Technology, and the implementation of personalized manufacturing of non-standard equipment is the synergistic effect of large enterprises after opening up resources. Liuzhou can also set up a special fund to support the pilot construction of “ artificial intelligence + manufacturing “ for small and medium-sized enterprises, promote the continuous optimization of industrial structure and reduce the dependence on traditional manufacturing industry.

5.3 Strengthen core technology research and industry-university-research collaboration, and break through technical bottlenecks

Digitization and intelligence should be the main direction of the future development of Liuzhou industry. We will accelerate the construction of Guangxi Industrial Design City and Big Data Industrial Park, build intelligent factories and digital workshops, and actively create a national intelligent manufacturing pilot area. Accelerate the construction of national standardization demonstration pilot, promote leading enterprises to participate in the development of important technical standards in the field of new energy vehicles and construction machinery. Accelerate the construction of the autonomous region of scientific and technological achievements transfer and transformation demonstration area, from scientific and technological achievements to the integration of industrialization road. Support enterprises to unite well-known universities and scientific research institutes at home and abroad to carry out research and development of key common technologies,

equipment and standards in the industry, accelerate the transformation of scientific and technological achievements, and provide funds and policies for basic research and technical pre-research on artificial intelligence algorithms, high-end sensors and other aspects to help enterprises solve the bottleneck of technology adaptation. Speed up the construction of municipal computing power center, meet the needs of large model training and industrial simulation, build Guangxi artificial intelligence application scenarios and industrial cluster innovation base, increase the synergy of industry, university and research, and shorten the cycle of technology industrialization.

5.4 Optimize the policy and regulation system, improve the financial security and cross-domain coordination mechanism

Encourage enterprises to actively participate in the autonomous region 's science and technology "overshoot "action, "double hundred double new" and "thousand enterprise technological transformation " and other preferential policies, through the cross-border data flow rules under the RCEP framework to connect with the local regional intellectual property protection mechanism, with the help of "nine measures" to accelerate the transformation of technological achievements. In the "Nine Measures, "it is mentioned that "support up to 10 million yuan for eligible public service platforms according to the proportion of construction costs. "This initiative provides assistance for the construction of technical research platforms in the short-board fields such as high-end chips, operating systems, and artificial intelligence algorithms. Liuzhou, as the second batch of pilot cities for the digital transformation of small and medium-sized enterprises in China, can focus on the policy system formed by the construction of Liuzhou digital government group, incorporate industrial funds, talent introduction and gathering, and scene opening into the policy package, improve the new highland of talent agglomeration oriented by innovation ability, and solve the problem of lack of high-end talents in Liuzhou. Try the four-in-one collaborative effectiveness evaluation system of enterprises, universities, scientific research institutions and functional management departments, and evaluate the operation effect of the innovation ecosystem by quantifying indicators such as patent conversion rate, number of industry-university-research innovation centers, number of enterprise cultivation and industrial added value.

5.5 Try a new sandbox model pilot program to promote cross-border integration and release new productivity

Drawing on the experience of sandbox supervision in the financial field, this paper attempts to explore the "policy sandbox" in the field of intelligent terminals and robotics industry, and discusses allowing enterprises to carry out breakthrough new technology trials and trial trials within a limited range. The research puts forward the industrial ecological development concept of "innovation has fault tolerance, R & D has support, and due diligence and controllable errors are not investigated. "Promote the integration of traditional industries such as steel and automobiles with intelligent terminals, create a " smart factory + digital twin " demonstration project, release synergistic kinetic energy, and drive the transformation and upgrading of traditional advantageous industries. Explore the customized production service platform of industrial robots, and guide the transformation of traditional manufacturing from products to "products + services. " Guangxi has proposed to build 100 artificial intelligence application scenarios. Among these contracted projects, there are 43 local projects in Liuzhou, with a total investment of 33.77 billion ^[20]. At the same time, it has also brought new formats to Liuzhou 's old industries, including intelligent logistics and intelligent detection, which is of great significance to the transformation and upgrading of the entire traditional industry.

6. Conclusion

In the tide of global scientific and technological revolution and industrial transformation, Liuzhou anchored the intelligent terminal and robot industry as the door to open up new productivity, seize the commanding heights of industrial development, build an innovative development platform for the artificial intelligence industry in the whole industrial chain, accelerate the layout of an industrial innovation ecosystem with regional characteristics, and support a number of representative leading enterprises while improving policy measures, so as to realize the transformation and upgrading from traditional manufacturing to intelligent manufacturing. In the face of the problems that hinder the operation power of the construction industry ecosystem, such as the dispersion of innovation resources, the lack of core technology innovation ability, and the

insufficient coordination and coordination of the government, the government is trying to make breakthroughs in many aspects: building an open and shared innovation resource network, integrating the advantages of enterprise collaboration, tackling key technical problems, improving the institutional guarantee system of legislative guarantee + dynamic evaluation, and releasing institutional dividends. In the future, Liuzhou should be closely integrated into the China-ASEAN Innovation Community, accelerate the pace of cooperation with ASEAN countries in mutual recognition of technical standards, open sharing of scenes, and joint training of talents, so as to build Liuzhou into an important base for the development of two major industrial clusters of intelligent terminals and robots. At the same time, we should give full play to the innovative role of technology co-research, ecological co-construction and achievement sharing, reshape the strength of Liuzhou 's traditional industrial city, provide Liuzhou's wisdom for the reconstruction of global industrial chain and regional coordinated development in the era of digital economy development, and open a new chapter of intelligent future.

Funding

25BEL05 Research on the construction of Liuzhou intelligent terminal and robot industry innovation ecosystem He Songxing
Liuzhou Institute of Science and Technology Information Key topics.

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Yu, M. (2020). Research on the problems and countermeasures of robot industry development policy [Master's thesis or Doctoral dissertation]. Shanghai University of Finance and Economics. <https://doi.org/10.27296/d.cnki.gshcu.2020.001743>
- [2] Zeng, G. P., Gou, Y. Z., & Liu, L. (2013). From "innovation system" to "innovation ecosystem". *Scientific Research*, (1), 4–12.
- [3] Yang, M., & Lin, Z. J. (2021). Building the Guangdong-Hong Kong-Macao Greater Bay Area international science and technology innovation center. *Science and Technology Management Research*, 41(13), 87–93.
- [4] Miller, W., Hancock, M., & Rowan, H. (2002). *Silicon Valley advantage: Habitat of innovation and entrepreneurship*. People's Publishing House.
- [5] Osemeike Gloria Eyieyien, V. I. A., Augusta Heavens Ikevuje, et al. (2024). Conceptual foundations of tech-driven logistics and supply chain management for economic competitiveness in the United Kingdom. *International Journal of Management & Entrepreneurship Research*, 6(7), 2292–2313.
- [6] Chesbrough, H., & Lian, Q. S. (2005). New ways of doing business with open innovation. *Manager*, (07), 54–56.
- [7] Adner, R., & Kapoor, R. (2010). Value creation in innovation ecosystems: How the structure of technological interdependence affects firm performance in new technology generations. *Strategic Management Journal*, 31(3), 306–333.
- [8] Zhang, P., & Li, X. H. (2025). Research on the driving mechanism and promotion path of the first economy from the perspective of innovation ecosystem theory. *China Soft Science*, (06), 88–98.
- [9] Wu, A. Q. (2025, March 7). Strengthening enterprise-led deep integration of industry-university-research to strengthen the dominant position of enterprise science and technology innovation (people's theory). *People's Daily*, (13).
- [10] Dong, Z. Y., & Bi, Y. (2025, June 26). Grasping new opportunities for industrial upgrading driven by artificial intelligence. *Economic Daily*, (Edition).
- [11] Li, X. H. (2025). Promoting the deep integration of scientific and technological innovation and industrial innovation. *Qishu*, (07), 54–60.
- [12] Organization for Economic Cooperation and Development. (2013). *Demand-side innovation policies* (Shanghai Institute of Science, Trans.).
- [13] Guilin Library of Guangxi. (2025). Decision information reference: 2025 "two sessions" special issue, future industries.
- [14] Li, J. (2023, July 23). Liuzhou robot industry is booming: Youbixuan Intelligent Technology Co., Ltd. to fill the gap in Guangxi intelligent service robot industry. *Liuzhou Daily*.

- [15] Huang, R., & Li, J. (2024, November 6). Observing the development of Liuzhou intelligent terminal and robot industry to the new track. Liuzhou Daily.
- [16] Guangxi Guilin Library. (2025). Decision information reference: 2025 "two sessions" special issue, future industries.
- [17] Dong, M., Lu, X. Y., Rong, Y., Xun, S. Y., & Zhou, Q. Q. (2024, November 4). To the new track: Liuzhou intelligent terminal and robot industry development observation. Liuzhou Daily.
- [18] People's Daily. (2020, June 9). High and full production of construction machinery boosts construction speed and quality. People's Daily, (02).
- [19] Tencent Cloud Developer Community. (2025). Open source technology drives new productivity of enterprises: EPP architecture and AI knowledge integration practice.
- [20] CCTV. (2025). AI empowers thousands of industries and innovates in Guangxi. Mobile Phone Sina.com.

The Manipulative Mechanisms and Multifaceted Impacts of Dark Patterns in Social Platform: A Case Study of Xiaohongshu

Xiaoyu Huang*

JT Academy, Beijing, 100000, China

*Corresponding author: Xiaoyu Huang, 17703320600@163.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This study explores the phenomenon and impact of Dark Patterns on social platform such as Xiaohongshu. Dark Patterns, like “Bait and Switch”, and “Confirmshaming”, are user interface design choices that benefit the social platform by coercing, steering, or deceiving users into making unintended and potentially harmful decisions. These manipulative practices exert negative impacts on users, publishers, and society at large, such as information cocoon and privacy leak. In order to mitigate these influences and protect users’ rights, this study advocates for legislation and the establishment of digital models to regulate Dark Patterns.

Keywords: Dark Patterns; Social Platforms; Manipulation

Published: Sept 4, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.590>

1.Introduction

With the rapid advancement of technology and information proliferation, human attention has emerged as an increasingly scarce resource. The more attention a platform captures, the higher the likelihood that users will visit online stores, prompting social platforms to revolutionize how people socialize and access information. Through sophisticated algorithms and personalized, precise services, many platforms strive to deliver high-quality user experiences.

However, these same algorithms are exploited by profit-driven platforms to collect user data and manipulate behavior, giving rise to Dark Patterns, tactics that induce users to take actions that benefit the platform but align with neither their true intentions nor best interests. Dark Patterns typically exploit cognitive biases to prompt online consumers to purchase unwanted goods or services, or disclose personal information they would rather keep private (Luguri & Strahilevitz, 2021).

Platforms fuel user dependence and addiction by leveraging psychological triggers (e.g., variable rewards) and behavioral biases (e.g., loss aversion), leading many users to unknowingly spend excessive time on these platforms. Meanwhile, high switching costs and loyal user bases make it difficult for users to switch to competing platforms, undermining fair market competition.

Several European and American countries have implemented legislative safeguards in areas like privacy and antitrust, such as the Federal Trade Commission Act and Kids Online Safety Act, to curb these harms. However, these regulatory efforts are limited. They only address the most severe abuses, leaving Dark Patterns underregulated and understudied despite their widespread negative impacts. Nevertheless, the growing academic attention to Dark Patterns highlights the need to analyze

their types, characteristics, and consequences while proposing targeted solutions.

This study examines Dark Patterns primarily through a case study of Xiaohongshu, a leading Chinese social media platform launched in 2013. Alongside giants like Douyin and Weibo, Xiaohongshu has become a staple in Chinese digital life, where users access information through posts and short videos.

As this study will illustrate, Xiaohongshu exemplifies Dark Patterns in action, Convoluted account exit processes. Users face unnecessary hurdles to delete their accounts, discouraging them from leaving. Invasive data collection: The platform aggressively harvests user preference data, for instance, browsing history, likes to refine its algorithms, often without clear consent. Manipulative content ecosystems: Xiaohongshu frequently promotes trending topics and incentivizes creators (via rewards like promotional support) to publish related content, creating a feedback loop that keeps users engaged for longer. These tactics not only erode user trust but also perpetuate a cycle of exploitation, where platforms prioritize profit over user well-being.

2. Definition and Manifestations of Dark Patterns

2.1 Definition of Dark Patterns

Dark patterns, also referred to as “internet traps”, were first coined in 2010 by British user interface expert Harry Brignull. The term describes a design approach that uses deceptive interface elements to manipulate users into taking unintended actions. Dark patterns are further defined as “user interface design choices that benefit online services by coercing, steering, or deceiving users into making unintended and potentially harmful decisions” (Mathur A., 2019). They exploit well-documented psychological principles, such as scarcity bias (fear of missing out), social proof (trust in others’ choices), and loss aversion (avoiding perceived losses), to drive user behavior. In summary, dark patterns combine tactical interface design with the exploitation of users’ psychological traits to boost short-term platform engagement. However, this comes at a cost: they erode user trust and undermine long-term brand or service sustainability.

2.2 Manifestation of Dark Patterns

In the digital era, amid an overwhelming abundance of information, human attention has become a scarce commodity. The more attention a platform can capture, the greater the likelihood of driving user visits and online purchases—making attention the lifeblood of modern digital business models.

This is the core driver behind the rise of Dark Patterns: platforms leverage deliberate design tactics to maximize user engagement time, harvest data for targeted advertising revenue, and outcompete rivals in a crowded market. As competition intensifies, these tactics evolve, with newer, more sophisticated Dark Patterns emerging on platforms like Xiaohongshu. Below are key manifestations of this phenomenon:

1. Disguised Advertising/Native. Manipulation Posts marked “Brand Partner” or “Sponsored” are seamlessly embedded into organic content feeds, mimicking genuine user recommendations to obscure commercial intent at first glance. For example, cosmetics or daily necessity ads are often subtly woven into lengthy, narrative-style posts, blurring the line between authentic reviews and paid promotions.
2. Engagement-Driven Design. Features like “endless scroll” (removing natural stopping points) and strategically positioned “Recommended For You” sections capitalize on the “just one more minute” effect, extending user sessions far beyond their intended length. This tactic exploits cognitive inertia, keeping users hooked on the platform for longer periods.
3. Confirmation Bias. Amplification Algorithms prioritize content aligned with users’ past interactions and inferred preferences, creating self-reinforcing “filter bubbles” that limit exposure to diverse perspectives. For individuals with low digital literacy or limited cognitive abilities, these “information cocoons” can foster addiction to specific services, while their range of choices gradually and unconsciously shrinks.
4. Obstructed Opt-Out/Privacy. Controls Privacy settings or notification preferences are deliberately made hard to find or understand, often buried in multiple menus or using confusing jargon. For instance, deactivating a Xiaohongshu account requires a week-long review process, and users may experience “fear of loss” (over losing accumulated followers) to deter them from leaving.
5. Choice Architecture. Manipulation Platforms use visual hierarchy, color contrast, or default settings to nudge users toward

preferred actions. A common example is a large, brightly colored “Continue Browsing” button paired with a small, greyed-out “Exit” option—subtly guiding users to stay on the platform rather than leave.

6. Social Pressure Tactics. Tactics like highlighting “X friends liked this” or “Popular in your area” trigger fear of missing out (FOMO) and exploit herd mentality, particularly among individuals prone to irrational decision-making. This encourages conformity and drives engagement by making users feel left out if they don’t participate.

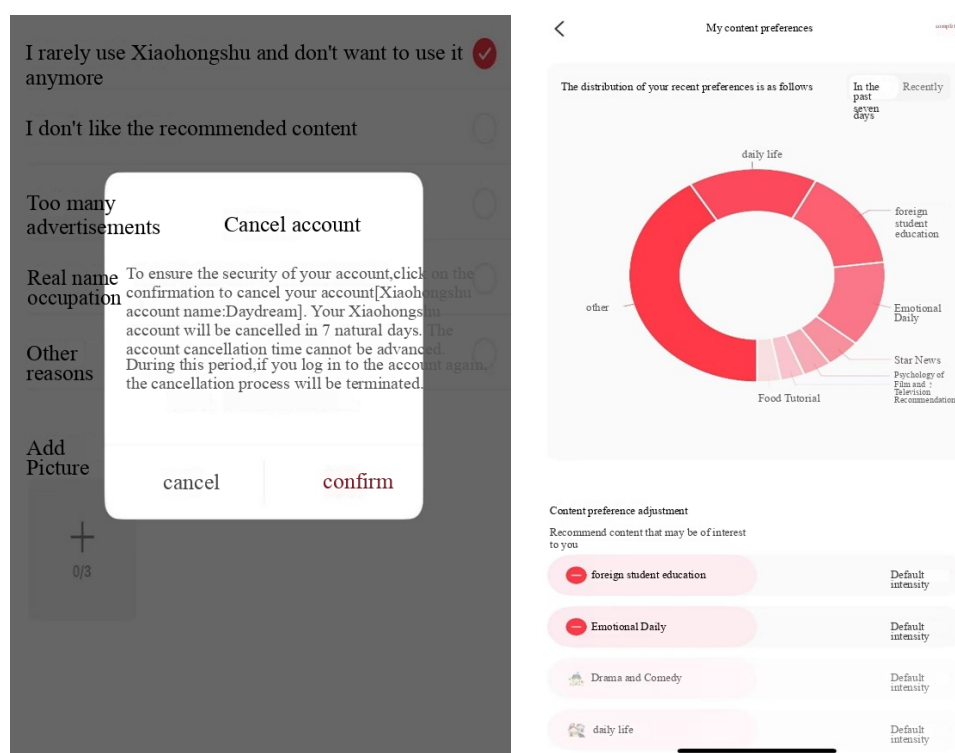
7. Rewarded Sharing. Small incentives (e.g., virtual coins, increased visibility) are offered for sharing app links or inviting contacts—masking extensive data collection in the process. While data itself has no intrinsic value as a production factor, it generates value through dissemination and redistribution, making user sharing a key part of the platform’s data ecosystem.

8. Emotional Analytics Manipulation. Sentiment analysis of user-generated content is used to deliver emotionally resonant (and potentially manipulative) content or advertisements. For example, the platform may send push notifications for safety shorts or self-defense sprays to users who exhibit signs of low security awareness, exploiting fear to drive engagement.

9. Drip Pricing. Mandatory fees (e.g., service charges for brand collaborations) are disclosed only at a late stage of a transaction, after users have already invested time or effort in the process. This tactic preys on commitment bias, making users more likely to accept unexpected costs rather than abandon the transaction.

It is worth noting that these Dark Patterns are not isolated. they are systemic, rooted in a business model that prioritizes attention capture and data extraction over user well-being. As platforms compete for scarce user attention, these tactics will continue to evolve, posing growing challenges to digital literacy and consumer autonomy in the years ahead.

Figure 1: Dark patterns on Xiaohongshu



3. The impacts of Dark Patterns

3.1 Impact on Users

The impact of Dark Patterns on platform users is profound, prompting questions about who is most vulnerable to such manipulative practices. Amit (2022) emphasizes that commonly employed Dark Patterns significantly distort user decision-making, with the majority of users displaying similar susceptibility patterns. Age, education level, and income serve as three standard proxies for measuring consumer vulnerability collectively, these factors reflect key traits linked to Dark Pattern susceptibility, including cognitive capacities, impulse buying tendencies, patience, risk-taking behavior, trust, risk tolerance, financial literacy, and digital literacy. Empirical studies highlight a strong correlation between susceptibility and demographic variables: individuals of advanced age, lower educational attainment, or lower income levels exhibit significantly higher

vulnerability, with older adults emerging as a particularly high-risk group. Dark Patterns inflict the most immediate harm on consumers through economic losses. Decisions made under their influence are often involuntary and irrational, as platforms may deliberately push higher-priced products or use interface designs that impede comparative shopping—effectively preventing users from making optimal choices aligned with their best interests. Privacy risks further compound these harms: mandatory login policies (requiring phone numbers or ID cards to access services) can expose personal and sensitive information. This issue is exacerbated by the “multi-platform ecosystem”, where social platforms collaborate with other companies to generate revenue—advertising for specific brands while sharing user data with partners. This creates joint information silos that profit at users’ expense. With their personal information locked into these ecosystems, users become highly prone to developing addictions to platform services. As Gregory and Abbey note, this addiction stems from dopamine release in the brain, mirroring gambling: random positive stimuli trigger dopamine surges, and repeated exposure fosters dependency, much like compulsive gambling. At its core, the internet operates on an “attention economy”. Platforms like Xiaohongshu leverage algorithms and user data to construct “information cocoons” tailored to individual preferences—mechanisms that increase users attention expenditure and personal information costs while diminishing their choices and autonomy. Prolonged engagement with such devices can also trigger physiological issues, including dysregulated cortisol secretion. Even for users aware of Dark Patterns, the constant vigilance needed to avoid them during regular social media use can induce stress and dissatisfaction. Moreover, if users cannot effectively exercise their preferences, both their economic and social efficiency will be significantly diminished.

3.2 impact on platforms and market competition

For private enterprises, the primary operational goal of various platforms is profit maximization, a driving that compels them to adopt such interface designs even though they recognize the unethical nature of Dark Patterns. As a strategic asset that reinforces platform monopolies, data can be converted into strategic investments when entering new markets. Enterprises with substantial data reserves have inherent advantages and potential for horizontal expansion (Li Y. J.). Dark Patterns enable platforms to acquire additional data resources: while this approach may initially boost metrics like Daily Active Users (DAU) and session duration, overreliance on Dark Patterns—instead of improving the quality of information products—will ultimately erode long-term user trust. Platforms associated with manipulative designs risk damaging their reputation and losing users. Moreover, while China’s Anti-Monopoly Law has long classified output restrictions as illegal, Dark Patterns undoubtedly constitute a novel form of anti-competitive behavior (Day & Stemler, 2020). First, platforms leverage traffic transmission within their ecosystems to amplify market influence via the multiplier effect, accelerating the expansion of their market dominance. Second, by orchestrating traffic flow dynamics, platforms create a “traffic pool” that directly raises market entry barriers and hinders the growth of potential competitors (Yang & Wang, 2021). If these platforms enter monopoly agreements or abuse their dominant market positions, they will restrict healthy market competition and undermine the fair competition environment. This also disadvantages competitors that adhere to ethical standards and may stifle genuine innovation. Additionally, they may distort the advertising market by artificially inflating engagement metrics.

3.3 Impact on Creators

For content creators, traffic and data revenue are tangible metrics of user engagement. However, driven by the innate psychological need for validation, creators often find themselves manipulated by social media platforms. For example, being coerced into paying to boost post visibility or inserting ads. Under relentless pressure, they are forced to align with algorithmic biases exacerbated by Dark Patterns, often prioritizing sensational or commercially oriented content over authenticity. The distinction between organic and sponsored content has grown increasingly blurred, largely due to the proliferation of native advertising, where shopping links are often embedded in content, eroding creator credibility. Complex visibility algorithms and opaque rules make it harder for creators to reach their audience organically without resorting to paid promotions or manipulative tactics. Furthermore, when creators attempt to leave a platform, they encounter week-long account reviews and warnings of losing all their data and followers.

4.Regulation and Governance of Dark Models on Social Platforms

Addressing Dark Patterns necessitates a multifaceted approach encompassing regulatory measures, platform accountability, and user empowerment.

4.1 Current status of regulation and legislation

From an international perspective, the European Union's Digital Services Act (DSA) explicitly bans specific Dark Patterns, including deceptive nudges and practices that render unsubscribing more cumbersome than subscribing. In the United States, the Federal Trade Commission (FTC) has actively pursued enforcement actions against companies engaging in deceptive practices, most notably in the Amazon Prime subscription cancellation case. Additionally, the Federal Trade Commission Act and Children's Online Privacy Protection Act (COPPA) establish robust legal safeguards for user privacy. China has made substantial progress in regulating Dark Patterns. The State Administration for Market Regulation (SAMR) released the Internet Marketing Guidelines in 2021, which explicitly prohibit practices such as fake likes, misleading comments, and deceptive interfaces. The Cyberspace Administration of China (CAC) focuses on algorithm governance and data protection, while the Personal Information Protection Law (PIPL) grants users enforceable rights over their data, rights often undermined by Dark Patterns. Notably, China's regulatory efforts to protect minors stand out globally, including restrictions on minors' online time and gaming login durations. While enforcement against specific manipulative tactics on major platforms is escalating, comprehensively defining and detecting all Dark Patterns remains a persistent challenge.

4.2 Governance Measures and Recommendations

Dark Patterns manipulate consumer decision-making by deliberately exploiting bounded rationality, limited willpower, and constrained self-interest, constructing sophisticated digital traps in the process. As Yang F. emphasized, "There is an urgent need to conduct in-depth research on establishing appropriate legal frameworks to tackle the misuse of Dark Patterns in e-commerce, thus mitigating the risk of consumer rights infringement at its root." For Government and Regulatory Bodies (e.g., SAMR, CAC) As the primary enforcers of Dark Patterns regulation, government and regulatory bodies like the State Administration for Market Regulation (SAMR) and the Cyberspace Administration of China (CAC) should prioritize the following actions: Firstly, Refine Technical Standards. Formulate and update detailed technical standards mandating that platform interfaces prioritize usability and user control. Existing laws must clearly delineate specific types of prohibited Dark Patterns. Measures such as "online blocking" and "opt-out system establishment" can counter manipulative practices on social platforms. Then, Enhance Enforcement Capabilities. Establish specialized technical teams dedicated to monitoring and investigating Dark Patterns on platforms, strengthening the ability to detect and address violations. Boost Public Awareness. Implement educational and awareness-raising programs while optimizing participation mechanisms to help users understand Dark Patterns and break free from information silos. Foster International Cooperation. Collaborate with global partners to tackle cross-platform manipulative behaviors, as Dark Patterns often transcend national borders. Introduce Behavioral Interventions. Offer platform-switching discounts and subsidies to users and creators to lower the costs of migrating between platforms, reducing reliance on manipulative ecosystems. Finally, Create Incentive Mechanisms. Grant subsidies or tax reductions to platforms that abstain from using Dark Patterns, rewarding ethical design practices.

For Social Media Platforms, as Xiaohongshu, platforms must take proactive steps to eliminate Dark Patterns and prioritize user welfare. Firstly, Establish independent review teams to perform self-assessments and compliance checks, ensuring interface designs align with ethical standards. Secondly, Adopt "Bright Mode" Interfaces. Design interfaces that prioritize clarity, user consent, and ethical control, such as clear advertising labels, one-click opt-out mechanisms, and reasonable privacy settings to empower users. Then, Increase Transparency: Provide consumers and reviewers with detailed explanations of algorithmic principles and content moderation practices, enhancing industry self-regulation and trust. Grant User Control: Give users substantive authority over algorithmic recommendations and data usage, preventing manipulation via "information cocoons" created by platform settings. Finally, Invest in User Education: Offer in-app or on-platform educational resources (e.g., tutorials, awareness campaigns) to elucidate platform operational mechanisms and potential manipulative strategies, helping users make informed decisions.

For Users and Civil Society, empowering users and civil society is critical to combating Dark Patterns. Firstly, Improve Digital Literacy. Implement programs focused on identifying common Dark Patterns and protective strategies. Strengthening

mathematical literacy will reduce susceptibility to framing bias, status quo bias, and information overload.

Secondly, Support Independent Monitoring. Establish civil society-led public interest organizations to operate independent research and monitoring platforms, providing objective oversight of platform practices. Then, Encourage Reporting. Urge users to proactively report privacy violations and manipulative interface designs, creating a feedback loop for accountability. Promote Critical Consumption. Foster thoughtful engagement with online content, raising awareness of persuasive design techniques to help users learn from experience and avoid deception. Lastly, Advocate for User Rights: Push for stronger user rights and platform accountability mechanisms, ensuring platforms are held responsible for manipulative practices.

5.Conclusion

Dark Patterns are a pervasive yet covert form of manipulation deeply embedded in the design of social media platforms like Xiaohongshu. Driven by user engagement metrics and revenue goals, these design tactics exploit psychological biases, erode user autonomy, distort competitive dynamics, pressure content creators, and disproportionately risk vulnerable groups, all in service of boosting interaction and profits.

While regulatory frameworks, especially in China, are gradually evolving to tackle these issues, the dynamic and adaptive nature of Dark Patterns continues to blur their definition and hinder enforcement. Their chameleon-like ability to evade rules complicates both how we classify them and how we police them.

Effective mitigation demands multi-stakeholder collaboration: Regulators must establish clear, actionable guidelines and robust enforcement mechanisms to create a level playing field. Platforms should embrace ethical design principles (e.g., avoiding “infinite scroll” or “confirmshaming”) and boost transparency about how algorithms shape user experiences.

Users need to build digital literacy to recognize manipulative tactics and access tools (like ad blockers or privacy settings) to protect their autonomy. Only through such concerted, cross-sector action can social media platforms fulfill their intrinsic value, connecting people, fostering creativity, and sharing information, without falling prey to the implicit control exerted by manipulative design practices. The future of ethical tech depends on balancing innovation with respect for user agency.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Luguri, J., & Strahilevitz, L. J. (2021). Shining a light on dark patterns. *Journal of Legal Analysis*. 2:1-76.
- [2] Mathur, A., Acar, G., Friedman, M. J., Lucherini, E., Mayer, J., Chetty, M., & Narayanan, A. (2019). Dark patterns at scale: Findings from a crawl of 11K shopping websites. *Proceedings of the ACM on human-computer interaction*, 3(CSCW), 1-32.
- [3] Zac, A., Huang, Y. C., von Moltke, A., Decker, C., & Ezrachi, A. (2023). Dark patterns and consumer vulnerability. *Behavioural Public Policy*, 1-50.
- [4] Li, Y. J.(2022). The economic implications of data elements and related policy recommendations. *Jiangxi Social Sciences*, 42(3), 50-63.
- [5] Day, G., & Stemler, A. (2020). Are dark patterns anticompetitive?. *Ala. L. Rev.*,72, 1.
- [6] Yang, D. and Wang, R. (2021). On the Impact of Traffic Conduction Behavior on Market Power in Digital Economy Platforms. *Financial and Economic Law*, (4),11.
- [7] State Administration for Market Regulation (SAMR). (2021). *Internet Guidelines on Regulating Online Marketing*.
- [8] European Commission. (2022). *Digital Services Act (DSA)*.
- [9] Federal Trade Commission (FTC). (2023). *FTC Sues Amazon for Enrolling Consumers in Amazon Prime Without Consent and Sabotaging Their Attempts to Cancel*.
- [10] Yang, F. (2022). Legal Regulation of Dark Pattern Abuse in E-Commerce. *China Circulation Economy*,36(8),40-50.

A Study on the Chinese Translation of European Automobile Brand Names from the Perspective of Skopos Theory

Yuanhao Lin*

Zhejiang Yuexiu University, Shaoxing, Zhejiang, 312000, China

*Corresponding author: Yuanhao Lin, 675231651@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Brand names are of great significance in reflecting the history and culture of their brands. Similarly, the translation of the name of an automobile brand profoundly affects its brand image, positioning and consumer acceptance, as well as the purchase price and consumers' willingness to buy. With the globalization of the automobile industry, the quality of a brand's translation has a direct impact on whether a European automobile manufacturer can successfully occupy a place in the Chinese market, therefore, effective translation of European automobile brands in the Chinese market is imperative. Successful Chinese translation is crucial for high sales of European car brands in China. The Chinese translation of the brand names has to be in accordance with the cultural psychology, customs and aesthetic interests of Chinese people. This study focuses on the application of skopos theory, aiming to explore how to translate European automobile brand names into Chinese using skopos theory through literature review and case study. It is found that European automobile brands mainly adopt the translation methods of literal translation, free translation and transliteration, which follow the principles of skopos, coherence and fidelity of the skopos theory.

Keywords: European Automobile Brand Names; Skopos Theory; Chinese Translation

Published: Sept 11, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.616>

1.Introduction

In current society, automobile has become a part of everyone's life. A large number of foreign automobile brands are pouring into China. To successfully break into the Chinese market, a foreign automobile brand needs not only maintain the quality of its products, but also let the Chinese translation of its brand name to be recognised by Chinese consumers.

The brand name of automobile usually has a specific meaning and carries the history and culture of a country or nation. The global automobile industry's development has led to a trend of globalisation. Therefore, a automobile brand seeking to export overseas requires an effective translation strategy. Therefore a good translation of the brand name is extremely important. Brand image, positioning and consumer acceptance are significantly influenced by the brand name. The translation of a brand name and the product itself can significantly impact both the price and the consumer's willingness to purchase the brand. It is not an exaggeration to say that the Chinese translation of the brand name is absolutely indispensable for the high sales of these European brand automobiles in China. Moreover, whether a foreign brand can be successfully marketed or not, the name of its product plays a crucial role as it is the first impression of a brand to the consumers. In the face of Chinese consumer groups, the translation of automobile brand names with Chinese cultural characteristics needs to be in

line with Chinese social customs, Chinese consumers' cultural psychology, consumer psychology and aesthetic taste. The translation of automobile brand names bridges the communication between different nationalities and cultures, and realizes the transformation between languages in different cultural backgrounds.

Translations of brand names into Chinese, such as Bayerische Motoren Werke (BMW) and Mercedes-Benz, are not only easy to read but also easier to remember among European automobile brands. To ensure accurate translations of European automobile brand names into Chinese, it is essential to have a deep understanding of the cultural connotations and differences between the two languages. Therefore, it is necessary to study the methods and strategies used for the Chinese translation of European automobile brands for reference. As defined by William & Andrew (1999), European automobile brands are automobile manufacturers that are based in Europe and legally registered in European countries. These brands produce a wide range of vehicles, from passenger cars to commercial vehicles, and often represent the continent's rich heritage of automobile engineering and design.

A legally European automobile brand is an entity that is legally established in a European country. They operate under the regulatory framework and commercial laws of their respective countries. Moreover, they comply with EU regulations on vehicle safety, emission standards and other industry-specific regulations. Geographically European automobile brands are headquartered in various European countries including but not limited to Germany, France, Italy, Sweden, the United Kingdom, Spain and others.

Skopos theory is a classic translation theory, which emerged in Germany in the 1970s. The theory puts the focus of translation on the function of translation and emphasizes the purpose of translation. The purpose of the brand name of an automobile is to convey the characteristics and connotation of the brand to the consumers, which coincides with the emphasis on the purpose of the skopos theory, so that the skopos theory is the most suitable translation theory for the translation of the brand name of an automobile.

This thesis aims to explore the methods of translating European automobile brand names into Chinese by studying skopos theory and the naming conventions of these brands. The research will include a literature review and a case study. The analysis will start with an examination of skopos theory and its relevance to brand translation, providing a theoretical foundation for subsequent analysis. The case study will focus on the translation methods and principles used for selected European automobile brands.

2. Literature Review

2.1 Studies Abroad

Katharine Reiss, a renowned German translation theorist, based her analysis and criticism of translation on the relationship between the function of the source language and the function of the target language. The foundation of her theory aimed to achieve equivalence between the source and target languages. However, when the communication function of the source language and the target language differ, the focus should be on the original function of the target text rather than pursuing equivalence. Reiss & Vermeer (1986) suggests that language functions should be integrated with translation practice, and the research focuses on the exploration of the importance of the function of the text, laying a solid foundation for the development of the skopos theory.^[1]

Hans Vermeer, a student of Katharine Reiss, innovated and enriched the skopos theory. Taking the function of the target text as a primary consideration, Hans Vermeer (1989) argues that translation cannot be effectively analyzed and studied by language translation theory alone^[2]. It is more effective to follow three major principles than to rely on language translation theory for translation work. The three principles are skopos rule, coherence rule and fidelity rule, which means that the process of translation should be based on the fact that the translated text fulfills its intended function in the translated culture. According to Hans Vermeer (2004), the translation must achieve intra-textual coherence and there should be some correspondence between the translated text and the original text in terms of what is to be presented^[3].

Christiane Nord (1991) proposes the principle of fidelity, which complements the original three principles of translation proposed by Hans Vermeer's skopos theory^[4]. It is important for a translator to remain faithful to both the source and target languages. However, this should not be conflated with the concept of fidelity, which pertains solely to the relationship

between the original and translated texts. Christiane Nord's theory in 1997, which focuses on pre-translation text analysis, is a functionally-based theory of translation that can be applied to all text types and language pairs^[5]. The theory proposes a translation-oriented model of source text analysis that aims to identify translation problems and strategies based on the factors of the source text and their relationship to the function and recipients of the target text.

Scholars in the field of translation studies often use these theories to translate texts with a clear purpose, such as brand names. When translating brand names, the goal is to effectively communicate the brand's image to the intended audience, which are the customers. For example, Al & Jack (2002) analyses the ways in which some of the world's top brands stand out as brands in today's market by examining their stories and brand marketing methods^[6].

2.2 Studies at Home

Most of the domestic studies have taken the skopos theory as a perspective, prioritising the perspective of translation on whether it can convey the connotation of the trade name. Whether the quality and efficacy of the product and the company's philosophy can be successfully publicized has become the focus of the current domestic translation work^[7].

Domestic scholars conduct research on brand name translation by analyzing and comparing different translation methods. Researchers such as Guo Huirong (2013) and Xu Xiaoshu (2013) have emphasized the importance and necessity of brand name translation from a business perspective^[8]. By comparing various translation methods, they have found that skopos theory is a suitable approach for the current market globalization. It is essential to note that brand name translation has a significant impact on the brand's image and sales^[9].

According to Liu Ning (2009)'s study on automobile trademarks translation, the main objective of automobile companies in creating their logos is to promote sales and stimulate consumers' desire to buy their products. Therefore, when translating automobile logos, translators should focus on the purpose and consider the cultural differences of the target readers^[10]. Skopos theory is well-suited to meet this requirement.

Wang Xin (2022) applied skopos theory to examine the translation strategy of automobile trademarks. She emphasized that in the era of economic globalization, the translation of automobile trademarks is crucial to the success of an automobile company^[11]. A well-executed translation of automobile trademarks can result in significant economic benefits for the company. The translation process should prioritize the needs of consumers, and therefore, skopos theory, which focuses on the purpose of translation, should be employed^[12].

By analysing the current automobile market, Li Beibei (2014) concluded that foreign cars are still the mainstream of the Chinese automobile market. The naming of foreign automobiles and the Chinese translation of their names become very important. In order to maximise the publicity of the product and the promotion of the product, she believes that the translation of the trademark plays a vital and realistic role^[13]. Therefore, a successful brand name translation is an important condition for a company's products to enter the international market. She concludes that the skopos theory can be used to select the best translation method by analysing the names of automobile trademarks, so that the translation reflects the characteristics and functions of the products.

Based on the translation theory of skopos theory, Fu Xiaohong (2012) uses specific domestic and international case studies and qualitative analysis methods. The study concludes that the characteristics of the skopos theory are well suited to the needs of a brand that wants to express the connotations of its products in the market^[14]. What's more, as Feng Xiuwen (2009) suggests, the translation of a brand name should appeal to the target language consumers and stimulate their imagination and shopping desire^[15].

All these studies show the conclusion that in the translation of brand names, it is most important to accurately convey the message that the brand wants to express to consumers^{[16][17]}.

3. Case Analysis on Chinese Translation of European Automobiles Brands from the Perspective of Skopos Theory

3.1 European Automobiles' Naming Methods

Most European automobile companies have gained great recognition from consumers in China, such as Mercedes-Benz, BMW, Audi and Porsche. Therefore, by studying the Chinese translation names of European automobile brands, people

can understand the marketing strategies of these brands better in order to learn excellent translation strategies and advanced marketing strategies. This has become particularly important in the context of China's automobile exports jumping to the top of the world and the successful implementation of The Belt and Road Initiative.

The naming convention for European automobile brands usually involves a variety of factors, including the following:

1. Geographical and historical context

Many European automobile brands derive their names from the geographical characteristics or historical traditions of the region in which they are based. For example, the Bavarian Motor Works (BMW) brand in Germany is a direct reflection of the culture, history and geographic location of the country to which it belongs.

2. Names of founders or founding teams

Some European automobile brands take their names from the names of their founders or founding teams. For example, the Porsche brand is named after its founder Ferdinand Porsche, while Alfa Romeo is named after its founder Nicola Romeo, and Aston Martin after its founder Lionel Martin and its founding place Aston Clinton in England.

Moreover, this type of naming is also very conducive to a brand's globalisation strategy, which is to be remembered by consumers with its unique name, as Li Shuang's (2009) theory suggests, a brand in the context of economic globalisation should give due consideration to the ways of dealing with it.

3. Product features or philosophy

Some European automobile brands may have names that reflect their product features or corporate philosophy. For example, the name Volkswagen means "people's car" in German, reflecting the brand's early positioning as a high-quality, practical automobile product for the general public.

4. Symbolic words or symbols

Some European automobile brand names may be based on symbolic words or symbols. For example, the Renault brand name is derived from the surname of its founder, Louis Renault. And it also suggests innovation and renewal. Moreover, Jaguar, named after Jaguar, refers to the powerful, agile big cat, conveying speed, grace and strength. Lotus, named after Lotus, refers to a genus of flowering plants often associated with purity and beauty.

Overall, the naming approaches of European automobile brands are diverse, reflecting the history of the brand, its regional characteristics, the spirit of its founder, the characteristics of its products, and its market positioning, among other factors. Not only do these names have unique meanings and historical contexts, they are also an important part of the brand image and market positioning. Whereas the names of these car brands contain unique connotations, skopos theory is the best way to translate them, centred on the purpose of translation and showing the brand characteristics.

3.2 The Application of Skopos Theory in the Chinese Translation of European Automobiles Brands

The skopos theory provides a strong framework for translating European automobile brand names into Chinese, emphasizing purpose-driven translations and cultural adaptation. This section provides specific examples that illustrate how the principles of skopos theory are applied in the translation of well-known European automobile brand names into Chinese.

3.2.1 The Application of the Skopos Rule

A delicate balance between preserving the essence of the original name and ensuring resonance in the target Chinese market is required when translating European automobile brand names into Chinese. Various translation methods have been used to manage this complex process. Each has its own implications for brand identity, cultural relevance and market appeal. Taking the entry of European car brands into the Chinese market as a background, when these different translation methods are examined and evaluated, it can be found that the skopos rule plays a significant role.

Skopos theory prioritises the purpose and function of the translation. When applied to an automobile brand name, it ensures that the translated name conveys the basic message about the brand to the target audience. The skopos theory states that the primary principle of all translation activities is the "skopos" principle. This principle suggests that a translation should be able to function in the way expected by the recipient of the translation in the context and culture of the target language. The purpose of the act of translation determines the entire process of translation. In other words, the result determines the method. BMW is an automobile company that produces high-performance engines and emphasises its sporty characteristics, so it is

particularly important to convey the brand's sporty attributes accurately. The skopos rule is perfect for this. BMW stands for Bayerische Motoren Werke AG, which translates to "Bavarian Motor Works" in English. It is a well-known brand that is known for its luxury vehicles and German engineering. In the 1990s, when BMW first entered the Chinese market, its brand name BMW was directly transliterated as "bayier". This name did not attract much attention at that time. Obviously, the Chinese translation of BMW's name initially used the transliteration method. But it was clear that the name "bayier" didn't fit, either because of its poor pronunciation or because it didn't convey the idea of a car company. The name did not make BMW a success in the Chinese market, and sales were dismal. Many people even thought the name was like Chanel, a little bit feminine. The Chinese translation does not fulfil the skopos of communicating the brand to consumers. Because it neither conveyed the luxury quality of BMW cars nor was it easy to remember. Meanwhile, the Hong Kong market translated BMW as "baoma", and the name was immediately popular. Not only was it easy to remember, but the word "BMW" in Chinese signified speed and dignity, which was very much in line with the brand image of BMW. Therefore, from 1992, the name "baoma" was gradually adopted in mainland China, while "bayier" was gradually forgotten.

The new translation uses the method of free translation. The word "baoma" in Chinese means a precious horse, which is a fitting representation of the BMW brand's luxury, power and agility. Additionally, the Chinese translation mirrors BMW's original industry, the manufacturing of engines. The correspondence between this Chinese translation and the original text is important. It follows the skopos rule and aims to communicate the brand's identity and message effectively to the Chinese consumers. The translation maintains relevance to the target audience by using a name "baoma" that is culturally appropriate and resonates with Chinese consumers. The term "a treasure like horse" is visually and phonetically appealing, contributing to its acceptance and popularity in the Chinese market. In order to ensure that the intended message of the BMW brand is accurately conveyed in the Chinese language and culture, the Chinese translation of the brand name has been carefully selected. This approach is in line with the skopos rule, which stresses the importance of translating brand names in a way that communicates relevant brand messages to the target audience, thereby meeting their communication needs.

Mercedes-Benz's previous Chinese translation is an example of a poor literal translation that fails to convey the brand's luxurious and elegant image. The brand's name was first directly translated as "moxietaisibenchi," which is a long and difficult name to remember. This translation only conveys the name of the brand's founder to Chinese consumers and does not effectively communicate the brand's connotation of comfort and luxury. As a result, the Chinese translation does not fulfil the skopos of effectively communicating the brand image to Chinese consumers.

Mercedes-Benz changed its name to "meisaidesi-baoma", also known as "benchi," which represented the brand's vision and positioning. The new Chinese translation followed the skopos theory, which focuses on the skopos of translation and aims to achieve the expected function of the Chinese culture in the translation process. It emphasizes the function of the translation in the cultural environment of the target language, which is to convey the meaning of the brand. The modified Chinese translation "benchi" is more coherent in the Chinese context and easier for consumers to remember compared to the original "benchi." It is more acceptable, understandable and culturally appropriate for Chinese consumers. The new Chinese translation of the name reflects the skopos rule in the skopos theory.

The name change of Mercedes-Benz was a deliberate move to convey the brand's characteristics to its target consumers through its name. The word "benchi" is simple yet powerful, suggesting high-speed driving and excellent performance, which is consistent with the luxury brand positioning of Mercedes-Benz. The new Chinese translation follows the skopos rule of the skopos theory. It gives the brand a humanistic meaning and conveys an image of luxury, sophistication, and elegance. This purpose-driven translation aligns with the mission of the skopos theory, which acknowledges the need to adapt translations to the cultural context of the target consumers. The Chinese name of Mercedes-Benz subtly captures the cultural values associated with luxury and advancement, aligning with Chinese perceptions of prestige and progress.

Another most widely known example that follows the skopos rule is Volkswagen.

Volkswagen is an automobile manufacturing company based in Wolfsburg, Germany, and the VW in the logo stands for the acronym Volkswagen. The logo is made up of three V's made with the middle and index fingers, indicating that Volkswagen and its products are sure to win.

Volks means “people” in German, Wagen means “car” in German, the full name means “people’s car”. Therefore, Volkswagen means “people’s car” in German. It reflects the spirit of Volkswagen’s approachability and affordability, as well as the historical background of Volkswagen’s origins in post-war Germany. Its’ name conveys not only the hope that the company can make cars that are recognised by the people, but also the hope that every person in the country will be able to drive a car.

Accurately conveying the “the mass” element in Volkswagen is the key point of its Chinese translation. The Chinese translation of “Volkswagen” is “dazhongqiche”, where “dazhong” means “people” or “the masses,” and “qiche” means “car.” This translation effectively conveys the concept of accessibility and mass appeal inherent in the original German name, and it also complies with the skopos rule by maintaining the message and intent of the original text, but is also more easily understood and recognisable in the Chinese market, in line with the aim of communicating the message effectively.

3.2.2 The Application of the Coherence Rule

Skopos theory emphasizes adapting translations to target audience’s cultural context. Applied to automobile brand names, it ensures resonance with cultural nuances and preferences. When a European automobile brands are translated into Chinese, the coherence rule of the skopos theory is usually applied, which usually involves the selection of characters that phonetically represent the original name or convey the meaning associated with the brand. Like Ferrari, which Chinese translation uses characters that represent the phonetics of “Ferrari”. These characters don’t directly convey meaning but closely mimic the sound. “Ferrari” is the surname of Enzo Ferrari, the founder of the luxury sports car manufacturer. It represents a brand known for its high-performance vehicles, luxury and racing heritage.

The Chinese translation uses the method of transliteration. It follows the coherence rule in skopos theory, which means that the translation must meet the criterion of intra-textual coherence. It also means that the translation is readable and acceptable, and can be understood by the receiver and make sense in the culture of the language into which it is translated as well as in the communicative context in which the translation is used. The Chinese translation of Ferrari adopts a phonetic translation method, directly translating as “fālālì” (Fālālì). There are three tones in the translation, which are alling tone, level tone and entering tone, which make up a very clear and coherent sounding Chinese phrase. This gives the target readers a sense of the power of the name. This is in line with the rule of coherence, the standard of translation intra-textual coherence. In addition, Ferrari is named after its founder, Enzo Ferrari, who was also very confident that he wanted customers to remember his name and his car.

Audi is another European automobile brand that uses the coherence rule as a translation method. Translating “Audi” as “aodi” in Chinese follows the coherence rule of the skopos theory, as the pronunciation and meaning of the two words are semantically and phonetically consistent. In Chinese, “ao” means deep and precious, while “di” means straight and leading to the far side. Combined together, the name “aodi” gives people a high-end and honorable feeling, which aligns with Audi’s consistent high-quality and luxury positioning. Additionally, the pronunciation of “Audi” is similar to that of Audi in English, as both words are composed of a falling tone and a rising tone, making the Chinese translation of the name “aodi” very easy to pronounce. This ensures that the Chinese translation of Audi maintains the consistency of the brand name in different languages. Therefore, the Chinese translation of “aodi” conforms to the coherence rule.

3.2.3 The Application of the Fidelity Rule

According to Christiane Nord (1997), there are two main different translation strategies, documentary and instrumental, which depend on the translation skopos and the recipient’s expectations. Documentary translation aims to preserve the original qualities of the source text and present the target text as a version or report of the source text, with the objective of informing the target readers about the form and content of the source text. Instrumental translation, on the other hand, is meant to meet the needs of the target readership, where the target text is considered as a substitute or a tool for the source text, with the aim of enabling the target readers to receive the same information and emotions that the author of the source text intends to communicate. For Chinese translations of European automobile brand names, the direct translation method that emphasizes fidelity is the most suitable. One of the key tasks in Chinese translation is to accurately convey the intended brand meaning expressed by the automobile brands.

Aston Martin, built in March 1913, was founded by Lionel Martin and Robert Banford. In 1923 Lionel Martin won a mountain car race at Aston Clinton Hill in a car he had built himself, and in 1923 he renamed the company Aston Martin in honour of the victory. The company was named for its founder and the race victory. For this reason, it is necessary to faithfully reflect the two elements of “Aston” and “Martin” in the Chinese translation of its name. The Chinese translation of the name “*asidunmading*” has faithfully conveyed these two elements to the consumers. The word “*asidun*” faithfully conveys the message of the *asidun·kelindunshandibisai* (Aston Clinton Mountain Race). The translation of Martin as “*mading*” not only follows the Chinese standard for translating foreign names, but also faithfully conveys the message that its founder was Lionel Martin. This Chinese translation complies with the fidelity rule, resulting in inter-textual coherence between the original text and the translated text; in other words, it is faithful to the original text.

The Chinese translation of the name Alfa Romeo is also using the fidelity rule. Alfa Romeo is a famous Italian automobile manufacturer, founded in 1910, headquartered in Milan. Originally known as ALFA (Anonima Lombarda Fabbrica Automobili), the company’s predecessor can be traced back to an automobile company founded by Alexandre Darracq in Naples in 1906 and then moved to Milan. In 1916, Nicola Romeo, a Neapolitan by birth, took ownership of the factory and incorporated his family name Romeo into the name of the factory, which became today’s Alfa Romeo. On its logo is written Alfa Romeo, the word Alfa is a reminder of its history, and Romeo is in honour of the Romeo family, and is always vigilant that it does not dishonour Milan’s glorious tradition.

4. Conclusion

Upon analysing these examples, it is evident that skopos theory’s principles are embodied in the translation of European automobile brand names into Chinese. Skopos theory serves as an invaluable framework, emphasizing the primacy of purpose in translation. It underscores the significance of achieving equivalence, functionality, linguistic accuracy, market effectiveness and cultural resonance in brand name translations to facilitate effective cross-cultural communication and market penetration. Its adaptability allows for the strategic selection of translation methods that effectively convey brand identity, cultural connotations and functional equivalence. This ensures that the translated brand names resonate harmoniously within the complex socio-cultural landscape of the Chinese market. The skopos theory recognizes the evolving nature of cultures and the need for translations to consider these changes. It emphasizes the importance of functional equivalence, where the translation should serve the purpose and needs of the target audience. This aligns perfectly with the idea that brand names should reflect contemporary socio-cultural environments and be adapted to suit them. Moreover, skopos theory’s adaptability enables the integration of brand attributes and innovative elements into the translated names, ensuring that they resonate effectively in the target culture. Skopos theory emphasizes cultural sensitivity and appropriateness, enabling the incorporation of cultural heritage while ensuring that the brand name remains relevant and appealing in the contemporary context.

Further analysis will examine the implications and effectiveness of these translations in terms of brand recognition, consumer perception and market success.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Al, R., & Jack, T. (2002). *The 22 immutable laws of branding*. Harper Collins Publishers, Inc.
- [2] Maloney, W. A., & McLaughlin, A. (1999). *The European automobile industry: multi level governance, Policy and Politics*
- [3] Nord, C. (1991). *Text analysis in translation: theory, methodology, and didactic application of a model for translation-oriented text analysis*. John Benjamins Publishing Company.
- [4] Nord, C. (1997). *Translating as a purposeful activity: functionalist approaches explained*. St. Jerome Publishing.
- [5] Nord, C. (1997). *Loyalty and freedom: on the translation of technical literature*. Routledge.

- [6] Reiss, K. (1971). *Möglichkeiten und grenzen der übersetzungskritik: kategorien und kriterien für eine sachgerechte beurteilung von übersetzungen*. Tübingen: Gunter Narr Verlag.
- [7] Reiss, K., & Vermeer, H. J. (1986). *Towards a general theory of translational action: Skopos theory explained*. Niemeyer.
- [8] Vermeer, H. J. (1989). *Skopos and commission in translational action*. Finn Lectura Ab.
- [9] Vermeer, H. J. (2004). *The role of the translator's intention in translation theory*. St. Jerome Publishing.
- [10] Feng, X. (2009). A cultural perspective on the translation of trademark and brand names. *Contemporary Literature* (Second Half-Month Edition), (04), 2–4.
- [11] Fu, X. (2012). *A Skopos theory-based study on the Chinese translation of cosmetic brand names* (Master's thesis, Hubei University of Technology).
- [12] Guo, H. (2013). *A study on the Chinese translation of foreign automobile brand names from the perspective of Skopos theory* (Master's thesis, Shanxi University of Finance and Economics).
- [13] Li, B. (2014). *A study on the Chinese translation of foreign automobile trademarks from the perspective of Skopos theory* (Master's thesis, Jilin University).
- [14] Li, S. (2009). *A study on English–Chinese translation strategies of automobile brand names* (Master's thesis, Dalian Maritime University).
- [15] Liu, N. (2009). *On the translation of automobile trademarks from the perspective of Skopos theory* (Master's thesis, Central South University).
- [16] Wang, X. (2022). A study on translation strategies of automobile trademarks from the perspective of Skopos theory. *Science & Technology Information*, (05), 5–17.
- [17] Xu, X. (2013). *The Chinese translation of Japanese automobile brand names from a commercial perspective: A case study of Toyota, Honda, and Nissan* (Master's thesis, Jilin University).

The Dilemma and Optimization Path of Performance Evaluation of Government Guided Funds

Wanqing Xu*

School of Management, Xi'an Polytechnic University, Shaanxi Xi'an, 710048, Chian

**Corresponding author: Wanqing Xu*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: As an important policy tool for promoting scientific and technological innovation and industrial upgrading, the performance evaluation mechanism of government-guided funds plays a key role in enhancing the efficiency of financial funds. At present, China's government-guided funds have gradually changed from pursuing incremental development to pursuing high-quality development of stock funds. At this stage of development, it is of great significance to construct a perfect performance evaluation system for government-guided funds in order to play the guiding role of such funds and realize the policy objectives.

Keywords: Government Guiding Fund; Performance Evaluation; Financial Funds

Published: Sept 11, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.617>

1.Introduction

With the continuous promotion of China's economic structure transformation and innovation-driven development strategy, government guiding fund has become an important policy tool for the government to support scientific and technological innovation and promote industrial upgrading. By guiding social capital, sharing investment risks and promoting entrepreneurship development, government-guided funds have played a positive role in promoting the cultivation of emerging industries and the growth of small and medium-sized enterprises. Along with the continuous expansion of fund scale and increasingly complex operation structure, how to carry out performance evaluation in a scientific and fair manner has become a key link to ensure the standardized operation of the fund and enhance the efficiency of the use of financial funds.

Performance evaluation is not only an important means to understand the actual operation effect of the fund, but also a key instrument to promote the improvement of fund management and policy optimization. At present, the performance evaluation system of China's government-guided fund has been gradually established, but there are still some problems in the construction of the index system, method selection, data acquisition and results utilization, which can hardly reflect the policy results and economic and social contributions of the fund. In this regard, this paper focuses on analyzing the main obstacles faced by the performance evaluation of government-guided funds, and proposes optimization paths that fit the actual problems, with the intention of giving reference to the improvement of relevant policies and practical exploration.

2.Basic positioning and performance evaluation of government-guided funds

2.1 Connotation and Basic Positioning of Government Guiding Fund

Government-guided funds are arranged by the budgets of governments at all levels, and are set up with separate funding or

co-funding with social capital, and invested in key areas of economic and social development and weak links by professional investment management institutions in a market-oriented way such as equity investment, so as to achieve the optimization of the allocation of social capital, give full play to the leverage effect of financial funds, improve the efficiency of the use of financial funds and social funds, and coordinate the development of the regional economy to promote innovation and entrepreneurship, and Promote the optimization and upgrading of the industrial structure^[1].

In recent years, government-guided funds have expanded rapidly. According to the latest statistics of Zero2IPO Research Center, as of 2024, China has cumulatively set up 2,178 government-guided funds, with a total target size of about 12.84 trillion yuan. Most of them focus on high-tech fields such as integrated circuits, biomedicine and green energy. Such a large-scale allocation of financial funds also puts forward higher requirements for the performance evaluation system. How to establish a scientific evaluation index system, integrate financial and social benefit indicators, and improve the dynamic tracking and whole-process management mechanism has become an important content and key link in the current policy management.

2.2 The basic structure and development status of government guiding fund performance evaluation

The performance evaluation system of governmental guiding funds has initially formed a basic structure with multiple dimensions, and the whole tends to be standardized and unified. In terms of indicator design, the central-level evaluation mainly starts from the three dimensions of policy effect, investment efficiency and management effectiveness; while the local-level evaluation mostly draws on the idea of project expenditure performance evaluation, and centers on the four aspects of decision-making/input, process, output and efficiency/effectiveness. Although there are differences in the expression of dimensions at the first level, they are basically the same in terms of specific evaluation content and focus, and a unified common evaluation index system has been initially formed, which lays a good foundation for the construction of a nationally unified performance evaluation method for governmental guiding funds in the future^[2].

In terms of evaluation practice, local governments have also started to explore a more practical and targeted differentiated evaluation mechanism. Some funds have tried to set different evaluation focuses according to the stage of life cycle, and a few regions have also extended the evaluation object to sub-funds and management organizations, and opened the exploration of the tiered assessment mode of mother-sub-funds, which is more in line with the actual situation of fund operation. For example, Zhejiang has constructed a “tax contribution discount model” to incorporate non-financial outputs; Shenzhen has built a “data cockpit” platform to realize the whole process of visualization and supervision of sub-funds, which effectively improves the scientific and practical nature of performance evaluation.

On the whole, the performance evaluation system of China’s government-guided funds is gradually developing in the direction of standardization, scientific rigor, and digitization, and has formed a comprehensive evaluation framework covering multiple dimensions and levels, such as financial, economic, social and management.

3.Realistic Dilemmas Facing the Performance Evaluation of Government Guided Funds

3.1 Lack of systematic and adaptive indicator system

The performance evaluation system of government guiding fund still faces the problem of insufficient unity and adaptability. Although a unified evaluation index system is generally adopted in many regions during the actual operation stage, this practice does not adequately measure the differences between different types of funds in terms of policy mission, investment direction, and degree of marketization, which leads to a lack of focus in the performance evaluation. Some zones still adopt a unified evaluation scale for different life cycle stages of the fund, such as fund raising, investment operation, post-investment management, liquidation and withdrawal, which makes it difficult to objectively reflect the real operational effectiveness of the fund at various stages and affects the scientific rationality of the evaluation results.

The current performance evaluation mechanism needs to be improved in terms of dynamics and periodicity. Even though the government-guided fund is oriented to realize the policy objectives, its operation relies on the market mechanism to a large extent, so the performance evaluation criteria should be dynamically adjusted according to the changes in the economic environment, industrial policies and fund management requirements. The existing evaluation system has not reflected the relative, stage and industry-specific characteristics during the actual operation, and lacks the synergistic linkage with the

external environment, making it difficult to accurately reflect the actual results of the fund. As a long-term policy tool, if the government-guided fund still takes the financial year as the main evaluation cycle, it is difficult to cover the fund's objectives and focuses at different stages of "raising, investing, managing and withdrawing", and it is not conducive to the comprehensive measurement of its long-term policy effectiveness and actual performance.

3.2 Imperfect fund dynamic data

In recent years, the rapid growth of government-guided funds around the world, the number and scale of funds continue to expand, but the corresponding information construction is still lagging behind^[3]. A unified and comprehensive information system has not yet been established, and it is difficult to integrate a comprehensive database including financial data, industry data, fund operation data and relevant evaluation standards, thus lacking strong support for accurate, dynamic and comparable data required for performance evaluation. Fund management organizations set up by governments at all levels have not yet formed a systematic and sustainable mechanism for accumulating operational data, and key information in the fund operation process, such as investment decisions, project progress, post-investment management and withdrawal, often lacks a complete record, making it difficult to conduct in-depth analysis based on facts for performance evaluation.

In government-guided funds in which several local governments or departments jointly invest capital, given the lack of an efficient information-sharing mechanism, each contributor tends to carry out performance evaluation separately, resulting in duplicate evaluations of the same fund, which not only increases management costs, but also triggers duplication of financial and human resources and wastage.

3.3 Inadequate institutional norms for management and evaluation

With the gradual improvement of the policy system, the state has continuously strengthened the system construction for the management and performance evaluation of government guiding funds, and has issued a number of major policy documents to regulate them. Among them, the Opinions of the State Council of the Central Committee of the Communist Party of China on the Comprehensive Implementation of Budget Performance Management, which was implemented in 2018, clearly states that government-funded investment funds should be included in the performance management system to promote the implementation of the whole process and all-round performance management; the Opinions on Further Deepening the Reform of the Budget Management System, which was issued by the State Council in 2021, also explicitly proposes specific proposals on the establishment of the government-guided fund, capital contribution, performance evaluation, and information disclosure^[4]. The Opinions on Further Deepening the Reform of the Budget Management System issued by the State Council 2021 also clearly put forward specific requirements for the establishment, contribution, performance evaluation and information disclosure of government guided funds. However, in actual operation, the relevant management system is still deficient, and there is a lack of uniform standards in the definition of the scope of evaluation, the formation of the index system, the setting of the implementation process and the application of the results of these key aspects, resulting in the implementation of different standards around the world, and the operational flexibility has exceeded reasonable limits, which affects the standardization and effectiveness of the performance evaluation.

3.4 Lack of strong planning for fund exit

After the government-guided fund enters the exit stage, some of the funds established in the early stage have gradually exposed the real problems such as difficult exit and slow progress. On the one hand, the planning of fund exit is not strong, and there is a lack of systematic arrangements and a clear timetable. At present, the survival period of the fund funded by the central government is generally 10~15 years, but a lot of funds near the deadline there are still a large number of projects that have not developed an exit path, part of the proposed exit through the transfer of equity or A-share listing of enterprises due to sustained losses, operational difficulties or financing constraints, etc. However, the exit is expected to fall short of the overall exit progress. There is a greater degree of uncertainty, a serious constraint on the evaluation of the performance and the effective recovery of funds.

On the other hand, poor exit mechanism is also an important factor restricting the realization of fund performance. Participating funds generally face problems such as multiple exit levels, difficulties in liquidation of underlying projects, and great resistance to industrial and commercial changes, leading to chain reactions such as slow liquidation and freezing of

custodian accounts. At the same time, there are big differences between fund managers and social capital in terms of priority exit arrangements, project valuation and transfer prices, which affect the exit efficiency. In addition, external factors such as complicated procedures for the transfer of state-owned assets, difficult valuation, and imperfect capital market systems (e.g., tightened IPO audits, poor M&A and restructuring mechanisms) have further exacerbated the difficulty of fund exit, directly affecting the objectivity of the performance evaluation results and the efficiency of fund recycling.

4. Optimization Path of Performance Evaluation of Government Guided Funds

4.1 Improve the performance evaluation index system

Constructing a scientific, comprehensive, hierarchical and categorized performance evaluation index system is a prerequisite for improving evaluation quality. In view of the fragmentation of the current evaluation system and the lack of uniformity in standards, a unified basic system and procedures for performance evaluation should be established, with clear common indicators, and on this basis, more targeted and refined indicators and evaluation methods should be formulated according to the differences in the types of funds and industry sectors.

In addition, performance evaluation should realize the organic unity of dynamic adjustment and stability of policy objectives, and cover the whole life cycle of the fund from establishment to exit. Combining the characteristics of each stage of “raising, investing, managing and withdrawing”, the evaluation focus should be set in a coordinated manner to ensure the wholeness and continuity of the evaluation and avoid fragmented assessment. The performance evaluation cycle should be reasonably set according to the operation stage of the fund, and the financial department and the relevant competent units should jointly organize the evaluation work by stages and focuses, and set differentiated indicators and weights in combination with different stages, so as to take into account the supervisory needs and the actual operation law of the fund, and to enhance the comprehensiveness and effectiveness of the performance evaluation.

4.2 Strengthening information exchange and sharing, and promoting the standard management of the fund

Informatization is an important way to improve the operation monitoring and performance evaluation of government-guided funds. Relying on the construction of a unified and efficient information platform, information integration and dynamic updating of the entire process of fund management can be realized. In cross-shareholding funds, informatization can help break down data barriers between departments and regions, promote the interoperability and sharing of evaluation results, and reduce the duplication of efforts and waste of resources caused by the separate performance evaluations conducted by each contributor.

Information sharing can also promote vertical and horizontal comparative analysis of performance evaluation results, so that differences in the performance of funds set up by the same government at different times or in different fields can be compared, and differences in the strengths and weaknesses of management mechanisms and investment strategies can be identified; it also facilitates the tracking and assessment of changes in the performance of the same fund at different stages of fund-raising, investment, management and exit.

4.3 Scientific and standardized performance evaluation to enhance the objectivity and fairness of the results

Currently, the performance evaluation system of governmental guidance funds is not detailed enough, and the system can be improved by organizing the evaluation work in a scientific manner. As this kind of fund generally has a long survival period, its performance will be subject to the stage, the state of development of the invested enterprises, changes in industrial policy and the macroeconomic environment and other factors, resulting in the same fund in different time nodes of the evaluation results may have significant differences. Therefore, it is necessary to establish a set of scientific and systematic evaluation mechanism, reasonably grasp the evaluation time point, set targeted indicators in combination with different life cycle stages of the fund, and introduce a third-party evaluation organization or team with professional capabilities to carry out the evaluation work.

In the process of promotion, the scientific design of evaluation methods should be strengthened, taking into account both quantitative and qualitative means of analysis, to ensure that the evaluation process is based on evidence and that the results

truly reflect the actual operation of the fund, so as to enhance the objectivity and fairness of performance evaluation. This not only helps to improve the performance management system, but also provides a more accurate and effective decision-making basis for subsequent financial funding arrangements and policy optimization.

4.4 Strengthening exit planning and realizing safe and orderly exit of financial funds

The fund should actively respond to the newly introduced regional equity market policy, explore the implementation of share transfer pilot and other exit initiatives, enhance the communication and cooperation with the contributors of the participating funds and invested enterprises, and legally broaden the exit paths in accordance with the rules and regulations, so as to enhance the proactive nature of the participating funds and invested enterprises in the exit phase. For some of the projects that are difficult to exit in the long term, it is possible to study the establishment of a coordination mechanism for major matters relating to the exit of the fund, promote the feasibility of the construction of an asset disposal platform, and formulate a systematic and operable exit package. By improving the mechanism arrangement and organizational guarantee, the possible risks of centralized exit can be effectively dealt with, and institutional support can be provided for the safe recovery and reasonable exit of the central financial funds.

5. Conclusion

After more than 20 years of development, government-guided funds have reached a deeper stage of development in pursuit of quality and effectiveness, and performance evaluation is both a general trend and an endogenous demand of the industry. Valuable experience has been accumulated in the pilot process in various regions, identifying common problems such as imperfect indicators, poor information flow and difficulties in exit, and laying a practical foundation for the continuous optimization of the performance evaluation system.

In the future, government authorities at all levels and fund management agencies should follow the development trend, strengthen the performance awareness, and promote the performance evaluation work to scientific, institutionalized and normalized direction. Improving the index system, optimizing exit mechanisms, and strengthening information sharing and institutional coordination can continuously enhance the quality and practical utility of performance evaluation, so as to guarantee the safety of financial funds and promote the realization of policy objectives while promoting the development of government-guided funds in the direction of more standardized, efficient and sustainable development.

Funding

Shaanxi Provincial Department of Science and Technology Soft “Assessment of the Effectiveness of Government-Guided Funds on Shaanxi’s Scientific and Technological Innovation Level and Optimization Pathways from a Categorized Perspective” (2025KG-YBXM-029)

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Liu, Q. S., & Zhao, U. (2020). Construction of performance evaluation indicator system of government guiding fund. *Finance and Accounting*, 2020(6), 54-57.
- [2] Li, H. J. (2010). Research on performance evaluation indicator system of government-oriented venture capital guiding fund. *Science and Technology Management Research*, 30(15), 45-49.
- [3] He, W. G., Xu, A. H., & Yang, S. R. (2025). Local exploration on performance assessment mechanism of government guided funds. *China Finance*, 2025(5), 86-87.
- [4] Zhang, Y. Y., & Xia, Q. (2024). Research on innovation and development of China’s government guided fund. *Southwest Finance*, 2024(3), 32-43.

The Impact of Media Reports on the Audit Quality of Listed Manufacturing Companies

Qi Bai *

School of Management, Xi'an Polytechnic University, Shaanxi Xi'an, 710048, China

*Corresponding author: Qi Bai, 1842323315@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This paper discusses the impact of media coverage on the audit quality of listed manufacturing companies. The study found that negative media reports significantly improve audit quality by increasing audit failure cost, reducing information asymmetry and strengthening agenda setting. Although positive reports have a positive impact on audit quality, they are not significant. The policy-oriented report relies on the official background and authority to effectively improve the audit quality. Although the market-oriented report is under the pressure of survival, it still improves the audit quality through information screening and public opinion supervision. It is suggested to strengthen media supervision, perfect government supervision and implement auditor reputation mechanism to further optimize audit quality.

Keywords: Media Reports; Listed Manufacturing Companies; Audit Quality

Published: Sept 11, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.618>

1.Introduction

In the information ecosystem of capital market, the role of the media as the “fourth power” is increasingly prominent, and its reporting behavior has become an important external force that affects the governance efficiency of listed manufacturing companies. As the gatekeeper of the credibility of financial information, audit quality is not only the basis for investors to make decisions, but also the key guarantee for the efficiency of market resource allocation. The existing research has provided an important basis for understanding the relationship between media and audit quality, but there are still the following limitations: First, there is a lack of theoretical integration on the mechanism of media reporting attitude, especially the “double-edged sword” effect of positive reporting is not yet clear; Secondly, the differential transmission path of media types needs to be empirically tested. Third, under the background of digital transformation, the impact of media discourse differentiation on auditor behavior has not been fully incorporated into the analysis framework. The purpose of this paper is to fill the above research gap, reveal its differentiated impact on auditor's risk perception and practice behavior by deconstructing the reputation incentive mechanism, public opinion deterrence effect, policy signal transmission function and information screening function of media reports, and provide a new theoretical perspective and practical enlightenment for optimizing audit quality.

2.Factors Affecting Audit Quality Caused by Media Reporting

2.1 Media Attitude and Audit Quality

Media reporting attitudes can be divided into positive and negative dimensions. Positive reports highlight the positive aspects

of the company, such as participation in public welfare activities, excellent product results, etc., to enhance the corporate image; On the other hand, negative reports expose corporate malpractices, such as corruption and environmental pollution, which have a negative impact on corporate image.

2.2 Impact of negative media reports on audit quality

From the perspective of reputation mechanism, media attention has increased the reputation cost and economic loss of CPA audit failures, especially when reporting financial distress signals involving corporate debt default warning, off-balance-sheet financing violations and other financial distress signals, the probability of regulatory penalties and the amount of civil compensation will significantly increase, so the CPA will provide higher-quality audit services, thus inhibiting the risk of corporate violations.^[1] In order to safeguard the reputation and avoid investors questioning the audit quality, the auditor may be prompted to issue a non-standard opinion.^[2], and then strictly abide by the professional ethics, conscientiously complete the audit task, improve the audit quality.

From the perspective of information asymmetry, negative media reports reduce the auditor's information verification cost by revealing the abnormal financial behavior of the enterprise. During the execution of audit procedures, incomplete information acquisition may lead to professional judgment errors of auditors. After the media exposure, the auditors' information acquisition cost was reduced and more comprehensive. They paid more attention to issues related to negative information, and the audit was more targeted and efficient.

Starting from the agenda-setting theory, the media has expanded the access to public information, mainly affecting the behavior of certified public accountants from two aspects: one is the "strategic hypothesis", certified public accountants as risk aversion, facing the possible legal risks caused by negative media reports, may urge auditors to strengthen accounting-related audit procedures, thus indirectly improving audit quality^[3]; The second is the "cognitive hypothesis". Under the uncertain environment, people tend to ignore the possibility of certain events and pay more attention to the representative events, i.e. negative media reports. Negative media reports have amplified the risks through high-frequency exposure, triggering a regulatory chain reaction. Its crisis framework has further activated the auditor's loss aversion and forced the audit process to be strengthened.^[4]

2.3 Impact of Positive Media Reporting on Audit Quality

Positive media reports will affect the final audit quality by influencing the CPA's behavior, mainly through the following two ways.

On the one hand, when listed companies receive a large number of positive media reports, CPAs are vulnerable to public perception. Since media reports are generally regarded as a concentrated reflection of public opinion, the reputation halo created by positive information may lead auditors to rely excessively on qualitative information. For example, the continuous reporting on the technological innovation achievements of enterprises may cause the audit team to ignore the abnormal fluctuations in quantitative financial indicators, such as the phenomenon that the capitalization proportion of research and development expenses is significantly higher than that of peers, and the proportion of government subsidies in profits is abnormally rising. Such cognitive bias may weaken professional skepticism and thus issue an unqualified audit opinion.^[5] The research shows that the auditor's verification adequacy of the management statement decreases under such circumstances, and the auditor is more inclined to rely on immaterial evidence.

On the other hand, the halo framework of positive reporting is easy to trigger the auditor to confirm the error, and due to the lack of agenda significance, it is difficult to translate into effective supervision pressure, which results in the weakening of its impact. Typical performance is to extend the internal quality control review cycle, or to reduce the tracking steps for abnormal accounting treatment. For example, in order to reduce audit costs or maintain customer relationships, the auditor may simplify procedures in high-risk areas: use sample checks instead of full checks in inventory audits, or reduce the frequency of on-site audits of foreign subsidiaries. This kind of behavior substantially increases the missed probability of material misstatement risk and may induce audit collusion risk. Analysis of regulatory cases shows that in some audit failure cases, the implementation rate of audit procedures of firms reporting positively to the media decreased by 19% on average.

2.4 Media type and audit quality

According to the type, media reports are divided into policy-oriented and market-oriented. The policy-oriented media maintains the traditional operation mode, and the information content focuses on the policy aspect; The market-oriented media gained relatively independent editorial rights and began to pay attention to the demands of the market for information. Policy-oriented media focus on national policies and report authority; The market-oriented media choose their own topics according to the market demand, with unlimited content. The policy-oriented reports selected in this paper include Securities Daily, Securities Times, china securities journal and shanghai securities news, while the market-oriented reports include China Operation News, Economic Observer, 21st century business herald and First Financial Daily.

2.4.1 The impact of policy-oriented reporting on audit quality

The policy-oriented report refers to the specific content released by the traditional media authorized by the CSRC and assuming the statutory information disclosure function. Its content attributes have the dual transmission functions of official information background and national regulatory will. When such reports involve a specific listed company, they will significantly arouse the regulatory authorities' targeted attention to the company, thus substantially increasing the probability that it will be included in the regulatory perspective.

From the analysis of reputation mechanism, the policy-oriented report urges the listed companies to exercise strict self-discipline to avoid reputation risk: the negative report will trigger the senior management to urgently carry out crisis public relations and rectification; Positive reports promote corporate reputation capital through official credit endorsement, but may induce earnings management motivation under political connection premium. Certified public accountants are highly sensitive to this—companies that receive official attention will trigger an increase in audit intensity, regardless of reporting bias: companies that report negatively will be subject to enhanced procedures to address regulatory risks; On the other hand, companies with positive reports focus on substantive testing to prevent financial manipulation covered by reputation aura.

From the perspective of information access, on the one hand, investors have limited ability to actively access information and will pay great attention to policy-oriented reporting in order to obtain comprehensive information. On the other hand, policy-oriented reporting, as a channel of information dissemination for government departments, has strong dissemination power, great influence and high contact probability for information users. Under this risk-sharing mechanism, the risk-sharing relationship between the CPA and the investors enables the stakeholders' continuous attention to the policy-oriented reports to be transmitted to the audit subjects, thus forming the practice pressure transmission effect, urging them to audit more carefully, and strive to issue reasonable reports and improve the audit quality.

2.4.2 Impact of market-oriented reporting on audit quality

Market-oriented reporting operates according to market demand without state support and needs to take risks independently to attract attention with novel content. Its negative report has aroused the vigilance of the market and stakeholders, forcing the management to strengthen self-discipline. At the same time, such reports urge certified public accountants to adjust audit procedures in a timely manner based on information to improve audit quality in response to regulatory pressure. Its positive report implies the risk of commercial propaganda, which may weaken the motivation for continuous improvement of the enterprise. Based on this, CPAs responded differently: adjusting audit procedures to respond to negative reports and responding to market pressure; For positive reports, the matching between publicity and financial data is verified to prevent distortion.

Although market-oriented reporting lacks state support and faces survival pressure, it is free from state interference and can comprehensively report the information collected. According to the theory of information asymmetry, the freedom of market-oriented reporting makes its information more comprehensive and the number of reports increases, which provides more information for certified public accountants and significantly reduces the impact of information asymmetry. From the perspective of agenda-setting theory, the dissemination characteristics of market-oriented reports will lead to significant attention bias effect of certified public accountants. Certified public accountants will pay close attention to financial related reports and collect information of listed companies in a more targeted and comprehensive way, which can better deal with follow-up follow-up reports, conduct audit work more accurately and improve audit quality.

3. Empirical Research

3.1 Making assumptions

This chapter is an empirical study on the factors that affect the audit quality in media coverage. Based on the above description, the following research assumptions are made:

Hypothesis 1: Negative media coverage is positively correlated with audit quality.

Hypothesis 2: Positive media coverage has a negative correlation with audit quality.

Hypothesis 3: there is a positive correlation between policy-oriented reporting and audit quality.

Hypothesis 4: there is a positive correlation between market-oriented reporting and audit quality.

3.2 Sample data

The sample data of this study are mainly from the National Taian Database (CSMAR) and the China Important Newspaper Full-text Database. The work of data processing and analysis is completed by means of Excel and Stata 15.0 statistical software.

3.2.1 Sample sources

This paper takes the listed companies in manufacturing industry as the research object, and takes the financial data and media report data of companies in manufacturing industry as the data source of empirical research. This is mainly because the manufacturing industry can obtain a large amount of complete relevant data, which provides great help for the author in data mining and model building.

3.2.2 Data selection

In order to carry out the empirical research smoothly, this paper screens the complete and appropriate sample data through the following processing:

- (1) Excluding sample companies that have been losing money for more than two consecutive years, namely ST and ST*;
- (2) exclude outliers and missing data samples;
- (3) Excluding disturbing reporting examples caused by name ambiguity (for example, expressions with multiple meanings such as “Northern Wilderness”).
- (4) In order to ensure the integrity of the data, the full name and abbreviation of the sample companies are searched through “title query” and “topic query” channels. During the data collection phase, unrelated information such as announcements of listed companies has been eliminated and single reports involving multiple companies have been removed.

3.3 Definition of variables

3.3.1 Interpreted variables

In this paper, earnings management, which is the most commonly used measure of audit quality, is used as the calculation method of earnings management. The calculation process is as follows:

$$\frac{TA_{i,t}}{A_{i,t-1}} = \alpha_1 \frac{1}{A_{i,t-1}} + \alpha_2 \frac{\Delta REV_{i,t}}{A_{i,t-1}} + \alpha_3 \frac{PPE_{i,t}}{A_{i,t-1}} + \alpha_4 ROA_{i,t-1} + \varepsilon_{i,t} \quad (\text{Formula 3-1})$$

$$NDA_{i,t} = \alpha_1 \frac{1}{A_{i,t-1}} + \alpha_2 \frac{\Delta REV_{i,t} - \Delta REC_{i,t}}{A_{i,t-1}} + \alpha_3 \frac{PPE_{i,t}}{A_{i,t-1}} \quad (\text{Formula 3-2})$$

$$DA_{i,t} = \frac{TA_{i,t}}{A_{i,t-1}} - NDA_{i,t} \quad (\text{Formula 3-3})$$

In the model, total accrued profit $TA_{i,t}$ is defined as net profit less net cash flows from operating activities. Controllability accrued profits $DA_{i,t}$ and non-controllability accrued profits $NDA_{i,t}$ form an integral part thereof, in which operating income change $\Delta REV_{i,t}$ refers to the change in operating income of the current period as compared with that of the previous period, and trade receivable change $\Delta REC_{i,t}$ represents the change in the balance of trade receivables of the current period as compared with that of the previous period. The original value of fixed assets, $PPE_{i,t}$, together with the total assets at the beginning of the period, $A_{i,t-1}$, and the asset return rate of the previous period, $ROA_{i,t-1}$, are taken as explanatory variables. The parameter estimates α_1 , α_2 and α_3 are obtained by regression of model (3-1), which are substituted into model (3-2) to calculate $NDA_{i,t}$, and finally $DA_{i,t}$ is obtained by the difference between the two models. The degree of earnings management is measured by

the absolute value of discretionary accruals $|DA_{i,t}|$, and subscripts i and t represent the individual and fiscal year of the listed company respectively.

3.3.2 Explanatory variables

In this paper, media reports are used as explanatory variables and the natural logarithm of “number of media reports by listed companies +1” is used as a measure of media reports. When collecting the data, we take the media positive report and the media negative report as two attitudes, the policy-oriented report and the market-oriented report as the research angle. When distinguishing between positive and negative reports, negative words such as violation of laws and regulations and positive words such as improvement and improvement are used as the basis of distinction.

3.3.3 Control variables

With reference to other literature, this paper also selects the following control variables: company size, cash asset ratio, asset return rate, growth, firm reputation, asset-liability ratio, current ratio and year.

Table 3-1 Definition Table of Relevant Variables

Variable category	variable symbol	Variable name	Variable description
Interpreted variable	DA	earnings management	Absolute value of profit accruals for controllability
Explanatory variable	Atti1	Negative media reports	The number of negative media reports plus the natural logarithm of one
	Atti2	Positive media coverage	The number of positive media reports plus the natural logarithm of 1
	Type1	Policy-oriented reporting	Policy-oriented Reports Plus Natural Logarithm of 1
	Type2	Market-oriented reporting	The market-oriented report plus the natural logarithm of 1
Control variable	Size	Company size	Natural logarithm of total assets of listed companies
	Cfo	Cash asset ratio	Average of cash flows from operating activities/total assets
	Roa	Asset return rate	Net profit/total assets
	Growth	Growth	Growth rate of operating revenue
	Big4	Firm reputation	The audited entity is audited as 1 by an international “big four” firm; otherwise, it is 0
	Lev	Asset-liability ratio	Total liabilities/total assets
	Liq	liquidity ratio	Current assets/current liabilities
	Year	year	Set by different years

4. model building

In this paper, two multivariate linear regression equations are proposed to study the relationship between explanatory variables and explanatory variables. The first model is to test Hypothesis 1 and Hypothesis 2. When the research hypothesis H1 holds, the coefficient β will show a significant positive correlation; If the study assumes that H2 is verified, β should exhibit a significant negative correlation. The measurement model for the hypothesis testing is set as follows:

$$|DA| = \beta_0 + \beta_1 \text{Atti} + \beta_2 \text{Size} + \beta_3 \text{Cfo} + \beta_4 \text{Roa} + \beta_5 \text{Growth} + \beta_6 \text{Big4} + \beta_7 \text{Lev} + \beta_8 \text{Liq} + \beta_9 \text{Year} + \varepsilon \quad (\text{Formula 3-4})$$

Where: ε : random perturbation term

β_0 : constant term

β_1 、 β_2 、 β_3 、 β_4 、 β_5 、 β_6 、 β_7 、 β_8 、 β_9 : represent coefficients of corresponding variables respectively

For the validation of assumptions H3 and H4, the coefficient β_1 in model 2 is expected to show significant positive correlation.

The construction logic of this measurement model is as follows:

$$|DA| = \beta_0 + \beta_1 \text{Type} + \beta_2 \text{Size} + \beta_3 \text{Cfo} + \beta_4 \text{Roa} + \beta_5 \text{Growth} + \beta_6 \text{Big4} + \beta_7 \text{Lev} + \beta_8 \text{Liq} + \beta_9 \text{Year} + \varepsilon \quad (\text{formula 3-5})$$

Where: ε : random perturbation term

β_0 : constant term

β_1 、 β_2 、 β_3 、 β_4 、 β_5 、 β_6 、 β_7 、 β_8 、 β_9 : represent coefficients of corresponding variables respectively

5. Empirical analysis

5.1 Descriptive statistical analysis

Based on the descriptive statistics and analysis of the financial data of 50 listed companies in the manufacturing industry in the sample for 5 consecutive years, the results show that the average value of earnings management of the sample companies is 0.0639, the maximum value is 0.408, and the minimum value is 0.0002, indicating that the earnings management of the listed companies in the manufacturing industry is not rigorous and the audit quality is good. The average value of media negative reports is 0.698, and the standard deviation is 0.537; The average value of positive reports is 0.648, and the standard deviation is 0.404. The difference between the two is not big, which indicates that the media have a small difference in reporting attitude towards listed companies, but the number of negative reports is more than positive reports, which indicates that the media prefer to report negative information and make the public pay more attention to negative reports. The average value of the policy-oriented report is 1.226 and the average value of the market-oriented report is 0.666, indicating that the public prefers the former. The statistical results of control variables show that the maximum value of the company size is 25.18 and the minimum value is 19.97, with significant difference. The average cash ratio is 0.144, with a maximum value of 0.587 and a minimum value of 0.0125, indicating that the Company has a low proportion of idle funds and its assets are mainly used for development, which is in line with the management philosophy of the Company. The maximum value of corporate growth is 2.402, the minimum value is -0.522, the standard deviation is 0.311, the difference is significant; The influence of other control variables is not different.

Table 3-2 Statistical Results Table

variable	N	average	standard deviation	minimum	maximum
DA	250	0.0639	0.0638	0.0002	0.408
Atti1	250	0.698	0.537	0	2.619
Atti2	250	0.648	0.404	0	3.116
Type1	250	1.226	1.036	0	3.007
Type2	250	0.666	1.078	0	2.595
Size	250	22.32	1.405	19.97	25.18
Cfo	250	0.144	0.104	0.0125	0.587
Roa	250	0.0478	0.0726	-0.384	0.432
Growth	250	0.136	0.311	-0.522	2.402
Big4	250	0.104	0.306	0	one
Lev	250	0.414	0.216	0.0351	0.941

5.2 Correlation analysis

Table 3-3 Correlation coefficient table

	DA	Atti1	Atti2	Type1	Type2	Size	Cfo	Roa	Growth	Big4	Lev	Liq
DA	one											
Atti1	0.0630***	one										
Atti2	0.0680***	0.873***	one									
Type1	0.0220***	0.825***	0.752***	one								
Type2	0.0270***	0.810***	0.742***	0.735***	one							
Size	0.0950***	0.591***	0.685***	0.558***	0.539***	one						
Cfo	0.0110*	-0.0610	-0.179***	-0.105*	0.00900	-0.403***	one					
Roa	0.0540***	0.0320	-0.0270	0.0790	-0.0180	-0.0720	0.230***	one				
Growth	0.159**	-0.0120*	0.0210	0.0370	0.00200	-0.0430	0.0530	0.391***	one			
Big4	0.105***	0.339***	0.394***	0.344***	0.263***	0.437***	-0.0870	-0.00700	-0.0320	one		
Lev	-0.0600	0.494***	0.572***	0.428***	0.450***	0.734***	-0.406***	-0.298***	-0.111*	0.327***	one	
Liq	0.0370	-0.244***	-0.320***	-0.270***	-0.217***	-0.450***	0.505***	0.278***	0.0810	-0.188***	-0.664***	one

Note: ***, ** and * are significant at 1%, 5% and 10%, respectively

From the results of correlation analysis, negative reports, positive reports, policy-oriented reports and market-oriented reports are significantly positively correlated with audit quality. The empirical results show that the enhancement of media coverage intensity has a significant positive impact on audit quality improvement (assuming H2 is not statistically supported). In addition, the correlation coefficient matrix shows that the correlation coefficients among explanatory variables, explanatory variables and control variables in the model are all below the threshold of 0.9, which effectively controls the potential interference of multicollinearity problem on the model validity.

5.3 Regression analysis

This study constructs a dual analysis framework: positive/negative media reports and policy/market-oriented reports are set as explanatory variables respectively, while audit quality is taken as the explanatory variable; Through the systematic test of models 3-4 and 3-5, the mechanism of the effect of media reports from different dimensions on audit quality is revealed. The regression results are shown in Table 3-4.

Table 3-4 Regression Results of Media Reporting and Audit Quality

variable			(3)	(4)
Atti1	0.011**			
	(0.52)			
Atti2		0.002		
		(0.09)		
Type1			0.014**	
			(1.32)	
Type2				0.003*
				(0.62)
Size	0.012***	0.011***	0.012***	0.012***
	(0.41)	(0.32)	(0.58)	(0.53)
Cfo	-0.012**	-0.010**	-0.015**	-0.018**
	(-0.26)	(-0.21)	(-0.32)	(-0.37)
Roa	0.070	0.068	0.075	0.068
	(1.04)	(1.02)	(1.12)	(1.01)
Growth	0.040***	0.040***	0.040***	0.040***
	(2.91)	(2.89)	(2.89)	(2.88)
Big4	0.012*	0.012*	0.013*	0.012*
	(0.84)	(0.82)	(0.91)	(0.82)
Lev	-0.025	-0.024	-0.024	-0.026
	(-0.72)	(-0.68)	(-0.72)	(-0.75)
Liq	-0.001	-0.001	-0.001	-0.001
	(-0.07)	(-0.06)	(0.05)	(-0.06)
Constant	0.202*	0.193*	0.217**	0.216**
	(1.93)	(1.81)	(2.12)	(2.04)
Observations	250	250	250	250
R-squared	0.092	0.092	0.094	0.093
F test	0.00501	0.00519	0.00406	0.00451
r2_a	0.0583	0.0579	0.0605	0.0594
F	2.712	2.701	2.782	2.747

Note: (1) The values in brackets are T statistics; (2)***, * * and * are significant at 1%, 5% and 10%, respectively.

(1) the regression results of negative media reports and audit quality

The regression results of model (1) show that the β_1 coefficient between negative reports and audit quality is 0.011($p < 0.05$), which supports the hypothesis that H1 holds, indicating that this variable has a significant positive impact on audit quality improvement.

(2) the regression results of positive media coverage and audit quality

The estimation results of model (2) show that the positive reported β_1 coefficient estimation value for audit quality is 0.002($p > 0.1$), which fails the significance test. This indicates that hypothesis 2 is not true, i.e. positive reporting does not inhibit the improvement of audit quality.

(3) the regression results of policy-oriented reporting and audit quality

Regression analysis of model (3) shows that the β_1 coefficient of policy-oriented reporting and audit quality is 0.014($p < 0.05$), which supports hypothesis H3, indicating that this variable has statistically significant positive effect on audit quality improvement.

(4) Regression results of market-oriented reporting and audit quality

The estimation results of model (4) show that the β_1 coefficient of market-oriented reporting on audit quality is 0.003($p < 0.1$), which supports hypothesis H4. At the level of control variables, return on assets, growth indicators and auditor reputation variables are significantly positively correlated. The positive relationship between company size and audit quality can be explained by the scale effect: large companies tend to reduce regulatory costs and earnings management, thus improving audit quality. In contrast to financial structure variables, cash asset ratio, asset-liability ratio and current ratio all show significant negative effects.

5.4 Robustness test

In order to test the robustness of the research conclusions, this study uses the alternative variable method (using the type of audit opinion to replace earnings management indicators) for quadratic regression analysis. As shown in Table 3-5, the correlation direction and significance level between media reports and audit quality are consistent with the main regression results, which verified the reliability of the research conclusions.

Table 3-5 Results of Robustness Test on Audit Quality Reported by Media

variable	(1)	(2)	(3)	(4)
Atti1	0.015*** (0.80)			
Atti2		0.015 (0.77)		
Type1			0.013*** (0.54)	
Type2				0.012*** (0.65)
Size	0.013** (1.29)	0.013** (1.20)	0.017** (1.67)	0.014** (1.33)
Cfo	-0.057 (-0.58)	-0.051 (-0.53)	-0.037 (-0.38)	-0.058 (-0.58)
Roa	0.631*** (4.70)	0.638*** (4.77)	0.646*** (4.80)	0.641*** (4.79)
Growth	-0.032	-0.034	-0.032	-0.033

variable	(1)	(2)	(3)	(4)
	(-1.12)	(-1.18)	(-1.12)	(-1.15)
Big4	0.028	0.027	0.031	0.030
	(0.93)	(0.89)	(1.02)	(0.99)
Lev	-0.238***	-0.238***	-0.229***	-0.235***
	(-3.36)	(-3.36)	(-3.27)	(-3.33)
Liq	-0.007*	-0.007*	-0.007*	-0.007*
	(-1.72)	(-1.72)	(-1.73)	(-1.71)
Constant	0.771***	0.777***	0.692***	0.764***
	(3.61)	(3.57)	(3.28)	(3.53)
Observations	250	250	250	250
R-squared	0.171	0.170	0.169	0.170
F test	2.83e-07	2.87e-07	3.33e-07	3.07e-07
r2_a	0.143	0.143	0.142	0.142
F	6.192	6.187	6.136	6.164

Note: (1) The values in brackets are T statistics; (2)***, * * and * are significant at 1%, 5% and 10%, respectively.

5.4.1 Results of hypothesis testing

According to the assumptions put forward above and the conclusions of regression analysis, the results of verification of corresponding assumptions are shown in the following table:

Table 3-6 Hypothesis Validation Results

suppose	Hypothetical content	Match
Assumption 1	Negative media reports have a positive impact on audit quality.	be
Hypothesis 2	Positive media reports have a negative impact on audit quality.	no
Assumption 3	Policy-oriented reporting has a positive impact on audit quality	be
Assumption 4	Market-oriented reporting has a positive impact on audit quality	be

5.4.2 Research results

Negative media reports have significant positive correlation with audit quality. Such reports expose the company's non-compliance events, arouse public attention, and bring market pressure and financial risks to the related auditors. Under this pressure, the CPA will intensify the audit to ensure reasonable audit results, reduce risks and improve audit quality.

Positive media reports showed a positive trend but did not reach statistical significance, and the results deviated from the hypothesis. It may be due to multiple factors: although the CPA converts the details in the positive report into audit clues, it is limited by cognitive bias, excessive reliance on qualitative information, lack of media credibility, interference of low-quality reports or advertising soft articles and failure of market pressure transmission, and investors' concern is passive, which results in dilution of its supervisory role.

There is a significant positive correlation between policy-oriented reporting and audit quality. Such reports received financial support from the state and mainly disseminated the contents of the state policies. The information was fair and just. Due to the support of the state, its report is influenced by the government and reflects the state's attitude. Based on this, CPAs should focus on such reports in order to analyze the policy direction and optimize the audit procedures.

Although there is a positive correlation between market-oriented reporting and policy-oriented reporting, the effect intensity is significantly weaker. The survival of such reports depends on the market demand-driven, and under great economic pressure in the absence of government support, they may obtain advertising revenue by undertaking publicity business, or cause bias in the content of the reports. However, in view of its core value derived from public content recognition, in order to maintain long-term market reputation, controversial content is voluntarily abandoned when necessary. Finally, through the continuous development of information screening and public opinion supervision functions, a net improvement effect on audit quality is formed.

6.Countermeasures and Suggestions for Improving Audit Quality

6.1 To strengthen the media's supervision of the information disclosure of listed companies

6.1.1 Enhance the credibility of the media

The credibility of the media originates from public trust, and real content can enhance the credibility of information and thus promote the sound development of the media itself. However, in reality, lack of funds or external pressure may lead to false reports. It is suggested that the media should implement a separation mechanism to ensure the objectivity of reporting, and at the same time, strengthen the training of practitioners' ability, and strengthen the sense of responsibility and reduce external interference by improving professional quality. Therefore, enhancing the credibility of the media can reduce the audit cost of certified public accountants and form a win-win situation.

6.1.2 Play the important role of the media

A benign environment can positively adjust the media's role in promoting the audit prevention function^[6]. Time-sensitive information can provide clues for CPA audit, but it is necessary to establish an information screening mechanism to eliminate distorted content in order to improve the effectiveness of decision-making. It is suggested to formulate laws and regulations to restrict the media, increase the cost of media false information violations, and enable them to strengthen the content audit. This can not only form the governance pressure of listed companies and restrain financial fraud through true reporting, but also optimize the quality of audit evidence sources and form a benign transmission chain.

6.2 To improve government regulation of the media

6.2.1 Respect the independence of the media

Negative media reports have significant inhibitory effect on listed companies' financial restatement behavior through information governance mechanism, but government administrative intervention will weaken the strength of this supervision effect^[7]. It is suggested that the government should appropriately adjust the intensity of intervention and allow the media to sort out the information and report, but the news that is obviously false should be corrected in time, and the media that is seriously false should be punished. The media should adhere to YEATION's content, abide by professional ethics and prohibit the use of improper means.

6.2.2 Safeguarding the media's right of supervision by public opinion

In the process of information collection, the media face many obstacles, which affect the reliability of the content of the report, and the negative media reports need to rely on audit supervision or policy intervention to give full play to the role^[8]. It is suggested that the government should improve the system to guarantee the media's access to information, ensure the objectivity and comprehensiveness of the reports, and avoid misleading the public due to lack of information. At the same time, the media should strictly abide by professional norms to prevent the abuse of rights, and the government should establish a restraint mechanism when empowering.

6.3 The implementation of the Institute of Certified Public Accountants to establish a reputation mechanism for auditors

At present, the auditor's responsibility is too easy to slack off, and the "top ten" auditors are less affected by the media because of their reputation capital accumulation and risk resistance, which confirms the role of reputation mechanism in ensuring audit quality.^[9] It is suggested to establish a reputation accumulation mechanism: 1) establish a quantitative evaluation and grading certification system; 2) Build a digital platform to track the practice track. When the audit fails, the platform will be demoted and publicized, which will force the audit quality to be improved by increasing the cost of failure.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Yin, M. Q., & Li, W. B. (2018). Internet media attention, audit quality and risk suppression: Based on empirical data of A-share listed companies in Shenzhen Main Board. *Audit and Economic Research*, 33(4), 24-33.
- [2] Li, X. H., & Yang, K. (2015). Media attention, audit opinion and transparency of accounting information. *Journal of Central University of Finance and Economics*, (10), 52-60.
- [3] Liu, Q. L., Li, H., Zhao, C., et al. (2014). Negative media reports, litigation risks and audit fees. *Accounting Research*, (6), 81-88+97.
- [4] McCombs, M. E., & Shaw, D. L. (1972). The agenda-setting function of mass media. *Public Opinion Quarterly*, 36(2), 176-187.
- [5] Zhang, L. P., & Lu, M. K. (2014). The mechanism and influence of media opinion on audit judgment: An interpretation based on journalism and communication theory. *Audit Research*, (1), 53-61.
- [6] Chi, G. H., Yang, J., & Gu, F. (2018). Does the media focus on improving the government audit function? —An empirical study based on provincial panel data in China. *Accounting Research*, (1), 53-59.
- [7] Dai, Y. Y., Pan, Y., & Liu, S. C. (2011). Media supervision, government intervention and corporate governance: Evidence from the perspective of financial restatement of listed companies in China. *World Economy*, (11), 121-144.
- [8] Zhang, Q., Bu, D. L., & Yu, Z. (2016). Media attention, reporting mood and government's "three public" budget restraint. *Economic Research*, 51(5), 72-85.
- [9] Lu, M. K., & Liu, Z. (2015). Media attitude, investor concern and audit opinion. *Audit Research*, (3), 64-72.

Research on the Current State of Supply Chain Finance - CiteSpace-based Analysis and Bibliometric analysis

Shuijing Wang, Zheng He*

School of Management, Xi'an Polytechnic University, Xi'an, 710048, China

**Corresponding author: Zheng He, heehzheng_128877@163.com*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In order to explore the current research status of supply chain finance and its development trend, this study uses CiteSpace software and bibliometric methods to visualise and analyse the core journal literature in Chinese and English for the period from 2008 to 2024, and combines bibliometric and knowledge graph analysis methods. The results of the study show that the research attention continues to rise, and the research hotspots gradually shift from basic theories to innovative applications, such as blockchain and fintech. The focus of domestic and foreign research is different, with domestic research focusing more on SME financing issues, while foreign research focuses more on operational decision-making. In addition, research cooperation is insufficient, and cross-regional and cross-institutional cooperation needs to be strengthened. Future research should deepen ecosystem research, promote technological innovation and application, strengthen internationalisation research, explore inclusive applications, and focus on the combination of policy and practice to promote the wide application of supply chain finance in the real economy.

Keywords: Supply Chain Finance; Literature Measurement; Knowledge Atlas

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.619>

Introduction

In the context of economic globalization, supply chain, as an important carrier for optimizing resource allocation and promoting market competition, has a direct impact on the competitiveness of enterprises and the vitality of the economy in terms of its level of development. Supply chain finance, as an innovative financing method, optimizes working capital management as well as liquid investment funds in supply chain processes and transactions by adopting financing and risk mitigation strategies and techniques. This model effectively responds to the problem of information asymmetry, opening up broader financing avenues for the demand side of funds, and promotes the expansion of the scale of enterprise transactions and the improvement of transaction efficiency, thus providing solid support for the development of the real economy.

In recent years, supply chain finance has been strongly supported by national policies. Various ministries and commissions of the State, including the State Council, the People's Bank of China, and the Ministry of Commerce, have issued a series of policies and guidelines aimed at incentivizing financial institutions to promote the development of innovative businesses such as accounts receivable financing, chattel financing and supply chain financing. These measures aim to improve the financing ecology of MSMEs, steadily promote the progress of supply chain finance, and support MSMEs to meet their funding needs through accounts receivable financing and other means, thereby serving enterprises in all links of the industry chain. Under this policy environment, the role of supply chain finance in promoting the real economy has become increasingly prominent

and continues to be the focus of academic research and discussion.

1. Overview of the study

Research in the field of supply chain finance has achieved fruitful results, and many scholars have conducted in-depth discussions on its development and core issues from different perspectives. In terms of qualitative research, Zhou and other scholars systematically analyzed the positive effects of the integration of the four streams (logistics, business flow, information flow and capital flow) on reducing the operating costs and capital risks of enterprises, and put forward optimization proposals on risk control, the construction of the information feedback mechanism, and management informatization^[1]. In terms of development history, Li et al. used bibliometric tools to summarize the evolution of supply chain finance into four progressive stages: initial stage, deepening stage, diversification stage and technology integration stage, and point out that the focus of the research has gradually shifted from the exploration of the basic model to the deeper issues such as risk management, operational decision-making and coordination mechanism^[2]. In terms of research methodological innovation, Lu and Zeng systematically sorted out the research methodology, core conclusions and future development direction of this field from three levels of operational decision-making, supply chain coordination and risk control^[3]. on the other hand, Wang and Du used a combination of co-occurrence analysis and literature review to reveal the evolutionary characteristics of domestic supply chain finance research, pointing out that financing risk control, model innovation and SME credit assessment have become the focus of current research^[4]. Based on the literature of CSSCI journals, Song and Huang used the method of combining content analysis and bibliometrics to propose that basic theory research, empirical research and innovative research should be strengthened in the future^[5]. In terms of theoretical framework construction, Yan and Xu focused on the core concept and characteristics of supply chain finance, stressing that it breaks through the traditional single enterprise credit model and realises the extension of risk management to the supply chain as a whole^[6]. Zhu mapped the research hotspot knowledge mapping and evolution path through the big data analysis of CNKI core journals, revealing five core themes and four development stages in the field^[7]. These studies have laid a solid foundation for the theoretical deepening and practical innovation of supply chain finance.

In summary, domestic scholars have rich research results in the field of supply chain finance, covering various aspects such as theory and practice, model and risk, qualitative and quantitative. However, the theoretical system of supply chain finance needs to be improved, practical experience needs to be further accumulated, and the impact of new technologies needs to be deeply explored. ① Most of the existing review-type studies are based on qualitative analyses. ② Research using bibliometric software such as CiteSpace is not yet sufficient. Therefore, this paper uses CiteSpace software to analyse the core journal literature included in CNKI between 2008 and 2024, aiming to comprehensively and accurately reflect the current research status in the field of supply chain finance.

2. Analysis of Supply Chain Finance Research Developments

2.1 Data sources

In order to deeply analyse the development of supply chain finance, this study selects the CSSCI core journals in the China Academic Journal Network Publishing Database (CNKI) and the Web of Science core database as the basic platform for data retrieval, and makes use of its advanced search function to carry out precise literature screening. The specific screening criteria are as follows: in the Chinese literature, the keyword is set as “supply chain finance”, the time range is set as 2008 to 2024, and the source of journals is limited to China Social Science Citation Index (CSSCI). The search strategy of exact matching was adopted to complete the collection of literature. During the screening process, the literature that did not match the research topic was eliminated, and finally 470 highly relevant academic papers were screened out; in English, WoS core set was selected, with “supply chain finance” as the main vocabulary, and “English” as the language. In English, WoS core collection was chosen, with “supply chain finance” as the main term, “English” as the language, “Article” as the article type, 225 articles were collected, and 200 valid articles were finally obtained after CiteSpace de-weighting. CiteSpace software was used for the visualisation and analysis of the literature in the subsequent study. In order to enhance the accuracy and depth of the analysis, the time segmentation unit was set as yearly. During the data processing stage, the threshold was adjusted to 20

to ensure the validity and specificity of the analyses.

2.2 Research methodology

Bibliometric analysis is a comprehensive research method that integrates the principles of information visualisation technology and bibliometrics. Through in-depth excavation and analysis of literature data in specific disciplinary fields and the use of multi-dimensional visualisation technology, the technique clearly shows the network structure relationship and the path of knowledge evolution in the field, providing a solid theoretical foundation and direction guidance for academic research. Through systematic statistics and in-depth analysis of the literature data, this method can accurately reveal the academic development trend and knowledge dissemination mode of a specific research field, so as to grasp the current development status, core issues and other key information of the field. In this study, CiteSpace software was used to visualise and analyse the literature in the field of “supply chain finance development”, which helps scholars and policy makers to gain insights into the development history of supply chain finance, research priorities, and the changing trends of academic co-operation, and thus provides scientific academic references and practical guidance for the progress of supply chain finance. This helps scholars and policy makers to understand the development history of supply chain finance and the trend of academic cooperation.

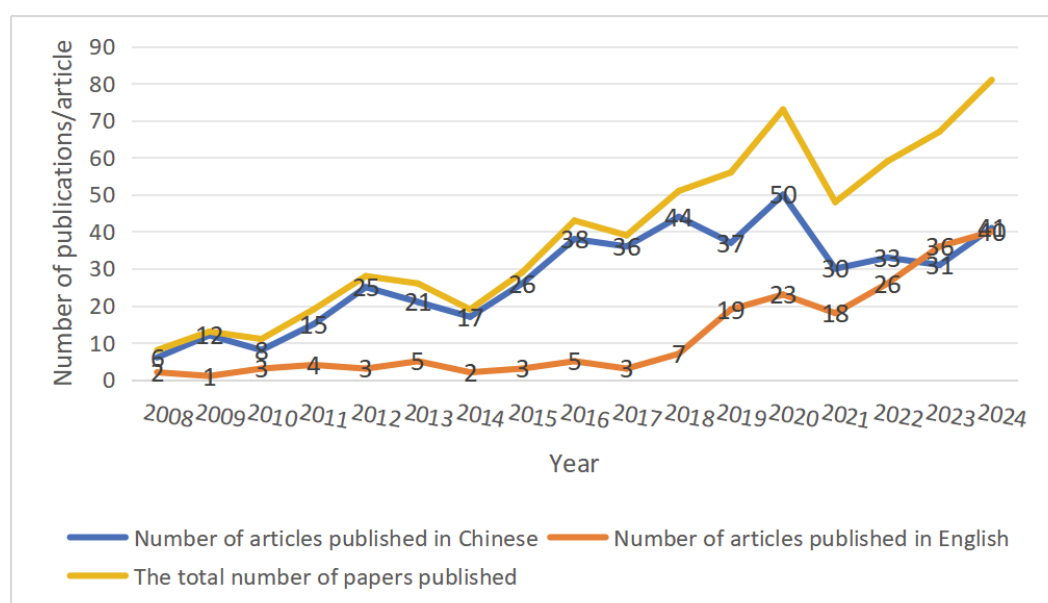
3. Basic status of supply chain finance research

3.1 Statistics on annual distribution of papers

The number of published subject literature is a key indicator to assess the distribution, development dynamics, research depth and change of research interest in a particular research area. After combing 470 Chinese and 200 English literatures in the field of supply chain finance, the trend of change in the number of publications on the topic of supply chain finance can be analysed. The following is a description based on the data in Figure 1:

1. Overall development trend: Observing the period from 2008 to 2024, the number of Chinese and English literature published on the topic of supply chain finance generally shows an upward trend. This phenomenon reflects the continuous increase in academic and industry attention to the field of supply chain finance.
2. Chinese-language publications: The number of Chinese-language publications was low in 2008, but has gradually increased over time, especially after 2015. This reflects that the Chinese language is strengthening in supply chain finance research.
3. The number of English language articles: the number of English language articles grew more slowly from 2008 to 2017, but grew faster in 2018, especially the latter can be basically comparable to the number of Chinese language articles, which reflects that the research on supply chain finance in the international academic community is also gradually increasing.

Figure 1 Trends in the timing of supply chain finance research publications



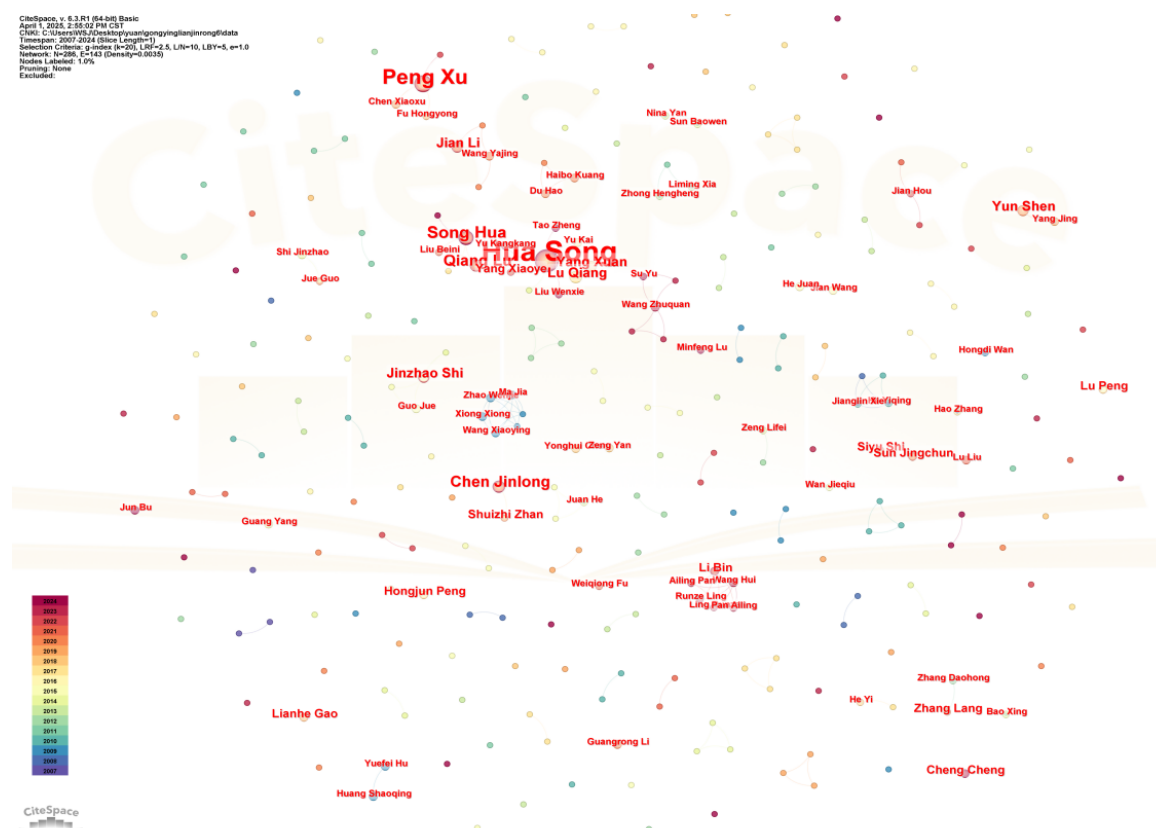
4. Total number of publications: The total number of publications (the sum of Chinese and English language publications) was low in 2008, but has grown steadily over time, and especially rapidly after 2015. This indicates that research and discussion on supply chain finance is also increasing globally.

In summary, the number of articles on the topic of supply chain finance has experienced a shift from low to high and from slow growth to rapid growth over the past decade or so. Especially after 2015, the growth in the number of publications has accelerated significantly, indicating that supply chain finance has become an important research area in academia and industry during this period. This trend is expected to continue in the coming years.

3.2 Author co-occurrence mapping analysis

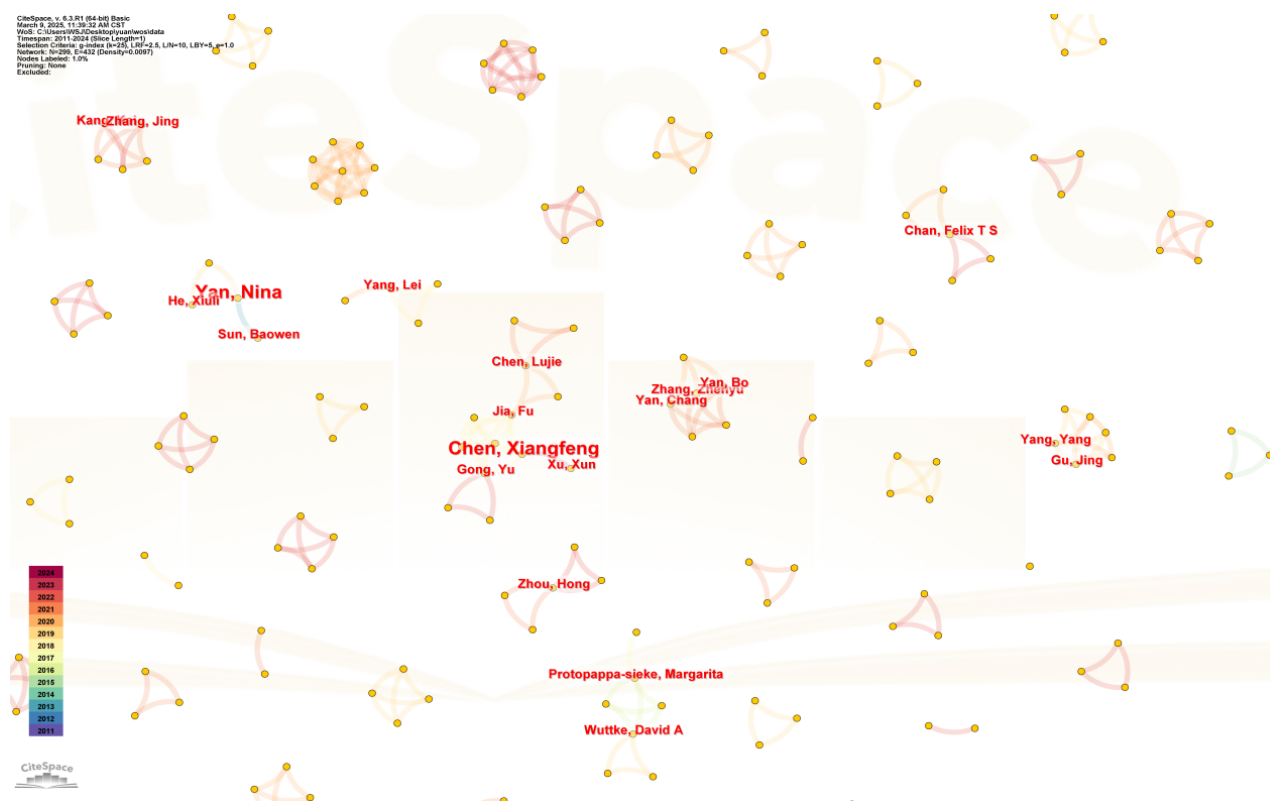
The number of academic papers published is an important indicator of scholars' contribution and influence in a particular field [8]. Visualising the study through the co-authorship analysis function of Citespace software can effectively identify the core researchers and their activity in the field of supply chain finance, so as to gain a deeper understanding of the research progress and trend evolution in the field. As shown in Figure 2, the node size and the font thickness of the authors' names increase according to the number of their publications, with larger nodes and bolded fonts indicating an increase in the number of publications; the thickness of the connecting lines show the degree of close cooperation, with thicker lines implying higher frequency of cooperation; the colour of the connecting lines on the left side of the figure distinguishes between different years or periods of time, demonstrating the development of the time-series of the core literature in the field of supply chain finance in China from 2008 to 2024. The analyses show that Song has the highest number of publications, and such as Lu and Xu also have more prominent publications. The top ten Chinese core authors in terms of publication volume include Song from Renmin University of China, Xu from Southwest University of Political Science and Law, Lu from Beijing Technology and Business University, Yang from Renmin University of China, Shi from City University of Hong Kong, and Yu from Chongqing University. There are a total of 286 nodes and 143 links in the graph, with a network density of 0.0035, indicating a large number of researchers; however, the number and density of links show that although there are collaborative relationships between some of the researchers, the overall frequency of interactions is low, revealing a lack of collaborative relationships.

Figure 2 Co-occurrence of domestic authors in supply chain finance, 2008-2024



Through the knowledge map of foreign authors (Fig. 3), it can be observed that the co-operation between authors is loose and no obvious core author group has been formed. Existing collaborative relationships are mainly confined to intra-country regions, and there is a lack of cross-border co-operation and exchanges. A similar situation occurs in the national author collaboration networks, where the collaboration between authors is also not strong enough and the main links are confined within the same institution. Further, the density of domestic collaborative networks is 0.0033, while the density of foreign collaborative networks is 0.0097, which suggests that overall the level of collaboration between domestic and foreign researchers is low, and influential research communities have not yet been constructed. Despite this difference, foreign researchers collaborate more frequently with each other relative to domestic.

Figure 3 Co-occurrence of foreign authors in supply chain finance, 2008-2024



3.3 Institutional mapping analysis

The in-depth analysis of the co-occurrence of research institutions can provide a comprehensive picture of the structure of the collaboration network and its geographic distribution characteristics within a specific academic field, thus identifying the key research institutions in the field. The distribution pattern of key research entities can be effectively assessed using the institutional collaboration visualisation mapping. In the graphical analysis of inter-institutional collaborations, the time span is set as an annual unit to ensure the clarity of the graphical presentation. In Figure 4, each node corresponds to a research institution in the field of supply chain finance, the node size and font thickness are positively correlated with the amount of its academic output, and the connecting lines between the nodes reflect the intensity of inter-institutional collaboration. It is found that research institutions are widely distributed; only a few institutions have sparse connections, indicating weak collaboration. Overall, most of the research institutions in China are isolated, indicating a low degree of inter-institutional collaboration in the field. In order to examine the academic output of each institution in depth, the top 10 institutions in terms of the number of articles published are selected as research objects. Statistics show that these 10 institutions have accumulated 88 papers, accounting for 18.7% of the total number of publications. Among them, Renmin University of China ranked first with a centre frequency of 39 times, accounting for 8.2% of the total number of publications and 44.31% of the top 10 institutions; followed closely by Xi'an Jiaotong University with a centre frequency of 10 times, accounting for 2.1% of the total sample and 11.36% of the top 10 institutions. These data indicate that the research results of these institutions have continued to grow in recent years, showing significant development potential.

Figure 4 Map of domestic institutional sources of supply chain finance, 2008-2024



As can be seen from Figure 5, the top 5 foreign institutions in terms of the number of articles are Hong Kong Polytechnic University (10 articles), South China University of Technology (6 articles), Southwestern University of Finance & Economics-China (6 articles), Shanghai Maritime University (5 articles), and Central University of Finance & Economics (5 articles). Economics-China (6 articles), Shanghai Maritime University (5 articles), and Central University of Finance & Economics (5 articles), and there are fewer mesh cooperation clusters among the nodes of each institution, which indicates that there is less cooperation among foreign institutions.

Figure 5 Source of foreign institutions in supply chain finance, 2008-2024

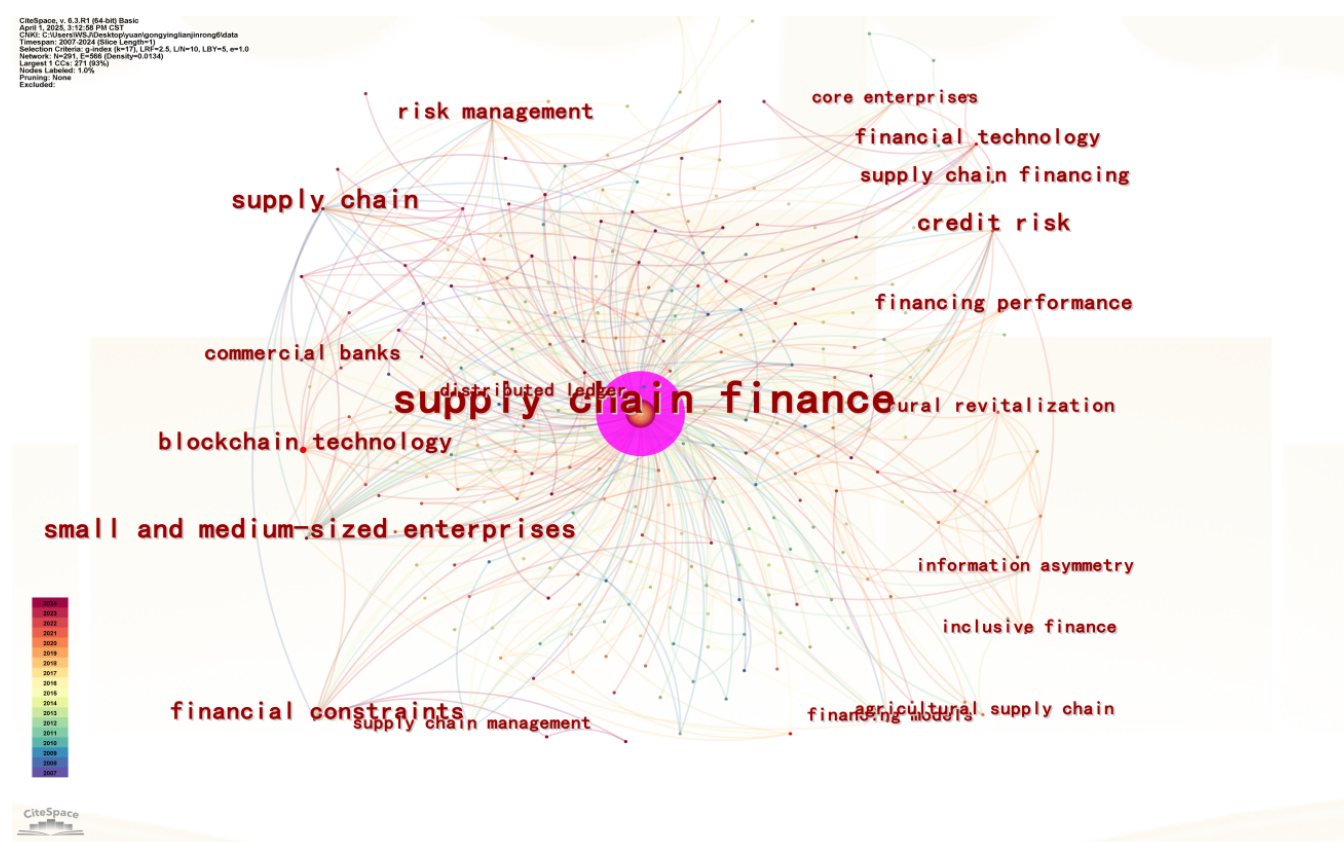


4. Supply Chain Finance Research Hot Spots

4.1 Comparative analysis of the co-occurrence of keywords in domestic and overseas supply chain finance research

A collection of keywords in academic literature can reflect the core topic of the research. In scientometrics research, co-occurrence analysis of sample data using mathematical statistics can mine and classify the data to reveal the focus of research in a particular research area. In this study, keyword co-occurrence analysis was carried out on supply chain finance research samples from CNKI and Web of Science (WoS) databases using Citespace software. In the process of analysis, “Keyword” was used as the node to generate a graph showing the co-occurrence of keywords in supply chain finance research in domestic and international journals, which are shown in Figures 6 and 7, respectively. 0.0338; in contrast, the mapping of Chinese keywords contains 291 nodes and 566 connecting lines, with a network density of 0.0134. In the mapping, the colour saturation of the connecting lines reflects the temporal attributes of the keywords, with lighter hues implying stronger time sensitivity; meanwhile, the size of the nodes is directly correlated with their frequency of occurrence, with larger nodes indicating a higher frequency of occurrence. Through comparative analysis, it can be seen that international studies show more focused attention and consistency of research in the field of supply chain finance innovation driven by fintech.

Figure 6 Domestic Supply Chain Finance Keyword Co-occurrence Map, 2008-2024



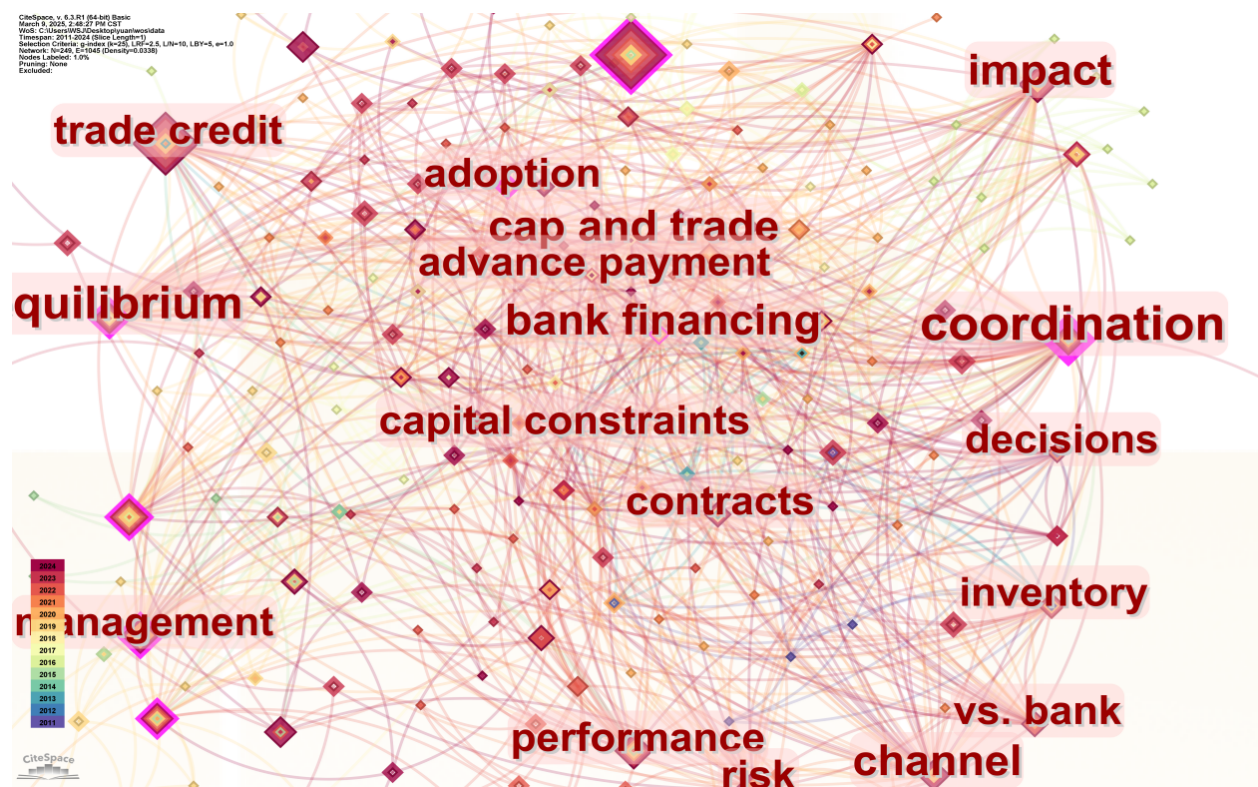
Combined with the comparative analysis of knowledge mapping, this study reveals the commonalities and differences between domestic and international research in the field of supply chain finance. In terms of commonality, scholars at home and abroad generally pay attention to trade credit (trade credit, 63 citations, centrality 0.05) and risk management (risk, 20 citations, centrality 0.09), of which the Chinese keyword “credit risk” has 16 citations, centrality 0.02, while “risk management” has 7 citations, centrality 0.01, and “risk management” has 7 citations, centrality 0.01, respectively. 0.02, while “risk management” has a total of 7 citations with a centrality of 0.01. However, judging from the total number of citations and the centrality of the keywords, foreign studies have explored the credit and risk management aspects of trading in greater depth.

In terms of differences, the following three points are particularly significant:

1. foreign studies have focused more on operational decision-making in supply chain finance, such as supply chain

performance (performance, 31 total citations, centrality 0.09), modelling (model, 31 total citations, centrality 0.12) and coordination (coordination, 27 total citations, centrality 0.23) and other topics, while domestic studies have not shown the the same degree of centrality.

Figure 7 Co-occurrence of foreign supply chain finance keywords, 2008-2024



2. Domestic research pays more attention to the optimisation of new modes of supply chain finance, especially in the areas of blockchain (total citations 24, centrality 0.05), small and medium-sized enterprises (total citations 11, centrality 0.01), supply chain (total citations 11, centrality 0.03), and fintech (total citations 11, centrality 0.02), which reflects domestic scholars' financing of SMEs' Practical needs of the attention of domestic scholars.

The specific keyword co-citation times and centrality data are detailed in Table 1, from which we can clearly see the current status and trend in supply chain finance research at home and abroad.

Table 1 Summary of supply chain finance keywords

form	English keywords (co-citation/centrality)	Chinese keywords (co-citation/centrality)
similarities	trade credit (63/0.05), management (32/0.18), risk (20/0.09),	Credit risk (16/0.02), risk management (7/0.01)
difference	performance (31/0.09), model (31/0.12), coordination (27/0.23)	Blockchain (24/0.05), SMEs (11/0.01), supply chain (11/0.03), fintech (11/0.02)

4.2 Keyword clustering mapping analysis

The clustering analysis of keywords in the research field can clearly show the aggregation characteristics of the research topic. In this study, keywords in the field of supply chain finance were analysed by clustering using CiteSpace tool. In the cluster analysis, each cluster is assigned a label and the decreasing cluster number indicates an increase in the number of keywords. According to the LLR algorithm, the cluster labels represent the keywords in the analysis, but not all the labels are displayed in the case of a large sample size or too many cluster categories. In the Chinese data, a total of 13 clusters were identified with a Modularity Q value of 0.5689, which exceeds the threshold of 0.3, indicating a significant clustering structure, and a Mean Silhouette value of 0.9522, which is higher than the threshold of 0.5, suggesting that the clustering results are valid and highly reliable. In the English data, 10 clusters were identified with Modularity Q value of 0.4743 and Mean Silhouette value of

0.7812. These metrics exceeded the threshold value, which verified the reasonableness of the clustering. Further arranged in descending order of cluster size, the top 12 categories with the most clustered keywords in Chinese data include “blockchain”, “commercial credit”, “rural revitalisation”, “blockchain technology”, etc., while in the English data, the top 9 categories with the most keyword clustering are “supply chain finance”, “financing strategy”, “capital constraint” and so on.

Table 2 Clustering summary of supply chain finance keyword

Cluster serial number	S value	name	Cluster serial number	S value	name
#0	0.98	Blockchain	#0	0.718	supply chain finance
#1	0.916	Commercial credit	#1	0.748	financing strategy
#2	0.928	Rural revitalization	#2	0.69	capital constraint
#3	0.949	Blockchain technology	#3	0.72	finance
#4	0.867	Credit risk	#4	0.791	sales effort
#5	0.935	Core enterprises	#5	0.768	bank financing
#6	0.923	Relationship embedding	#6	0.992	credit risk
#7	0.946	Enterprise innovation	#7	0.877	supply chain management
#8	0.965	Text analysis	#8	0.888	technology innovation
#9	0.977	Green supply chain	#9	0.957	fashionable products
#10	0.982	New development pattern			
#11	0.962	Empirical analysis			
#12	0.971	Internet Finance			

4.3 Keyword emergence analysis

Keyword emergence analysis can reveal changes in the level of attention paid to a topic in the research field over a specific time period. By analysing the keyword emergence mapping, it is possible to clearly identify the research directions that have suddenly emerged in the field at different stages. Combined with the changes in current research dynamics, it is possible to make reasonable predictions about future research trends. Specific keyword emergence data and related analysis results are shown in Table 3 and Table 4, respectively.

Figure 8 Keyword bursting in Chinese literature

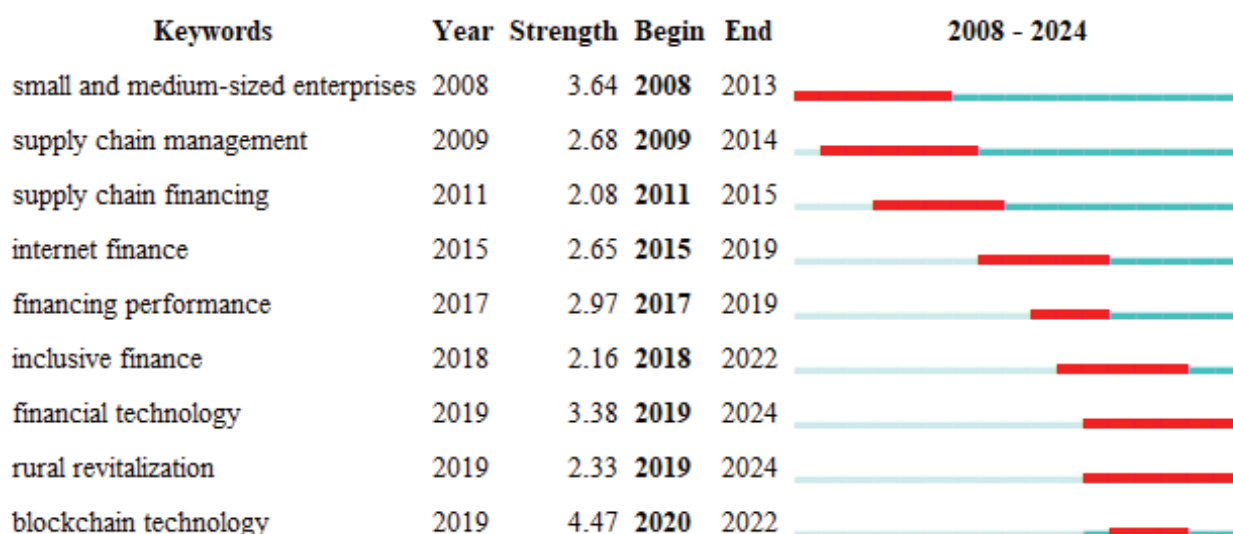
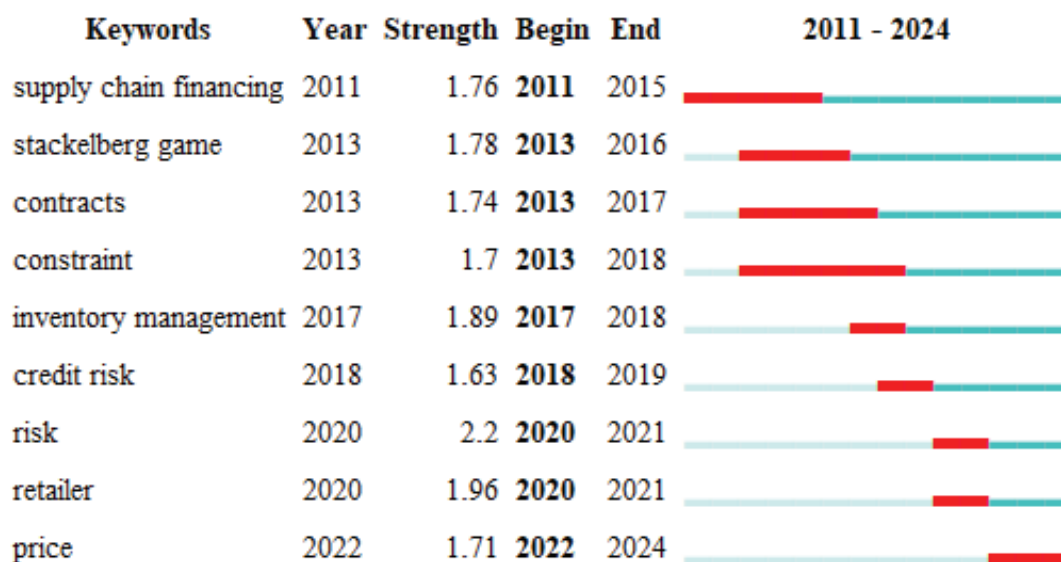


Figure 9 Keyword highlighting in English literature



According to the data in Figures 8 and 9, we can observe that there are 9 burst keywords in both Chinese and English literature. By comparing the quantity and categories of these burst terms, it can be seen that the research hotspots in both Chinese and English literature are relatively concentrated, with a comparatively small number of prominent keywords.

4.4 Supply Chain Finance Research Trend Analysis

Based on the above keyword emergence analysis, it can be seen that supply chain finance research has gone through the following two main stages of development.

In the first time period (2008-2018), Chinese and English literature studies focus on the basic theory and application practice of supply chain finance. Keywords in this phase mainly include financing model^[9], credit risk^[10], industry-finance integration^[11], financing performance^[12], commercial bank^[13], risk management^[14], internet finance^[15], supply chain financing^[16-17], stackelberg game^[18-19], contracts^[20], constraints^[21], inventory management^[22] and credit risk^[23]. Research at this stage focuses on the basic concepts, operational mechanisms and risk control of supply chain finance, and explores how to enhance the stability and efficiency of the entire ecosystem through effective supply chain governance before risks occur.

In the second time period (2019-2024), Chinese and English literature studies focus on the innovation and development of supply chain finance. The keywords in this phase mainly include blockchain technology^[24], agricultural supply chain^[25], financial inclusion^[26], fintech^[27], supply chain governance^[28], retailer^[29-30], and price^[31-32]. Compared with the first phase, the second phase presents a reduction in the number of keyword emergent hotspots and a shorter duration, and researchers in this phase pay more attention to studying the application and development of supply chain finance in the context of new technologies, and how to stabilise supply chain finance through innovation and development after the occurrence of risks in the face of risky processes.

The field of supply chain finance research has shown the following major trends:

1. Research attention continues to grow

From 2008 to 2024, the number of Chinese and English language publications in the field of supply chain finance has shown a general trend of growth, especially after 2015 when the growth was significant. This indicates that supply chain finance has been gaining attention as an important research field in academia and industry. Moreover, the number of English-language publications has grown rapidly after 2018, basically equal to the number of Chinese-language publications, indicating that the research on supply chain finance has not only been paid attention to domestically, but also that the international academic community has gradually increased its attention to this field.

2. Research hotspots shift from basic theories to innovative applications:

In 2008-2018 more emphasis is placed on basic theory and application practice, and early research mainly focuses on

the basic theories of supply chain finance, such as financing mode, credit risk, industry-financing combination, financing performance, etc., and explores the operation mechanism and risk control of supply chain finance. And in 2019-2024 the research hotspot turns to the innovative application of supply chain finance, especially the emerging fields such as blockchain technology, agricultural supply chain, inclusive finance, and financial technology. This indicates that the application and development of supply chain finance in the context of new technology has become a research focus.

3. The focus of research at home and abroad is different:

Foreign research pays more attention to operational decision-making in supply chain finance, such as supply chain performance, modelling and coordination, and other topics, emphasising the optimisation and efficiency improvement of supply chain finance; while domestic research focuses more on the innovation of new modes of supply chain finance, especially in the fields of blockchain, SME financing, supply chain management and financial technology, reflecting the high attention of domestic scholars to the practical needs of SME financing.

4. Research cooperation is insufficient and cross-regional cooperation needs to be strengthened:

Both domestically and abroad, researchers in the field of supply chain finance do not cooperate closely with each other, and there is a lack of cross-regional co-operation and exchange. The density of domestic authors' co-operation network is 0.0033, while that of foreign countries is 0.0097, indicating a low level of overall co-operation. The cooperation between research institutions is also more limited, with most of the institutions showing independent nodes and a clear lack of cross-institutional cooperation. The top 10 domestic research institutions ranked in terms of the number of articles published have published 88 articles, accounting for 18.7% of the total number of articles, of which Renmin University of China tops the list, but the inter-institutional cooperation is still insufficient.

5. Keyword emergence analysis reveals research dynamics:

Chinese literature is rich in research hotspots: the research hotspots in Chinese literature are richer in number and involve a wider range of research, such as blockchain, SME financing, supply chain management, etc. Concentrated research hotspots in English literature: the research hotspots in English literature are more concentrated and relatively few in number, mainly focusing on the basic theories of supply chain finance and operational decision-making.

In summary, the research field of supply chain finance presents trends such as the continuous increase of research attention, the shift of research hotspots from basic theories to innovative applications, the different research focuses at home and abroad, the lack of research cooperation, the concentration of the distribution of research institutes, and the analysis of keyword emergence revealing the research dynamics. These trends provide directions and suggestions for future supply chain finance research.

5. Conclusions and Outlook

5.1 Conclusions of the study

This paper adopts the bibliometric analysis method, combined with CiteSpace software, to systematically analyse the Chinese and English literature in the field of supply chain finance between 2008 and 2024, which visually demonstrates the general trend, developmental vein and cutting-edge progress of Chinese scholars' research in the field, and predicts the direction of future development. The main conclusions are as follows:

1. The multi-level nature of supply chain finance research: Supply chain finance research has expanded from the single issue of enterprise financing to the optimisation of the overall ecosystem of the supply chain. The research not only focuses on the credit risk of core enterprises, but also gradually penetrates into the synergistic mechanism of upstream and downstream enterprises in the supply chain, the innovation of financing mode and the inclusive application of supply chain finance. This multi-level research perspective provides more comprehensive theoretical support for supply chain finance practice.

2. Supply chain finance innovation led by emerging technologies: Driven by the rapid development of blockchain, big data, artificial intelligence and other cutting-edge technologies, the focus of supply chain finance research is shifting from traditional financing methods to technology-driven innovative applications. In particular, the use of blockchain technology has significantly enhanced the transparency and traceability of the supply chain, while opening up new avenues for SME financing. Looking ahead, technology-driven supply chain finance innovation will become an important direction for

research.

3. Trend of globalisation of supply chain finance: Despite the quantitative dominance of domestic supply chain finance research, international academic attention to supply chain finance is gradually increasing. Foreign researches pay more attention to the operational decision-making and efficiency optimisation of supply chain finance, especially in financial coordination and risk management in transnational supply chains. In the future, with the further integration of global supply chains, the globalisation research of supply chain finance will become a trend that cannot be ignored.

4. Diversification of research methods: This paper uses CiteSpace software to conduct a visual analysis of supply chain finance literature, revealing the research hotspots and evolution paths in this field. The introduction of econometric analysis of literature not only provides a new perspective for supply chain finance research, but also promotes the diversification of research methods in this field. In the future, the multidimensional research method combining quantitative and qualitative analyses will further enhance the depth and breadth of supply chain finance research.

5. Close integration of policy and practice: The study of supply chain finance not only has theoretical significance, but also has important practical value. In recent years, with the national attention to the financing difficulties of SMEs, supply chain finance has gradually become a key area of policy support. Future research should pay more attention to the combination of policy and practice, and explore how to promote the wide application of supply chain finance in the real economy through policy guidance and financial innovation.

5.2 Outlook

1. Deepening research on the ecosystem of supply chain finance: Supply chain finance is not only a tool for enterprise financing, but also a core component of the entire supply chain ecosystem. Future research should further explore the role of supply chain finance in supply chain synergy, risk management and sustainable development, and build a more complete supply chain finance ecosystem.

2. Promoting technological innovation and application of supply chain finance: Emerging technologies such as blockchain, artificial intelligence and the Internet of Things (IoT) provide a broad space for innovation in supply chain finance. Future research should focus on the application scenarios and effects of these technologies, especially their role in enhancing supply chain transparency, reducing financing costs and enhancing risk management capabilities.

3. Strengthening international research on supply chain finance: With the increasing complexity of global supply chains, international research on supply chain finance is becoming more and more important. Future research should focus on the operation mechanism, risk management and policy coordination of cross-border supply chain finance, so as to promote the application and development of supply chain finance on a global scale.

4. Exploring inclusive applications of supply chain finance: The problem of SMEs' financing difficulties is a global challenge, and supply chain finance provides new ideas to solve this problem. Future research should further explore how to enhance the accessibility of financing for SMEs through the innovative model of supply chain finance and promote the inclusive development of supply chain finance.

5. Strengthening the combination of policy and practice: Research on supply chain finance should pay more attention to the combination of policy and practice, and explore how to promote the wide application of supply chain finance in the real economy through policy guidance and financial innovation. Future research should focus on the impact of policies on the development of supply chain finance and put forward more operational policy recommendations.

In summary, supply chain finance research is characterised by multi-level, technology-driven, globalisation trend, diversification of research methods and close integration of policy and practice. Future research should deepen the ecosystem research of supply chain finance, promote technological innovation and application, strengthen internationalisation research, explore inclusive application, and strengthen the combination of policy and practice, so as to provide theoretical support and practical guidance for the further development of supply chain finance.

Funding

2025 Shaanxi Provincial Philosophy and Social Science Research Special General Project: Research on the Realisation Path and Countermeasures of Generative Artificial Intelligence Enabling Digital Intelligence Transformation of Shaanxi

Manufacturing Industry (2025YB0189).

Ministry of Education Humanities and Social Sciences Research in Western and Border Areas Project (20XJA630001);

2025 Shaanxi Province Philosophy and Social Science Research Special General Project (2025YB0189);

Shaanxi Province Soft Science Research Programme Project (2023-CX-RKX-015);

Soft Science Project of Xi'an Science and Technology Programme (23RKYJ0029).

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Anh, D. P., Vincent, H., & Jean-Laurent, V. (2023). Integrating point-of-sale financing into the coordination of a price and credit dependent e-commerce supply chain. *International Journal of Production Economics*, 259, 108825.
- [2] Chen, C., & Kieschnick, R. (2018). Bank credit and corporate working capital management. *Journal of Corporate Finance*, 48, 579–596.
- [3] Chen, X. X., & He, S. (2022). Research on risk measurement of supply chain finance in commercial banks - based on the perspective of financial technology. *Journal of Southwest University for Nationalities (Humanities and Social Sciences Edition)*, 43(7), 123–128.
- [4] Cheng, C., Yang, S. G., & Tian, X. (2024). Impact of supply chain finance on enterprise value empowered by financial technology. *Journal of Management Science*, 27(2), 95–119.
- [5] Fu, H. Y., Zhang, F., Su, Z. Y., et al. (2021). Application of blockchain technology in supply chain finance risk management. **Financial Science*, (2), 152–160.
- [6] Guo, J. X., & Lu, Y. (2023). Supply chain finance, supply chain concentration and inefficient investment in corporate innovation. *East China Economic Management*, 37(5), 119–128.
- [7] Heng, L., & Qiang, Y. (2024). Revenue-sharing contract in a three-tier online supply chain under EB platform financing. **Finance Research Letters*, 59, 104773.
- [8] He, T., Pei, P., & Wu, X. H. (2024). Construction, mechanism and application of alliance chain-type supply chain financial system. **Journal of Xi'an Jiaotong University (Social Science Edition)*, 44(4), 47–61.
- [9] Huang, S., Fan, P. Z., & Li, Y. (2024). Financing the retailer in the pharmaceutical supply chain: charge interest or not? **Computers & Industrial Engineering*, 196, 110514.
- [10] Janan, M., Taleizadeh, A. A., & Jolai, F. (2025). Electric energy supply chain finance and pricing in an energy blockchain environment: sustainable energy bonds and evolutionary game theory. *Energy*, 320, 135186.
- [11] Li, G. L., Huang, D. Y., & Zhu, N. (2023). The impact and mechanism of digital inclusive finance on the transformation and upgrading of small and medium-sized enterprises. *Economic and Management Research*, 44(8), 38–54.
- [12] Li, J., Wang, Y. J., Feng, G. Z., et al. (2020). A review of supply chain finance: current status and future. **Systems Engineering Theory and Practice*, 40(8), 1977–1995.
- [13] Li, Y. R. (2024). Effective path of digital upgrading of supply chain finance. **Theory Exploration*, (4), 122–128.
- [14] Li, Y., Zhang, Y., & Geng, L. (2024). Digital finance, financing constraints and supply chain resilience. **International Review of Economics and Finance*, 96, 103545.
- [15] Liu, C. R., Geng, W. D., Liu, C., et al. (2024). Research on the mechanism and key factors of the interface between small farmers and modern agriculture - based on the perspective of co-operatives and supply chain finance. *Management World*, 40(10), 103–120.
- [16] Liu, L., Rao, W. Z., & Wang, B. C. (2021). How to effectively respond to the competition of other financing models? --The development strategy of supply chain finance based on the perspective of commercial banks. **Research and Development Management*, 33(3), 14–29.
- [17] Lu, Q. H., & Zeng, L. F. (2014). Research status and review of supply chain finance. *Soft Science*, 28(4), 131–134.
- [18] Lu, Q. H., Zhang, S. L., & Tan, Q. H. (2024). Research on agricultural supply chain financing model based on pre-sale

- order of e-commerce platform. **Operations Research and Management*, 33(6), 118–124.
- [19] Qin, J., Lyu, X., Fu, H., et al. (2024). Carbon emission reduction and financing strategies of capital-constrained supply chains using equity financing under different power structures. *Annals of Operations Research Advance online publication*.
- [20] Song, X. C., & Mao, J. Y. (2022). Research on inter-organisational trust construction process based on blockchain--taking digital supply chain finance model as an example. *China Industrial Economy*, (11), 174–192.
- [21] Song, Y. F., & Huang, Q. Y. (2018). Progress of domestic supply chain finance research: an analysis based on CSSCI literature from 2005-2017. **China Circulation Economy*, 32(1), 47–54.
- [22] Sun, F., & Ye, F. (2019). Research hotspots and frontier dynamics of international government performance management-based bibliometric analysis of SCI (2008-2017). **Public Management and Policy Review*, (5), 82–96.
- [23] Wang, C., Chen, X., Xu, X., et al. (2024). The impact of blockchain technology on equilibrium financing guarantee strategy in a three-tier supply chain. *Annals of Operations Research. Advance online publication*.
- [24] Wang, H., & Liu, M. (2025). Credit risk assessment of green supply chain finance for SMEs based on multi-source information fusion. *Sustainability*, 17(4), 1590.
- [25] Wang, S. J., & Du, Z. P. (2016). A review of domestic supply chain finance literature based on co-occurrence analysis and literature review. *Finance and Accounting Monthly*, (24), 107–112.
- [26] Xin, C., Zhu, R., & Guo, F. (2025). Corporate sustainability and supply chain financing: an analysis of environmental, social, and governance (ESG) consistency. **Journal of Environmental Management*, 377, 124688.
- [27] Yan, J. H., & Xu, X. Q. (2007). Analysis of the financing model of small and medium-sized enterprises based on supply chain finance. *Shanghai Finance*, (2), 14–16.
- [28] Yang, Y., & Jie, L. (2023). Price timing and financing strategies for a capital-constrained supply chain with price-dependent stochastic demand. **International Journal of Production Economics*, 261, 108885.
- [29] Zhao, H. D., Liu, J. G., & Zhang, G. Q. (2024). Blockchain-driven operation strategy of financial supply chain under uncertain environment. **International Journal of Production Research*, 62(8), 2982–3002.
- [30] Zhou, Y. H. (2020). A review of supply chain finance research. **Electronic Commerce*, (2), 56–57+84.
- [31] Zhu, H. (2020). Analysis of hot topics and evolution paths of supply chain finance research: literature statistics based on CNKI. **Journal of Shanghai Lixin College of Accounting and Finance*, (3), 16–29.
- [32] Zhu, Y., Jia, R., Wang, G. J., et al. (2023). A review of supply chain finance risk assessment research - based on knowledge mapping technology. **Systems Engineering Theory and Practice*, 43(3), 795–812.

Research on Service Robot's Willingness to Use: Extended TAM Model

Dapeng Xu*

School of Business, Macau University of Science and Technology, Macau, 999078, China

**Corresponding author: Dapeng Xu*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This study investigates service robot acceptance factors through an extension of standard TAM for measuring user willingness. Service robots demand new TAM principles because users recognize them through emotional factors and experience technical interaction and safety issues. The research uses perceptual intelligence and human-computer interaction and personification and privacy risk factors to extend the Technology Acceptance Model framework. The survey research instrument operated through both internet and physical methods to collect valid participant responses from 500 qualified users. SPSS and AMOS software were used throughout the research process to test the reliability and validity of the study while conducting structural equation modeling (SEM). The study reveals that both perceived usefulness and ease of use with intelligence and personification and interaction quality lead to user satisfaction while privacy risk reduces this satisfaction level. User satisfaction levels immediately impact the system usage preferences of the users. The study provides practical guidelines and theoretical principles to improve user-focused service robot development and foster better social acceptance of these robots.

Keywords: Service Robot; Willingness to Use; TAM Model

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.620>

1.Introduction

The fast implementation of service robots across multiple fields continues driven by modern technology which results in new lifestyle patterns yet demanding healthcare institutions along with maintenance services and consulting organizations to change their occupational requirements. The critical acceptance level of users stands as the main barrier inhibiting service robot technology progress. Deep evaluation of service robot acceptance provides critical advantages for image-based development as well as actual implementation of service robots in real-life settings. Service robots face difficulties when assessing user acceptance because achieving physical bonds and both emotional and cognitive bonds leads to acceptance. Service robots demonstrate unique operational features because they process vocal commands and process facial signals to create motions emulating human motion patterns. The user-perceived system intelligence as well as emotional reactions to the system stem from these characteristics alongside variations in system trust. Users make decisions about accepting new solutions based on both perceived utilities together with system interface traits along with privacy risks that occur when using these solutions.

Several research studies across multiple disciplines depend on the Technology Acceptance Model (TAM) for quantifying user

reactions toward digital technology. Service robots require supplementary factors introduced to the Technology Acceptance Model in order to perform efficient evaluations. The behaviors of human-computer interaction together with perceptual intelligence and personification and privacy risks significantly impact overall evaluation. This research extends the TAM to study additional factors and their influence on satisfaction together with willingness to use. The study aims to develop an improved framework that demonstrates effective strategies for boosting user acceptance and service robot implementation in genuine scenarios.

2. Literature review and theoretical basis

2.1 Technology Acceptance Model (TAM)

During 1989 Davis established Technology Acceptance Model (TAM) as an extension of rational behavior theory although he used it to predict and explain information systems user behavior acceptance. According to TAM model users will accept information technology based on their behavior intention that stems from perceived usefulness and perceived ease of use. Users evaluate system usefulness by considering how it enhances their work efficiency while easiness of use represents their belief about system operation simplicity. During the decades since the TAM model's introduction academics have used it for multiple information systems acceptability researches to verify user intention development patterns. Traditional TAM models could encounter restrictions for explaining acceptability of complex technology products because of ongoing information technology advancements and emerging application settings^[1]. Therefore, scholars have constantly expanded and revised the TAM model to meet the needs of different research situations.

2.2 Extended TAM model

In order to explain and predict users' willingness to accept complex technical products more comprehensively, scholars have extended the traditional TAM model. Additional external and intermediary variables have entered the expanded TAM model which maintains perceived usefulness and perceived ease of use while expanding the explanation of technical product user acceptance. The conventional TAM model lacks effectiveness when applied to service robots given that their nature as technical products combines with human-computer interaction and emotional interaction elements. This paper develops a theoretical model for understanding service robots' willingness to use through extended TAM based variables of perceptual intelligence, human-computer interaction, personification and privacy risk.

2.3 The research model and assumptions

2.3.1 Research model construction

The specific model is shown in Table 1.

Table 1 TAM Model Variable Table Based on Extension

TAM model variable	Variable content
Perceived usefulness	The degree to which users think that using service robots can improve their life or work efficiency.
perceived ease of use	How easy do users think it is to use service robots?
Perceptual intelligence	User's Perception and Evaluation of Service Robot's Intelligence Level
human-computer interaction	Interaction process and experience between users and service robots
personification	Human-like characteristics and behaviors exhibited by service robots.
Privacy risk	Users think that using service robots may bring the risk of privacy leakage.
degree of satisfaction	Users' overall satisfaction with the performance and service of the service robot after using it.
Willingness to use	Willingness and inclination of users to continue using service robots in the future.

2.3.2 Research hypothesis put forward

Based on the above research model, this paper puts forward the following research hypotheses, as shown in Table 2.

Table 2 Research Hypotheses Based on Extended TAM Model

Hypothetical serial number	Hypothetical content
H1	Perceived usefulness has a positive impact on user satisfaction.
H2	Perceived ease of use has a positive impact on user satisfaction.
H3	Perceptual intelligence has a positive impact on user satisfaction.
H4	Human-computer interaction has a positive impact on user satisfaction.
H5	Personification has a positive impact on user satisfaction.
H6	Privacy risk has a negative impact on user satisfaction.
H7	Satisfaction has a positive impact on users' willingness to use.

2.3.2 Research Hypotheses and Derivation Process

This research utilizes the extended Technology Acceptance Model (TAM) while introducing specific variables related to human-robot interaction to better investigate user willingness towards service robots. Researchers derive every hypothesis both from theoretical explanations and empirical observations.

The reasoning process behind each proposed relationship is detailed below:

H1: Perceived usefulness has a positive impact on user satisfaction.

The fundamental element of TAM is Perceived usefulness that measures how much users believe a system will boost their work productivity. The perception that a robot improves efficiency within work environments alongside homes and service areas creates positive attitudes towards service robot technology in users. Research by Davis (1989) demonstrates that users' perceptions regarding system usefulness define how they feel and act regarding the system. Research conducted by Zou (2024) demonstrates how user satisfaction rises when users identify discernible advantages of technology application. The more users believe a service robot serves them well the more satisfaction they expect to gain from its use.

H2: Perceived ease of use has a positive impact on user satisfaction.

Perceived ease of use is the extent to which users believe that operating the system is free from effort. Ease of use determines satisfaction because it controls first-time user views together with making systems easier to handle. The usability of service robots plays a critical role in improving user experiences when learning procedures requires little effort. According to Davis (1989) as well as Tao (2023) user satisfaction begins with interface ease of use during interactions with complex or new interfaces. Users experience better satisfaction with service robots that maintain user-friendliness and user-intuitiveness which creates feelings of competence and control.

H3: Perceptual intelligence has a positive impact on user satisfaction.

Perceptual intelligence refers to the user's perception of the robot's cognitive capabilities—such as the ability to respond appropriately, understand commands, and adapt to user needs. Service robots of modern times implement artificial intelligence features to exhibit intelligent behavior patterns. Research by Wang et al. (2024) shows that increased perceptions of robot intelligence instill trust along with comfort to produce better satisfaction. People tend to feel more contentment and admiration toward robots that show intelligent responsiveness and situational awareness while operating independently. The emotional and functional satisfaction factor validates perceptual intelligence's inclusion within drivers of service satisfaction.

H4: Human-computer interaction has a positive impact on user satisfaction.

Human-computer interaction (HCI) refers to the quality of the interactive process between the user and the service robot. Positive HCI achieves its aims through precise feedback along with seamless communication that avoids user frustration. The human-computer interaction method directly influences the bonding development between users and their service robots. The authors Tan and Lv (2022) maintain that superior human-machine interaction promotes both emotional involvement and trust in the system. The robot achieves greater user satisfaction when it provides seamless communication because users recognize

its cooperative nature and dependability.

H5: Personification has a positive impact on user satisfaction.

Personification involves endowing the robot with human-like features such as facial expressions, gestures, or emotional responses. The combination of these characteristics enhances robotic devices to appear friendly and related to humans. According to Zou (2024) robots which receive anthropomorphic design enable users to build emotional ties while minimizing their social gap. Service users tend to show improved satisfaction because personified robots help them create emotional bonds which are highly valued in these human-centered service settings. The implementation of personified features should produce positive effects on user evaluation of the entire experience.

H6: Privacy risk has a negative impact on user satisfaction.

Privacy risk refers to the user's concern that personal or sensitive data may be misused by the robot or associated systems. People experience emotional discomfort alongside trust problems at the hands of perceived risks present in smart technologies. Tao (2023) illustrated that privacy issues present the major challenge for device adoption during periods of user data collection or processing. Service robots incorporating sensors and cameras create feelings of exposure among users because they function as monitoring devices. System effectiveness does not prevent users from being dissatisfied because of privacy risks thus establishing a plausible hypothesis about this negative connection.

H7: Satisfaction has a positive impact on users' willingness to use.

Satisfaction reflects users' overall evaluation of their experience with the service robot. Satisfaction appears as one of the most vital predictors of continued usage as per both the extended TAM and behavioral intention models. In his initial research from 1989 Davis showed that users who experienced satisfaction would adopt new technology and make recommendations about it. Tan and Lv (2022) show that satisfaction works as a mediating link between perceptions (including usefulness and ease of use) to eventual behavioral intention. A positive service robot experience leads users to follow its usage while establishing it as part of their regular activities.

3. Research methods

3.1 Questionnaire design

In order to verify the above research hypothesis, this paper designed a questionnaire to investigate. The contents of the questionnaire mainly include the following parts, as shown in Table 3.

Table 3 Questionnaire

Questionnaire items	content
Basic information	Gender, age, occupation and educational background of the respondents.
Perceived usefulness	Measure respondents' perception of the usefulness of service robots through questions, such as "service robots can improve my work efficiency"
perceived ease of use	Measure the respondents' perception of the ease of use of service robots through questions, such as "It doesn't take much effort to learn to use service robots"
Perceptual intelligence	Measure the respondents' perception and evaluation of the intelligence level of service robots through questions, such as "I think the intelligence level of service robots is very high"
human-computer interaction	Measure the interaction process and experience between the respondent and the service robot through questions, such as "My interaction with the service robot is very smooth"
personification	Respondents' perception and evaluation of anthropomorphic characteristics of service robots are measured through questions, such as "the appearance and behavior of service robots are very similar to human beings"
Privacy risk	Measure the risk of privacy leakage that respondents think may be brought by using service robots through questions, such as "I'm worried that using service robots will reveal my personal information"
degree of satisfaction	By measuring the respondents' overall satisfaction with the service robot through questions, "I will recommend this service robot to others"
Willingness to use	Measure respondents' willingness and inclination to continue using service robots in the future through questions, such as "I plan to continue using service robots in the future"

The questionnaire adopts Likert five-level scoring method, and the respondents are required to score each question according to their actual situation and feelings (1 means very different, 5 means very agree).

3.2 Data collection

This paper collects data online and offline. Users access questionnaire links published on online platforms while the offline method involves on-site distribution and collection of paper surveys in business locations and education institutions and residential areas ^[2]. The data collection process included efforts to achieve diverse and representative sample collection that included individuals from different age groups and both genders and various employment sectors and educational profiles. We finalized the data analysis with 500 valid questionnaires which would be utilized for hypothesis testing.

3.3 Data analysis methods

In this paper, SPSS and AMOS are used to analyze the data. Specific analysis methods include descriptive statistical analysis (analyzing the basic characteristics of the sample, such as gender, age, occupation, etc.), reliability analysis (evaluating the reliability and internal consistency of the questionnaire by calculating Cronbach's α coefficient and other indicators), validity analysis (evaluating the validity and accuracy of the questionnaire, testing by exploratory factor analysis (EFA) and confirmatory factor analysis (CFA)) and structural equation model (SEM).

4.Data analysis and results

4.1 Descriptive statistical analysis

Through descriptive statistical analysis of 500 valid questionnaires collected, we get the following results:

Gender distribution: The respondent population consists of equal male and female participants at 52% each; while the age breakdown reveals 20% between 18-25 years old and 35% between 26-35 years old and 30% between 36-45 years old with 15% at or above 46 years old. The research sample includes all participants but has the most members between young adulthood and middle age. Enterprise employees make up 40% of the respondents while students comprise 20% and freelancers make up 15% and people in other occupations such as teachers and doctors make up the remaining 25%. These occupational categories appear in the sample group which includes Bachelor-level students and higher academics representing 60% and 40% respectively. About sixty percent of the participants possess an educational attainment of either undergraduate or lower levels. The sample data shows excellent representation because it includes participants of different genders and ages across various occupational types along with different education degrees. This strengthens the ability to understand user willingness toward service robots.

4.2 Reliability analysis

By calculating Cronbach's α coefficient to evaluate the reliability of the questionnaire, we get the following results, as shown in Table 4.

Table 4 Cronbach's α coefficient table for reliability analysis

Reliability analysis project	Cronbach's α coefficient	Degree of internal consistency
Perceived usefulness	0.85	higher
perceived ease of use	0.82	higher
Perceptual intelligence	0.80	higher
human-computer interaction	0.78	higher
personification	0.76	higher
Privacy risk	0.75	higher
degree of satisfaction	0.83	higher
Willingness to use	0.81	higher

From the above results, it can be seen that Cronbach's α coefficient of each part of the questionnaire is greater than 0.7, which indicates that the questionnaire has high reliability and internal consistency and can meet the requirements of subsequent data analysis.

4.3 Validity analysis

Through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) to evaluate the validity of the questionnaire, we get the following results:

Exploratory Factor Analysis (EFA): Maximum variance rotation and principal component analysis extracted the factors which showed that each component in the questionnaire had a distinct factor structure. The measurement quality exceeds 0.5 in each factor without dimensional interference which demonstrates solid structural validity according to the questionnaire results or Confirmatory factor analysis (CFA): A structural equation model created in AMOS software checked the questionnaire's dimensionality structures. Structural equation model assessment shows the fitting indexes of χ^2/DF , RMSEA, CFI, TLI and more reach the desired criterion points of $\chi^2/DF = 2.34$ and RMSEA=0.06 and CFI=0.92 and TLI=0.90.

4.4 Structural equation model (SEM) analysis

Through the structural equation model (SEM) to verify the research hypothesis, we get the following results, as shown in Table 5.

Table 5 Hypothesis Table of Structural Equation Model (SEM) Verification Research

research hypothesis	Satisfaction path coefficient	P value	Influence (positive/negative)	Assumption holds (Yes/No)	The results show that
H1 perceived usefulness	0.32	$p < 0.001$	forward direction	be	When users think that using service robots can improve their life or work efficiency, they will have higher satisfaction with service robots.
H2 perceived ease of use	0.28	$p < 0.001$	forward direction	be	Users think that the easier it is to use the service robot, the easier it is to have a good impression and trust on it, thus improving satisfaction.
H3 Perceptual Intelligence	0.25	$p < 0.001$	forward direction	be	The higher the user's perception and evaluation of the intelligence level of the service robot, the easier it is to trust and rely on it, thus improving the satisfaction.
H4 Human-computer interaction	0.22	$p < 0.001$	forward direction	be	The better the interaction process and experience between users and service robots, the easier it is to have a good impression and trust on them, thus improving satisfaction.
H5 personification	0.18	$p < 0.01$	forward direction	be	The more human-like features and behaviors the service robot exhibits, the easier it is to establish emotional connection with users, thus improving satisfaction.
H6 privacy risk	-0.15	$p < 0.05$	negative direction	be	Users think that the higher the risk of privacy leakage caused by using service robots, the easier it is to have distrust and resistance to them, thus reducing satisfaction.
H7 willingness to use	0.45	$p < 0.001$	forward direction	be	The higher the user's satisfaction with the service robot, the more willing they are to continue to use the service robot.

In addition, we also evaluated the overall fitting degree of the model. The results show that the χ^2/df value of the model is 2.13, the RMSEA value is 0.05, the CFI value is 0.93, and the TLI value is 0.91, all of which have reached the ideal level, indicating that the overall fitting degree of the model is good, which can better explain and predict the user's willingness to use the service robot^[3].

5. Discussion

5.1 Perceived usefulness, perceived ease of use and satisfaction

The results show that both perceived usefulness and perceived ease of use have a significant positive impact on user satisfaction. Users accept new technology products because they find them useful and easy to use in accordance with the standard TAM model. Users experience higher service robot satisfaction because of their beliefs that these tools increase efficiency in life and work tasks. Moreover ease of service robot operation leads users to develop positive feelings and trust which contributes to better satisfaction.

5.2 Perceptual intelligence, human-computer interaction, personification and satisfaction

The service robot achieves better service delivery through its high perceptual intelligence capability to match user requirements and expectations. A positive human-computer interaction improves user satisfaction together with anthropomorphic features creating better acceptance of the service robot which enhances emotional user experience during interactions.

5.3 Privacy risk and satisfaction

The results show that privacy risk has a significant negative impact on user satisfaction. Service robot users demonstrate substantial concern about their privacy protection needs. User trust and satisfaction diminishes when they think service robots expose their privacy information to others.

5.4 Satisfaction and willingness to use

The results show that satisfaction has a significant positive impact on users' willingness to use. The obtained finding upholds the fundamental TAM model which presents satisfaction as a crucial determinant for users' upcoming utilization decisions. User satisfaction levels toward service robots strongly affect their willingness to keep using service robots according to the field of service robots. The key factor to increase users' willingness to use service robots is focused on improving their satisfaction levels. Service robot providers should pay attention to user satisfaction, and improve user satisfaction and willingness to use by providing high-quality services and solving user problems in time ^[4].

6. Tag

In this paper, the willingness to use service robots is deeply studied through the extended TAM model, and the following conclusions are drawn: All features from perceived usefulness, perceived ease of use, perceived intelligence, human-computer interaction and personification positively influence user satisfaction whereas privacy risk produces negative effects on satisfaction levels which leads to increased willingness to use among users. The revealed findings establish a theoretical basis which delivers practical application for improved comprehension of what drives users to adopt service robots. The following findings allow designers to enhance service robot usability while improving intelligence and human-machine interface quality and anthropomorphic elements and privacy features and user satisfaction for overall user experience enhancement.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Tan, S. Q., & Lv, W. (2022). Study on the influence of service robot interaction on consumers' willingness to use-with AI-self-connection as the intermediary. *Shanghai Management Science*, 44(5), 39–45.
- [2] Tao, W. (2023). Intelligent development strategy of high-star hotels in the era of digital intelligence-analysis based on the extended TAM technology acceptance model. *Contemporary Economy*, 40(4), 22–32.
- [3] Wang, L. L., Zhang, R. S., & Zhang, Y. L. (2024). Study on the influencing factors of consumer service robots' willingness to use. *Shopping Mall Modernization*, (10), 22–24.
- [4] Zou, Y. X. (2024). Study on the impact of anthropomorphization of service robots on consumers' willingness to use. *Business Watch*, 10(34), 49–51+63.

Marketing Channel Planning Analysis and Recommendations for Anshan Nanguo Pears

Xuyan Pu*

School of Management, Shenyang University of Technology, Neijiang Sichuan, 641000, China

*Corresponding author: Xuyan Pu, 1807724152@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Food is the foundation of people's livelihood, with nutrition being the primary concern. People focus on nourishing their bodies through diet, pursuing healthy lifestyles in both ingredient selection and cooking methods. Amid the current trend of consumption downgrading, local consumers increasingly emphasize cost-effectiveness, adopting a consumption philosophy of "spending wisely and buying appropriately." Anshan Nanguo Pears, renowned as the "queen of pears" in the fruit industry for their unique nutritional value, are the subject of this study. This paper aims to fully leverage the resource advantages of the Nanguo Pear industry, focusing on industrial development, cultivating market entities, promoting agglomeration, and building a distinctive brand.

Keywords: Consumption Downgrading; Nutritional Value; Nanguo Pear Industry; Distinctive Brand

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.621>

1. Macro-Environment Analysis

1.1 Policy Environment Analysis

The 2025 "Opinions of the Central Committee of the Communist Party of China and the State Council on Further Deepening Rural Reform and Solidly Advancing Comprehensive Rural Revitalization" proposes to enhance rural industrial development, infrastructure, and governance. The goal is to boost agricultural efficiency, rural vitality, and farmers' incomes, thereby laying a solid foundation for Chinese modernization.

1.2 Economic Environment Analysis

Anshan City has cultivated 400,000 mu (approximately 26,667 hectares) of Nanguo Pear orchards, with an annual output exceeding 400,000 tons and a total annual output value of 1.74 billion yuan. The integrated output value, covering production, storage, and processing, reaches 2.35 billion yuan, directly benefiting 80,000 households and over 200,000 people engaged in production, storage, processing, sales, and related services.

1.3 Social Environment Analysis

Consumer demand for natural and healthy foods continues to rise. Nanguo Pears, rich in anthocyanins and polyphenolic antioxidants, perfectly align with modern healthy dietary trends due to their "green and organic" attributes, making them a preferred choice for quality-conscious consumers. Preferences for specialty agricultural products have shifted from mere consumption to cultural and emotional value, highlighting Nanguo Pears as a signature agricultural product that carries Anshan's century-long cultivation history and regional cultural heritage.

1.4 Technological Environment Analysis

Anshan faces significant technological gaps in intelligent cultivation, green pest control, and deep processing. Traditional manual experience dominates planting, lacking precision technologies such as smart irrigation and IoT monitoring, resulting in low resource utilization efficiency. Chemical pesticides remain over-relied upon for pest control, with insufficient adoption of biological control and physical trapping technologies.

2.STP Analysis

2.1 Market Segmentation

For male consumers, marketing emphasizes the pear's lung-moistening and dryness-relieving effects, beneficial for smokers or those in arid environments. For female consumers, the focus is on its antioxidant properties.

2.2 Target Market Selection

Product strategies vary by age group:

- Children: Fun-shaped Nanguo Pear derivatives, such as cartoon-shaped gummies and sweet pear juice, to spark interest.
- Teenagers: Social and trendy products, such as creative gift boxes featuring internet memes or anime designs, and low-calorie Nanguo Pear sparkling water.
- Adults: Premium-quality products, such as high-end gift boxes and pear-based fruit wines, for refined lifestyles.
- Elderly: Health-focused offerings, such as health-preserving canned pears and low-sugar pear paste, for wellness benefits.

2.3 Market Positioning

Leveraging its health benefits, Nanguo Pears will be positioned around product promotion concepts. High-quality products and services enhance brand perception, allowing premium pricing to secure additional profits and increase farmers' income.

3.Marketing Mix Strategy

3.1 Product

A product-centric strategy requires rapid updates and responsive channels. Marketing resources should prioritize 1–2 flagship derivative products for broad appeal, with other products tailored to segmented market demands.

3.2 Price

Pricing reflects consumer motivations, brand value, and profit distribution. Aligned with brand positioning, pricing should encourage purchases while ensuring long-term competitiveness. The strategy avoids low-end pricing, instead leveraging intangible cultural heritage to justify premium pricing and support rural revitalization.

3.3 Channel

3.3.1 Meiyijia

As a Guangdong-based convenience store chain, Meiyijia offers high store density and accessibility. Strategies include:

- Exclusive coupons and discounts for members.
- Holiday bundles pairing Nanguo Pear gift boxes with best-selling convenience store products to increase average transaction value.

3.3.2 Wholesale Markets

These hubs serve retailers and catering businesses with large-scale, fast turnover. Nanguo Pears are graded (premium, standard, and substandard) for differentiated pricing, targeting high-end fruit stores, general retailers, and feed factories. Wholesalers receive tiered discounts and “single-item drop-shipping” services to reduce inventory pressure.

3.4 Promotion

Collaborations with Meiyijia stores in Guangdong establish sales points, leveraging the chain's brand to attract loyal customers through community-driven marketing. Storytelling and high-quality services enhance brand image, enabling premium pricing.

4.Research Conclusions

Deepen the exploration of Nanguo Pear cultural essence, extracting the spiritual symbols of Liaoning culture. Strengthen research to articulate its philosophical systems, thought patterns, and values, integrating them into the brand's core value,

product design, and marketing.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Jiang, N. (2023). Introduction to the development of Nanguo pear industry in Qianshan District. *New Agriculture*, (2), 37–39.
- [2] Sun, M. Z. (2024). Current status, issues, and recommendations for Nanguo pear industry in Qianshan District, Anshan. *Fruit Growers' Friend*, (4), 106–108.
- [3] Sun, M. Z. (2024). Current status, issues, and recommendations for Nanguo pear industry in Qianshan District, Anshan. *Fruit Growers' Friend*, (4), 106-108.

Detailed Analysis of the Anshan Nanguo Pear Market and Related Recommendations

Zixuan Wang^{1*}, Yahui Qian², Xinying Zhong¹, YaNuo Wang¹

1.School of Management, Shenyang University of Technology, Shenyang Liaoning, 110000, China

2.School of Economics and Management, China University Of Geosciences, Wuhan Hubei, 430000, China

*Corresponding author: Zixuan Wang, 3118343039@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: The 2025 “Opinions of the Central Committee of the Communist Party of China and the State Council on Further Deepening Rural Reform and Promoting the Comprehensive Revitalization of Rural Areas” proposes to enhance the level of rural industrial development, rural construction, and rural governance, and to make every effort to increase agricultural efficiency, rural vitality, and people’s income, thereby providing a solid foundation for advancing China’s modernization. This paper aims to analyze the market customer segmentation of Nanguo Pear, enabling these nutritionally valuable pears to thrive with new vitality in the new era, and to leverage brand empowerment to uncover new product value-added potential.

Keywords: Rural Industrial Development; Market Customer Segmentation; Nanguo Pear

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.622>

1.Classified by Consumption Purpose

Accurately identifying the target customer group for Anshan Nanguo Pears will help to boost sales of Anshan Nanguo Pear. The selection of the target customer group for Anshan Nanguo Pear has a significant impact on the sales volume and market share of Anshan Nanguo Pear.

1.1 Health-conscious People

Health-conscious individuals are the most important target group for Anshan Nanguo Pear. This group of people are concerned about the nutritional value of food and its health benefits. Nanguo Pear is rich in various vitamins, minerals, and fiber, and have certain health benefits, such as aiding digestion and supplementing the body’s nutritional needs, which can meet their demand for healthy food.

1.2 Fruit Lovers

Targeting fruit enthusiasts as a potential customer base can help build a loyal customer base for Anshan Nanguo Pears. This group has a keen interest in fruits and enjoys trying different varieties and flavors. The unique aroma, sweet-tart taste, and delicate flesh of Nanguo Pears can attract fruit enthusiasts to taste and purchase them.

1.3 Local Residents and Tourists with a Sense of Local Pride

Nanguo Pear is a specialty product of Anshan, Liaoning Province. For local residents, Nanguo Pear carries regional sentiment and cultural memories, and is a common fruit in their daily diet. For tourists visiting Anshan, Nanguo Pear is a specialty agricultural product and a memorable souvenir. It can be enjoyed by oneself or given as a gift to family and friends.

1.4 Gift Consumer Groups

For gift consumers, there is a demand for gift-giving during holidays, celebrations, or visits to relatives and friends. Nanguo Pears have local characteristics, and when packaged in exquisite gift boxes, they can serve as unique gifts that express heartfelt sentiments and local characteristics, making them suitable for the gift consumption market.

2. Classified by Consumption Capacity

2.1 High-end Consumer Group

This group of people has high demands on the quality, taste, and brand of fruit, and is willing to pay a higher price for high-quality fruit. High-quality Nanguo Pears, such as those that have been carefully selected, finely packaged, and transported using cold chain logistics, can satisfy the pursuit of quality and experience of mid-to high-end consumers.

2.2 Mid-range Consumer Group

This group of people are mainly customers who pursue health and cost-effectiveness. They place greater emphasis on practicality and health balance. We will provide standardized graded fruits and focus on health benefits that combine traditional Chinese medicine effects such as “moisturizing the lungs and relieving coughs” and “antioxidant” with modern nutrition science to meet consumers’ dual expectations for quality and efficacy. We will use channels such as short videos on health education to establish a brand image as a “trustworthy health choice.”^[2]

2.3 Low-end Consumer Group

This segment of the population focuses on economical and affordable products, primarily targeting mass consumers with a high cost-performance ratio positioning. It emphasizes traditional health benefits such as “moisturizing the lungs and quenching thirst” and “vitamin supplementation,” reaching users through scenarios such as “daily specials” and “people’s livelihood fruit and vegetable zones,” and offering discount formats such as “family-sized bulk purchase discounts” to meet basic dietary and health needs.^[3]

3. Classification by Age of Demand

3.1 Teenagers

This group seeks novel tastes, and the unique sweet and sour flavor of Nanguo Pears appeals to them. They also enjoy snacking during school breaks or after school, and Nanguo Pears are convenient to carry and eat, meeting their needs.

3.2 Young Adults

Young adults are easily influenced by social media, and online promotions for Nanguo Pears are likely to catch their attention. Furthermore, during work breaks or when gathering with friends, they often choose Nan Guo Li as a fruit to share, valuing its appearance. The golden-red hue of Nanguo Pears is particularly appealing.

3.3 Middle-Aged Adults

This group prioritizes health and is aware of Nanguo Pear’s nutritional value, making it an important choice for family fruit purchases to meet nutritional needs. Additionally, they may consider gifting Nanguo Pear gift boxes during business interactions or visits to relatives and friends, valuing their regional characteristics and quality.

3.4 Elderly

Elderly individuals have relatively weaker digestive functions, and the soft, tender flesh and abundant juice of ripe Nanguo Pears make them easy to chew and digest. Furthermore, they have more time to focus on health preservation, and the health benefits of Nanguo Pears align with their needs, often making them a top choice for daily fruit consumption.

4. Customer Engagement

To promote and sell the Anshan Nanguo Pear brand, an O2O business model is adopted to establish connections with commercial clients and end consumers through direct or indirect means.

4.1 Community Expansion

In community marketing, share farmers’ planting stories, lifestyle photos, and videos to enhance the brand’s authenticity and approachability, fostering emotional connections between consumers and farmers. Through social media platforms, establish communities centered around the Anshan Nanguo Pear theme to attract consumers interested in the pear and its derivative

products.

4.2 Media Accounts

Utilize social media platforms to build an account matrix, create a unique IP by posting valuable and attractive content, and retain target customers. Simultaneously, leverage the fan base and influence of KOLs, influencers, and opinion leaders to expand the community's influence and reach, jointly driving the promotion and community expansion of Anshan Nanguo Pear.^[1]

4.3 B-end Cooperation and Expansion

We establish close partnerships with B-end customers and sign cooperation agreements to clarify the rights and obligations of both parties. Cooperation models include, but are not limited to, supply chain cooperation, joint promotion, and customized product development to meet the diverse needs of B-end customers.

4.4 C-end Private Domain Customers and Community Fission

C-end private domain operational customers are the direct consumers of the Anshan Nanguo Pear project. Through private domain traffic, we conduct precise marketing and provide personalized services. By optimizing the platform's shopping process, we enhance purchasing convenience and user experience. We offer comprehensive sales services, such as product descriptions and return/exchange policies, to address issues customers encounter during purchasing and usage, thereby improving customer satisfaction.

5. Research Conclusions

Create a dedicated group chat for the Anshan Nanguo Pear project and invite interested customers and potential customers to join. Post product information, promotional activities, seasonal fruit recommendations, etc., in the group, and interact with customers in a timely manner to increase customer loyalty. Regularly interact with group members, provide benefits such as coupons and tasting events, and enhance customer loyalty. Attract more customers to join the group through sharing within the group and word-of-mouth marketing. Simultaneously, establish a dedicated private customer group on social media platforms, regularly share content and activities to strengthen relationships with followers. Implement a membership system where customers can earn points by purchasing Nanguo Pear products, which can be redeemed for products or exclusive member discounts, thereby increasing customer repurchase rates and loyalty.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Fan, M. H., & Bai, J. (2024). Issues and countermeasures for online sales of agricultural products in Jiangsu Province under the new e-commerce context. *Southern Agriculture*, 18(14), 91–93.
- [2] Rui, W. (2024). Current status and countermeasures for the development of rural e-commerce in the digital economy era. *Modern Business*, (20), 91–94.
- [3] Zhou, W. J., & Zou, M. D. (2024). Research on the role of the digital economy in promoting the development of rural e-commerce. *Market Modernization*, (21), 50–52.

The Influence and Mechanism of ESG Peer Effect on Green Innovation of Heavy-Polluting Enterprises

Mingyue Li*, Xin Wang

School of Finance and Trade, Wenzhou Business College, Wenzhou, 325000, China

*Corresponding author: Mingyue Li, 20219067@wzbc.edu.cn

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: With the establishment of the Chinese “dual-carbon” goal, green innovation is becoming increasingly important for enterprises, and ESG performance provides opportunities for green innovation development by conveying non-financial information to the market. Although studies have demonstrated that ESG performance impacts green innovation, it is still necessary to clarify the peer effect perspective of this relationship. Thus, from the standpoint of industry spillovers, this article examines how peer firms’ publication of ESG ratings affects target firms’ innovation in green technologies. The research object for the paper is the listed businesses of major polluters in the Chinese A-share market between 2009 and 2022. It empirically examines the impact of peer ESG disclosure on corporate green innovation and the mechanism of its role. The results show that there is indeed a peer effect on ESG disclosure of heavy polluters, and corporate ESG performance is affected by ESG ratings of peers. Meanwhile, the peer effect promotes improving the green innovation level of target companies. It still holds after robustness tests. The mediating mechanism test shows that the ESG peer effect promotes green innovation by alleviating financing constraints, mitigating information asymmetry, and increasing firms’ green awareness. Heterogeneity analysis finds that the impact of ESG peer effects on green innovation is more significant in State-owned firms, large-scale firms, and firms in the east-central region.

Keywords: ESG Ratings; Peer Effects; Green Technology Innovation; Financing Constraints; Information Asymmetry

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.623>

1.Introduction

In recent years, environmental pollution, global warming, and other issues have become the focus of attention of countries worldwide ^[1]. The Party Central Committee has decided to “Aim for carbon neutrality by 2060 and carbon peaking by 2030” as a key strategic move. The report of the 20th National Congress of the Communist Party of China pointed out that it is necessary to coordinate industrial restructuring, pollution control, and ecological protection and promote ecological priority, conservation and intensification, and green and low-carbon development.

ESG (Environmental, Social, and Governance) concept takes into account economic benefits and social development, advocates green, low-carbon, and environmental sustainability, focuses on the development ability of enterprises in the environment, social responsibility, and governance.

Given the “dual carbon” goal, heavy-polluting businesses urgently need to perform green transformation based on enhancing their potential for green innovation ^[2]. Since the ESG concept has emerged as a crucial metric for assessing an organization’s

non-financial data, many literature studies have discovered that ESG performance also has a necessary effect on the quality of green technology innovation across organizations.

The study on how peer information disclosure affects businesses' behavioral choices has been limited to focusing on peer social responsibility^[3] and peer product quality information^[4]. However, studies on the effect of peer ESG disclosure on corporate green innovation are scarcer, and this study adds something new to the pool of existing literature. In light of the aforementioned research gaps, this study investigates whether ESG peer effects impact target firms' green innovation and identifies the mechanism behind the effect.

This study thoroughly examines how peer ESG disclosure affects corporate green technology innovation using the theories of dynamic competition, games, and social comparison. It chooses relevant data from Chinese heavy pollution listed enterprises from 2009 to 2022 as the study sample, empirically tests it using a fixed-effect model, and uses robustness testing to guarantee the research findings' scientific validity.

The article's remaining content is arranged as follows: The literature review is the second section, and the theoretical analysis is the third, a meticulous and comprehensive examination of the topic with research hypotheses; the model setting and study design make up the fourth section; the data analysis is in the fifth; and the conclusion and suggestions are in the sixth.

2. Literature review

2.1 Studies on corporate ESG practices

The literature currently in publication concentrates on the determinants and economic impacts of corporate ESG performance. The macroeconomic climate and the firm's attributes are the primary determinants of corporate ESG disclosure. Scholars of macroeconomic factors have examined the state of economic development at the national level^[5], financial policy uncertainty^[6] and international trade^[7], global trade and capital markets^[8], etc. on firms' ESG performance. Regarding the firm's characteristics, it has been found that firm size^[9], internal corporate governance structure^[10], and stock price^[11], executive characteristics^[12], institutional investors' shareholding^[13] significantly affect corporate ESG performance. Innovation, financial risk, and company value are the main topics of the literature on the economic impacts of ESG disclosure. Meira^[14] et al. found that active ESG activities help firms to develop differentiation strategies, which in turn enhance firm value.

2.2 Studies on intra-industry spillovers

The term "peer effect" describes how a company's actions are impacted by both individual traits and the actions of other companies operating in the same sector. Lieberman and Asaba^[15] developed a theoretical framework to support corporate imitation behavior by classifying corporate imitation motives into two essential types: information-based and competition-based. Regarding peer effects, scholars have found that corporate mergers and acquisitions^[16, 17], corporate governance^[18] Green innovation^[19] Investment^[20] and share buybacks^[21, 22] and other behaviors have peer effects. In addition, scholars have found peer effects in financial decisions through empirical tests, and by differentiating the empirical results, it is found that peer effects in financial decisions are mainly caused by product market competition, learning, and internal capital markets.

In summary, most of the literature on corporate ESG focuses on how a company's ESG performance affects its value, risk, innovation, and other behaviors, treating firms as individuals in action and ignoring peer-to-peer interactions. However, firms practice observing and learning from their peers' behavior to reduce decision-making risks and costs. Less research has been done on how ESG peer effects affect green innovation. In order to fill the related research gap, this paper will investigate the relationship between target firms' green innovation and the ESG performance of other firms through peer effects.

3. Theoretical analysis and research hypotheses

3.1 Peer ESG disclosure on green innovation spillovers from target firms

First, Based on the theory of dynamic competition, firms' behavioral decisions are influenced by individual characteristics and the interaction effect with other firms in the industry. Thus, they will be influenced by other competitors.

Second, according to game theory, enterprises make different decisions under different environmental information disclosure rules when making green innovation decisions. When other businesses disclose more ESG information, the zero-sum game competition between peers based on ESG performance intensifies.

Third, according to social comparison theory, individuals compare themselves to others to maintain self-esteem and self-worth^[23,24]; in general, firms are similar to individuals and tend to compare themselves to each other^[25] that tends to achieve a social performance level that is higher than the industry average.

The following research hypotheses are put forth in this paper in light of the analysis above:

H1. ESG performance in the same industry will encourage green innovation in the target company.

3.2 Financing constraints, information asymmetry, and the mediating role of green consciousness

Funding limitations are critical for enterprise green technology innovation. Firms facing higher financing constraints lack the resources and assets to promote green innovation and strengthen their edge over competitors. Unlike general innovation, green innovation is complex and requires significant financial, material, and human investment.

ESG is a business philosophy that emphasizes both financial performance and sustainable development. For investors, companies with good ESG performance can convey non-financial information to the market, help stakeholders identify investment risks, enhance their willingness to invest, and provide more capital support for corporate green innovation. Secondly, as the capital market recognizes ESG ratings, investors focus on ESG performance when investing^[26]. Finally, there is a high level of uniformity among businesses in the same sector^[27]; investors assume that businesses with and without ESG practices share similar inclinations toward green development, which helps to target firms to bring in capital. This study puts forth the second research hypothesis in light of the analysis above:

H2. The ESG peer effect can encourage the development of green technologies by easing the target firms' financial burden.

The positive ESG information disclosure of a specific industry can convey a signal of good development prospects to the outside world, draw in analysts' and institutional investors' attention, and decrease information asymmetry by fully utilizing professional intermediaries' "information effect"^[28], enhance the connection between enterprises and market investors, help the outside world obtain information on corporate characteristics, break the information gap, and improve investment efficiency^[29]. The study's third hypothesis is presented in comparison with the previous analysis:

H3. The ESG peer effect can raise the level of green innovation attained by target firms by lowering the level of information asymmetry.

Enterprise green innovation activities require a sustained capital outlay, often a lengthy process, and generally do not prioritize the allocation of resources in the strategic decision-making process, thus requiring an enterprise-wide eco-culture and green awareness on the part of management and employees. Corporate green awareness is a critical factor in developing green innovation strategies and improving green innovation levels^[30].

Recently, listed companies' ESG performance has been a subject of increasing and widespread market attention. A strong ESG performance is not just a measure of a company's potential for sustainable development but also influences its market and media visibility^[31]. This external attention pressure often catalyzes target firms to enhance their environmental consciousness and actively participate in green innovation developments. In this context, we give the fourth research hypothesis:

H4. The ESG peer effect may increase target firms' green awareness, promoting green innovation.

4. Research design

4.1 Sample selection and data sources

This research takes the listed Chinese heavy-polluting enterprises from 2009 to 2022 as a sample group. We chose 2009 as the study's starting point because the ESG data in this paper is based on CSI's ESG ratings, which were first released in 2009. To guarantee the study's validity and scientific integrity, we treated the samples in the following ways: we excluded ST, *ST samples, and samples with significant missing data and applied 1% indentation to the continuous variables, resulting in 11,100 annual observations. This paper's ESG performance is based on the ratings disclosed by "Shanghai Huazheng"; based on Li et al.^[32], we use the values "9" - "1" respectively to replace the rating "AAA-C" indicator, with larger values representing higher ratings. The explanatory variables (green innovation level), control, and mediating mechanism variables are all from CSMAR.

4.2 Main variables

4.2.1 Dependent variable: green innovation (Green)

Green technological innovation, a significant aspect of enterprise R&D, encompasses a variety of technological advancements that prioritize energy conservation and environmental preservation. Among various indicators, the overall quantity of green patent applications is a reliable indicator of a company's capacity for technological innovation. These applications, which include utility model applications and patents for green inventions, are crucial. We use the number of green patent applications plus one logarithmic process as a proxy variable to measure the degree of green innovation.

4.2.2 Core independent variable: ESG peer effect (ESG_peer)

According to Sahin et al. ^[33], ESG ratings have evolved into a reference standard for measuring enterprises' environmental protection, social responsibility, and sustainable growth. Thus, this study adopts the ESG ratings provided by the Shanghai CSI information platform to assess the ESG efficiency of corporations. This paper measures the ESG peer effect by this year's average ESG rating value for the same industry, excluding this company.

4.2.3 Mediating mechanism variables

(1) Financing constraints (SA). The existing literature has WW, SA, and KZ indexes to evaluate financing constraints. However, to ensure the SA index's reliability, Hadlock and Pierce ^[34] meticulously constructed it using only exogenous variables, such as firm size and age, following the KZ methodology. This careful approach helps to avoid endogenous disturbances and enhances the index's credibility. We calculated the SA index using the following formula:

$$SA_{i,t} = -0.737 \times \text{Size}_{i,t} + 0.043 \times \text{Size}_{i,t}^2 - 0.04 \times \text{Age}_{i,t} \quad (1)$$

$\text{Size}_{i,t}$ is the firm's total assets data processed into millions of dollars and then logarithmically processed, and $\text{Age}_{i,t}$ is the length of time the company has been listed. The SA index is negative, and a higher value indicates that the firm is less constrained by financing.

(2) Information asymmetry (Asy). This paper utilizes data on stock transactions of listed companies to capture the degree of the information asymmetry between inside-knowledgeable traders and outside investors. Drawing on Amihud et al. ^[35] Liquidity ratio indicator LR, Amihud ^[36] Illiquidity ratio indicator ILL, and Pastor & Stambaugh ^[37] Return reversal indicator, we rigorously extract the first of these three indicators' principal components. This component is related to asymmetric information and is known as the symbol for information asymmetry Asy. The degree of information asymmetry increases with a more extensive Asy index.

(3) Green awareness (CSRReport). Green awareness was measured by whether the company disclosed environmental information in its annual social responsibility report, with a value of 1 if it did and 0 otherwise.

4.2.4 Control variables

We select company size (Size), operating cash flow (Cash), growth capacity (Growth), profitability (Roa), and gearing ratio (Lev), etc. as control variables. We define the variables in Table 1, and the relevant data can be obtained from the CSMAR database.

Table 1. Definition of variables.

Variable Category	Variable Name	Abbreviation	Variable Explanations
Dependent variable	Green innovation	Green	The degree of green innovation is measured by taking the natural logarithm of the quantity of green patent applications submitted by firms plus one.
Independent variable	ESG Peer Effect	ESG_peer	The average ESG ranking of other firms in the same industry do not include current year's performance.
Intermediary variable	Financing constraints	SA	Financing constraints index. The larger the index, the fewer financing restrictions the firm faces.
	Information asymmetry	Asy	The first principal components are extracted to determine the level of information asymmetry for the liquidity indicator LR, the illiquidity indicator ILL, and the return reversal indicator GAM.

Variable Category	Variable Name	Abbreviation	Variable Explanations
Grouping variable	Green awareness	CSRReport	If the firm disclosed environmental information in its annual social responsibility report, CSRReport=1; otherwise, it would be 0.
	Nature of property rights	Soe	Whether the actual controlling shareholder is a state-owned enterprise (1=yes, 0=no).
	Company size	Size_big	Size_big = 1 if the firm size exceeds the sample median; if not, 0.
	District	District	The region to which the enterprise belongs is divided into eastern, central, and western areas, with East=1 representing that the business is located in the eastern region, Middle=1 representing that the enterprise is located in the central area, and East=0 and Middle=0 representing the enterprise's location in the western area.
Control variables	Company size	Size	Natural logarithm of total company assets.
	Operating cash flow	Cash	Company's net cash flows from operations/total assets
	Growth capacity	Growth	Revenue growth rate.
	Ratio of sole director	Indirect	Number of independent directors/number of board directors
	Executive Team Size	Tmtsize	The natural logarithm of the number of executives plus one.
	Profitability	Roa	Net profit/total assets
	Asset-liability ratio	Lev	Total liabilities/total assets
	Shareholding concentration	Top10	The proportion of the top ten shareholders' shares.
	Age of business	LnAge	Natural logarithm of age of business

4.3 Modeling

4.3.1 Baseline regression model

This study examines how the ESG peer effect affects the degree of green innovation using a fixed-effect model. The following is the benchmark regression model:

$$\text{Green}_{it} = \alpha_1 + \beta_1 \text{ESG_peer}_{it} + \sum_j \beta_j \text{Controls}_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (2)$$

In the above equation, Green represents companies' green innovation levels, ESG_peer represents the ESG peer effect, and Controls represents firm size, profitability, and several additional control variables listed above. *i* denotes firm, *t* denotes year, and λ_i is the fixed effect of the individual, and μ_t is the time fixed effect, and ε represents the term for random error. Where the coefficient in front of ESG_peer β_1 reflects the impact of ESG peer effects on company Green Development, if β_1 is significantly positive, indicating that raising the industry average for ESG can encourage green innovation in the target company.

4.3.2 Mediating mechanism test model

To analyze the mediating mechanism effect of ESG peer effects through alleviating financing constraints, mitigating information asymmetry, and increasing corporate green awareness, thus promoting green innovation, reference is made to Zhang et al.^[17] research method, the following two-stage regression model is constructed based on equation (2):

$$\text{MV}_{it} = \alpha_2 + \beta_2 \text{ESG_peer}_{it} + \sum_j \beta_j \text{Controls}_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (3)$$

$$\text{Green}_{it} = \alpha_3 + \beta_3 \text{ESG_peer}_{it} + \gamma \text{MV}_{it} + \sum_j \beta_j \text{Controls}_{it} + \lambda_i + \mu_t + \varepsilon_{it} \quad (4)$$

In model (3), MV refers to the three mediating mechanism variables SA, Asy, and CSRReport selected in this paper, and the equation describes the ESG peer effect regression model on each mediating variable. If β_2 is significantly positive, it means that the ESG peer effect positively impacts the mechanism variable and vice versa. Model (4) belongs to the two-stage regression method's second step, and the coefficients β_3 illustrate how the ESG peer effect affects green innovation. γ indicates the

result of mediating mechanism variables on green innovation. According to the stepwise regression method, if β_1 , β_2 , γ are significant, and γ is less than 0, it is demonstrated that the mechanism variables establish the indirect influence of the ESG peer effect on corporate green innovation.

4.4 Descriptive statistical analysis

In this paper, Table 2 displays the descriptive statistics for the primary variables. It is evident from there that Chinese heavy pollution listed firms' ESG ratings are as low as C and as high as AA, with a 4-point mean and a 1.1005 standard deviation, which indicates that the enterprises' ESG ratings are generally low and do not differ much. With a standard deviation of 0.21, a minimum of 2.66, a maximum of 5.25, and a mean value of 4, the ESG peer effect, or ESG_peer, shows minimal variation in the ESG peer effect among heavy pollution industries.

Table 2. Descriptive statistics.

Variable	N	Mean	SD	Minimum	Maximum
ESG	11100	4.05018	1.100543	1	8
ESG_peer	11100	4.048734	0.2199509	2.666667	5.25
Green	11100	0.7091325	1.055869	0	6.931472
Size	11100	22.30502	1.36283	18.15785	28.63649
Cash	11100	0.0582079	0.0780332	-1.686297	2.221612
Growth	11100	6.844198	566.9389	-4.491724	59411.55
Indirect	11100	0.3709759	0.0522486	0.1667	0.7143
Tmtsize	11100	1.955233	0.298371	0.6931472	3.091043
Roa	11100	0.0395337	0.1256281	-3.199699	7.445077
Lev	11100	0.4281924	0.2227112	0.007521	3.261896
Top10	11100	57.44867	15.63286	1.3103	98.5883
Lnage	11100	2.846079	0.370877	0.6931472	3.828641

5.Data analysis

5.1 Basic regression test and robustness tests

5.1.1 Basic regression test

The findings of this paper's basic regression are displayed in Table 3. Column (1) is the outcome of the test of whether the ESG peer effect exists among heavy-polluting enterprises. When individual and year effects have been taken into account, at the 1% level, the ESG_peer coefficient is 0.463, implying that the ESG peer effect exists. Columns (2) and (3) are without and with control variables, respectively. When individual and time effects have been taken into account, ESG_peer coefficients for the impact of ESG peers on green innovation levels are 0.164 and 0.186, respectively, which, at the 1% level, are both statistically positive, indicating that peer ESG disclosure encourages green innovation in the target companies. As a result, this paper's H1 is true.

Table 3. Basic regression results

Variable	(1) Esg	(2) Green	(3) Green
Esg_peer	0.463*** (9.79)	0.164*** (4.39)	0.186*** (5.08)
Size	0.220*** (11.56)		0.252*** (17.07)
Cash	-0.248**		0.0606

Variable	(1)	(2)	(3)
	Esg	Green	Green
	(-2.08)		(0.66)
Growth	-0.0000456***		0.00000281
	(-3.21)		(0.26)
Indirect	1.202***		0.413**
	(5.34)		(2.37)
Tmtsize	0.0440		0.00781
	(1.04)		(0.24)
Roa	0.0509		0.0232
	(0.72)		(0.42)
Lev	-0.860***		0.00427
	(-12.98)		(0.08)
Top10	0.000669		0.00202**
	(0.64)		(2.49)
Lnage	-0.337***		-0.235***
	(-3.35)		(-3.01)
Observations	11100	11100	11100
Firm Effect	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes
Adj.R-squared	0.1597	0.113	0.142

t statistics in parentheses

* p<0.1 ** p<0.05 *** p<0.01

5.2 Robustness Tests

5.2.1 Changing the regression model

Because there are many zeros in corporate green patent applications, the Tobit model is used to estimate more accurately for robustness testing. The Tobit model test is shown in Table 4's column (1), and at the 1% level, the ESG_peer coefficient of 0.223 is significant. It shows that after changing the regression model, peer ESG disclosure still contributes significantly to the advancement of green innovation initiatives in target companies.

5.2.2 Shorter sample period

Before conducting the test, this paper excludes data after 2020 to exclude the epidemic's effect on businesses' innovation in green technologies. Table 4's column (2) displays the regression results, and the ESG_peer coefficient is 0.203; it remains significantly positive at the 1% level, proving the validity of the conclusion that the ESG peer effect stimulates green innovations, which is in line with the previous findings.

5.2.3 Use of first-order and second-order lag terms for explanatory variables

The endogeneity problem is due to some unmeasured factors left out and the potential for reverse causality between ESG peer effects and green innovation. Therefore, this study employs the explanatory variable ESG_peer's first- and second-order lagged terms as instrumental variables for endogeneity tests. Table 4's columns (3) and (4) display the test results, and regression results display the outcomes of the test's second stage in the two-stage regression, where the coefficients of the core explanatory variables, the first-order lag L.ESG_peer and the second-order lag L2.ESG_peer are both significantly positive at the 1% level, which is consistent with the finding of the baseline regression and proves the research findings' validity.

5.2.4 Propensity score matching

Firms in the same industry may share specific characteristics, leading to sample selection bias that impacts the study's findings. Therefore, the article uses the propensity score matching (PSM) method to match the control variables as covariates in a 1:1 near-neighbor matching to match the experimental and control groups better. The Table 4's column (5) displays the regression results upon matching, and the core independent variables' coefficients remain positive, showing that the research conclusions of this article are valid.

Table 4. Robustness check.

Variable	Changing the regression model	Shorter sample periods	First-order lag of explanatory variables	Second-order lag of explanatory variables	Propensity score matching
	(1) Green	(2) Green	(3) Green	(4) Green	(5) Green
ESG_peer	0.223*** (2.97)	0.203*** (4.30)			0.241*** (4.74)
L.ESG_peer			0.307*** (6.97)		
L2.ESG_peer				0.249*** (5.13)	
Control variable	Yes	Yes	Yes	Yes	Yes
Observations	11100	8201	10121	9153	6622
Firm Effect	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes
Adj.R-squared		0.3578	0.4194	0.4024	0.4312

t statistics in parentheses

* p<0.1 ** p<0.05 *** p<0.01

5.3 Mechanism testing

5.3.1 Mechanism test based on financing constraints

The financing constraint mechanism test results are displayed in Table 5's columns (1) and (2). Column (1) displays the regression findings of the ESG peer effect on financing constraints, and the ESG_peer coefficient is significantly positive, which indicates that peer ESG disclosure can help decrease the target firms' financial restrictions. Next, both financing constraints and ESG peer effects are included in the model, and Column (2)'s findings demonstrate that both coefficients are significantly positive. This proves how financial constraints mediate green innovation and ESG peer effects, and H2 holds.

5.3.2 Mechanism test based on information asymmetry

Table 5's columns (3) and (4) display the research results of the information asymmetry mediation mechanism test; column (3) indicates that the ESG peer effect reduces the degree of information asymmetry, and column (4)'s findings demonstrate that simultaneous incorporating the information asymmetry and ESG peer effects into the model, ESG_peer has a significantly positive coefficient. In contrast, the Asy has a significantly negative one. This result supports the mechanism role of information asymmetry in ESG peer effect to encourage green innovation, and H3 holds.

5.3.3 Mechanism test based on green awareness

Table 5's columns (5) and (6) display the test results. The ESG_peer coefficient of 0.0436 in the result of column (5) is significantly positive, suggesting that the ESG peer effect has a positive influence on the enterprise's green awareness has a positive facilitating effect. Column (6) shows how the regression model incorporates green awareness and the ESG peer effect

to investigate the impact on corporate green innovation. The significance and direction of the coefficients demonstrate that green innovation mediates the ESG peer effect to promote green innovation. This outcome validates H4.

Table 5. ESG Peer Effect Mediation Mechanism Test Results.

Variable	Financing constraints		Information asymmetry		Green awareness	
	(1) SA	(2) Green	(3) Asy	(4) Green	(5) CSRReport	(6) Green
SA		1.535*** (10.13)				
Asy				-0.2192*** (-10.02)		
CSRReport						0.0647*** (4.44)
ESG_peer	0.0121*** (3.72)	0.023*** (6.49)	-0.0307*** (-6.30)	0.1656*** (4.46)	0.0436*** (3.00)	0.1692*** (9.78)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11100	11100	11100	11100	11100	11100
Firm Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adj.R-squared	0.2140	0.2168	0.1314	0.1050	0.1967	0.2095

t statistics in parentheses

* p<0.1 ** p<0.05 *** p<0.01

5.4 Heterogeneity analysis

5.4.1 Character of property rights

This study separates the sample into state-owned businesses, and those that are not, and the benchmark regression model is regressed into groups. The study results are displayed in Table 6's columns (1) and (2), where the core explanatory variables' coefficients are significantly positive at the 1% level regarding the state-owned as well as the non-state-owned enterprise group; however, the state-owned enterprise group's coefficients are more significant. It could be related to the status of state-owned businesses in the national economy, which are responsible for the production and distribution of essential products and receive more social attention.

5.4.2 Company size

This study separates the sample into large and small companies, and the statistical results are displayed in Table 6's columns (3) and (4). Statistically, the coefficients are favorable for the large firm group and negative but not significant for the small firm group, indicating that peer ESG disclosure's impact on green innovation exerts its influence only in large firms and does not significantly affect small firms.

5.4.3 District

Given the specific inequalities in economic growth, policy resources, and public awareness among Chinese eastern, central, and western areas, firms in different locations may embrace different levels of ESG construction and green business investments when facing ESG disclosure by their peers. Consequently, this study separates the area where the sample enterprises are located into east, center, and west for group regression. The test results, as displayed in Table 6's columns (5), (6), and (7), show that ESG peer effects coefficients are significantly positive in the center and eastern areas. In contrast, the western region's coefficients are not significant.

Table 6. Heterogeneity analysis results.

Variable	Nature of property rights		Company size		District		
	(1) State-owned enterprise	(2) Non-state-owned enterprise	(3) Big corporation	(4) small corpora- tion	(5) Eastern region	(6) Central region	(7) Western re- gion
ESG_peer	0.194*** (3.21)	0.096** (2.04)	0.257*** (4.86)	-0.026 (-0.54)	0.1214** (2.52)	0.2961*** (3.63)	0.1209 (1.43)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4448	6499	5880	5220	6662	2329	2109
Firm Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj.R-squared	0.1021	0.0542	0.0562	0.0217	0.0386	0.0888	0.0833

t statistics in parentheses

* p<0.1 ** p<0.05 *** p<0.01

6. Conclusions and Recommendations

This study focuses on the impact and mechanism of ESG peer effects on green innovation by using competition theory, game theory, and signalling theory to enrich our comprehension of the connection between green innovation and ESG peer effects by taking Chinese heavily polluting listed firms as the research object from 2009 to 2022. The study's findings are as follows:

First, based on the essential regression findings, when the ESG disclosure level of peer firms increases, target firms will take action to improve their ESG performance based on competitive pressure and comparative tendency; that is, the ESG peer effect exists. After the robustness test, the spillover effect of peer ESG disclosure still exists.

Second, according to the intermediate mechanism test's findings, improving ESG performance by peers can encourage target enterprises' green innovation by reducing financial limitations, information asymmetry, and green awareness.

Third, according to heterogeneity tests, the influence of peer ESG performance on green innovation is significantly more significant in SOEs, large-scale businesses, and businesses located in the eastern central region.

The following are the study's policy recommendations: First, the government and regulators should improve the mechanism for ESG disclosure and the system for rewards and penalties, provide financial subsidies, tax breaks, credit support, and other benefits to companies that do well in ESG, and penalize and supervise companies that do poorly in ESG. Second, industry management departments should actively optimize the industry's competitive environment, create a business-friendly environment, improve the information environment, and promote healthy competition among enterprises. Third, enterprises should create ESG development strategies and integrate green awareness into corporate strategy, management systems, and daily operations.

Additionally, this study has certain limitations. First, there is not enough sample coverage. Only the heavily polluting listed enterprises are selected, and other industries are not included in the study, which may lead to limited universality of the research conclusions. Second, this paper's research conclusion is based on the Chinese institutional environment, and whether it impacts developed countries needs to be tested. In the future, we can continue to track the practice frontier and constantly improve relevant research.

Author Contributions: Conceptualization, Mingyue Li; Data curation, Mingyue Li; Formal analysis, Mingyue Li; Investigation, Xin Wang; Methodology, Mingyue Li; Supervision, Xin Wang; Writing – original draft, Mingyue Li; Writing – review & editing, Mingyue Li.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Adhikari, B. K., & Agrawal, A. (2018). Peer influence on payout policies. *Journal of Corporate Finance*, 48, 615–637.
- [2] Amihud, Y. (2002). Illiquidity and stock returns: Cross-section and time-series effects. *Journal of Financial Markets*, 5(1), 31–56.
- [3] Amihud, Y., & Mendelson, H. (1997). Market microstructure and securities values: Evidence from the Tel Aviv Stock Exchange. *Journal of Financial Economics*, 45(3), 365–390.
- [4] Bazrafshan, E. (2023). The role of ESG ranking in retail and institutional investors' attention and trading behavior. *Finance Research Letters*, 58, 104551.
- [5] Bustamante, M. C., & Fresard, L. (2021). Does firm investment respond to peers' investment? *Management Science*, 67(8), 4703–4724.
- [6] Cai, Y., Pan, C. H., & Statman, M. (2016). Why do countries matter so much in corporate social performance? *Journal of Corporate Finance*, 41, 591–609.
- [7] Deng, P., Wen, J., He, W., Chen, Y.-E., & Wang, Y.-P. (2023). Capital market opening and ESG performance. *Emerging Markets Finance and Trade*, 59(13), 3866–3876.
- [8] Dremptic, S., Klein, C., & Zwergel, B. (2020). The influence of firm size on the ESG score: Corporate sustainability ratings under review. *Journal of Business Ethics*, 167(2), 333–360.
- [9] Foroughi, P., Marcus, A. J., Nguyen, V., & Tehranian, H. (2022). Peer effects in corporate governance practices: Evidence from universal demand laws. *Review of Financial Studies*, 35(1), 132–167.
- [10] Grennan, J. (2019). Dividend payments as a response to peer influence. *Journal of Financial Economics*, 131(3), 549–570.
- [11] Gu, Y., Ben, S., & Lv, J. (2022). Peer effect in merger and acquisition activities and its impact on corporate sustainable development: Evidence from China. *Sustainability*, 14(7), 4210.
- [12] Hadlock, C. J., & Pierce, J. R. (2010). New evidence on measuring financial constraints: Moving beyond the KZ index. *Review of Financial Studies*, 23(5), 1909–1940.
- [13] Huang, X., Ren, Y., & Ren, X. (2024). Legal background executives, corporate governance and corporate ESG performance. *Finance Research Letters*, 69, 105125.
- [14] Jiao, J.-l., Zhang, X.-l., & Tang, Y.-s. (2020). What factors determine the survival of green innovative enterprises in China? —A method based on fsQCA. *Technology in Society*, 62, 101314.
- [15] Li, J., & Xu, X. (2024). Can ESG rating reduce corporate carbon emissions? —An empirical study from Chinese listed companies. *Journal of Cleaner Production*, 434, 140094.
- [16] Li, J., Lian, G., & Xu, A. (2023). How do ESG affect the spillover of green innovation among peer firms? Mechanism discussion and performance study. *Journal of Business Research*, 158, 113676.
- [17] Lieberman, M. B., & Asaba, S. (2006). Why do firms imitate each other? *Academy of Management Review*, 31(2), 366–385.
- [18] Liu, M., Lu, J., Liu, Q., Wang, H., Yang, Y., & Fang, S. (2024). The impact of executive cognitive characteristics on a firm's ESG performance: An institutional theory perspective. *Journal of Management and Governance*. Advance online publication.
- [19] Lu, Y., Wang, R., Shi, Y., Su, C., Yuan, J., Johnson, A. C., Jenkins, A., Ferrier, R. C., Chen, D., Tian, H., Melillo, J., Song, S., & Ellison, A. M. (2018). Interaction between pollution and climate change augments ecological risk to a coastal ecosystem. *Ecosystem Health and Sustainability*, 4(7), 161–168.

- [20] Meira, E., Cunha, F. A. F. S., Orsato, R. J., Miralles-Quiros, M. M., & Miralles-Quiros, J. L. (2023). The added value and differentiation among ESG investment strategies in stock markets. *Business Strategy and the Environment*, 32(4), 1816–1834.
- [21] Ni, J., Jin, S., Hu, Y., & Zhang, L. (2023). Informative or distracting: CSR disclosure of peer firms and analyst forecast accuracy. *International Review of Financial Analysis*, 87, 102592.
- [22] Pastore, L. M., & Stambaugh, R. F. (2003). Liquidity risk and expected stock returns. *Journal of Political Economy*, 111(3), 642–685.
- [23] Sahin, O., Bax, K., Czado, C., & Paterlini, S. (2022). Environmental, Social, Governance scores and the Missing pillar—Why does missing information matter? *Corporate Social Responsibility and Environmental Management*, 29(5), 1782–1798.
- [24] Shin, H., Kim, S.-I., Park, S., & Shin, H. (2019). The effect of industry homogeneity on the magnitude of post-earnings announcement drift: Evidence from Korea. *Asian Academy of Management Journal of Accounting and Finance*, 15(1), 107–127.
- [25] Siew, R. Y. J., Balatbat, M. C. A., & Carmichael, D. G. (2016). The impact of ESG disclosures and institutional ownership on market information asymmetry. *Asia-Pacific Journal of Accounting & Economics*, 23(4), 432–448.
- [26] Tan, X., Yan, Y., & Dong, Y. (2022). Peer effect in green credit induced green innovation: An empirical study from China's Green Credit Guidelines. *Resources Policy*, 76, 102619.
- [27] Velte, P., & Stawinoga, M. (2020). Do chief sustainability officers and CSR committees influence CSR-related outcomes? A structured literature review based on empirical-quantitative research findings. *Journal of Management Control*, 31(4), 333–377.
- [28] Verdi, S., Marquand, A. F., Schott, J. M., & Cole, J. H. (2021). Beyond the average patient: How neuroimaging models can address heterogeneity in dementia. *Brain*, 144(9), 2946–2953.
- [29] Vural-Yavas, C. (2021). Economic policy uncertainty, stakeholder engagement, and environmental, social, and governance practices: The moderating effect of competition. *Corporate Social Responsibility and Environmental Management*, 28(1), 82–102.
- [30] Wang, J., Wu, G., Huang, X., Sun, D., & Song, Z. (2023). Peer effects of corporate product quality information disclosure: Learning and competition. *Journal of International Financial Markets, Institutions & Money*, 88, 101832.
- [31] Wang, Z., & Xing, T. (2024). ESG information disclosure, stock price informativeness and corporate digital transformation. *Applied Economics*. Advance online publication.
- [32] Wu, H., Zhang, K., & Li, R. (2024). ESG score, analyst coverage and corporate resilience. *Finance Research Letters*, 62, 105179.
- [33] Xu, H., & Wu, Y. (2022). The China trade shock and the ESG performances of US firms. *arXiv*.
- [34] Zell, E., & Alicke, M. D. (2010). Comparisons over time: Temporal trajectories, social comparison, and self-evaluation. *European Journal of Social Psychology*, 40(3), 375–382.
- [35] Zhai, X., & An, Y. (2020). Analyzing influencing factors of green transformation in China's manufacturing industry under environmental regulation: A structural equation model. *Journal of Cleaner Production*, 251, 119760.
- [36] Zhang, B., Wang, Z., & Lai, K.-h. (2015). Mediating effect of managers' environmental concern: Bridge between external pressures and firms' practices of energy conservation in China. *Journal of Environmental Psychology*, 43, 203–215.

Research On the Impact of Data Assetization on Enterprise New Quality Productivity

Zichen Wang*

University of Shanghai for Science and Technology, shanghai, 200082, China

*Corresponding author: Zichen Wang, 19512498386@163.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In the era of digital economy, data assets have become one of the key assets that affects the competitiveness of enterprises. The most important assets of enterprises since the 21st century is data; An important factor to significantly improve the production level and production efficiency of enterprises, and also an important engine to promote the transformation of enterprise productivity from “old” to “new”. How to manage and apply data assets to promote the development of new quality productivity of enterprises is one of the important issues for the survival and development of enterprises in the era of digital economy. As an important step in mining the value of data, data assetization has aroused extensive attention and discussion on the enabling effect and enabling way of new quality productivity.

This paper focuses on the specialized small and medium-sized enterprises, and studies the impact and mechanism of data assets on the new quality productivity of enterprises. The results show that: 1. The improvement of data assets will help to promote the development of new quality productivity in a variety of specialized company sizes. 2. Data assets can significantly improve the new quality productivity of specialized companies, and its core mechanism as follows: data credit enabling and capital allocation optimization; collaborative optimization of intelligent decision-making and operation; knowledge precipitation and R&D paradigm transformation; demand insight and driving mechanism of industrial upgrading; ecological coordination and value network reconstruction. 3. Data assets play a stronger role in promoting the new quality productivity of firms with smaller scale, higher information transparency and those in the western region.

Keywords: Data Assetization; New Quality Productivity; Specialized Small and Medium-Sized Enterprises

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.625>

1.Introduction

In the context of the digital economy, data has become a key factor of production alongside: land, labor, capital and technology - profoundly reshaping the global economic development model and competition pattern. With the in-depth development of the new round of technological revolution and industrial transformation, the value creation capacity of data elements is increasingly prominent^[1]. Data assetization, as an important path to release the value of data elements, is attracting widespread attention and practical exploration worldwide. China is currently at a critical stage of high-quality economic development, and cultivating new quality productivity has become a strategic choice to promote industrial upgrading and transformation of economic growth patterns. Data assetization, by empowering enterprises to innovate and develop, is becoming an important engine for generating new quality productivity. Against this macro background, in-depth exploration

of the impact mechanism of data assetization on enterprises' new quality productivity has significant theoretical significance and practical value.^[2]

At present, the construction of the data element market in China is in a stage of rapid development. From the policy perspective, the state has successively issued important documents on enterprise data, providing institutional guarantees and practical guidance for the assetization of data. From the perspective of market practice, data exchanges have been established in various regions, and the service system for data registration, evaluation, and trading has gradually improved.^[3] Financial innovation products such as data asset pledge financing and data insurance have emerged continuously. Especially in the field of specialized, refined, distinctive, and innovative small and medium-sized enterprises, the assetization of data is becoming an important way to solve financing problems, enhance innovation capabilities, and strengthen market competitiveness. However, the process of data assetization still faces challenges such as difficulty in rights confirmation, valuation, and accounting entry, and it is urgent to seek breakthroughs through theoretical research and practical exploration.

From the perspective of theoretical development, although existing research has already paid attention to the importance of data elements, the research on the specific mechanism by which data assetization affects the new quality productivity of enterprises is still not systematic. Especially in the context of the accelerated advancement of digital transformation, it is necessary to deeply analyze how data assetization promotes the quality, efficiency, and power transformation of enterprises through optimizing resource allocation, empowering technological innovation, and reshaping business models. This study aims to systematically construct a theoretical framework for the impact of data assetization on the new quality productivity of enterprises, deeply analyze its mechanism of action, and provide theoretical support and practical guidance for promoting the value release of data elements and cultivating new quality.

2. Definition of data capitalization

Data assetization refers to the process by which enterprises transform raw, scattered, and disordered data resources into strategic economic assets that are identifiable, measurable, controllable, and tradable through systematic technical processing, governance integration, value assessment, and compliance-based rights confirmation. This process not only involves the technical organization of data (such as cleaning, tagging, and modeling), but also includes the institutional construction of its property rights, value measurement, and financial empowerment, enabling it to rise from a by-product attached to business operations to an independent core production factor. For specialized, refined, distinctive, and innovative small and medium-sized cities, data assetization is not merely a collection of data, but rather the in-depth extraction and capital reorganization of high-value data accumulated in specialized production, refined operation, and distinctive innovation (such as process parameters, supply chain logs, user behavior trajectories, and R&D test data). Its essence lies in promoting the transformation of enterprises from traditional factor-driven to innovation-driven through the asset recognition of data elements, thereby solidifying the micro-foundation of new-quality productivity.

The theoretical framework of data assetization encompasses multiple dimensions: at the technical level, it requires enterprises to transform raw data into standardized and modular data products (such as API interfaces, analysis reports, and digital twins) through tools like data platforms, Internet of Things perception, and algorithm models; at the management level, a full life-cycle governance system covering data collection, storage, sharing, and destruction needs to be established, along with a clear property rights structure that separates data resource ownership, processing and usage rights, and product operation rights; at the value level, it is necessary to realize the economic value of data assets and their circulation through assessment and pricing, financial instrument design, and market trading mechanisms. For specialized, refined, distinctive, and innovative enterprises, this process particularly emphasizes the deep integration of data elements with the main business, such as optimizing production processes through industrial data modeling or developing differentiated products by leveraging market data insights, ultimately forming a positive cycle of "data-driven innovation - innovation enhancing asset value - value feeding back into R&D".

At present, the development of data assetization in specialized, refined, distinctive and innovative small and medium-sized enterprises (SMEs) shows a phased characteristic of "active policy-driven, nascent practical exploration, and core challenges yet to be resolved". At the policy level, both the national and local governments are making efforts: The "Special Action Plan

for Digital Empowerment of SMEs “ jointly issued by the Ministry of Industry and Information Technology and other four departments explicitly requires “supporting SMEs to conduct data asset value assessment and legally and properly record them in the books”, and sets the goal of achieving full digital transformation coverage for specialized, refined, distinctive and innovative enterprises and a key process numerical control rate of 75% by 2027. Jiangsu, Zhejiang and other regions have taken the lead in piloting the data intellectual property rights registration system, and through standards such as the “Service Specifications for the Registration of Enterprise Data Resource Holding Rights”, they are granting rights and certificates to data, exploring application scenarios such as data asset valuation for equity investment and securitization. For instance, Jiaxing Nanhu District issued the country’s first data resource holding rights registration certificate, providing ownership guarantee for data transactions of SMEs; a cultural and tourism enterprise in Xingyi, Guizhou obtained bank financing through data intellectual property rights pledge, highlighting the potential of data assets in financial empowerment.

However, specialized, refined, distinctive and innovative enterprises are confronted with core bottlenecks such as difficulty in rights confirmation, valuation, and accounting. Firstly, there is a lack of a unified national standard for the definition of data ownership. Although some localities have explored the “registration certificate” model (such as Hangzhou and Jiaxing), the cross-regional mutual recognition mechanism has yet to be established, leaving enterprises under the pressure of both legal risks and high compliance costs. Secondly, the data valuation system is still immature. Traditional cost and income approaches are not suitable for the scenario dependence and value volatility of data assets, leading to cautious risk control by financial institutions and limited scale of pledge financing. Moreover, although the Ministry of Finance has promoted the inclusion of data resources in financial statements, small and medium-sized enterprises, due to the lack of professional talents and financial norms, face challenges in practical operations such as the absence of accounting measurement and disclosure standards. Additionally, there are also technical obstacles: most companies have weak data governance capabilities, with a low proportion of DCMM (Data Management Capability Maturity) standardization, and data quality is uneven and isolated, making it difficult to support the transformation of high-value assets.

3. Definition of new quality productivity

New-quality productivity is the modernization of Marxist productivity theory with Chinese characteristics in the era of digital economy. Its core essence lies in being led by scientific and technological innovation, breaking away from traditional economic growth paths and productivity development models, and embodying the characteristics of high technology, high efficiency, and high quality, which conforms to the advanced productivity state of the new development concept. It is not a breakthrough in a single technology or element, but a systematic leap in productivity driven by revolutionary technological breakthroughs, innovative allocation of production factors, and in-depth transformation and upgrading of industries. New-quality productivity emphasizes the creation of new industries, new models, and new driving forces through original and disruptive scientific and technological innovation, promoting the evolution of production factors to more advanced and complex forms. Its essence is productivity where innovation plays a leading role. For the group of specialized, refined, distinctive, and innovative small and medium-sized enterprises (hereinafter referred to as “specialized, refined, distinctive, and innovative enterprises”), the development of new-quality productivity is not only about technological upgrading but also means the reshaping of their status as innovation subjects and the climbing of their positions in the global value chain.

In terms of theoretical framework, new-quality productivity presents multi-level structural features. Firstly, its factor structure undergoes fundamental changes, with data as a new type of production factor deeply integrated with traditional factors such as labor, capital, land, knowledge, technology, and management, enhancing the efficiency of resource allocation and stimulating the improvement of total factor productivity. Secondly, its technological foundation is composed of clusters of cutting-edge technologies, with disruptive and frontier technologies such as artificial intelligence, advanced manufacturing, new materials, and biotechnology becoming the core engines driving growth, promoting the transformation of the industrial paradigm from “factor-driven” to “innovation-driven”. Thirdly, its industrial carriers are highly modernized, reflected not only in the cultivation and expansion of strategic emerging industries and future industries but also in the high-end, intelligent, and green transformation of traditional industries through digitalization and environmentally friendly. Specialized, refined, distinctive, and innovative enterprises, as the main force of innovation focusing on niche markets and mastering key core

technologies, their development state directly affects the micro foundation of new-quality productivity.

As the key bearers and practitioners of new-quality productivity, the “newness” of the productivity state of specialized, refined, distinctive, and innovative enterprises is mainly reflected in three aspects: technological novelty, outstanding efficiency, and sustainable development. Technological novelty refers to the formation of “filling the gap”, “strengthening the weak points”, or “filling the blank” technological advantages in specific fields through independent research and development or collaborative innovation, with their innovation activities featuring high R&D intensity, high patent density, and high market exclusivity, such as developing key components or specialized equipment to replace imports. Outstanding efficiency is demonstrated by achieving cost reduction and efficiency improvement as well as precise control throughout the entire process through lean production, intelligent transformation, and digitalization, with their labor productivity per capita, resource utilization rate, and product quality stability reaching industry-leading levels, such as realizing predictive maintenance of production equipment and dynamic optimization of energy consumption through industrial internet platforms. Sustainable development requires embedding green and low-carbon concepts into the entire process of product design, process selection, and supply chain management, achieving the unification of economic and ecological benefits through the development of energy-saving products, the use of clean energy, and the reduction of waste emissions.

The generation and expansion of new-quality productivity in specialized, refined, distinctive, and innovative enterprises highly depend on the collaborative empowerment of the innovation ecosystem. This ecosystem, with enterprises as the main body, universities and research institutions providing knowledge spillover and technological support, the government providing institutional supply and policy incentives, and financial institutions providing risk capital and financing services, jointly form a support network promoting a virtuous cycle of technology, industry, and finance. The role of the government lies in creating an institutional environment conducive to original innovation through industrial policies, innovation funds, and tax incentives, especially addressing issues such as insufficient investment in basic research and poor conversion of scientific and technological achievements. Financial institutions need to innovate financial tools and develop businesses such as intellectual property pledge and data asset financing to alleviate the financing constraints faced by light-asset-operating technology enterprises. Only when the innovation chain, industrial chain, capital chain and talent chain are deeply integrated can specialized, refined, distinctive and innovative enterprises break through the innovation bottleneck of long research and development cycles and high uncertainty and continuously climb to the high end of the value chain.

4. Research on the effect mechanism of data assets on new quality productivity of enterprises

4.1 Mechanism 1: Data Credit Empowerment and Capital Allocation Optimization Mechanism

The core of the data credit empowerment and capital allocation optimization mechanism lies in the transformation of data assets to improve information asymmetry, reshape the enterprise credit system, guide the precise allocation of financial resources, and break the financing constraints of scientific and technological innovation activities. During the process of data assetization, enterprises collect, govern, confirm the rights to, and value their internal and external data, making the potential value of their data resources explicit and quantifiable. Particularly with the implementation of the “Interim Provisions on Accounting Treatment of Enterprise Data Resources”, eligible data resources can be included in financial statements, providing a system foundation for data assets to serve as new types of collateral and credit endorsements. For technology-oriented small and medium-sized enterprises with abundant data assets but lacking traditional collateral, their innovation capabilities, market prospects, and user value can be more comprehensively demonstrated through data assets. Financial institutions can leverage big data risk control models to integrate and analyze multi-dimensional information such as transaction flows, logistics information, patent dynamics, and public opinion data of enterprises, conducting more accurate credit profiling and risk assessment. This enables credit resources to break free from the traditional reliance on fixed asset collateral and financial indicators, and flow more effectively to those “specialized, refined, distinctive, and innovative” enterprises with high growth potential and high technological content, addressing the most critical issue of capital supply for the development of new quality productivity. Research shows that data assets can effectively alleviate the financing constraints of enterprises, thereby enhancing their willingness and ability to invest in innovation. This process not only

optimizes the capital structure of micro-enterprises but also enhances the overall efficiency of capital allocation in society, providing fertile financial soil for the nurturing of new quality productivity.

4.2 Mechanism 2: Intelligent Decision-making and Operational Synergy Optimization Mechanism

The core of the intelligent decision-making and operational synergy optimization mechanism lies in the data assetization breaking down information silos, empowering real-time perception and intelligent decision-making across the board, achieving a leap in full-chain efficiency, embodying the “high efficiency” feature of new quality productivity. Data assetization is not merely the accumulation of data but involves building a unified, standardized, and high-quality enterprise-level data platform and indicator system to transform raw data into “data asset units” that can be directly utilized by business. This lays a solid foundation for the application of advanced data analysis, artificial intelligence algorithms, and digital twin technologies. At the production level, real-time monitoring and analysis of equipment sensor data, process parameters, and environmental information can achieve predictive maintenance, dynamic energy optimization, and online quality control, minimizing unplanned downtime and quality losses, and enhancing production capacity utilization. At the supply chain level, by integrating and analyzing multi-source data such as market demand, inventory levels, and logistics status, enterprises can achieve precise demand forecasting, dynamic inventory optimization, and intelligent transportation route planning, building a flexible, agile, and risk-resistant supply chain network. For instance, studies show that the application of data assets can significantly reduce enterprise management costs, and many enterprises have achieved substantial cost savings through data application. This not only enables parallel collaboration among internal departments such as R&D, production, and marketing in specialized, refined, distinctive, and innovative small and medium-sized enterprises but also drives real-time networked collaboration among upstream and downstream in the industrial chain, upgrading from a “chain series” model to a “network parallel” model, greatly enhancing total factor productivity and system resilience.

4.3 Mechanism 3: Knowledge Accumulation and R&D Paradigm Transformation Mechanism

The core of the knowledge accumulation and R&D paradigm transformation mechanism lies in converting data into reusable and iterative knowledge assets, promoting the transformation of R&D from “experimental trial and error” to “simulation and emulation”, driving revolutionary technological breakthroughs, and solidifying the “high-tech” foundation. The core of new quality productivity is innovation. Data assetization transforms the massive dark data generated in the R&D, experimentation, production, and service processes into structured machine learning fuel and digital twins. In research-intensive fields such as bio-medicine, new materials, and aerospace, AI models trained on high-quality data assets can simulate compound interactions, predict material properties, and optimize complex system designs, enabling massive screening and iteration in the digital space. This significantly shortens the R&D cycle and reduces the high cost of physical trial and error. This new paradigm of “AI-driven R&D” (AI4R&D) transforms the innovation process from an art dependent on individual scientists’ experience and inspiration to a systematic and engineering science. Moreover, data assets are non-competitive and reusable. A high-quality experimental data-set or a trained algorithm model can be reused in different projects and teams, continuously generating value and accelerating the accumulation and inheritance of knowledge. This not only solves the problem of innovation efficiency but also may bring unexpected original innovations in basic research, serving as a key mechanism for achieving “breakthroughs from 0 to 1”.

4.4 Mechanism 4: Demand Insight and Industrial Upgrade Driving Mechanism

The core of the demand insight and industrial upgrade driving mechanism lies in using data assets to deeply understand users and the market, promoting precise matching of supply and demand, fostering new business forms, and guiding industries towards high-end evolution. Data assets enable enterprises to perceive, understand, and predict market demands in real time with unprecedented granularity. By analyzing user behavior data, sentiment tendencies on social media, and product usage data from sensors, enterprises can not only discover explicit demands but also uncover latent demands that users themselves are not aware of. This drives the production model to shift from traditional mass manufacturing (B2C) to user-centered mass customization (C2M), achieving a high-level dynamic balance between supply and demand and reducing resource misallocation and waste. Furthermore, data assets themselves can be productized and serviced, giving rise to new business models and revenue sources, such as providing data API services, industry insight reports, and data-based subscription

services. At the industrial level, the penetration and integration of data elements drive the deep digital transformation of traditional industries, empowering data-driven emerging industries such as intelligent connected vehicles, smart energy, and digital healthcare to grow stronger. Ultimately, this mechanism guides the economic structure from factor-driven to innovation-driven, promoting the entire industrial system towards high-end, intelligent, and green upgrades, serving as the core driving force for deep industrial transformation and upgrading.

4.5 Mechanism 5: Ecological Synergy and Value Network Reconstruction Mechanism

The core of the ecological synergy and value network reconstruction mechanism lies in the secure and trusted circulation of data elements to build cross-organizational innovation ecosystems and value co-creation networks, elevating competition from individual enterprises to industrial ecosystem competition. The development of new quality productivity is not the result of a single enterprise's closed efforts but relies on the vitality of the entire innovation ecosystem. The process of data assetization is accompanied by the gradual improvement of data rights confirmation, pricing, security auditing, and compliance circulation frameworks. This provides the possibility for the secure, trusted, and compliant sharing and integration of data elements on a larger scale, including among enterprises, upstream and downstream partners, peers, and even cross-industry entities. Based on shared data assets, enterprises can engage in deeper R&D cooperation (such as joint research), more efficient business collaboration (such as collaborative manufacturing), and more agile value co-creation (such as jointly building solutions). For instance, leading enterprises can open their industry data platforms to attract numerous small and medium-sized enterprises and developers, forming a "platform + ecosystem" business model that stimulates the innovation vitality of the entire ecosystem. This transforms competition from a battle between individual enterprises to a confrontation between ecological networks. An enterprise that can efficiently integrate and utilize internal and external data assets and is adept at collaborative innovation within the ecosystem will gain unprecedented networked competitive advantages and continuous evolutionary capabilities. This mechanism unlocks the value of data elements from a higher dimension and is the key to achieving systematic and holistic development of new productive forces.

5. Conclusions

This study systematically analyzes the mechanism by which data assetization affects the new quality productivity of enterprises, revealing the profound impact of data, as a new production factor, on enterprise development through five core paths. Data assetization is not merely a technical process but a systematic project involving the reconstruction of production factors, innovation in business models, and organizational transformation. The study discovers five mechanisms: optimization of credit resource allocation, intelligent decision-making and operational synergy, knowledge accumulation and transformation of R&D paradigms, demand insight and driving industrial upgrading, and ecological collaboration and value network reconstruction. These mechanisms, interrelated and progressive, jointly promote the transformation of enterprises towards a high-tech, high-efficiency, and high-quality development model from multiple dimensions, including capital supply, efficiency improvement, technological innovation, market orientation, and ecological construction.

The research finds that data assetization effectively alleviates the financing constraints of enterprises, especially small and medium-sized specialized, refined, distinctive, and innovative enterprises, by improving information asymmetry and risk pricing capabilities, providing crucial financial support for innovation and development. Moreover, by breaking down data silos and building intelligent decision-making systems, data assetization significantly enhances operational efficiency and resource allocation capabilities of cities, achieving a leap in total factor productivity. More importantly, data assetization drives a fundamental transformation in R&D paradigms, shifting from traditional trial-and-error models to data-driven and simulation-based models, accelerating technological innovation and knowledge accumulation. At the market demand level, data assetization enables enterprises to more accurately perceive and create demand, promoting industrial upgrading towards high-end and intelligent directions. Finally, by facilitating the secure circulation of data elements and ecological collaboration, data assetization helps enterprises build more open and collaborative innovation networks, moving from individual competition to ecological competition.

However, the development of data assetization still faces many challenges. Issues such as difficulty in rights confirmation, valuation, and accounting entry have not been fundamentally resolved. The data governance system and security guarantee

mechanisms still need improvement, and barriers to cross-regional and cross-industry data circulation remain. The resolution of these problems requires the joint participation and collaborative efforts of multiple stakeholders, including the government, enterprises, research institutions, and financial institutions. In the future, it is necessary to further strengthen the construction of data basic systems, improve the data asset evaluation and trading system, promote the standardized development of the data element market, and encourage enterprises to enhance their data governance capabilities and cultivate a data-driven innovation culture.

The theoretical contribution of this study lies in constructing a systematic analysis framework for the impact of data assetization on the new quality productivity of enterprises, enriching the theoretical research on data elements and productivity development. At the practical level, it provides theoretical guidance and practical paths for enterprises to advance the process of data assetization and enhance new quality productivity. Looking ahead, with the in-depth advancement of data element market-oriented allocation reforms and continuous innovation in data technology, data assetization will play an increasingly important role in cultivating new quality productivity and promoting high-quality economic development. This requires not only technological and management innovation but also institutional innovation and ecological construction, with the joint efforts of multiple parties to release the potential value of data elements and continuously inject impetus into enterprise innovation and development.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Birge, J. R., Capponi, A., & Chen, P. (2023). Disruption and rerouting in supply chain networks. *Operations Research*. Advance online publication.
- [2] Fisher, T. (2009). *The data asset: How smart companies govern their data for business success*. John Wiley & Sons.
- [3] Williamson, O. E. (2007). *The economic institutions of capitalism: Firms, markets, relational contracting*. Springer.

Analysis on the Impact of Digital Finance on Carbon Emissions under the Background of “Double Carbon”

Rong Liang*

School of Management, Xi'an Polytechnic University, Shaanxi Xi'an, 710048, China

*Corresponding author: Rong Liang, 2412458450@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Under the background of frequent global extreme climate problems, achieving the goal of peak carbon dioxide emissions and carbon neutrality has become the main policy to promote the process of carbon emission reduction. At the same time, as a new financial form, digital finance has gradually increased its impact on carbon emissions. Through in-depth analysis of the multiple influence mechanisms between digital finance and carbon emissions, this paper discusses the direct and indirect roles of digital finance in promoting the development of low-carbon economy. However, digital finance also faces many challenges in the process of carbon emission application, such as the lagging digital system of carbon finance market, insufficient innovation of digital products of carbon finance, and insufficient understanding and participation of all parties. Therefore, in order to give full play to the positive role of digital finance in reducing carbon emissions, it is necessary to strengthen the construction of digital system of carbon finance market, speed up the design of digital products of carbon finance and improve the understanding and participation of all parties. This paper has important theoretical and practical significance for understanding and using digital finance to promote the development of low-carbon economy.

Keywords: “Double Carbon” Target; Digital Finance; Carbon Emissions; Carbon Finance

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.626>

1.Introduction

Destructive human activities such as industrialization and the extensive use of fossil fuels have caused frequent global extreme climate problems. Among them, a large number of greenhouse gas emissions pose a serious threat to the global ecosystem and human survival. Therefore, achieving the goal of carbon emission reduction is not only the need to protect the earth's ecological environment, but also the inevitable requirement to achieve sustainable development. As one of the largest emitters of greenhouse gases in the world, China bears an important responsibility in tackling climate change. In order to promote the process of carbon emission reduction, it has become an important strategy for China to achieve the “double carbon” goal of peak carbon dioxide emissions and carbon neutrality, which will promote the adjustment of China's industrial structure and energy structure, promote the research and development and application of green low-carbon technologies, improve energy utilization efficiency and reduce greenhouse gas emissions. As a new model of modern financial services, digital finance provides new solutions and financial support for carbon emission reduction and gradually plays an important role in the process of carbon emission reduction. Based on the goal of “double carbon”, this paper explores the mechanism of the impact of digital finance on carbon emission reduction from both direct and indirect perspectives, deeply analyzes the

challenges faced by digital finance in carbon emission application, and finally puts forward relevant suggestions on enabling carbon emission by digital finance, with a view to providing theoretical support and practical guidance for the realization of the goal of “double carbon”.^[1-3]

2.The multiple impact mechanism of digital finance on carbon emissions

2.1 Direct influence

First, innovative investment and financing channels. By providing innovative investment and financing channels for green and low-carbon projects, digital finance enables enterprises and consumers to obtain green financial products and services more conveniently, helps investors better understand and invest in green technology projects, evaluates and screens green technology projects, and guides funds to flow to low-carbon and environmentally-friendly carbon emission projects and gather in the field of green technology. It can not only give priority to providing financial support for projects or enterprises with low carbon emissions, but also provide investors with green investment choices, thus promoting the transformation of the whole society into a low-carbon economy. Second, reduce the intensity of energy consumption. Digital finance reduces the use of paper documents and physical bank outlets by optimizing financial services and improving financial efficiency, and through digital means such as Internet payment and mobile payment, thus reducing the energy consumption intensity of financial activities. Third, improve efficiency and reduce costs. Digital financial platform has Internet financial platform and intelligent investment. Through intelligent service means, traditional financial transactions and financial service processes are simplified, green financial products can be traded and transferred more conveniently, the financing efficiency of green financial market is improved, and the cost of financial transactions involved in carbon emission projects is reduced, so as to accelerate the process of carbon emission reduction.^[4]

2.2 Indirect effects

From the perspective of consumption patterns. Digital finance can reduce carbon emissions by promoting greener consumption patterns. The convenient payment method provided by digital finance can reduce dependence on traditional physical currency and bank cards, thus reducing resource consumption and environmental pollution related to these physical media. In addition, convenient payment methods such as mobile payment accelerate customer decision-making, drive customer demand and improve customer consumption patterns. Some payment platforms have also launched a green point system to encourage users to use green travel modes or buy environmentally-friendly products, and promote green consumption through the point reward mechanism. From the perspective of industrial structure. By supporting green technology innovation, digital finance can accurately assess the environmental impact of projects, effectively integrate various information resources into production decisions, promote the restructuring of industrial systems, and promote the transfer of labor-intensive industries to environmentally friendly technology-intensive industries, and improve the efficiency of resource allocation. Technological progress can not only improve energy efficiency, but also reduce energy consumption and carbon emission intensity during manufacturing.^[5-6]

3.challenges faced by digital finance in the application of carbon emissions

3.1 carbon financial market digital system lags behind

Compared with developed countries, China’s low-carbon financial system has been formed slowly, and the development of low-carbon finance faces many challenges. Moreover, the lag of the digital system of carbon finance market also reflects that the impact of digital finance on carbon emissions is still weak. First of all, low-carbon finance is a new financial development mode, and commercial financial institutions are cautious about economic needs such as loans involving low-carbon economy, which makes the digital development of low-carbon finance lack the support of financial institutions, resulting in a poor financing environment for digital low-carbon finance and a lack of sufficient development momentum. Secondly, the digital system of carbon finance market in China is relatively backward, and the relevant rules and mechanisms for the application of digital finance have not been fully established, and there are problems such as regulatory gaps and overlapping, which limit the development of carbon finance and the application of digital finance in carbon emissions to some extent. At the same time, because the price of carbon emission rights is affected by the relationship between market supply and demand, there will be

corresponding fluctuations, which makes it difficult for all parties involved in carbon finance to plan and predict the benefits and risks of carbon finance business. It may lead to market chaos and risk events. Therefore, although digital technology provides convenience for the collection and processing of carbon emission data, in practice, the application of digital finance in carbon emission still faces some challenges.

3.2 carbon finance digital product innovation is insufficient

Due to the late start of carbon financial market, domestic enterprises and financial institutions lack a deep understanding of low-carbon economic operation mode, social benefits and other aspects, and lack awareness of carbon resources trading. To a certain extent, domestic enterprises, commercial banks or financial institutions have a single category of digital financial products in carbon emission reduction, and the types and quantities are relatively small, and there is still a lack of characteristic digital financial products for carbon emission projects, which cannot meet the diversified needs of the market. Although some financial institutions have initially developed digital financial products for carbon emission reduction, compared with diversified digital financial products around the world, China's carbon financial products are difficult to meet the market demand in terms of quantity and function, which leads to insufficient activity of the carbon financial market and affects its attractiveness and influence. Moreover, in terms of innovation, digital financial products aimed at carbon emission reduction are weak in innovation and lack new carbon financial products with high added value and market competitiveness. In addition, the government's support for the innovation of carbon financial products is insufficient, and the incentive measures are insufficient, which leads to the lack of sufficient motivation for financial institutions and enterprises to promote the digital innovation of carbon financial products.

3.3 insufficient understanding and participation of all parties.

For a long time, environmental education has not penetrated into all levels of society, and the popularity of carbon finance market is not high. As a result, most domestic financial institutions have limited understanding of low-carbon financial business with carbon emissions and its impact on climate change, which makes enterprises and the public have limited awareness and acceptance of carbon financial products. It takes time and patience to change the long-term consumption habits with high energy consumption and high carbon emissions. Friction and resistance in the process of transformation make it difficult for the public to practice a low-carbon lifestyle. At the same time, low-carbon lifestyles and green financial products require the public and all participants to bear additional economic costs in the short term. Because buying energy-saving appliances or choosing green products means increasing additional initial investment, and the research and development and promotion of high-end green technologies need a long period, it is difficult for enterprises to fully realize the transformation of production mode in a short period of time. Due to the contradiction between personal interests and environmental protection objectives, all participants will give priority to traditional products or production modes with lower costs when facing economic pressure. In addition, the potential risks of digital financial products and green financial products also deter some participants. Digital financial products and green financial products, as the products of new national policies, belong to emerging fields. In addition, the lack of financial knowledge and limited understanding of new digital green financial products lead to low awareness and participation, and all participants prefer traditional and familiar financial products in investment selection.

4.digital finance to enable carbon emission reduction countermeasures and suggestions

4.1 Digital system construction of carbon financial market

At the production level, improve the energy efficiency of digital financial infrastructure. The green transformation of digital financial data center is the key step, and the data center should adopt the latest energy-saving equipment and advanced cooling technology. At the same time, the intelligent management system is introduced into the production enterprises, the energy efficiency evaluation and certification system is established, and through real-time monitoring and dynamic adjustment of the running state and working mode of equipment, excessive cooling and waste of resources are avoided, refined energy consumption control is realized, and energy consumption is further reduced. In addition, we will optimize the allocation of credit resources through digital technology, improve the technology and finance system, promote the development of green and low-carbon technology enterprises, and then promote carbon emission reduction. At the consumption level, establish a

comprehensive carbon market database to promote the digital transformation of the carbon financial market. Use big data, artificial intelligence and other technologies to improve the efficiency and convenience of financial services and develop an intelligent carbon financial trading platform. Moreover, it is necessary to establish a carbon pricing trading system, set up a carbon quota reservation mechanism and serve the carbon market stabilization fund, and use digital finance to improve the flexibility and efficiency of the carbon trading market. Through digital finance, we will continuously optimize the market transaction process, improve the flexibility and efficiency of the carbon trading market, reduce transaction costs, and improve the market competitiveness of carbon financial products. At the regulatory level, establish a sound regulatory system for the carbon financial market, and formulate and improve relevant laws and regulations to ensure fairness, transparency and standardization of the market. But also strengthen the supervision of carbon financial market, prevent the occurrence of improper behaviors such as market manipulation and insider trading, and protect the legitimate rights and interests of investors.

4.2 Accelerate the design of carbon finance digital products

First, many digital green financial products have complicated structures and asymmetric information, which makes investors feel confused when investing and choose traditional financial products with better understanding. Financial institutions can design more green bonds and funds similar to traditional products, which will lower the public's understanding threshold and enable investors to clearly understand the direction of capital use and environmental benefits. Second, strengthen top-level design and innovative ideas. Financial institutions should strengthen the top-level design, actively practice the ESG development concept, combine the design of carbon financial digital products with the national carbon neutrality goal, and clarify the strategic direction of product design. Third, promote the innovation of carbon financial products and services. Encourage financial institutions to develop more innovative carbon financial products and services, and provide data support for the design of carbon financial digital products. Research and develop innovative financial derivatives such as carbon futures and carbon options, and financing tools such as green credit and green bonds to meet the diversified needs of the market. Fourth, design the product line around the carbon trading market. Use blockchain technology to build the upstream and downstream connection of carbon trading, and take digital finance to empower the carbon trading market as a breakthrough to form a carbon financial product system with digital technology content. The product line constructed by fully displaying the carbon activity map as the underlying technology can completely match and support the operation of the carbon market.

4.3 Improve the awareness and participation of all parties.

The first is to enhance public awareness and participation. Strengthen publicity and education, publicize the important role of digital finance in carbon emission reduction through government, media, enterprises and other channels, and improve public awareness and acceptance of digital finance. By popularizing carbon finance knowledge, we will guide the public to actively participate in carbon trading and investment, and encourage enterprises and individuals to buy and sell carbon emission rights through carbon trading platforms, thus forming a good atmosphere for all people to participate in emission reduction. The second is to provide economic incentives. Most participants often face the pressure of economic cost when choosing green products. The government and enterprises can jointly launch a series of economic incentives. By providing direct financial subsidies, the purchase cost of green products can be reduced and the economic burden of the public can be reduced. The third is to enhance the acceptance of green financial products by all parties. Financial institutions should strengthen the transparency of digital finance, regularly disclose the operation of green financial products and environmental protection achievements, and enhance public trust and investment confidence through detailed reports and data. Fourth, the government can introduce relevant policies to encourage and support financial institutions to develop digital finance business, promote the application of digital finance in carbon emission projects or wider fields, and encourage all parties to practice low-carbon lifestyles. The fifth is to strengthen cooperation and sharing. Simplify the financial service process through digital means, reduce unnecessary links and time-consuming, and improve service efficiency. Financial institutions can also carry out cross-border cooperation with environmental protection departments and technology enterprises to jointly promote the application of digital finance in carbon emission reduction. Promote the popularization of green lifestyle, attract more investors to buy

and use digital financial products, enhance public participation in environmental protection, and guide consumers to gradually favor environmental protection consumption patterns.

5. Conclusion

Climate change has become a major challenge for all countries in the world, which has a profound impact on natural ecosystems and human living environment. There is a contradiction between environmental benefits and economic efficiency to a great extent, and the feasible solution at present is to ensure the development of green economy. Therefore, China has put forward the “double carbon” goal of achieving peak carbon dioxide emissions and carbon neutrality, and digital finance has important potential and role in the process of achieving the “double carbon” goal. By analyzing the direct and indirect mechanism of digital finance affecting carbon emission, it is found that digital finance plays a significant role in promoting carbon emission reduction and sustainable development. However, digital finance also faces certain challenges in the application of carbon emissions. In order to meet these challenges, this paper puts forward many measures, such as strengthening the construction of digital carbon finance market, speeding up the design of digital carbon finance products and improving the understanding and participation of all parties, which can effectively overcome the challenges of digital finance in carbon emission reduction application. It will not only help China achieve its climate goal and promote the coordinated development of economy and environment, but also provide useful experience and reference for the global response to climate change and achieve the goal of sustainable development.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Liu, H. Y., Zheng, S., Sun, Y. J., et al. (2024). Supply-demand analysis and management suggestions of carbon sinks in ecosystem into the national greenhouse gas voluntary emission reduction mechanism. *Environmental Protection*, 52(06), 38–42.
- [2] Feng, Z. Y., Song, D. L., & Xie, W. S. (2023). Digital economy helps realize the goal of "double carbon": Basic approach, internal mechanism and action strategy. *Journal of Beijing Normal University (Social Science Edition)*, (01), 52–61.
- [3] Feng, S. L., Xu, D. H., & Zhang, R. (2023). How can the development of digital finance enable carbon dioxide emission reduction?—Empirical evidence from prefecture-level cities. *Contemporary Economic Science*, 45(04), 15–28.
- [4] Wu, H. J. (2024). Analysis on the green and low-carbon transformation path of digital technology empowering traditional industries. *Digital Communication World*, (02), 164–166.
- [5] Yang, T. S., & Wang, D. (2023). Analysis of the communication path of China's green consumption concept in the new media era. *Journalist*, (11), 101–103.
- [6] Lv, H. Y., Ma, C. A., Tang, T., et al. (2024). Fiscal and tax incentive policy, green technology innovation and carbon intensity of industrial enterprises. *Statistics and Information Forum*, 39(05), 59–72.

Exploration of University Data Asset Management

Hongfei Ding^{1*}, Qin Liu²

1. Finance Department of Wuhan University, Wuhan, Hubei, 430072, China;

2. Audit Office of China University of Geosciences (Wuhan), Wuhan, Hubei, 430074, China

**Corresponding author: Hongfei Ding*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: With the advent of the digital and big data technology era, data is developing at an unprecedented speed and scale. It has become a consensus that data assets are an important resource for the development of enterprises and institutions. Universities are not only data consumers in the digital economy but also data producers. They generate massive amounts of data in teaching, research, and administrative management. Transforming this data into data assets and managing these new types of assets has become an urgent challenge for university managers. This paper explores the definition and value attributes of university data assets, analyzes the challenges in their management, and proposes corresponding strategies.

Keywords: Data Assets; Management System; Management Strategy

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.627>

1. Introduction

In the era of digitalization and big data technology, data is developing at a scale and speed that surpasses the evolutionary patterns of traditional assets. The significance of data is increasingly prominent, gradually becoming a critical source of wealth for various enterprises and institutions. With the development of digital and big data technologies, the concept of data assets has evolved from information assets and digital assets to a new type of asset form. Data assets are now a strategic resource driving the construction of a digital China and the acceleration of the digital economy.

At present, the informatization construction of Chinese universities has developed from scratch and entered the era of “three smart campus platforms” (data platform, portal platform, and authentication platform), with data resource services generally popularized. However, in the actual management of university data, problems such as inconsistent data standards, uneven data quality, complex data sharing, unsound management mechanisms, unclear management boundaries, and lack of data asset ledgers persist. Therefore, data asset management and governance are of great practical significance for university development. Faced with massive data, universities urgently need to address how to manage data as assets to support teaching, research, and operations.

2. Definition and Scope of University Data Assets

The earliest academic description of data assets can be traced back to the statement by Viktor Mayer-Schönberger, the “father of big data”: “Including data assets in the balance sheet is not a matter of possibility but of time.”^[1] Currently, the core data (master data) of universities mainly refers to basic data shared by multiple systems and operational data. These massive data sources are scattered, with prominent data silos, insufficient interoperability between platforms, low integration, and poor quality, leading to the accumulation of data in individual systems without effectively realizing their value.

Based on relevant research, the authors define university data assets as follows: University data assets are important data resources generated, collected, stored, and used in educational, teaching, research, and management activities. They are controlled and owned by the university, quantifiable over their full lifecycle, and expected to generate future benefits, value, and even drive educational, research, and management transformations. They cover multiple aspects, including but not limited to:

- (1) Student data: Personal information, academic records, course selection, scholarship evaluations, etc.
- (2) Faculty data: Personal information, teaching assignments, research achievements, academic participation, etc.
- (3) Teaching resource data: Course materials, teaching slides, question banks, teaching videos, etc.
- (4) Research data: Research project information, research results, experimental data, academic papers, etc.
- (5) Management data: Financial data, personnel data, equipment asset data, campus security data, etc.

Among these massive data, master data is the most critical.^[2] Therefore, master data management is the foundation of data governance and management in universities. Establishing an effective master data management system, conducting in-depth data mining and analysis, and continuously improving data quality are key to realizing the value of data assets.^[3]

3.Value of University Data Assets

In the era of big data, data assets have become an indispensable part of university development. Faced with the growing volume of generated data, universities must first address how to realize the value of these assets to support teaching, research, and management.

3.1 Enhancing Teaching Quality

Analyzing student learning data through modeling can reveal learning progress, difficulties, and preferences, providing references for personalized teaching and course popularity analysis. Integrating and sharing teaching resource data can enrich teaching content and improve resource utilization efficiency.

3.2 Promoting Research Innovation

Accumulating and analyzing large datasets helps identify emerging research hotspots and trends, providing insights for researchers. Cross-disciplinary data integration also fosters interdisciplinary innovation and the development of cutting-edge scientific achievements.

3.3 Optimizing Management Decision-Making

Data assets support evidence-based decision-making for administrators, improving resource allocation efficiency. For example, financial data analysis can optimize budget distribution, while personnel data analysis can rationalize faculty deployment. Additionally, universities can use data assets to enhance their social service functions, aligning talent training with societal needs.

4.Challenges in University Data Asset Management

While bringing significant value, university data assets face multiple management challenges.

4.1 Clarifying Ownership and Inventorying Assets

The primary challenge is inventorying data assets and clarifying ownership. Similar to tangible assets, data assets require regular inventorying, which is a prerequisite for effective management. Confirming and authenticating data assets (especially those generated internally) requires institutional frameworks.

Ownership is complex, involving the university, faculty, and students. Defining the full rights holder among these parties remains a critical issue.

4.2 Measuring Value and Ensuring Quantity-Value Consistency

For data assets to be recognized as assets, their value and quantity must be measured, requiring a sound valuation system. Additionally, addressing value amortization and impairment for this new asset type is challenging.

4.3 Establishing Full Lifecycle Management Mechanisms

The value creation of data assets involves their full lifecycle: generation, use, computation, and disposal. According to the “Guidelines on Strengthening Data Asset Management” (Cai Zi [2023] No. 141) issued by the Ministry of Finance, data

asset management must adhere to the principles of “clear responsibilities, transparent processes, and controllable risks.” This requires establishing a closed-loop management system covering legal compliance, dynamic maintenance, development, circulation, value reuse, and disposal. Supporting systems (e.g., asset ledgers, standards, valuation, and reporting) are essential.

4.4 Data Security and Quality

4.4.1 Security and Privacy Protection:

University data contains sensitive information (e.g., student IDs, contact details) and intellectual property (e.g., research results). Protecting data from theft, tampering, or deletion requires robust security measures: encryption, access control, multi-factor authentication (MFA), and regular backups.

4.4.2 Data Quality:

Data from diverse sources often suffers from incompleteness, inaccuracies, and inconsistencies, reducing usability and analytical reliability. Improving quality requires standardized collection processes and rigorous management of data capture, recording, and verification.

4.4.3 Data Sharing, Openness, and Application

(1) Low Sharing Efficiency: Data silos persist within universities and between universities and external institutions, limiting value realization.

(2) Weak Analytical Capabilities: Universities lack specialized data analysts and advanced tools, hindering the extraction of maximum value from data assets.

5. Management Strategies for University Data Assets

5.1 Strategies for Clarifying Ownership

5.1.1 User-Generated Data:

Data created by users (e.g., student papers, faculty courseware) should grant users partial ownership. However, universities may retain usage rights for management or service purposes (e.g., analyzing student learning records). User agreements should clarify rights and obligations under privacy protection.

5.1.2 Institution-Generated Data:

Data from administrative, teaching, or research activities (e.g., financial data, enrollment data) is owned by the university, which holds full rights to manage and use it.

5.1.3 Processed Data:

When data is processed by third parties or internal units, ownership depends on contractual agreements. For example, third-party analysis of student performance data may grant limited usage rights without transferring ownership.

5.1.4 Shared/Open Data:

When sharing data externally, ownership remains with the university, and recipients must adhere to usage limits and privacy obligations.

5.1.5 Intellectual Property Overlap:

For creative data assets (e.g., academic papers, patents), intellectual property laws (e.g., patent law) further complicate ownership.

5.2 Strategies for Value Measurement

Data asset measurement includes initial and subsequent valuation.

5.2.1 Initial Measurement:

Self-generated data assets can be valued similarly to self-developed intangible assets. Purchased data assets use acquisition cost.

5.2.2 Subsequent Measurement:

Historical cost or fair value models can be applied.

5.3 Strategies for Full Lifecycle Management

5.3.1 Governance Structure:

Establish a university-level data governance committee (including data owners, managers, and department representatives) to formulate strategies, coordinate efforts, and set standards (data quality, security, etc.).

5.3.2 Risk Management:

Regularly assess risks (security, quality) throughout the data lifecycle and implement monitoring systems.

5.3.3 Training and Communication:

Train staff on governance concepts, policies, and operational skills. Establish communication channels to resolve management issues.

5.4 Strategies for Security and Quality

5.4.1 Security:

Classify and grade data to apply differentiated protection. Use MFA (password + dynamic codes/biometrics) for access control.

5.4.2 Audits and Monitoring:

Conduct regular security audits and quality checks. Address identified issues promptly.

5.4.3 Source Management:

Improve data collection quality through standardized processes.

5.5 Strategies for Sharing and Application

5.5.1 Promote Sharing:

Develop policies for data sharing (principles, scope, methods). Build a shared platform with query, download, and API access functions.

5.5.2 Collaborate Externally:

Strengthen partnerships with external institutions to jointly advance data openness and application.

6. Conclusion

In the era of big data, data assets are critical resources for universities. Managing these assets is a long-term, systematic project requiring top-level design, long-term strategies, and cross-departmental collaboration. By improving data quality, promoting sharing, and enhancing analytical capabilities, universities can fully realize the value of data assets, supporting talent cultivation, research, and management. This will contribute to high-quality development and societal progress.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Li, Y. J., Peng, L., Lin, C., et al. (2016). Exploration of big data governance in university informatization management. *China Management Informationization*, 19(3), 185–187.
- [2] Liu, Y. (2014). On the recognition and measurement of big data assets. *Commercial Accounting*, (18), 3–4.
- [3] Zhang, X. H. (2020). Constructing a full education data asset system in the big data era. *Zhejiang Economy*, (2), 75–76.
- [4] Zou, L. (2020). Current status and countermeasures of university data asset management. *Management and Standardization*, (24), 212–213.

Analysis of Online Reviews on Hanfu Based on Text Mining: A Case Study of JD.com

Xie Wei*

School of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 71048, China

*Corresponding author: Xie Wei

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Hanfu is a component of China's excellent traditional culture, but there is relatively little research on consumer satisfaction with Hanfu products. This paper takes JD.com as an example to conduct statistical analysis on the brand information, price range distribution, and discount information of Hanfu products, and uses text mining methods to conduct sentiment analysis and social network analysis on product reviews. The research finds that consumers have a high recognition of brands, are willing to pay for the high-end pricing of Hanfu, and labels such as "reassuring purchase", "free shipping", and "JD Logistics" have a certain promoting effect on the sales of Hanfu. Consumers have a good overall perception of Hanfu, and when purchasing Hanfu online, they mainly focus on product quality, price, and other aspects. In the future, Hanfu brands should strictly control product quality and closely integrate Hanfu with Chinese traditional culture.

Keywords: Hanfu; Online Reviews; Text Mining; Social Network Analysis

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.564>

Introduction

Hanfu embodies the beauty of inheritance and is a component of China's outstanding traditional culture^[1]. With the enhancement of China's comprehensive national strength and the strengthening of cultural confidence construction, contemporary young people have shown a significant emotional identification and belonging to traditional culture^[2]. In 2019, the transaction volume of Hanfu on the Taobao platform exceeded 2 billion yuan, and it is still growing at an average annual rate of 150%; although the consumer group is small, the growth rate is considerable. The number of Hanfu enthusiasts has reached 3.561 million, with a year-on-year growth of 74.4%^[3]. With the development of technology and the increase in residents' disposable income, online shopping has become the preferred shopping method for consumers, and the way consumers obtain product information has also changed from traditional word-of-mouth to online reviews. This paper takes the JD.com as an example to collect the sales feature information and product review data of Hanfu, analyzes the sales features of Hanfu and conducts text mining on product reviews, explores consumers' preferences for purchasing Hanfu and puts forward relevant suggestions, so as to help merchants better understand consumer needs and market conditions, and provide reference for the strategic decision-making of e-commerce enterprises. It has strong innovation and practical significance.

1. Research Overview

Hanfu, also known as Chinese traditional clothing or Huaifu, is the full name "Traditional Han Ethnic Clothing". It evolved

continuously in the areas where the Han ethnic group lived and gathered from the reign of Emperor Huangdi to the late Ming and early Qing dynasties, around the 17th century AD^[4]. Hanfu, as the representative clothing of the traditional clothing culture of the Chinese nation, vividly showcases the characteristics of Chinese culture and is an important carrier of Chinese culture. According to its form, Hanfu can be classified into four categories: “Shangfang”, “Shenyi”, “Paofu”, and “Ruanshen”. With the revival of traditional Chinese culture and the enhancement of cultural consciousness, Hanfu culture, as an important part of traditional Chinese clothing culture, has gradually attracted the attention and affection of young people. At the same time, the rapid development of Internet technology has provided new opportunities for the inheritance and innovation of traditional culture. The Internet has provided new ideas for the dissemination of Hanfu culture, and the promotion methods and marketing strategies of traditional clothing brands have changed due to the emergence of the Internet.

Hanfu in each dynasty has its own characteristics of the dynasty, but overall presents the style of “top garment and bottom dress” and “deep clothing”. Currently, the research on Hanfu mainly focuses on Hanfu culture. Wei Pengju (2021) believes that Hanfu is not an ordinary cultural industry, but a cultural industry with Chinese characteristics^[5]. Yang Xue et al. (2022) used Hanfu as the starting point and investigated the evolution of its style representations and the interaction relationship of its changes among young people to explore the cognitive and value changes of contemporary youth towards the “traditional” image^[6]. Jiang Na (2022) believes that Hanfu has become a cultural totem that people love, and with this strong cultural sentiment trend, China’s excellent traditional clothing culture thus has the opportunity to integrate into modernity and go global^[7]. Studies have shown that online product reviews have a significant impact on consumers’ purchase decisions^[8]. Therefore, many scholars analyze consumers’ online reviews to improve enterprise products and services and increase customer stickiness. Kang Lei and Zhang Yu (2024) used data from the Russian e-commerce platform Wildberries and applied text mining technology to analyze the online review content of products on the platform for sentiment analysis. Through the weight of consumer evaluation dimensions, the positive rate of emotions, and the degree of improvement needed, they obtained feedback information from clothing consumers^[9]. Qiu Dongyang and Yi Xian (2023) mined the online reviews of personal care and beauty products on Tmall during the Double Eleven period to explore consumer satisfaction before and after the event^[10]. Lin Weizhen et al. (2023) used 11,349 online review data from Amazon’s shopping website and used the LDA model to identify customer satisfaction dimensions, combined with machine learning algorithms to construct a satisfaction model. The results showed that consumers’ attention to products focused on functional attributes, service attributes, and quality attributes, etc., in 13 product dimensions of 7 comprehensive attributes^[11].

In conclusion, using online reviews to study consumer satisfaction is a current research hotspot. In recent years, research on Hanfu has also increased, but there is less research on the satisfaction of Hanfu products. Online reviews are the real feedback of consumers’ shopping experience. Digging out the consumer satisfaction from them is of great significance for promoting the development of Hanfu e-commerce. This paper analyzes the sales characteristics information and product review data of Hanfu on JD Mall through sentiment analysis, feature keywords, word cloud charts, and network visualization analysis, aiming to explore the impact of Hanfu online reviews on consumers’ purchase intentions on the new media platform.

2. Research Plan Design

2.1 Research Method

Text mining refers to data mining of unstructured text, such as sentiment analysis, word frequency analysis, and semantic network analysis, etc. This method has been widely applied by scholars at home and abroad in comment analysis^[12]. Compared with market research methods and expert interviews, text mining method can more conveniently and quickly identify consumers’ concerns and preferences, saving time, manpower and resources^[13].

2.2 Data Collection

JD Mall is the second largest e-commerce platform in China, with a large customer base. Its online comment module is comprehensive, detailed and convenient for consumers to read, and has strong representativeness^[14]. This paper uses the Octopus software to collect the Hanfu comment data of JD Mall, including basic information such as the brand, price and positive rate of the products. The data is up to May 1, 2024. Secondly, to understand the satisfaction and factors of concern of Hanfu product comments, the comments of the top five children’s Hanfu and adult Hanfu products with the highest number

of comments were obtained. A total of 3,058 comments for children's Hanfu and 1,384 comments for adult Hanfu were collected.

Part of the original comment data in Table 1

User	Comment
Yuyi***tears	The fabric and craftsmanship of the dress are excellent. It is comfortable and breathable to wear. It is made of chiffon fabric, with a lot of drape. The lining is made of cotton yarn fabric, and there are embroidery patterns. The style is simple and elegant... You can buy it with confidence.
u***d	A beautiful Hanfu dress. The actual product is very beautiful. The fabric is soft, comfortable, and skin-friendly, breathable. The waistline design is cinched, and there are flower embroideries. It looks great when worn. The pink color complements one's skin tone. I'm satisfied.
j***t	A very beautiful Hanfu skirt. It is made of chiffon fabric, soft and comfortable, breathable. It is just suitable for summer. The small bag it comes with is also very cute.
u***m	The style is very nice, the fabric is comfortable, the workmanship is good, it doesn't pinch the flesh, and it is safe to wear for children.
u***y	Finally, I bought a satisfactory dress. It exceeded expectations. I really like it. Everyone around me says it looks nice. The fabric is very comfortable, and the child is very happy.
Xixi***cai	The quality is quite good. The fabric is smooth and soft, not pinching the skin, and it is breathable and cool. My daughter looks very nice when wearing it. It is very beautiful when paired with the small bag.
c***a	The Hanfu skirt is so beautiful. My daughter loves it very much. Wearing it gives a feeling like a little fairy. The quality is very good, and the delivery is very efficient.
Wanxi***xi	A very beautiful piece of clothing. It looks beautiful when wearing it in spring and summer with the baby. A friend asked where I bought it, and I have recommended it.

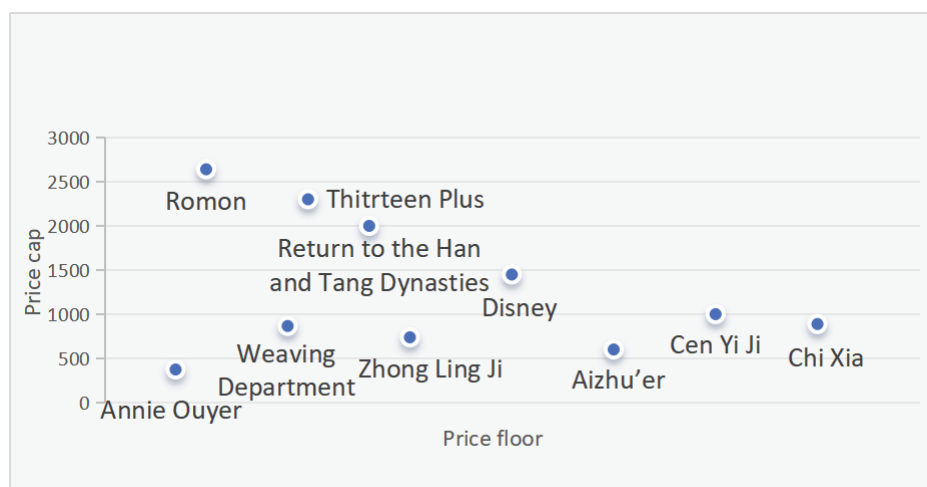
3.Sales Characteristics of Clothing

To understand the sales characteristics of Hanfu products on JD Mall, this article analyzes the data related to the brands, prices, and ratings of Hanfu products.

3.1 Brand Positioning of Hanfu

By conducting research on the Hanfu products on JD Mall, it was found that there are over 500 brands included, such as Return to Han and Tang, Zhiyeshi, San Yuyu, Anni Youyu, etc. This article selects ten Hanfu brands for analysis, and the price range distribution of each brand's Hanfu is shown in Figure 1. The price levels among the brands are clearly distinct. The lowest price of each brand's Hanfu is 0, and the highest price is the highest among Romon, San Yuyu, and Return to Han and Tang, all exceeding 2000 yuan; the highest price of the Disney brand is around 1500 yuan; and the prices of Zhiyeshi, Zhongling Ji, and Ai Zhu'er are all below 1000 yuan.

Figure 1 Price Positioning of Hanfu Brands



3.2 Product Price Range

Jingdong Mall has a total of 1.3 million sets of Hanfu. The price range distribution is from the Jingdong website. As shown in Table 1, the distribution of Hanfu in different price ranges is presented. Hanfu priced below 79 yuan accounts for 1,700 pieces, accounting for 0.1% of the total, and the proportion of users who like it is 9%; Hanfu priced between 79 and 197 yuan has the largest quantity, approximately 1.3 million pieces, accounting for 99.64%, and the proportion of users who like it reaches 30%; Hanfu priced between 197 and 349 yuan has 5,300 pieces, accounting for 0.4%, and the proportion of users who like it is 43%; Hanfu priced between 349 and 491 yuan has 1,100 pieces, accounting for 0.08%, and the proportion of users who like it is 12%; Hanfu priced between 491 and 2,038 yuan has 900 pieces, accounting for 0.06%, and the proportion of users who like it is 6%. The most numerous price range is not the one that users like the most. 99% of the products have only about 30% of users who like them. Thus, it can be seen that consumers recognize the higher price positioning of Hanfu. Compared to the price, they may pay more attention to product quality or other factors when making purchases.

Table 2 Price Distribution of Hanfu

Price range	Quantity (pieces)	Percentage (%)	Percentage of users who like it (%)
0-79	1700	0.1	9
79-197	1300000	99.64	30
197-349	5300	0.4	43
349-491	1100	0.08	12
491-2038	900	0.06	6

3.3 Product Discounts and Labels

Promotions such as discounts, gift vouchers, member prices, gift giveaways, and discounts are common forms of offers. Analyzing the top 200 best-selling products on JD Mall, it was found that the most common discount method used by merchants was the JD PLUS member price, with a discount of 40% off for every 300 yuan spent. The second most common discount was a 30% discount for every 200 yuan spent, followed by a 10% or 5% discount for every 100 yuan spent. Discounts mainly include a 9.5% discount for one item and a 90% discount for two items. The most common product labels were “Trust Purchase”, “Free Shipping”, and “JD Logistics”, followed by “Self-operated” and “New Products”, etc. These discount situations have a certain promoting effect on the sales of Hanfu. JD’s self-operated stores have a good reputation image, and “Trust Purchase” provides services such as shipping insurance or lightning refund. Flash sales promotions and discount promotions mean price discounts. Such labels can satisfy consumers’ desire for price discounts or reduce perceived risks to promote purchases.

4. Text Comment Analysis

To further explore the information contained in online comments about Hanfu and understand the evaluations and concerns of online consumers regarding Hanfu, this paper uses sentiment analysis to explore consumers’ satisfaction with existing Hanfu products, and uses word frequency analysis and social network analysis to explore consumers’ focus points.

4.1 Sentiment Analysis

With the improvement of social economy and culture, consumers’ fashion awareness has continuously increased, and their demand for clothing is no longer limited to the physical performance of practicality, but tends more towards emotional functions^[15]. Image perception has a processual and multi-dimensional characteristic. Analyzing the sentiment of comments from Hanfu consumers is a common method for evaluating the image of Hanfu. This paper conducts consumer sentiment analysis of Hanfu comments using ROST CM6.0.

First, sentiment analysis was conducted on children’s Hanfu (as shown in Table 3), and it was found that consumers had a relatively high level of positive emotions, with 2,781 comments, accounting for 90.94%; the proportion of intermediate emotions was relatively small, with 141 comments, accounting for 4.61%; the proportion of negative emotions was the

lowest, with 136 comments, accounting for 4.45%. It can be seen that consumers' overall perception of the image of children's Hanfu is relatively good.

Table 3 Analysis of Emotional Image of Children's Clothing and Hanfu

Emotional Type	Percentage (%)	Segment Type	Percentage (%)
Positive Emotion	90.94	General (0-10)	16.91
		Moderate (10-20)	21.78
		High (20 or above)	52.26
Intermediate Emotion	4.61	—	—
Negative Emotion	4.45	General (-10-0)	2.81
		Moderate (-20 to -10)	1.60
		High (-20 or below)	0.03

Secondly, an emotional analysis was conducted on adult Hanfu (as shown in Table 4), revealing that consumers had a relatively high level of positive emotions, with a total of 1194 comments, accounting for 86.27%; the proportion of moderate emotions was relatively low, with 132 comments, accounting for 9.54%; and the proportion of negative emotions was the lowest, with 58 comments, accounting for 4.19%. Consumers had a relatively favorable perception of the overall image of adult Hanfu, but their positive emotions were less compared to those of children's Hanfu, while the negative emotions were the same. Consumers were generally in a pleasant mood during the consumption process.

Table 4 Analysis of Emotional Image of Adult Hanfu

Emotional Type	Percentage (%)	Segment Type	Percentage (%)
Positive Emotion	86.27	General (0-10)	23.27
		Moderate (10-20)	25.43
		High (20 or above)	37.57
Intermediate Emotion	9.54	—	—
Negative Emotion	4.19	General (-10-0)	3.11
		Moderate (-20 to -10)	0.91
		High (-20 or below)	0.14

4.2 Feature Keyword Analysis

The frequent words mainly focus on two aspects: one is the overall perception of consumers' image, and the other is the material of Hanfu, the degree of liking, and the perception of consumers' consumption image. Through the frequency analysis of NVivo, the top 100 frequent words were selected for tabulation and summary.

By analyzing the 100 frequent words in Table 5, it can be seen that when consumers evaluate children's Hanfu online, they mainly focus on four parts: feeling, quality, price, and workmanship. The words that dominate are "like", "good", "nice", "beautiful", etc., which are words of praise. The frequency of mentioning "quality", "fabric", "suitable", "comfortable" is relatively high. The frequent words related to price are mainly descriptive words such as "affordable", "shopping", "worth it", "price", "cheap", etc. The words related to workmanship are mainly perception words such as "style", "workmanship", "fabric", "comfortable", etc. From the frequent words of these four parts, it can be seen that consumers' perception of the image of children's Hanfu leans towards the quality and price of the Hanfu.

Table 5 Summary of Frequent Words in Online Reviews of Children's Hanfu Clothing

Frequent Word	Frequency	Frequent Word	Frequency	Frequent Word	Frequency	Frequent Word	Frequency
Like	1658	Fabric	186	Hope	83	Guys	48
Quality	869	Dress	181	Fine	79	Physical	48
Very	698	Speed	181	Quite	78	Complete	47
Good	524	Size	173	Feel	77	Immediately	46
Baby	455	Soft	167	Must	76	Cousin	46
Affordable	410	Child	162	Product	72	Come in	46
Logistics	365	Cheap	160	Patient	72	Children	46
Child	353	Clothing Size	154	Say	71	Seller	45
Received	341	Color	151	Safe	66	Business	45
Nice	321	Recommend	148	JD	64	Style	44
Service	316	Not	141	Shop Owner	63	Always	43
Pretty	314	Express	132	Boss	63	Outside	43
Shopping	290	Packaging	130	Price	58	A lot	43
Attitude	280	In the Future	128	Material	58	Activity	43
Price	278	Positive Review	105	Doubt	58	Really	43
Next Time	268	Effect	104	Overall	55	Think of	42
Worthwhile	260	On Body	98	Whole Set	55	Imagine	42
Seller	248	Soft	98	One	53	Somewhat	41
Suitable	234	Continue	96	Consistent	53	Sure	40
Very Soon	221	Cosmetic Comfort	96	Attention	53	Standard	40
Purchase	216	Visit	91	Merchant	50	Truly	40
Delivery	206	Description	91	Fit	49	Introduction	39
Style	192	Overall	90	Colleague	49	Cheap	39
Workmanship	188	Compare	89	Happy	49	Just Now	39
Satisfied	187	Product	87	Have Something	49	Happy	39

A further analysis of the 100 frequently used words in the adult Hanfu reviews in Table 6 reveals that when consumers evaluate adult Hanfu online, their main focus is on four aspects: feeling, quality, price, and craftsmanship. Consumers' perception of the image of adult Hanfu leans towards quality and price, which is consistent with the preferences of consumers when purchasing clothes.

Table 6 Summary of Frequent Words in Online Reviews of Adult Hanfu Clothing

Frequent Word	Frequency	Frequent Word	Frequency	Frequent Word	Frequency	Frequent Word	Frequency
Good	417	Soft	66	Things	32	Girlfriend	19
Very good	402	Worth	60	Shop owner	32	Imagination	19
Quality	392	Comfortable	59	Clothes	31	Wife	19
Like	329	Shipment	58	Packaging	30	Height	19
Clothes	254	Dress	55	Express delivery	29	Style	19
Nice	238	Speed	54	Correct fit	28	Reliable	18
Fabric	210	Positive review	52	Description	28	Try on	18
Satisfied	189	Slightly	52	Just now	25	Five-star	16
Style	159	Fine	51	Next time	24	Merchant	16
Effect	154	Tactility	51	Some degree	24	Matching	16
Comfortable	154	Service	47	First time	24	Indeed	16
Workmanship	145	Images	46	High quality and low price	23	Happy	15
Received	141	Feeling	46	Material	22	Standard	15
Suitable	130	Attitude	44	Delicate	22	Unique	15
Beautiful	124	JD	43	Consistency	21	Now	15
Size	109	Recommendation	42	Child	21	Always	14
Wear	102	Design	42	Cloth	21	In the future	14
Shopping	90	Baby	41	New	21	Body type	14
Size	78	Friend	40	Generous	20	Weight	14
Price	77	Comparison	40	Already	20	Happy	14
Material	74	Trend	38	Details	20	Overall	14
Color	72	Touch	37	Body shape	20	Whole picture	14
Logistics	70	Superior	35	Suitable	20	Truly	14
Comfortable	69	Seller	34	A little bit	19	Know	14
Purchase	67	Practical	33	Daughter	19	Fine	14

4.3 Cognitive Image Analysis

Further cognitive image analysis was conducted using the NVivo software, generating a word cloud chart from the consumer cognitive comments. Visually, the consumers' perception of the consumption image of Hanfu was presented.

Figure 2 shows the cognitive image analysis word cloud chart of children's Hanfu. In this figure, the larger the font size, the higher the frequency of its appearance in the online evaluations of consumers. It can be clearly seen that the attention on "feeling" and "quality" is the highest, and various demands and feelings have been derived from these two focus points.

Figure 2 Word Cloud Chart for Analyzing the Cognitive Image of Children's Clothing Hanfu

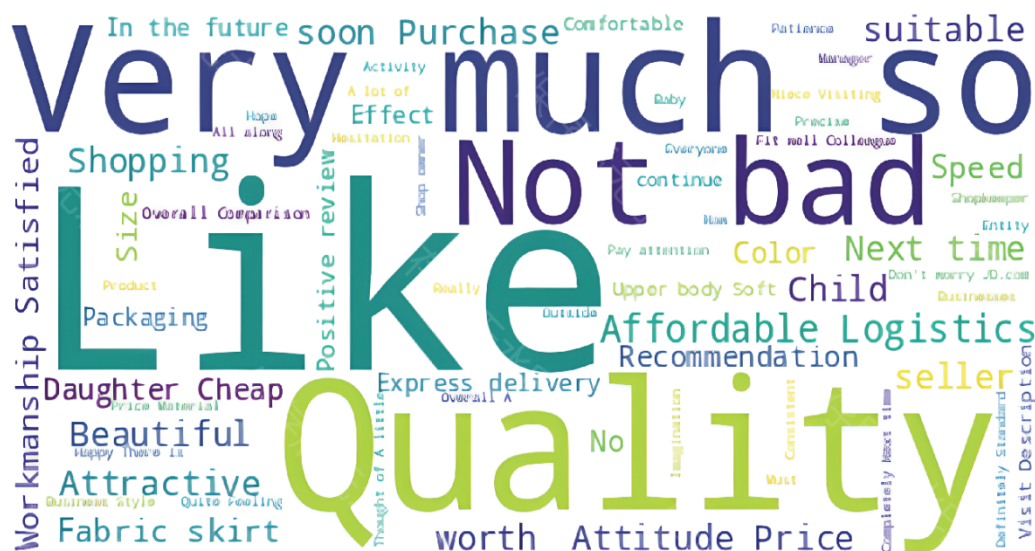


Figure 3 is a word cloud chart for the analysis of the cognitive image of adult Hanfu. It is clearly visible that the terms “quality”, “not bad”, and “like” have the highest attention levels, and these focus points have led to various demands and feelings.

Figure 3 Word Cloud Chart for Analyzing the Cognitive Image of Adult Hanfu



4.4 Semantic Network Analysis

Word frequency analysis can reflect the main characteristics of the sample data, but it cannot reflect the relationships between sample phrases and the structure of the sample. The construction of a semantic network can better reflect the correlation degree among high-frequency words. Therefore, based on the previous research, this paper uses Gephi to generate a semantic network diagram. The semantic network diagram is in a divergent shape. The more vocabulary connections there are, the closer the relationship is.

As shown in Figure 4, words such as “like”, “satisfied”, “quality”, and “recommend” are located at the core position of the graph. These words are the high-frequency words that appear frequently in online consumer reviews and are the first impression for children’s clothing and Hanfu. Consumers’ online reviews often start from these words. “Nice”, “logistics”, “workmanship”, “attitude”, and “delivery” are located at the secondary core of the graph. These keywords represent the basic cognitive needs of consumers for purchase intentions. The peripheral associated words of the graph further describe and explain the core words. Further analysis of the strength of the word associations in the graph reveals that the connection nodes around “like” and “price” are the most numerous.

5. Conclusions and Implications

The rise of Hanfu fashion has led to a significant increase in the transaction volume of Hanfu clothing. Many Hanfu merchants have seized the opportunity and stood out in this trading trend. However, related development issues have gradually emerged. This article takes JD Mall as an example to analyze the brands, prices, and product discounts of Hanfu, summarizes the online sales characteristics of Hanfu, and conducts social network analysis on online reviews of Hanfu products, summarizing the factors that consumers pay attention to. Based on this, four suggestions are proposed.

First, clarify the target audience group. For different audiences, corresponding marketing strategies can be formulated, such as the youth group, culture enthusiasts, history enthusiasts, etc. The focus of comments on children's Hanfu and adult Hanfu is different. In terms of price, Hanfu should be designed within the price range that consumers like. Different types of Hanfu should adopt different pricing strategies in terms of brand, material, positioning, etc. In the market competition, it is very important to distinguish from other brands.

Second, strictly control the quality of Hanfu. The words "quality", "material", "very", "comfortable" frequently appear in the comments. It can be seen that consumers are very satisfied with purchasing Hanfu. Consumers pay the most attention to the quality and fabric when purchasing Hanfu. Therefore, the brand should strictly control the quality of the product and obtain high satisfaction consumers through high-quality fabrics.

Third, update the styles of Hanfu in a timely manner. The words related to the design appearance appear frequently in the comments, such as "nice", "beautiful", "style", etc. Therefore, the brand should increase investment in Hanfu design, "nice" and "beautiful" are important reasons for consumers to purchase Hanfu and be satisfied with it.

Fourth, combine Hanfu with Chinese traditional culture closely. Hanfu brands can emphasize their unique cultural value through attention to design style, craftsmanship technology, etc., to create a unique brand image, making it have a unique and high-quality image in the consumers' minds, to attract those who are interested in traditional culture. It can be done through cultural exhibitions, theme activities, etc., to enable consumers to have a deeper understanding and experience of the cultural connotation represented by Hanfu.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Zhang Chao, Dai Qinling, Yao Xinnan, et al. (2023). Research on Design Elements of Hanfu in the Ming Dynasty Based on Eye Tracking Technology. *Silk*, 60(09): 120-127.
- [2] Zhou Yaqiu, Zhu Hong. (2024). Perspective on the "Hanfu Trend": Cultural Value Re-creation of Chinese Cultural Products from the Perspective of Symbolic Consumption. *Academic Sea*, (03): 143-149.
- [3] Wu Mengrou, Yang Liping, Xie Yuhuan, et al. (2020). Research on the Development of Hanfu Industry under the Revival of Traditional Culture. *Cooperative Economy and Science & Technology*, (17): 36-38.
- [4] Han Xin. (2012). Cultural Reflection on the Contemporary Revival of Hanfu. *Journal of Art College of Inner Mongolia University*, 9(04): 38-45.
- [5] Wei Pengju. (2021). "Hanfu Craze" from the Perspective of Cultural Economics: The Coincidence of Ontological Cultural Consciousness and Clothing Industry Segmentation. *People's Forum*, (27): 100-104.
- [6] Yang Xue, Zhang Ran, Kong Lingxu. (2022). "Reconstruction of Tradition" and Popularity: An Investigation into the Evolution Logic of Youth Hanfu Culture. *Contemporary Youth Studies*, (02): 40-47.
- [7] Jiang Na. (2022). From Cultural Behavior to Identity Expression: The Popularity and Controversy of Hanfu Culture from the Perspective of "Actor Network Theory". *Shanghai Culture*, (10): 94-103.
- [8] Huang Kesin, Zhang Jianlin, Zhang Ziyong, et al. (2024). Research on the Influence of Consumer Online Evaluation

- Intentions in the Context of Good Reviews Reward. *Jiangsu Business Review*,(11):39-43.
- [9] Kang Lei, Zhang Yu.(2024).Consumption Demand of Russian Down Jackets Based on Text Mining. *Modern Textile Technology*,32(08): 108-116.
- [10] Qiu Dongyang, Yi Xian.(2023).Research on Consumer Satisfaction during the Double Eleven Campaign - Based on Text Mining of Tmall's Personal Care and Beauty Products. *Journal of Chongqing University of Posts and Telecommunications (Social Science Edition)*,35(02):131-145.
- [11] Lin Weizhen, Liu Hongwei, Chen Yanjun, et al.(2023).Research on Customer Satisfaction Based on Online Reviews - Taking Health Monitoring Wearable Products as an Example. *Data Analysis and Knowledge Discovery*,7(05):145-154.
- [12] Liu Jiakai, Li Min.(2023).Online Review Analysis of Silk Blankets Based on Text Mining - Taking JD Mall as an Example.*Silk*,60(08):11-20.
- [13] Sun Baosheng, Ao Changlin, Wang Jingxia, et al.(2022).Research on Satisfaction Evaluation of Ecotourism Based on Network Text Mining.*Operations Research and Management*,31(12):165-172.
- [14] Guo Li, Li Jie.(2022).The Impact of Consumer Crisis Perception Risk on Online Review Effects.*Journal of Northeastern University (Natural Science Edition)*, 43(11):1662-1672.
- [15] Xiao Jinrong.(2012).Analysis and Construction of Emotional Factors in Clothing Brands.*Journal of Textile Research*,33(10):117-121.

Research on Basic Issues of State-owned Asset Management in Higher Education Institutions

Jianqiang Wang*

Xi'an Polytechnic University, School of Management, Xi'an, Shaanxi, 710048, China

**Corresponding author: Jianqiang Wang*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In recent years, the quantity, quality category and form of state-owned asset allocation of colleges and universities have undergone a fundamental transition and transformation from extensive to precise, management to performance, single allocation mode to efficient utilization, and from property ownership to shared utilization, which also fundamentally reflects the overall requirements and reform achievements of comprehensively deepening reform in the field of state-owned asset management since the 18th National Congress of the CPC. Based on the reform of delegating powers, enhancing regulation and strengthening public service, this paper analyzes the inherent bottlenecks and contradictions in the operation, supervision and performance evaluation of state-owned asset management, as well as the shortcomings and deficiencies in the construction of governance system and governance capacity. From the perspective of control specification, the path and measures to standardize the management of state-owned assets are proposed, and the improvement of quality and efficiency, resource allocation, performance management and whole-process supervision are taken as the core values and ultimate goals of improving the governance system and governance capabilities. The ultimate value of state-owned assets management is realized from two dimensions: the reform of delegating powers, enhancing regulation and strengthening public service, and living on a tight budget.

Keywords: State-Owned Assets; Value Management; Performance Evaluation

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.629>

1. Preface

With the development of higher education institutions entering a new stage and the continuous advancement and deepening of the scale of asset allocation in higher education institutions and the reform of “streamlining administration, delegating power, improving regulation and upgrading services”, new goals, new requirements and new tasks have been put forward for the reform and development of improving the quality and efficiency, preserving and increasing value, and performance management of state-owned assets. State-owned asset management has undergone a complete transformation: The first is the transformation from asset scale expansion to efficient asset operation, the second is the transformation from stock management to optimized resource allocation, the third is the transformation from extensive management to precise use performance and benefits, the fourth is the transformation from self-supervision as the main body to integrated supervision effectiveness (institutional reform), and the fifth is the transformation from asset stock management to supervision throughout the entire process of asset existence. Sixth, the shift from a purely property-owning purchase orientation to a value-oriented

shared utilization, which is also the fundamental aspect of implementing the new development philosophy and promoting high-quality development in the new era, and the ultimate value and goal of comprehensive deepening of reform.

Since the Third Plenary Session of the 18th Central Committee of the Communist Party of China, in accordance with the “Decision of the Central Committee of the Communist Party of China on Some Major Issues Concerning Comprehensively Deepening Reform”, the “Decision of the Central Committee of the Communist Party of China on Deepening the Reform of Party and State Institutions”, the “Plan for Deepening the Reform of Party and State Institutions”, and the strategic direction, strategic tasks and strategic goals established by the Central Committee of the Communist Party of China and The State Council, first, the intensity of institutional reform has been increased Reform and reorganization of state-owned asset management, operation and supervision institutions, thorough integration, reconstruction and optimization of confusing functions and responsibilities that were not independently distinguished in the original state-owned asset operation, supervision and oversight aspects, transfer and reorganization of relevant functions, institutions and personnel, with a focus on establishing a new pattern of independent operation, independent supervision and all-round independent supervision, A three-in-one institutional operation and functional performance framework has been formed, with the operation part belonging to the market entity or the actual user entity, the supervision part belonging to the government’s dedicated regulatory agency or the superior administrative department, and the supervision part belonging to the dedicated audit supervision agency, fundamentally solving the inherent systemic fundamental problems in the management and operation of state-owned assets;

^[1]Second, the state-owned assets management system and mechanism have been further improved and perfected. The Central Committee of the Communist Party of China, The State Council and the superior authorities have successively issued the “Opinions on the Full Implementation of Budget Performance Management”, the “Regulations on the Management of State-owned Assets of Administrative and Public Institutions” (State Council Decree No. 738), and the “Opinions on the Full Implementation of Budget Performance Management” (Jiaocai [2019] No. 6) of the Ministry of Education. It put forward clear opinions and requirements on the performance management of state-owned assets of administrative and public institutions throughout the entire process and all links, mainly focusing on the established goals of comprehensive deepening of reform and promoting the modernization of the governance system and governance capacity of state-owned assets.

Based on a comprehensive consideration of a series of problems existing in the management of state-owned assets, such as the management system, functional performance, regulatory system, stock management, performance evaluation management, etc., in the practical need of modernizing the governance system and governance capacity in the field of state-owned assets, it is necessary to coordinate the management efficiency of state-owned assets themselves and the supervisory efficiency of state-owned assets, In two dimensions, it is necessary to fully implement the overall goals and tasks of the comprehensive deepening of reform and make the “streamlining administration, delegating power, improving regulation and upgrading services” reform a priority strategic task for state-owned asset management, that is, to clarify the main business and main responsibilities of state-owned asset management and distinguish between the investment subjects, regulatory (supervisory) subjects, operation subjects and market relationship subjects of state-owned assets^[2]; Clarify the relationship between the government, the market and the responsible entities, and distinguish the basic functional positioning of operation, regulation and supervision; Clarify ownership and interests, distinguish rights, responsibilities and entrusted responsibilities, and then sort out institutional and mechanism obstacles, solve problems such as unclear rights and responsibilities, ambiguous duties, buck-passing and other blank or overlapping duties, and improve the governance system. On the other hand, taking the optimization of audit office and government audit responsibilities as the starting point, following the unified and efficient audit supervision system, taking the division and reconstruction of responsibilities in the field of state-owned asset management as the opportunity, adhering to problem-oriented and result-oriented, taking management effectiveness, operational efficiency, business performance and the level of risk (supervision) management as the ultimate goal and value, giving full play to the synergy of responsibilities, Comprehensively enhance the modernization level of governance capacity.

2.Raising the Problem

From the perspective of the overall strategic goals and tasks of the comprehensive deepening of reform in the field of state-owned asset management, the implementation of laws and regulations and the adjustment of policy basis, theoretical research

and practical level, value orientation and practical demand, the inherent bottlenecks and contradictions are mainly reflected in aspects such as the operation of state-owned asset management, regulatory supervision and performance evaluation and assessment. The main problems, such as the implementation of systems and the fulfillment of duties, the management of stock and the allocation of resources, the implementation of procedures and the management of processes, the main business and the division of rights and responsibilities, have restricted the progress and intensity of the “streamlining administration, delegating power, improving regulation and upgrading services” reform from both subjective and objective perspectives and hindered the effective improvement of the governance system and governance capacity in the field of state-owned assets management. It is difficult to fundamentally and effectively address the transformation related to state-owned asset management. In order to adapt to the reform of the social and economic system, respond to a series of policies issued by our country, meet the regulatory requirements and the goal of strengthening the internal management of state-owned assets in various units, there are still problems such as the need to improve the internal control management system, the need to standardize and diversify asset allocation, the need to improve the efficiency of asset use and the need to enhance the quality of state-owned asset reporting management^[3].

2.1 Poor implementation of internal control and confusion of functional positioning relationships

From the perspective of comprehensive deepening of reform, the “streamlining administration, delegating power, improving regulation and upgrading services” reform and the “abolition, reform and establishment” of systems are two important paths to consolidate the achievements of comprehensive deepening of reform, and there are mainly two levels of problems and contradictions: On the one hand, in addressing the issue of institutionalized guarantees at the system (architecture) level, there are often problems of incomplete systematization and systematization in aspects such as the improvement and evaluation of internal control mechanisms, the comprehension and judgment of laws and policies, the construction and implementation of institutional systems, and the review and performance evaluation of institutional implementation. There is a mechanistic paradox between the fragmented guarantee operation mode and the practical need to systematically construct the governance guarantee system; On the other hand, in addressing the issue of implementation at the governance (practice) level, there are often problems of rough simplicity, regulation for the sake of regulation and incomplete mechanisms, and a lack of working mechanisms based on the synergy of internal control and internal checks and balances for the fulfillment of duties, institutional guarantee and performance assessment. The professional, scientific, information-based and clear governance pattern is far from the top-down policy requirements and institutional designs^[4].

The problems and contradictions at these two levels are mainly manifested in several aspects in management practice: First, the problem of subjective rent-seeking caused by imperfect or looped systems, mainly manifested as: Differentiated implementation of the system (lack of rigid constraints), regular implementation of special provisions of the system (circumvention of normal procedures), inversion of system authorization and functions (reverse influence of non-functional departments on the performance of functional departments); The second is the failure of internal control caused by the improvement of the system and the operation mechanism, which is mainly manifested as: Deficiencies in the internal control mechanism (the failure of checks and balances due to insufficient authorization and performance of duties), the tendency of the authorization approval process to reverse (the degradation of forward process management to reverse process avoidance), the conflict between the actual needs of internal control governance and the formalization of evaluation (contrary to the original intention of internal control evaluation - to improve internal control and governance); The third is the problem of functional positioning, which is mainly manifested as: unclear boundaries of duties (unclear authorization or unclear division of duties), problems of performance ability (awareness of duties and professional skills), authorization deficiency (authorization not based on duties); Fourth, the problem of the coordination and balance mechanism between asset management and supervision, mainly manifested as: mismatch between management links and supervision links (some links have not established supervision mechanisms), incomplete coverage of control nodes (insufficient systematicness of supervision), incomplete regulatory governance system (effectiveness).

From the two aspects of bottleneck problems and practical manifestations, the ultimate manifestation of the poor implementation of all internal controls and the confusion of functional positioning relationships is the finiteness and limitation

of their own functional performance, that is, the deviation from the strategic positioning and goals of the organization (higher education institution), and there must be problems of overlapping or vacuum of rights and responsibilities between their own institutional responsibilities and the responsibilities of related parallel institutions. This leads to low overall governance effectiveness, mismatch of powers and responsibilities, confusion of authorization, insufficient capacity for performance, and low efficiency within the organization, making it difficult to systematically, efficiently, and scientifically construct the organizational governance system^[5]. In the absence of a sound supervision and restraint mechanism within the organization, not only is it difficult to achieve good results in management, but it also hinders the smooth implementation of internal control work and makes it difficult to solve the bottleneck of the “streamlining administration, delegating power, improving regulation and optimizing services” reform from the source.

2.2 The overall efficiency of stock management and resource allocation is not high

From the perspective of the process of the urgent and management demands for the transformation and upgrading of state-owned asset management, all along, The demand for the stock of assets, which is mainly based on the expansion of the scale of higher education institutions, the evaluation of teaching disciplines and levels, the construction of “Double First-Class” universities (disciplines), the application for scientific research levels and major projects (awards), and the upgrading of some higher education institutions, has objectively contributed to the traditional extensive operation and management model, which blindly pursues blind scale expansion as the direct goal. Stock management, as a relatively direct and single indicator and evaluation standard in the field of performance management in state-owned asset management, is monotonous, extensive and direct. This is reflected in management practice mainly as purchasing instead of allocation, increment instead of efficiency, emphasis on ownership (ownership) over utilization (sharing), and emphasis on stock scale (quantity) over quality improvement (efficiency). It is difficult to align with the overall strategic goals of the transformation and upgrading of state-owned asset management, the reform of “streamlining administration, delegating power, improving regulation and upgrading services”, and performance management, and there are several problems^[6] ;

On the one hand, the management of the state-owned assets stock is limited to simply increasing the self-owned stock through purchase, ignoring the value orientation of demand orientation, performance as the result, and effective allocation as the ultimate goal. It lacks systematic inventory management, scientific evaluation of utilization, sufficient argumentation of the process, and realistic prediction of actual demand, which leads to the blindness and randomness of stock management. In the practice of state-owned asset management, it is mainly manifested as: the lack of overall planning and argumentation of stock in the early stage (stock inventory, allocation and demand management), purchasing independently (lack of unified and scientific argumentation), replacing process management with formalized process operation (process virtualization and thus becoming a disguise to avoid procedures), and taking the allocation of funds as the sole basis for asset allocation (purchase as long as funds are available).

On the other hand, the effectiveness, systematization and scientification of the overall allocation, disposal and utilization cannot effectively meet the actual needs of “living frugally” and asset utilization efficiency. Its essence is based on departmentalism as the main body, lacking a systematic institutional design and working mechanism for top-down overall allocation of existing resources and bottom-up performance evaluation of utilization. In practice, it is mainly manifested as: No systematic mechanism for selecting asset allocation schemes has been established (determining how to allocate state-owned assets based on top-down pooling of existing resources and whether the decision-making mechanism is strictly followed), and no effective mechanism for determining and evaluating the use value of assets has been established (simply judging whether they have use value based on years, The absence of a value assessment mechanism and the lack of a scientific and effective operational mechanism for the utilization of asset value (shared allocation and utilization platforms and operational models).

2.3 There are inappropriate asset disposal mechanisms and models

In the practice of state-owned asset management, no management behavior at any stage can be isolated from other stages and links, especially in the asset disposal stage, in addition to strict decision-making mechanisms, work procedures and approval processes, there must also be strict inventory clearance, value appraisal, evaluation and revitalization mechanisms, That is, it is necessary to improve and perfect the trade-off and confirmation mechanism based on the value of the asset itself

and its use value, fundamentally solve the problem of purely formalism, simplification and one-size-fits-all in the process of asset disposal and clearance, and re-evaluate and confirm the mechanism and model of asset disposal on the basis of fully considering “living a tight life”, the actual function of the asset and the effectiveness of revitalization and reuse.

First, the asset disposal mechanism and standards need to be improved. Although there are relatively mature institutional guarantee mechanisms in asset disposal, they are limited to procedural and procedural operation levels and lack a top-down trade-off, evaluation and confirmation mechanism, that is, not exercising substantive authority in accordance with the main business and main responsibilities of asset management. In practice, the main responsibilities and decision-making authority are essentially delegated to the departments to which the assets belong (use), which objectively leads to differences in disposal mechanisms and standards due to differences in funds, usage requirements, and departmental decision-making mechanisms, and further leads to blindness and arbitrariness in stock management, mainly manifested in two aspects: On the one hand, from the perspective of value level, there is a lack of necessary value assessment mechanisms for asset disposal and renewal. It cannot be simply based on the level of years, nor purely based on the level of financial guarantee, but only on the value level of revitalization and reuse; On the other hand, from the perspective of systematically improving the performance of the use of state-owned assets, an effective trade-off mechanism between asset allocation and asset disposal has not been established, and a mechanism for asset disposal has not been constructed from the perspective of organizational strategic goals and strategic asset allocation, that is, asset disposal must be based on the premise of systematic asset allocation and the necessity of disposal. The establishment of an asset disposal mechanism with clear standards (including premises and basis), unified standards (including mechanisms and procedures), and practical needs, of course, does not have sufficient funds as a prerequisite factor^[6].

Second, there is a lack of standardized and effective process management for the disposal of state-owned assets. The existing asset disposal process is generally limited to the back-end process, that is, the basis for asset disposal is the existing system norms and work processes at the disposal stage, and its starting point is set as the asset usage life set by the system norms and as the determination to be disposed of, simply following the main processes and links such as application, approval and disposal. There is a lack of necessary working mechanisms and procedural designs such as pre-disposal inventory and clearance, use value (exploitable value) assessment and evaluation, and asset revitalization. It is difficult to avoid simplistic and one-size-fits-all disposal models, which are mainly manifested in the practice of state-owned asset management: There is a lack of systematic full-process design (the absence of top-down decision-making and assessment mechanisms at the front end of the disposal process), a lack of systematic and scientific assessment and confirmation of the use value of assets to be disposed of (the working mechanism for asset revitalization), and a resource allocation model for coordinating asset disposal and stock optimization (the disposal mechanism based on the systematic optimization of resource stock).

Third, the quality of state-owned asset reporting management needs to be improved. Before the Central government issued the “Opinions on Establishing The State Council’s Reporting to the Standing Committee of the National People’s Congress on the Management of State-owned Assets” in December 2017, universities had established corresponding systems for the reporting of state-owned assets, but the problem of not attaching importance to the reporting of state-owned assets still emerged. The concept of “big state-owned assets” management that combines physical assets and assets has not been fully formed. Data statistics only achieve real-time grasp and point-based statistics at the end of the year without comprehensive control of the data. State-owned assets reports only do information statistics without using data for analysis of the utilization and disposal of state-owned assets. All of these problems are, to varying degrees, hindering the all-round construction of the state-owned assets supervision system.

2.4 Imperfect asset performance evaluation system and mechanism

From the above, it is not difficult to see that in the context of “living frugality”, asset allocation should be regarded as a systematic asset management event, that is, it must be based on the premise of coordinating purchase funds, stock management, resource allocation and asset disposal, and on the basis of necessity, value and efficiency. Simply classifying asset allocation into a process model of declaration, approval, purchase, evaluation (formal meaning), and disposal is manifested in practice as a lack of asset management level and governance effectiveness, lacking both the necessary cognition

and evaluation of the asset itself and the necessary evaluation and revitalization mechanism at the front end. A systematic, scientific, and effective asset performance evaluation mechanism needs to be established^[8]. The lack of supervision and incentive mechanisms and mutual restraint mechanisms in the property rights system of state-owned assets in universities, coupled with backward management concepts, imperfect management systems and non-standard management organizations, makes it difficult to quantitatively measure the conversion efficiency from resource input to target output of university organizations in China in the practice of state-owned asset management. There are several main bottlenecks and problems in the asset performance evaluation system and mechanism:

First, the standard system is limited. The existing standard system for asset performance evaluation is based on the main standards and factors such as actual holding (ownership nature), stable stock (pursuing scale and quantity), useful life management (depreciation period), and value pursuit (residual value after depreciation), which formally meets the basic requirements of asset evaluation regulation, but in management practice, There is a contradiction between the formal satisfaction of assessment results and the substantive need for improving the quality and efficiency of asset management, which is divorced from the asset value system and the use value system to manage value assessment standards, which is contrary to both the requirement of “living frugally” and the need for the effectiveness of asset management and governance, and requires the construction of a standard system based on value and demand in management practice.

Second, the assessment system is limited. As mentioned earlier, the existing assessment system is based on the existing standard system and assessment model, which contrasts with the policy expectations and practical needs of state-owned asset performance management, “living frugally”, and asset revitalization and utilization, and lacks support in several dimensions such as demand, value, and process management. The evaluation system itself has shortcomings and bottlenecks in the value management, decision-making mechanism, professional evaluation, and all-domain supervision of state-owned assets throughout their life cycle, namely inherent flaws in the compatibility (demand argument management), extension (value front-end management and back-end reuse management), and systematicness (element comprehensive analysis) of the state-owned assets performance evaluation system. The lack of necessary value assessment, process reengineering and mechanism optimization is mainly manifested in two aspects: on the one hand, performance assessment is based on depreciation, useful life and value, divorced from the use value itself; On the other hand, the performance evaluation system is based on value recognition, formal processes and existing cognition, and is disconnected from value reuse and development.

Third, technical means are limited. From the perspective of the trend of digital management, in the face of the current situation and limitations of asset management that is large in scale, complex in form and diverse in value, the performance evaluation of inherent assets is difficult to achieve precise, effective and clear performance management level by relying on human means and subjective judgment, and the pursuit of modernization of the performance evaluation system is even more out of reach. Therefore, The technical means of performance evaluation of state-owned assets are mainly manifested in two aspects: informationization of stock and digitalization of node management. In terms of the level of informationization of stock^[9], it is difficult to effectively solve the basic problems of information asymmetry and performance evaluation of state-owned assets in stock in specific practice, mainly including: Asset stock information (the stock of assets that can be included in performance evaluation) and value information asymmetry (the availability of asset value); In terms of the level of digitalization of node management, the problem of the accuracy of node information data and actual value information data cannot be effectively solved in practice, mainly manifested in several aspects: System node information (stock data based on time points), process node information (stock data based on adjustments), terminal node information (stock data based on physical objects) and value node information (stock data based on users).

2.5 Low level of asset categorization identification and management efficiency

From the perspective of the overall requirements of the regulatory system and the policy trend of policy mechanism adjustment, precise asset classification and identification management is one of the prerequisite, fundamental and procedural conditions for achieving asset efficiency utilization and performance realization. In practice, it is mainly limited by the implementation mechanism and implementation efficiency, mainly manifested in: First, precise category identification is limited. In practice, the classification management of assets often adopts traditional methods based on inherent thinking and

experience for category identification, lacking the guidance of scientific classification. Such as whether the identification of fixed assets is based on value limits or actual uses, and whether the identification and management of cultural relics assets are based on historical value conservation management (intrinsic intrinsic value) or real valuation depreciation management (formal artificial valuation), etc. Second, the value management mechanism is limited^[10]. In practice, asset value is generally restricted by financial management and book treatment, lacking a systematic value revaluation mechanism based on revitalization and reuse, resulting in a one-size-fits-all simplification of asset value management. Such as the asset exit mechanism based on life expectancy and depreciation, the value recognition mechanism based on book value, the stock management mechanism oriented by user demands, etc. Third, the management model is limited. In practice, the management of state-owned assets is restricted by the top-down management system construction and approval mechanism and the bottom-up demand management and user self-control mechanism for stock demand, lacking a two-way value selection, shared utilization and revitalization mechanism. For example, user demand is detached from the demand for asset stock balance, and the exit mechanism of assets is simply based on age value management and user demand, etc.

3.Pathways, measures and methods for regulating state-owned asset management based on control

In terms of the current situation of value orientation, performance management, policy orientation and institutional system construction, the basic problems of state-owned asset management are mainly manifested as a series of bottlenecks and limitations in scale expansion, stock management, self-control demand, value management, control effectiveness, etc. In essence, they still manifest as deficiencies and deficiencies in governance system construction and governance capacity construction. In management practice, it is necessary to strengthen systematic control management from aspects such as mechanism reconstruction, model selection, application of technical means, value revaluation and responsibility supervision, and then find the path, measures and methods for the standardized management of state-owned assets in the new era. Quality improvement and efficiency enhancement, resource allocation, performance management and full-process supervision are the core values and ultimate goals for improving the governance system and governance capacity in the field of state-owned assets.

From the perspective of regulations, policies and institutional design, the ultimate goal of state-owned asset management should be the overall optimization and improvement of performance levels, resource allocation, value activation and efficiency play, and thereby achieve the ultimate value of state-owned asset management in the two dimensions of “streamlining administration, delegating power, improving regulation and upgrading services” reform and “living frugally”.

3.1 Build an effective model management mechanism for state-owned assets based on internal control

From a practical perspective, the model is mainly “institutional norms (procedures and processes) - division of responsibilities (boundaries of responsibilities) - guarantee mechanisms (operation and supervision)” : First, establish a regular institutional mechanism for the abolition, amendment, and review and interpretation of systematic systems, and review the main contents and mechanisms such as dynamic management of asset stock, coordinated review mechanism of incremental, systematic allocation of resources, effective limitation of specific matters, and checks and balances of responsibilities as the main matters to plug institutional loopholes and prevent rent-seeking behavior, The essence of this is to establish procedural operation and operating procedures at the institutional normative level to make up for deficiencies in internal control; The second is to establish a clear demarcation of responsibilities with consistent rights and responsibilities and distinct authorizations, and to implement authorization approval and internal checks and balances in all areas, links and nodes of asset management, including project initiation and resource allocation in the early stage^[11], process stock management and value assessment, revitalization and invalidation in the later stage, and evaluation and reflection after the event. Effectively connect systematic matters such as resource allocation, revitalization and utilization, and performance evaluation with specific duties such as stock management, value recording, and physical demand; Third, establish an effective guarantee, operation and supervision mechanism, uniformly regulate the implementation of institutional guarantee, the effective operation of procedures and the control of process nodes in the decision-making mechanism, authorization approval and review supervision mechanism, take objective, unified and standardized judgment criteria and judgment basis as the core essence and value orientation choice,

and implement them in all areas, links and nodes of state-owned asset management, To eliminate problems and phenomena such as the regular implementation of specific provisions, the limited remediation of institutional loopholes and the artificial limitations of decision-making mechanisms, to build a supervision mechanism that pursues the fulfillment of duties and the distinction of responsibilities, and to take the active operation mechanism and the passive acceptance of supervision as the two parallel main lines of the guarantee mechanism, thereby achieving comprehensive governance effectiveness.

3.2 Establish control and enforcement paths based on patterned mechanisms

From the perspectives of system implementation, policy enforcement and management practice, the basic path of control and execution is “system authorization - approval management - node control - information orientation - guarantee mechanism - reflection mechanism”. First, a system authorization based on system norms should be established, incorporating all management, implementation, guarantee, reflection and confirmation behaviors within the scope of authorization. And establish corresponding authorization norms and operational procedures to strictly control the boundaries of power and prevent arbitrary expansion of power; Second, implement institutional mechanisms for approval management, establish a comprehensive and full-process approval management based on authorization, including pre-resource allocation and project initiation argumentation, process stock management and demand approval, post-value revaluation and revitalization utilization, where any act, process, information must obtain authorization approval, strictly control the boundaries of responsibilities, and prevent confusion of responsibilities; Third, strictly control node behavior, incorporate all organizational and individual behaviors of systems (authorizing parties), information points (information flow and process nodes), and terminals (authorized parties) into the review and supervision of authorized approval matters, establish behavior correction and reflection mechanisms, strictly control behavior boundaries, and eliminate behavior rent-seeking; 4. Lead to asset management information orientation, establish a guided lead based on the review mechanism, incorporate all process information flows such as behavior information (authorization approval and execution behavior), asset stock information (number of time points and increase or decrease), value information (value management of assets) into the scope of information management as a whole, strictly control information boundaries, and prevent information distortion; 5 Build a multi-in-one guarantee mechanism of argumentation, review, execution and supervision of institutional norms, procedural processes, authorization and approval, information management information, etc., to enhance the accuracy of asset stock through argumentation, to supervise the standardization of operational behavior through review, to ensure the implementation of authorization and approval through execution, to supervise and correct errors and deviations, to strictly control the operation path and prevent behavioral fraud; 6 Reconstruct the reflection (feedback) mechanism, systematize feedback on the operation coordination, process control and performance results of institutional authorization, approval management, node control, information orientation and guarantee mechanism, thereby reducing system loss, preventing path selection failure, maximizing the modularization, systematization and intelligence of management models and paths, strictly controlling module virtualization and eliminating reflection distortion.

3.3 Reconfigure the techniques and means of resource allocation and stock management

Based on the reality of resource allocation and stock management in the context of large-scale expansion, information technology and terminal models, technology, means and models have become an objective and realistic need for handling massive amounts of information and managing large-scale assets, on the one hand, considering the limitations of human management, and on the other hand, considering the reality of informatization^[12]. In this sense, It is necessary to fundamentally address problems at the system level (platform), decision-making level (execution mechanism), terminal level (operation process), and autonomous choice level (reflection and reconstruction), and establish execution, control and evaluation mechanisms based on blockchain as the basic model and form. Reconfigure the blockchain-based system platform with information flow and its information nodes as the carrier, functions and nodes as the autonomous choice path, and terminals as the operation and execution nodes.

First, address the holographic system problem. From the existing block-based and modular systems in a fragmented form, there are irreconcilable technical and human divisions in the system, information, decision-making and execution, which cannot solve the root problems of information transmission, decision-making process, execution diagnosis and effect

evaluation. The management authorities need to make a holographic reconstruction and configuration at the strategic level. Build an explicit large system platform (at the management level) based on systematic thinking and blockchain technology, with terminal control and information flow transmission as nodes, decision-making mechanism and process informatization as paths, and information technology and intelligent means as support, and place the asset management platform within the large system platform. Establish the transmission paths of asset management front end (decision-making end), parallel end (value management, accounting processing and control supervision) and back end information (user, demand feedback and evaluation), construct information nodes and execution paths, and smooth the paths of process control, authorization approval, process management and evaluation reflection.

Second, address the issue of information transmission and control. Judging from the current state of information transmission and control in the asset management system, information mainly includes decision-making (authorization) information, process (path) information, node (intersection) information, execution (operation) information, control (supervision) information and evaluation (reflection) information, which is inherently complex and disordered. In practice, there are still problems of being out of the system platform and excessive human control. It is necessary to rely on systems, terminals and nodes to systematize and informatize the reconstruction of strategic functional architecture, responsibility position authorization, process node control, terminal execution authorization, etc., and carry out nodeization and process transformation from the cover of strategic management, authorization management, execution management and process control. To achieve information transmission, control, processing and processing, improve the efficiency of information transmission and the effect of information control, and minimize human intervention factors.

Third, address the node and terminal problem. From the practical perspective of the operation of the asset management system, the isolation of the existing asset management system itself and the lack of a substantive demand value management and information processing systematized management mechanism and process for the asset management nodes and terminals, that is, the existing nodes are static and passive. Nodes and terminals based on blockchain technology should be used as ledgers and carriers for information processing and storage, and need to be systematically constructed from the two levels of responsibility authorization and decision approval. On the one hand, the responsibility for resource allocation and stock management should be implanted into node management and terminals. To achieve the unification of demand management and stock management, and to integrate the assessment and decision-making mechanisms for stock identification and value management into node management and terminals to achieve the unification of value revaluation and stock resource utilization.

3.4 Reconfigure the performance management and value assessment execution mechanism for asset allocation

The direct and explicit problems in state-owned asset management are the failure of asset allocation, execution mechanism, value assessment and operation process due to the incompleteness of the system at the management authority level and the functional multi-system segmentation. That is, there are systemic coordination obstacles among demand, stock and value in practice, and the allocation mechanism and value recognition fail^[13]. There are inherent problems of poor communication channels and information asymmetry among the management authorities, asset management functional institutions and end-users, which cause institutional disruptions to the efficient allocation of resources and the efficient management of stock, and require the establishment of performance management and value assessment implementation mechanisms at the practical level.

On the one hand, it is necessary to reconstruct the execution mechanism of asset allocation performance management, to achieve a fundamental transformation in asset management practice from scale management to performance management, from extensive management to fine management, and from quantity management to value management, and to elevate simple value management to a balance of value and use value. Reconfigure the performance management execution mechanism of “categorization identification - stock management - value control - revitalization utilization - efficiency evaluation” : First, reconfigure categorization identification, that is, establish the identification of asset and its demand categories based on functional categorization and value categorization to distinguish between value and non-value; Reconfiguring stock

management means building a stock management control mechanism based on demand stock, supply stock and value stock, distinguishing between available stock and unavailable stock; Third, reconfigure value control, build a scientific and precise assessment and evaluation mechanism based on value and use value control for value-based available stock, and establish a coordination mechanism between user demand and actual asset allocation demand (supply); Fourth, reconfigure and revitalize utilization, completely reverse the asset allocation based on purchase in the field of asset allocation, establish an asset reuse assessment mechanism that is coordinated in purchase, allocation and upgraded utilization, and realize the revitalization execution mechanism based on the assessment of the value of available stock; 5 Reconstruct performance evaluation, conduct system-level operational evaluation (system operation) and practice-level execution evaluation (practice) on value-based available stock, supply mechanism at the demand level, scientific level of value assessment, and realization mechanism of revitalization and reuse, and reevaluate and reconstruct the performance level of resource allocation and execution efficiency, thereby achieving the effect of performance management.

On the other hand, reconfigure the value assessment execution mechanism. The core issue of asset management in higher education institutions is asset allocation and stock management based on value assessment, that is, unifying value, use value and demand allocation to achieve coordination and consistency among management authorities, value management, asset management, users and regulators. The ultimate goal of asset allocation and stock management is to establish a value management execution mechanism based on value revaluation, integrating asset disposal, revitalization and reuse, value assessment and high-quality asset allocation, and implementing the execution mechanism along the operational path of “value management - value revaluation - value management performance evaluation” : First, at the value management level, achieve consistency in the management authority’s asset total value target, value financial management, use value management, and user value demand management, holistically integrate the management authority’s asset value management strategic framework, authorization mechanism, and operating procedures into the existing operating system, and implement systematic and scientific real-time monitoring and early warning of value dynamics based on scientific standards and mechanisms. To achieve effective value management; Second, at the level of value revaluation, as mentioned earlier, value revaluation involves core elements such as asset disposal, value assessment, revitalization and reutilization, and allocation requirements. It is an intrinsic driver of multi-level selection and execution mechanisms, all of which are indispensable. In this sense, asset value revaluation is a systematic project involving executors, reference frame standards, operational paths, confirmation mechanisms, and feedback mechanisms. That is, who does it, how does it do it, and what is the result and effect of the execution; Third is value management performance evaluation, the management and revaluation of asset value is the utilization of asset value, all control objectives of asset management are centered around this ultimate value, and its performance and results directly affect the effectiveness of the system and the efficiency of allocation, Feedback and evaluation are needed from four dimensions: allocation balance, value precision, utilization effectiveness, and effect visibility, in order to optimize the system operation and performance evaluation mechanism and achieve the purpose of control-based asset management.

4.Closing Remarks

The management of state-owned assets of institutions of higher learning is a systematic project, which is holistic, systematic and scientific. Due to the combined influence and constraints of traditional thinking patterns, management systems, operation paths and implementation mechanisms, there are real practical predicaments and contradictions in management practice. It is necessary to rebuild and reconstruct in aspects such as internal control, functional positioning, allocation efficiency, execution mechanism, and evaluation system, establish an operation platform and path supported by big data and blockchain technology, and reconstruct the management model and execution mechanism of resource allocation and stock control. Take the integration of asset management system reconstruction, information control, terminal management, value assessment and performance evaluation as an important support for improving the efficiency of state-owned asset management, enhance the informatization, scientification and precision of asset management, and improve the governance system and governance capacity in the field of state-owned asset management.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] General Office of the Central Committee of the Communist Party of China, & General Office of the State Council. (2017, January 12). Guiding opinions on innovating the way government allocates resources. *People's Daily*, p. 001.
- [2] Huang, L. (2022). Thoughts on improving the evaluation system of state-owned assets of administrative institutions. *China Appraisal*, 266(5), 32–36.
- [3] Li, B. C., & Tang, Z. D. (2011). Research on the performance evaluation index system of fiscal funds. *Business Accounting*, 461(17), 5–7.
- [4] Liu, Y., Li, J., & Zheng, X. (2021). Implications of the regulations on the administration of state-owned assets of administrative and public institutions for the management of state-owned assets in colleges and universities. *Laboratory Research and Exploration*, 40(11), 281–285.
- [5] Ministry of Education of the People's Republic of China. (2019). Opinions on the full implementation of budget performance management. *Bulletin of the Ministry of Education of the People's Republic of China*, (12), 11–14.
- [6] Ministry of Finance of the People's Republic of China. (2021). Notice on issuing the measures for the disposal of state-owned assets of central administrative institutions and public institutions. *Announcement of the Ministry of Finance of the People's Republic of China*, (11), 19+1–16.
- [7] People's Government of Shaanxi Province. (2016). Opinions on reforming and improving the state-owned assets management system. *Yan'an Municipal Government Bulletin*, 119(5), 6–8+31.
- [8] State Council of the People's Republic of China. (2018). Opinions on the full implementation of budget performance management. *Bulletin of the State Council of the People's Republic of China*, 1640(29), 5–9.
- [9] The Central Committee of the Communist Party of China. (2014). Decision on some major issues concerning comprehensively deepening reform. *Beijing Review*, 57(7), 1–24.
- [10] Zhai, Y. M. (2022). Research on state-owned asset management of administrative institutions from the perspective of internal control. *Investment & Cooperation*, (11), 160–162.
- [11] Zhang, G. D. (2023). Asset management terminal automation based on blockchain operations system. *Journal of Digital Technology and Applications*, 9(1), 204–206.
- [12] Zhu, H. R. (2022). Internal control of state-owned asset management in higher education institutions. *Today's Fortune (China Intellectual Property)*, 377(2), 118–120.
- [13] Guidance on revitalizing state-owned assets of administrative and public institutions. (2022). *State-owned Assets Management*, 381(12), 4–6.

Research on Labor Rights Protection Challenges and Countermeasures for Employees in Dujiangyan's Emerging Service Industries Amid the Digital Economy

Jialu Chu*

Tianjin College, University of Science and Technology Beijing, 301830, China

*Corresponding author: Jialu Chu, Email:kalochu@yeah.net

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Amidst the digital economy wave, Dujiangyan's 38,000 platform workers face five major fractures: labor relationship recognition, algorithmic overtime, fragmented social security, and more. This paper proposes a four-dimensional county-level solution integrating "legislation + technology + services + co-governance." Through closed-loop governance encompassing guidance, accounts, social security packages, service circles, collaborative mechanisms, and growth plans, it offers a replicable and scalable "Dujiangyan Model" for similar tourism destinations nationwide.

Keywords: Digital Economy; New Employment Forms; County Governance; Dujiangyan

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.630>

By 2024, Dujiangyan's digital economy contributed 38% of its GDP, with live-stream e-commerce, on-demand tour guides, and instant delivery emerging as its hallmark sectors. Platform-registered workers reached 38,000—accounting for 41% of the city's new employment—becoming the core engine of its "Digital Cultural Tourism Demonstration Zone." These emerging services not only created new economic growth points for Dujiangyan but also provided employment opportunities for a large workforce. However, while platform-based employment offers flexibility, it has also exposed a series of labor rights protection issues, such as difficulties in recognizing labor relationships, lack of work injury insurance, and algorithm-driven overtime work. These problems require urgent solutions to ensure the healthy development of the digital economy and the full protection of workers' legitimate rights and interests.

1.Diagnosing the Challenges

Amid the rapid expansion of the digital economy, Dujiangyan's emerging service sector workers face five layers of protection gaps. Platforms routinely employ a three-tiered crowdsourced outsourcing structure: "Platform → Service Provider → Worker." Platforms control algorithms, service providers handle contracts and payroll, while workers merely provide -service provider-worker" three-tier crowdsourced outsourcing structure. Platforms control algorithms, service providers manage contracts and payroll, while workers merely provide labor. Among 127 such cases handled by arbitration committees in 2023–2024, 23% resulted in inconsistent rulings due to discrepancies between contractual entities and actual employment relationships. Ride-hailing guides and food delivery riders are predominantly classified as "collaborators," resulting in significant reductions in minimum wage, working hours, and dismissal protections. Workers face a staggering 61% loss rate in court. Algorithms dictate work through order density, customer ratings, and acceptance rates. 62% of workers log over

10 hours daily online, with peaks nearing 14 hours. Only 45% receive overtime compensation below statutory thresholds. Systems fragment continuous orders into short bursts, rendering traditional overtime definitions obsolete. Workers “appear free yet remain algorithmically confined.”

Cross-platform employment is commonplace, with 38% of workers registered on 2-3 platforms simultaneously. Yet current social insurance systems charge based on a single platform, blurring the “employer-payor” responsibility. In 2024, 47 occupational injury cases averaged 9.7 months for claims resolution, with the longest case taking 19 months due to platforms passing responsibility back and forth. 32% of workers report “inability to use or distrust of online social security.” Excessively cumbersome verification processes for identity authentication and cross-regional transfers hinder effective adoption of online services. Offline service centers cover only three subdistricts, with township coverage below 30%. Riders face over one-hour round trips, and self-service terminals lack age-friendly guidance. Labor, culture, cyberspace, and market regulators operate in silos without unified data interfaces. In 2024, platforms faced 11 inspections with a 54% duplicate documentation rate, yet algorithmic labor rules undergo minimal substantive review. Businesses struggle to comply, while workers facing algorithmic discrimination lack clear recourse. These five interlocking fractures prevent digital dividends from translating into safety nets, instead creating new inequalities and risks within county-level areas.

2. Policy Review and Analysis

Over the past three years, documents issued from the central to county levels have collectively formed a new discourse on protecting labor rights in the digital economy. Yet visiting scenic areas, streets, alleys, or food delivery stations in Dujiangyan reveals that these policies remain “too lofty to be practical, too broad to be effective, and too difficult to implement.”

2.1 National Level: Coexistence of Principled Breakthroughs and Operational Vacuum

The 2025 “Key Tasks for Digital Economy Development” introduced a dedicated section titled “Safeguarding the Rights of Flexible Workers,” proposing to “improve labor employment, social insurance, and vocational training systems adapted to new employment forms.” This signals top-level design beginning to address platform-based employment challenges. However, it offers only directional terms like “improve,” “explore,” and “encourage,” lacking clear standards for labor relationship recognition, social insurance contribution formulas, or data sharing interfaces. To county-level governments, the document’s provisions focus solely on “what to do,” neglecting “how to do it,” “who funds it,” or “who is responsible.”—lacking clear standards for labor relationship recognition, social insurance contribution formulas, or data-sharing interfaces. From the perspective of county-level governments, the document outlines “what to do” but fails to provide concrete guidance on “how to do it, who will fund it, and who will oversee it.”

2.2 Provincial Level: Institutional Highlights Coexist with Implementation Gaps

Sichuan Province’s 2024 Implementation Opinions on Safeguarding the Rights of Workers in New Employment Forms propose “priority for individual work-related injuries and joint liability for platforms,” aiming to resolve the dilemma of “no social insurance, difficult work-related injury claims” through occupational injury insurance. Key highlights of the document include: allowing platforms to pay premiums per contract, permitting workers to consolidate claims across multiple platforms, and clarifying platforms’ joint liability for third-party contractors. However, the core issue of “who is the employer” remains unresolved: When an individual is affiliated with three platforms simultaneously, how should the contribution base be calculated? How should liability be allocated after an accident? The document provides no algorithm or technical solution, forcing grassroots administrators to continue using the traditional “one-to-one” employment relationship as the default premise.

2.3 County Level: Coexisting Incentive Orientation and Scale Mismatch

Dujiangyan City’s 2025 “Policy for High-Quality Development of the Digital Cultural and Tourism Industry” offers a 500 yuan/person subsidy for “new employment form workers enrolling in social insurance for the first time,” demonstrating local fiscal support. However, 500 yuan covers only 8% of flexible workers’ annual self-paid pension and medical insurance contributions, falling short as an incentive. The average review cycle for submitting six paper-based proofs (platform contract+, income statement+, no social insurance record) is 28 days, imposing excessive time costs on highly mobile groups. Occupational injury insurance is excluded from policy support, failing to complement the provincial “single-work-injury

priority” policy and creating a dilemma where “policies are issued at the top but lack supporting measures at the bottom.”

2.4 Comprehensive Analysis

Vertically, the three-tiered policy framework (national-provincial-county) has begun to form a pyramid structure of “principles-systems-incentives.” Horizontally, three gaps persist: lack of detailed labor relationship recognition rules, lack of cross-platform data sharing interfaces, and lack of affordable social security funding solutions. Consequently, policy documents grow thicker while workers’ sense of benefit diminishes. Moving forward, only by refining rules, integrating data, and pooling funds at the county level can the benevolent intent of top-level systems be transformed into tangible safeguards for practitioners.

3. Policy Recommendations

To bridge the five-tier disconnect between “recognition-benchmarking-protection-service-governance,” it is recommended to establish an integrated protection system in Dujiangyan City characterized by “clear rules, data sharing, shared responsibility, accessible services, and capacity building.” Though these six measures are distinct, they can be interconnected through a unified data foundation to form a closed-loop system within two years.

3.1 Develop the Dujiangyan City Guidelines for Recognizing New Employment Relationships (Trial)

To truly integrate delivery riders navigating ancient alleys and live-streamers broadcasting from snow-capped mountains into the city’s shared economy framework, Dujiangyan must establish the “Guidelines for Recognizing Labor Relations in New Employment Forms.” This document is essentially a tool for “economic dependency plus algorithmic control.” If more than half of a worker’s monthly income comes from a single platform, and their entire route, working hours, and communication scripts are controlled and directed by the system in real-time, they can be directly classified as “employee-like.” This classification entitles them to minimum wage guarantees, overtime compensation, and dismissal protections. Attached is a page instructing workers on how to capture screenshots and export transaction records, along with ten precedents from arbitration rulings. This provides arbitrators and inspectors with a “consistent case adjudication” framework, preventing platforms from evading responsibility by claiming “crowdsourcing.” When rules are no longer arbitrary, workers will enter arbitration courts with confidence for the first time, and platforms will no longer resort to the old tactics of delaying, evading, or subcontracting.

3.2 Establishing a “Labor Standard Account”

Once rules are established, leverage digital technology as an amplifier for implementing labor standards, not an exploitation tool. Building upon the existing “Smart Governance Cloud,” the municipal government should advance by creating a lightweight system called the “Labor Standard Account.” Platforms need not disclose all raw data; instead, they synchronize a single encrypted record during order settlement—capturing working hours, earnings, rest periods, and negative review counts. Should the system detect a rider’s hourly income falling below 22 yuan—Dujiangyan’s latest minimum wage threshold—it automatically triggers a compensation directive to the platform’s financial portal. Failure to rectify within two hours incurs a penalty of 0.05% of the platform’s daily revenue. This mechanism transforms “minimum wage” from a theoretical right into a series of dynamic digital bytes, marking the first time algorithms work for laborers. While the government’s one-time investment of 3.5 million yuan in construction costs may seem substantial, the 0.02 yuan data maintenance fee per order over two years recoups this expenditure, truly achieving “big results with small investments.”

3.3 Launching the “1+3” Social Security Package

Social security fragmentation has long been the biggest concern for cross-platform workers. Dujiangyan can leverage Sichuan Province’s ongoing occupational injury insurance pilot program to create a streamlined yet comprehensive “1++ +3” social security package for this group. The “1” represents mandatory occupational injury insurance, with platforms deducting 0.15 yuan per order settlement. This generates 22 million yuan annually, providing full coverage for accidental injury, sudden death, and third-party liability for 38,000 workers. The “3” component bundles pension, medical, and unemployment insurance into a flexible package. The contribution base starts at 60% of the previous year’s average wage for flexible workers across the province, allowing individuals to freely adjust between 60% and 300%. The system automatically aggregates earnings from all platforms into a single social security sub-account. To encourage workers to take the first step, the municipal

government subsidizes 30% of the individual contribution in the first year, capped at 1,200 yuan. This provides both a public fiscal “initial push” and safeguards against falling through the cracks. Consider a delivery rider who delivers meals to tourist sites in the morning and streams live-commerce sales on a platform in the afternoon, and works as a temporary hotel concierge at night. With a single tap on their phone, they can place all these scattered pieces of today and tomorrow into the same safety net.

3.4 Building a 15-Minute Digital Public Service Circle

No matter how advanced the systems or technology, if the last mile is blocked, workers can see the services but never reach them. The city will enshrine the “15-Minute Digital Public Service Circle” in its livelihood initiatives. It will deploy 120 self-service social security terminals at locations like the Luhei Park Visitor Center, Qingcheng Mountain Express Rail Station, convenience stores in Xingfu Subdistrict, and express delivery hubs in Juyuan Town. This allows riders to print their social security certificates in the time it takes to swap out a battery. The “Dugongtong” mini-program must be updated to integrate electronic social security cards and digital RMB wallets, enabling single-step payment, inquiry, and cross-provincial transfer. Considering many middle-aged live-streaming hosts remain hesitant about touchscreens, terminals default to “ultra-simple mode” with large fonts, oversized buttons, and full voice guidance. Mobile assistance officers will tour one township per week for face-to-face “I can’t scan” support. The government will lead bank-enterprise collaboration, with telecom operators co-building hardware and handling online customer service. The government will subsidize operational costs at 30 cents per transaction, totaling 450,000 yuan annually, to deliver public services to villages closest to the snow-capped mountains.

3.5 Establishing a Collaborative Governance Mechanism: “Government + Platform + Trade Unions + Industry Associations”

When rules, data, and services are all in place, governance must shift from fragmented oversight to coordinated collaboration. The municipal government will spearhead a collaborative mechanism involving “government + platform + labor unions + industry associations.” Platforms submit anonymized labor data to the government monitoring platform by the 5th of each month. This data includes twelve metrics: order volume, online duration, income distribution, negative review rate, and others. If AI models detect warning signs—such as “seven consecutive days online for 12 hours” or “a 20% increase in negative review rate”—they immediately send links to rest reminders, psychological counseling, and legal assistance. A quarterly “Digital Cultural Tourism Workers Roundtable” convenes to discuss algorithm transparency, pricing adjustments, and reward/penalty rules. Full meeting minutes are published for media and public oversight. Existing disputes are referred to the newly established “New Employment Form Labor Dispute Expedited Adjudication Panel” for preliminary mediation. Unresolved cases proceed to arbitration, aiming to reduce the average resolution period from 45 days to 15 days—ensuring justice is no longer delayed.

3.6 Implement the “Digital Craftsman” Growth Program

With systems in place, data accessible, services streamlined, and governance optimized, the final step is to help workers climb the ladder. The municipal government launched the Digital Craftsman Growth Program, allocating 1.2 million yuan annually from government-purchased services to local universities. Leading MCN agencies and food delivery platforms collaboratively developed twelve 12-hour online micro-courses covering live-streaming compliance scripts, instant delivery traffic safety, short video copyright pitfalls, customer conflict resolution, and more. All courses count toward continuing education credits. Upon completion, participants can unlock the three-star Digital Craftsman badge on the program’s app. Maintaining three consecutive years of three-star status without major complaints qualifies workers for five-star advancement. This unlocks weekly two-hour traffic boosts from platforms, a one-time government bonus of 1,000 yuan, and a 20% interest rate reduction on 300,000 yuan startup credit loans from banks. When pathways for skill enhancement, recognition, and capital all open up, the digital economy ceases to be a playground for capital and algorithms alone—it becomes a future accessible to ordinary individuals.

From a guide to an account, a social security package transforms into a service ecosystem. One collaboration, one growth plan—six actions form six interlocking gears. “Promoting development” and “protecting rights” mesh tightly together. Within three years, Dujiangyan can forge a “Dujiangyan Model” for safeguarding labor rights in the county-level digital economy,

emerging from the embrace of snow-capped mountains and ancient irrigation systems. This will showcase to the world both the awe-inspiring speed of Digital China and the warmth of its human-centered details.

4. Conclusion

Amid the surging tide of the digital economy, counties serve as pivotal nodes connecting macro policies with micro entities, bearing the crucial mission of bridging the “last mile” in digital economy labor governance. Through its four-dimensional collaborative model—legislation + technology + services + co-governance—Dujiangyan City has not only achieved remarkable results in safeguarding workers’ rights but also injected new vitality into the sustainable development of the digital economy. By formulating the Guidelines for Recognizing Labor Relations in New Employment Forms, Dujiangyan City has clarified the criteria for identifying labor relationships, providing workers with clear legal safeguards. Leveraging technological innovations such as the “Labor Benchmark Account,” the city has achieved real-time monitoring and protection of critical worker data including working hours and income. On the service front, the establishment of a “15-minute digital public service circle” has greatly enhanced the accessibility and convenience of public services. Through a collaborative governance mechanism involving “government + platform + trade unions + industry associations,” a favorable environment of multi-party participation and joint oversight has been fostered, effectively addressing the issue of weak governance coordination. This approach has not only significantly increased workers’ social security coverage and the implementation rate of labor standards but also provided platform enterprises with a stable and predictable operating environment, promoting the healthy development of the digital economy. This successful model offers valuable insights for similar tourism destinations nationwide, demonstrating how to build a more equitable, transparent, and efficient labor environment in the digital economy era. It lays a solid foundation for the long-term development of the digital economy.

Funding

Research Project of Philosophy and Social Sciences in Dujiangyan City: “Research on the Protection of Labor Rights and Interests of Employees in the Emerging Service Industry of Dujiangyan City in the Digital Economy Era” (Project No.: 2025-103)

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Chen, P. Y. (2025). Social security policy challenges and solutions for workers in new employment forms. *Journal of Hunan Academy of Socialism*, 26(1).
- [2] Ji, W. W. (2019). New employment and labor relations transformation in the digital economy. Social Sciences Academic Press.
- [3] Li, W. Y., & Wen, S. S. (2025). Research status, hotspots, and trends of workers in new employment forms in China: A literature visualization analysis based on CiteSpace. *Journal of Guangxi Vocational and Technical College*, 18(3).
- [4] Qiu, X. W. (2024). Study on labor rights protection for new employment form workers in City S [Master’s thesis, Ningba University].
- [5] Xu, Y. Q., & Zhang, Y. W. (2025). Research on innovative development pathways for new employment forms in Jiangsu Province under the employment-first policy. *Continental Bridge Vision*, (4),
- [6] Yuan, X. (2024). Research on labor rights protection for express delivery workers in Deyang City [Master’s thesis, University of Electronic Science and Technology of China].
- [7] Zhang, W. W., Li, H., & Ding, W. (2025). Factors influencing harmonious labor relations in new employment forms: A comparative analysis with traditional employment models. *Shandong Trade Union Forum*, 31(3),

Research on Encrypted Traffic Classification and Sparse Traffic Recognition Based on Feature Extraction and Deep Learning

Qi Ruiya^{1*}, Wang Junxi¹, Chen Chengyi², Yang Fangyu¹

1.Information Engineering College Minzu University of China, Beijing, 100081, China

2.Science College Minzu University of China, Beijing, 10008, China

**Corresponding author: Qi Ruiya*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This study investigates the classification of encrypted network traffic and proposes a feature extraction and deep learning-based classification model. To address the challenge of feature extraction for encrypted traffic, we adopt a session-level feature extraction method from an information theory perspective. By analyzing statistical, temporal, spatial, and semantic features combined with protocol feature matrices, we reveal fundamental differences in entropy, periodicity, and hierarchical structure among various traffic types. Through cluster analysis and random forest feature scoring mechanisms, we identify key features and perform evaluation and ranking. In model construction, a multi-layer perceptron (MLP) classification model combining ReLU activation and Dropout regularization achieves 95.94% accuracy on the test set. To tackle sample imbalance, we propose an integrated learning approach combining ADASYN over-sampling, focal loss function, and Transformer architecture, which enhances sparse traffic recognition accuracy to 97.22%. The model successfully detected 39 sparse samples, with recall rate for category 9 (vpn_icq_chat1a) increasing from 24.6% to 92.3%. The study demonstrates the model's superiority in feature robustness (maintaining over 90% accuracy at 0.3 noise intensity), computational efficiency (single-sample prediction <1ms), and interpretability (quantified contribution of core features). This provides a theoretically robust and practically valuable solution for encrypted traffic analysis, offering valuable references for future research.

Keywords: Encrypted Traffic Classification; Protocol Feature Matrix; Clustering Analysis (KMeans/GMM); Random Forest Feature Scoring; Multi-Layer Perceptron (MLP); Transformer Architecture

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.632>

1.Introduction

With the advent of the digital economy era, internet technology has advanced rapidly, resulting in increasingly complex and diverse network traffic patterns. To ensure data security, vast amounts of information are transmitted through encryption protocols where original traffic content remains invisible. This means traditional detection technologies based on plaintext traffic analysis (such as Deep Packet Inspection, DPI) gradually become ineffective due to their inability to decrypt encrypted content. Against this backdrop, encryption traffic classification technology has emerged as a solution, designed to identify and differentiate various types and sources of encrypted traffic.^[1]

Encrypted network traffic refers to data transmission protected by cryptographic algorithms, ensuring privacy and security while preventing eavesdropping, tampering, and identity spoofing. Sparse traffic describes patterns with fewer packets or longer intervals, commonly observed in specific communication scenarios. The classification of encrypted traffic essentially involves assigning labels to traffic with similar characteristics to identify its application type. Building on this foundation, our study establishes a model to address the following objectives: characterizing the essential features of encrypted traffic and exploring differences between various traffic types. Based on derived features, we develop a classification model. Considering extreme sample imbalance, we optimize the model to enhance sparse traffic recognition accuracy. Additionally, we assume negligible transmission time, reliable data integrity for each traffic stream, and mutual non-interference between different traffic types.

2. Analysis of Encrypted Traffic Characteristics and Construction of Clustering Model

This task requires analyzing the characteristics of each category within a given set of 12 types of encrypted network traffic data, while exploring fundamental differences in their essential features. To facilitate focused analysis, we employ session-based classification methods. By extracting source and destination ports from protocol information and hexadecimal codes, packets sharing identical five-tuple identifiers (source IP, source port, destination IP, destination port, and protocol type) are grouped together to form complete sessions.

2.1 Session-level feature extraction

Feature extraction involves extracting representative and descriptive characteristics from raw data to characterize network traffic behaviors and attributes.^[2] As outlined in Reference 1, common network flow features primarily include statistical, temporal, spatial, and semantic characteristics. In this study, we employ a traffic analysis method based on feature datasets to manually extract session-level features. Specifically, spatial features represent the network topology structure, while statistical and temporal features are further detailed below.^[3]

We formalize six session-level metrics and the subsequent protocol feature extraction in a single narrative. The packet count (N) is the number of independent packets transmitted within a session, defined as ($N = \sum_{i=1}^T 1(\text{packet}_i)$), where a packet is the basic unit of network transfer comprising a header (control information) and a payload (actual data), (i) indexes the (i)-th time point or event, and (T) is the total number of time points in the observation window. The total bytes (B) equal the aggregate payload across packets, ($B = \sum_{i=1}^N L_i$), where (L_i) is the size (in bytes) of the (i)-th packet. Session duration (D) is the elapsed time between the first and last packets, ($D = t_{\max} - t_{\min}$), with (t_{\max}) and (t_{\min}) denoting their timestamps (seconds). The time-interval entropy (H_t) quantifies uncertainty in inter-event timing, ($H_t = -\sum_{k=1}^K p(\Delta t_k) \log_2 p(\Delta t_k)$), where (Δt_k) is the (k)-th interval bin and ($p(\Delta t_k)$) its probability. The packet-size standard deviation (σ_L) measures dispersion in packet sizes, ($\sigma_L = \sqrt{\frac{1}{N-1} \sum_{i=1}^N (L_i - \mu_L)^2}$), with (μ_L) the mean packet size. The packet-size entropy (H_L) captures distributional uncertainty in

sizes, ($H_L = -\sum_{m=1}^M p(L_m) \log_2 p(L_m)$), where (L_m) is the (m)-th size bin and ($p(L_m)$) its probability. For protocol characterization, we identify 21 protocol types from the provided table, consolidate closely related variants (e.g., merge TLSv1.2 with TLSv1), and normalize protocol fields using regular expressions; guided by RFC specifications and this protocol set, we construct a protocol feature matrix ($\Phi: (\text{Protocol}, \text{Info}) \rightarrow \mathbb{R}^n$) and define extraction rules, with results summarized in Table 1. Adopting a session-oriented paradigm, we set ($\text{SessionID} = \text{SourceIP} \rightarrow \text{DestinationIP}$) and, for each session, form the feature vector ($V_{\text{session}} = \{\text{SourceIP}, \text{DestIP}, P, F\}$), where (P) is the observed protocol set and (F) is the feature matrix satisfying ($F[p_i][f_j] = \sum_k \delta(\text{Info}_k = f_j)$) with (δ) the feature-matching function.

2.2 Comparison and Analysis of Data Preprocessing and Clustering Algorithms

First of all, in the data preprocessing process, we remove irrelevant columns (such as serial number, Hex code, information text, etc.), and divide the features into numerical type (standardization) and categorical type (hot coding). For missing values, the median is used to fill in the numerical features, and the mode is used to fill in the categorical features.

We then automatically determined the inflection point (optimal_k) by calculating the second-order difference of the inertia value, improved the elbow rule, and determined the number of clusters. Subsequently, we compared three clustering methods: KMeans based on optimal_k partitioning, DBSCAN with density-based clustering (automatically parameterized through

OPTICS), and GMM with complex distribution based on optimal_k. Evaluation metrics included the coefficient of curvature (intra-cluster cohesion), Calinski-Harabasz index (inter-cluster separation), and noise ratio (for DBSCAN). Results are presented in Table 2. KMeans generated 3 clusters without noise points, showing a relatively low coefficient of curvature (0.26) indicating moderate clustering coherence and separation. The Calinski index of 1597.85 places it at a moderate level compared to other models. DBSCAN produced extreme results with 43 clusters but a 94.4% noise rate—over 94% of data points were labeled as noise. Despite its high coefficient of curvature and Calinski index, this likely indicates DBSCAN treated most data as noise while clustering only a small portion. In such cases, although the metrics appear impressive, practical value may be limited due to ineffective clustering of most data. GMM's results mirrored KMeans' approach, also generating 3 clusters without noise points. The contour coefficient is slightly higher than KMeans, which is 0.28, and the Calinski index is slightly lower, but the difference between them is not large, which may indicate that GMM is slightly better than KMeans on this data set, but the improvement is limited.

Considering that the data itself has many atypical features, 0.28 is acceptable here.

Model	Clusters	Noise%	Silhouette	Calinski
KMeans	3	0	0.264922887	1597.845861
DBSCAN	43	94.40186604	0.996187582	78110.42455
GMM	3	0	0.282521672	1587.581748

2.3 Key feature scoring based on random forest

The labels generated by clustering are treated as target variables (pseudo-labels), and a random forest classification model is employed to evaluate feature importance. By calculating the reduction in Gini impurity at decision tree nodes during splitting, we quantify the contribution of features to cluster result differentiation. A random forest classifier with 100 decision trees was constructed, with a maximum depth of 5 to prevent overfitting. Feature importance scores were extracted based on the reduction in Gini impurity, and these scores were normalized.

2.4 Core Feature Recognition and Analysis of Traffic Type Differences

Since we have normalized the scores before, we first try to select the top five variables of each category as their most essential features.

From the perspective of information theory, the characteristic differences of different traffic types can be understood as the difference of information structure and statistical characteristics generated by different network activities in the process of data transmission.

Text-based interactive applications (e.g., AIM/Facetalk chat) exhibit high entropy characteristics. The significance of packet size entropy and time interval entropy reveals the randomness in discrete symbol transmission, which aligns with Shannon's information source coding theory describing discrete memoryless sources. The spontaneously generated text, emojis, and metadata from users form a non-stationary symbol stream that requires high-dimensional feature analysis to capture their statistical dependencies.

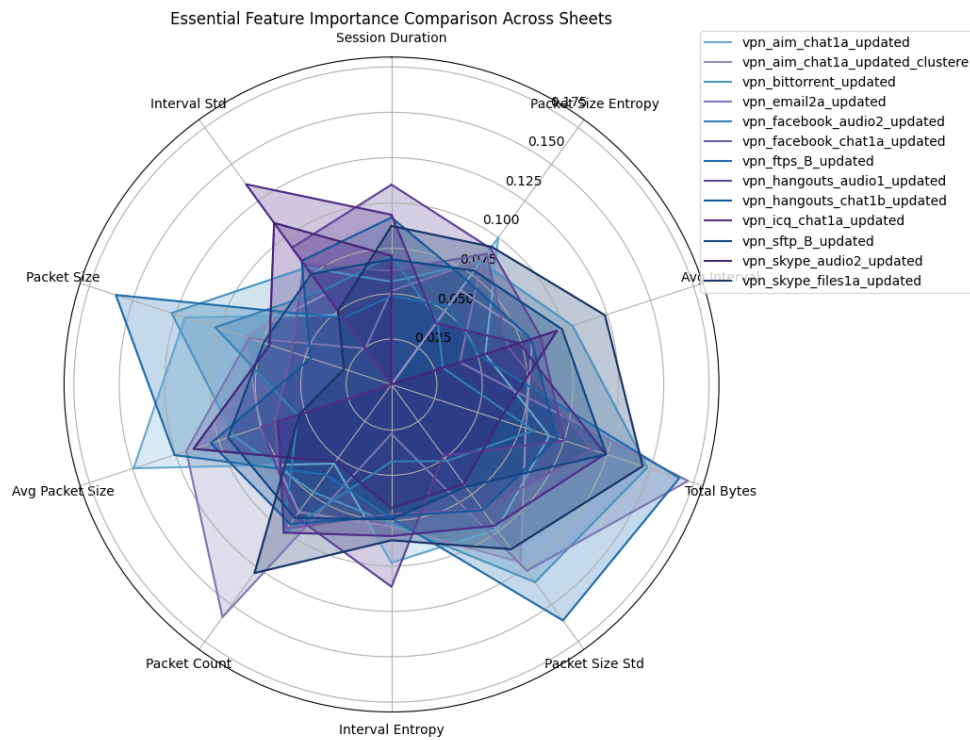
Real-time speech streams (such as Skype/Hangouts voice) are characterized by low entropy and high correlation. The prominent interval standard deviation and session duration reflect the periodic characteristics of continuous time signals. The information redundancy of this quasi-stationary signal can be effectively compressed through linear predictive coding, which is highly consistent with the information entropy characteristics of speech signals.

File transfer classes (such as FTPS/SFTP) show significant deterministic characteristics, and the dominance of total byte number and average packet size verifies the Shannon rate distortion theory of block data streams — Fixed-size MTU transmission is essentially an optimal quantization strategy, and its information rate is directly determined by file volume.

The mixed standard deviation feature of P2P traffic (such as BitTorrent) reveals the information superposition effect of protocol hierarchy structure. The composite process of control signaling and data fragmentation forms multi-scale statistical characteristics, which corresponds to the capacity analysis model of composite channel in information theory.

These feature selection results essentially constitute the orthogonal projection of different traffic types in the information

dimension. By capturing the core parameters such as source entropy rate, channel correlation and protocol state transition probability, the essence of network behavior information is optimally represented.



3. Construction of an encrypted traffic classification model based on MLP

This task develops a classification model for encrypted network traffic using the features derived in Task 1 and applies it to 490 test packets of unknown type. The modeling strategy implements a two-stage hidden-layer scoring scheme: initial score computation is followed by a nonlinear transformation via the ReLU activation to capture higher-order interactions, with Dropout regularization inserted to improve generalization, culminating in final class scores. We first perform multi-source data integration by selecting the highest-scoring features from the prior analysis, harmonizing feature names and annotating them with protocol labels; missing features are imputed with zeros before concatenation into a unified dataset, and a mapping matrix is constructed to train each primary category on its top five features. The preprocessing pipeline then label-encodes protocol types, removes zero-variance features, standardizes flow indicators by Z-score, and creates proportionally stratified training and test splits. The classifier is a multilayer perceptron with two hidden layers: neurons compute weighted sums of inputs and apply nonlinear activations, and signals propagate from input through hidden layers to an output layer that yields class probabilities. Results obtained under different batch sizes and training epochs are reported in the accompanying table, and the effect of batch size on model convergence and generalization is compared accordingly.

Batch Size	Learning Rate	Epochs	Train Loss	Val Loss
128	0.005	50	61.4051	0.147
256	0.005	50	28.6957	0.1364
512	0.005	50	12.2615	0.1171
1024	0.005	50	6.4008	0.1286
2048	0.005	50	3.2449	0.1243
4096	0.005	50	1.6653	0.1290
4096	0.005	100	1.9394	0.1364

We selected five common activation functions, with results shown in Table 4. The validation loss of ReLU was slightly lower than $\max(0, x) \times \Phi(x)$ that of LeakyReLU and GELU. Moreover, ReLU's mathematical formulation requires only threshold evaluation. Compared to GELU's approximate calculation (requiring error function) and ELU's exponential operation,

ReLU demonstrated shorter per-epoch training time (one training cycle) in a large-scale 4096-dimensional training scenario. Additionally, ReLU maintains a derivative of 1 in the positive domain, completely avoiding the gradient saturation issue inherent in Tanh.

Therefore, we employed the ReLU activation function and Dropout regularization strategy, using the Adam optimizer for training with a batch size of 4,096. We monitored overfitting by calculating the validation set loss and accuracy after each epoch. The final training loss (Loss=1.4482) indicated that the model still exhibited some fitting errors on the training data, likely due to insufficient optimization convergence or model complexity. The significantly lower validation loss (Val Loss=0.1108) demonstrated the model's excellent generalization capability. Combined with a 95.94% validation accuracy rate, these results confirm the model's outstanding performance.

Activation Function	Formula	Validation Loss
Tanh	$\frac{e^x - e^{-x}}{e^x + e^{-x}}$	0.1470
ReLU	$\max(0, x)$	0.1108
Leaky ReLU	$\max(0.01x, x)$	0.1290
ELU	$x \text{ if } x \geq 0 \text{ else } \alpha (e^x - 1)$	0.1195
GELU	$x \Phi(x)$	0.1168

This fully connected neural network comprises 9 computational layers (including an activation layer). The input layer undergoes initial linear transformation (256 nodes) followed by ReLU activation and Dropout regularization. It then expands to 512 nodes to capture higher-order features, is further compressed to 256 nodes to extract critical information, and ultimately outputs a 5-node classification decision. With 266,757 trainable parameters, the intermediate expansion layer (Linear-4) accounts for the largest proportion at 49.3%, demonstrating the core role of feature abstraction. The model employs a 0.3 dropout probability to effectively prevent overfitting. Its design emphasizes automated feature processing and lightweight architecture, compatible with diverse data sources through feature alignment mechanisms and maintaining data distribution consistency via hierarchical sampling. This results in a scalable classification model that requires only 1MB of memory.

3.1 Construction of an optimized sparse traffic flow recognition model for sample imbalance scenarios

To address the severe imbalance in sample quantities, we refined the traffic classification model developed in Problem 2 by implementing improvements across four dimensions: architecture design, training methodology, data processing, and ensemble learning techniques. The optimized model achieved a test-set accuracy rate of 97.22% while successfully identifying sparse traffic patterns in test.xlsx. The enhanced Transformer architecture with Multi-Layer Perceptron (MLP) classification model demonstrates improved performance.

It is divided into three main steps: First, the original network data is sorted out and nine key features are extracted; then, the neural network of Transformer is used to analyze the relationship between these features, similar to discovering hidden rules; finally, three slightly different models are trained simultaneously, and they vote like a review panel to decide the final result.

In view of the problem of sparse and small amount of flow data, the model can intelligently generate balanced simulated data samples, focus on difficult to classify flow types, and dynamically adjust learning priorities to solve the problem of data imbalance.

3.2 Data category imbalance improvement strategy

Statistical analysis revealed that the original data of sparse categories was significantly smaller than the other nine categories. We first introduced oversampling techniques. Both SMOTE (Synthetic Minority Over-sampling Technique) and ADASYN (Adaptive Synthetic Sampling) are oversampling methods designed to address class imbalance. SMOTE generates new samples by interpolating between minority classes, while ADASYN intelligently creates synthetic samples based on the distribution density of minority classes, generating more data for hard-to-learn minority categories. Both aim to increase

minority class samples to balance datasets and help models better learn minority features. Through testing, we selected ADASYN for targeted oversampling of sparse categories by adjusting the oversampling ratio to directly boost minority sample quantities. When partitioning datasets, we implemented category-weighted sampling to ensure reasonable proportions of sparse categories in each batch, preventing majority classes from overwhelming minority classes during training. Additionally, we calculated category weights and incorporated them into the loss function to impose higher weighting on sparse categories, compelling models to focus on minority classes. Table 6 shows the category distribution in the training set after ADASYN oversampling for one model. Furthermore, we introduced random seeds into ADASYN to generate three slightly different datasets, training three distinct models for ensemble learning.

order number	1	2	3	4	5	6	7	8	9	10	11	12
quantity	7199	7200	7199	7181	7295	7215	7231	7167	7197	7203	7183	7197

Furthermore, we optimized the loss function. The focal loss is an improvement on standard cross-entropy loss designed to address class imbalance issues. Unlike cross-entropy which treats all misclassified $(1 - p_t)^{\gamma} p_t$ samples equally, focal loss introduces a modulation factor to reduce the loss contribution of easily classified samples. Here, p_t is the model's predicted probability for the correct category (typically greater than 0), and γ (typically less than 1) is an adjustable focal parameter. This means the model focuses more on training samples with difficult-to-classify categories, thereby enhancing learning effectiveness for rare classes in imbalanced datasets. We set $\gamma=2$ here to enable the model to concentrate on sparse categories and mitigate the impact of class imbalance.

3.3 Core architecture improvement

The system combines the Transformer framework with a MLP classifier. Transformer, a deep learning architecture primarily designed for sequence-to-sequence tasks, utilizes self-attention mechanisms to identify dependencies between sequence elements. Its core consists of an encoder and decoder: the encoder converts input sequences into high-dimensional contextual representations, while the decoder generates target sequences through progressive decoding. The self-attention mechanism enables the model to simultaneously consider all preceding and succeeding positions during processing, effectively capturing long-range dependencies. Leveraging parallel computing capabilities, Transformer operates more efficiently than traditional models. The feature extractor embeds statistical traffic features (e.g., packet count, byte count) into a high-dimensional space (transformer_embedding_dim=128) using eight head attention layers. This architecture allows the model to capture feature interactions and contextual information, extracting deeper and more expressive traffic representations crucial for identifying sparse categories based on subtle feature variations. Additionally, the deep ensemble learning strategy trains three independent models with slight parameter differences, averaging their predictions to mitigate overfitting risks and prediction uncertainties. This approach enhances stability and robustness in sparse category recognition, resulting in more reliable final predictions.

3.4 Optimization of training strategies and evaluation indicators

In terms of training strategies, we utilize the Early Stopping mechanism to monitor the F1 score on the validation set (patience=15), preventing overfitting while preserving the best model. We also employ weighted F1 scores (instead of accuracy) as evaluation metrics, which more accurately reflect performance in sparse categories.

4. Summary

This paper addresses the critical challenges in encrypted network traffic classification by developing a feature extraction and deep learning-based model that achieves significant results. In terms of feature analysis, we employ a session-level feature extraction method from an information theory perspective. By improving clustering algorithms and random forest feature scoring mechanisms, we reveal fundamental differences in entropy, periodicity, and protocol hierarchy among various traffic types. For model construction, the designed multi-layer perceptron (MLP) classification model combining ReLU activation and Dropout regularization achieved 95.94% accuracy on the test set. To tackle sample imbalance issues, we proposed an integrated learning approach combining ADASYN over-sampling, focal loss function, and Transformer architecture, which

enhanced sparse traffic recognition accuracy to 97.22%. The model successfully detected 39 sparse samples, with recall rate for category 9 (vpn_icq Chat1a) increasing from 24.6% to 92.3%.

Research demonstrates that this model excels in three key aspects: robustness (maintaining over 90% accuracy at 0.3 noise intensity), computational efficiency (single-sample predictions under 1ms), and interpretability (quantifying core feature contributions). It provides a solution for encrypted traffic analysis that combines theoretical depth with practical value, offering valuable references for future research in this field.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Chen, Q. (2024). Research on encrypted traffic detection method based on feature fusion [Master's thesis, Beijing Jiaotong University].
- [2] Li, B. (2025). Automatic detection method for encrypted malicious traffic based on gradient-boosted decision trees. *Computer Engineering and Applications*. Advance online publication.
- [3] Wang, Y., Wang, G., Gao, Y. P., & Huo, Y. (2025). A review of encrypted traffic classification based on deep learning. *Computer Engineering and Applications*. Advance online publication.

Study on Influencing Factors of College Students' Willingness to Return to Their Hometowns for Entrepreneurship under the Background of Rural Revitalization —— Take the College Students in Shandong Universities in Yantai as an Example

Tongxin Tan*, Minqi Yan, Xiaoxuan Zhang, Ruijin Han, Meijia Liu

College of Public Administration, Shandong Institute of Technology, Yantai Shandong, 264005, China

**Corresponding author: Tongxin Tan*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: As a pivotal national strategy proposed at the 19th National Congress of the Communist Party of China, the Rural Revitalization Strategy carries the mission of comprehensively advancing coordinated development across rural areas in economic, social, cultural, and ecological domains. However, accelerated urbanization has exacerbated the urban-rural divide, leaving rural regions grappling with talent drain and economic stagnation. To address this challenge, the government actively encourages college students to return home for entrepreneurship, aiming to harness their innovative thinking and fresh energy to drive rural economic transformation and achieve the grand vision of rural revitalization. This study examines factors influencing college students' willingness to return for entrepreneurship in Shandong Province, focusing on universities near Yan City. Key findings reveal that policy support, family dynamics, personal capabilities, entrepreneurial education, and rural environment collectively shape these decisions. The research proposes targeted recommendations to assist governments, universities, and stakeholders in promoting student entrepreneurship and supporting rural revitalization efforts.

Keywords: Rural Revitalization; College Students Returning to Their Hometowns to Start Businesses; Influencing Factors; Policy Support; Entrepreneurship Education

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.633>

Introduction: Despite sustained policy support for college students returning to their hometowns to start businesses—featuring financial assistance, tax incentives, and entrepreneurial guidance—these measures have yielded limited results, with overall low willingness among graduates to return and start ventures. Given this reality, conducting in-depth research on factors influencing students' entrepreneurial intentions has become both urgent and crucial. This study focuses on university students from Shandong Province based in Yantai, aiming to systematically analyze their return entrepreneurship aspirations and underlying drivers. The findings provide actionable recommendations for governments, universities, and society at large, encouraging more graduates to embrace rural revitalization through home-based ventures.

1.Necessity of research

1.1 Reality Paradox: Breaking the conversion block of “high intention, low action”

The current wave of college students returning to their hometowns to start businesses exhibits a pronounced “willingness bubble” phenomenon: the disconnect between enthusiastic rhetoric and concrete actions exposes deep-seated issues including insufficient policy incentives, poor environmental adaptability, and fragmented educational systems. Information asymmetry in rural markets leads to homogenized business models, intergenerational clashes in family values undermine entrepreneurial stability, while mismatched academic curricula hinder technology transfer capabilities. Systematically analyzing the interactive mechanisms among these constraints is crucial for bridging the gap between intentions and action, carrying urgent practical significance for boosting the actual success rate of returnee entrepreneurship.

1.2 Policy lag: fill the structural blind spot and build a long-term support mechanism

Current policy designs overemphasize short-term economic incentives while neglecting long-term ecological development. Urban-centric incubation platforms have created a dual challenge in rural industrial parks: spatial underutilization and service deficiencies. Talent evaluation systems dominated by urban standards create institutional barriers for returning entrepreneurs, including professional title evaluations and social security challenges. This study reveals the compatibility patterns between policy instruments and rural contexts, proposing a three-dimensional optimization framework of “basic guarantees + ecological cultivation + value recognition”. The solution systematically addresses the issues of policy disconnection and fragmentation through comprehensive measures.

1.3 Education gap: reconstruct the dual-track training system and improve the adaptability of talents

For decades, entrepreneurship education in Chinese universities has been trapped in an urban-centric mindset. The curriculum system focuses on generic skills like business model design and investment management, while lacking targeted training for rural industries’ characteristics such as long cycles, high risks, and heavy resource dependence^[1]. This has led to phenomena like “technological mismatch” and “difficulty integrating into industrial chains” among students returning to their hometowns. By analyzing the coupling mechanism between educational systems and rural needs, this study proposes a dual-track reform path of “urban general skills + rural specialized skills”, providing a practical model for universities to cultivate versatile entrepreneurial talents who “understand rural areas, love rural communities, and contribute to rural development”.

1.4 Regional particularity: Responding to the challenges of differentiation in the eastern coast

Compared to central and western regions, rural entrepreneurship in eastern coastal areas faces unique challenges such as higher land costs, fiercer talent competition, and more complex property rights. While the reform of collective business-use construction land market entry enhances resource utilization efficiency, it also increases compliance risks for entrepreneurial projects. Under the backdrop of free flow of urban-rural elements, rural entrepreneurs must simultaneously address dual pressures from urban capital encroachment and local resource protection. This study focuses on regional particularities by comparing and analyzing differences in rural entrepreneurial ecosystems across economic zones, providing theoretical support for developed regions to formulate “targeted and differentiated” talent policies, thereby facilitating the stepwise advancement of rural revitalization strategies.

2. Analysis of influencing factors

2.1 Policy support factors

Policy support plays a crucial role in shaping college students’ willingness to return home for entrepreneurship. Government initiatives such as start-up guarantee loans, tax incentives, and training subsidies have significantly influenced this decision^[2]. However, current policies still face challenges in terms of communication effectiveness, implementation efficiency, and coverage scope. These shortcomings result in many students not fully understanding the policies, thereby failing to maximize their potential benefits.

2.2 Family factors

The influence of family factors on college students’ willingness to return to their hometowns for entrepreneurship cannot be overlooked. Factors such as family financial status, parents’ educational perspectives, and occupational backgrounds all impact students’ entrepreneurial decisions. For instance, students from well-off families are more likely to receive financial support from their parents, making them more inclined to attempt returning home for entrepreneurship. Students

whose parents work as farmers or self-employed business owners may also prefer starting businesses in rural areas due to familiarity with the local environment. However, some families remain cautious about returning to their hometowns for entrepreneurship, fearing excessive risks that might deter students from pursuing entrepreneurial ventures.

2.3 Individual Competency Factors

Individual capabilities are a key factor influencing college students' willingness to return home for entrepreneurship. Starting a business requires multifaceted skills such as market insight, organizational coordination, and risk tolerance. However, current shortcomings in innovation and entrepreneurship education at universities have left many students lacking essential entrepreneurial knowledge and skills. Moreover, some students lack confidence in their own entrepreneurial abilities, fearing failure, which leads them to choose safer career paths rather than taking risks.

2.4 Entrepreneurship education factors

Entrepreneurship education significantly influences college students' willingness to return home and start businesses. Universities can stimulate students' entrepreneurial enthusiasm and enhance their awareness and capabilities through initiatives like offering innovation courses, hosting entrepreneurship seminars, and organizing startup competitions. However, some institutions still face challenges in entrepreneurship education, including incomplete curriculum design, insufficient faculty resources, and limited practical opportunities, which ultimately lead to suboptimal educational outcomes.

2.5 Rural environmental factors

As a pivotal factor influencing college students' willingness to return to rural areas for entrepreneurship, the rural environment is undergoing complex transformations with societal development. Under the vigorous implementation of the Rural Revitalization Strategy, villages have been revitalized with wide roads, stable internet connectivity, and emerging industries sprouting up like mushrooms after rain—creating fertile ground for entrepreneurship. However, it's crucial to recognize that compared to urban areas' comprehensive conveniences and advanced infrastructure, rural regions face limitations: limited public service resources, scarce quality educational opportunities, monotonous cultural activities failing to meet young people's diverse needs, and inadequate medical security systems with insufficient capacity to handle sudden health emergencies^[3]. These shortcomings have, to some extent, diminished rural areas' appeal to college graduates and hindered their entrepreneurial endeavors in returning to their hometowns.

3. Policy recommendations

3.1 Strengthening policy support

The government should further strengthen policy support for college students returning to their hometowns to start businesses, with particular focus on university students from Shandong Province in Yantai. Specifically, efforts should include: expanding entrepreneurship guarantee loans, establishing special funds to lower loan thresholds for startups and individual entrepreneurs, simplifying approval processes and shortening disbursement times while offering flexible repayment options to ease initial financial pressures; providing tax incentives and fiscal subsidies through corporate income tax reductions, value-added tax exemptions, startup capital allocations, and differentiated operational subsidies to gradually reduce entrepreneurial costs; enhancing entrepreneurship training services by collaborating with universities, enterprises, and training institutions to develop systematic courses such as market analysis and business model design, while establishing dedicated entrepreneurship guidance centers for one-on-one consultations to effectively address practical challenges. Additionally, policies should be widely promoted through multiple channels including university websites, social media, and offline promotional events. Policy interpretation sessions targeting Yantai-based universities should be organized, with department heads providing detailed explanations to ensure precise policy dissemination and effective implementation.

3.2 Optimizing the family support environment

In the process of college students returning to their hometowns to start businesses, family support serves as an indispensable pillar. For students from Shandong Province's universities in Yantai, optimizing family support environments is particularly crucial^[4]. Regarding mindset guidance, communities and schools should collaborate through community outreach campaigns and family education seminars. By leveraging real-life cases and detailed data, parents can gain a deep understanding of the opportunities and policy benefits of returning entrepreneurship. This helps them recognize that starting a business back

home not only supports rural revitalization strategies but also aligns with their children's interests and career plans, thereby encouraging them to courageously pursue entrepreneurial ventures. Economically, when family finances permit, parents should proactively provide startup funds to alleviate initial financial pressures. They should actively assist in applying for government-backed startup loans and subsidies, jointly research policies, prepare materials, and share entrepreneurial risks to build a solid financial foundation. Emotional support is equally vital. Parents need to maintain close communication with their children, patiently listen to their entrepreneurial needs and challenges, offer full understanding and encouragement. When children face setbacks, they should comfort them with warm words and steadfast support to help them regain confidence and keep moving forward. Additionally, parents can provide resources like business premises and equipment based on family circumstances, or leverage their networks to expand cooperation channels and market opportunities, ultimately helping their children realize their entrepreneurial dreams.

3.3 Improve personal entrepreneurship ability

As a crucial platform for cultivating innovative talents, universities should comprehensively strengthen entrepreneurship education to genuinely enhance students' entrepreneurial awareness and capabilities. In curriculum development, it is essential to refine the innovation and entrepreneurship course system by breaking free from traditional theoretical teaching constraints. Emphasis should be placed on integrating theoretical knowledge with real-world business cases and market trends through diversified teaching methods like case analysis and simulated entrepreneurship, enabling students to learn by doing and master the essence of entrepreneurship through hands-on experience. Faculty development remains pivotal. Universities should intensify talent recruitment efforts by actively recruiting entrepreneurs and industry experts with rich practical experience as adjunct faculty, while enhancing existing teachers' entrepreneurial guidance skills through training programs and corporate internships. To help students accumulate practical experience, universities should establish practice platforms such as startup incubation bases providing comprehensive support including venues, equipment, and funding to lower entry barriers. Regular entrepreneurship competitions should be organized to ignite students' passion while honing their teamwork and market analysis skills. Additionally, universities must strengthen entrepreneurial guidance services by setting up dedicated counseling centers with professional mentors who offer personalized consultations based on students' project characteristics and individual traits, addressing challenges and supporting students in realizing their entrepreneurial dreams.

3.4 Improve rural entrepreneurship environment

The government and all sectors of society must form a powerful synergy to jointly improve the rural entrepreneurial environment, injecting continuous vitality into rural entrepreneurship. In terms of infrastructure, efforts should focus on strengthening rural infrastructure construction, particularly enhancing transportation accessibility to establish closer and more convenient connections with the outside world. Optimizing communication networks ensures timely and accurate information transmission, building efficient information bridges for entrepreneurs. Improving energy supply systems guarantees stable operation of entrepreneurial projects. Regarding public services, it is essential to further refine rural public service systems, elevate educational quality to alleviate concerns for entrepreneurs and their families, strengthen medical security to ensure entrepreneurs can focus on their endeavors, and enrich cultural and recreational activities to foster a positive rural atmosphere. In terms of policy environment, the government should continuously optimize the rural entrepreneurial policy framework by introducing tax incentives to reduce financial burdens, providing fiscal subsidies to help entrepreneurs overcome funding challenges, and lowering entry barriers. Meanwhile, all sectors of society should jointly enhance rural entrepreneurial culture through events like entrepreneurship seminars and sharing sessions. These initiatives disseminate entrepreneurial concepts, create an atmosphere that encourages innovation and tolerates failure, enabling entrepreneurs to dare to explore and realize their dreams in the vast rural landscape, thereby driving vigorous development of the rural economy.

3.5 Strengthen school-local cooperation and exchange

As the cradle of talent cultivation, universities should actively deepen cooperation and exchanges with local governments to jointly advance college students' return entrepreneurship initiatives to new heights. Both parties need to establish a close and long-term university-local cooperation mechanism. Through regular joint meetings and setting up specialized task forces, they should collaboratively develop entrepreneurship support policies tailored to local realities and student

needs, providing robust guarantees in terms of funding, venues, tax incentives, and other aspects^[5]. In project matchmaking for entrepreneurial ventures, universities and local governments should leverage their respective strengths to integrate resources and build efficient matching platforms. Local governments should promptly release rural entrepreneurship demand information, while universities should precisely screen and match suitable student projects, offering diverse entrepreneurial opportunities and resource support. Simultaneously, various forms of entrepreneurial practice activities should be actively organized. Universities can arrange field trips for students to experience rural development potential and entrepreneurial opportunities firsthand, or involve them in rural entrepreneurship projects to accumulate practical experience and enhance capabilities. Additionally, to ignite students' entrepreneurial passion, universities and local governments should jointly strengthen experience-sharing through regular lectures and seminars featuring successful alumni entrepreneurs and rural entrepreneurship leaders. By sharing lessons learned from their entrepreneurial journeys, students can be inspired to firmly commit to returning entrepreneurship and actively participate in the rural entrepreneurship wave.

4. Conclusion

Research findings indicate that policy support, family factors, personal capabilities, entrepreneurship education, and rural environment are key determinants influencing college students' willingness to return to their hometowns for entrepreneurial ventures. Based on these insights, this paper proposes targeted countermeasures including: strengthening policy support to establish solid institutional safeguards for student entrepreneurship; optimizing family environments to maximize familial involvement in the entrepreneurial process; enhancing personal entrepreneurial competencies through education and training programs; improving rural business ecosystems to create conducive conditions; and fostering university-local collaboration to integrate resources for joint entrepreneurship initiatives. Future research can be expanded across multiple dimensions. First, broadening research scope by conducting comparative studies between different regions and university types could yield more universal conclusions. Second, advancing methodologies through sophisticated models and analytical approaches would enhance scientific rigor and precision in identifying factors affecting entrepreneurial intentions. Additionally, practical application research should focus on translating findings into real-world policy-making and entrepreneurship guidance to improve policy effectiveness. Concurrently, attention should be paid to sustainable development post-return, such as growth mechanisms for startups and psychological adjustment strategies for entrepreneurs, thereby providing comprehensive support for college students' rural entrepreneurship endeavors.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Kang, S. X. (2025). Research on the enhancement of college students' returnee entrepreneurship intention in the context of rural revitalization. *Cooperation Economy and Science & Technology*, (14), 83–85.
- [2] Li, L. X., Xin, X. H., & Yang, S. L. (2025). Factors influencing college students' return to rural employment in the context of the rural revitalization strategy. *Innovation and Entrepreneurship Education*, 16(2), 59–68.
- [3] Liu, F. S., Zhang, L., Fan, S. L., et al. (2025). Challenges and strategies for college students' return entrepreneurship in the context of rural revitalization. *Journal of Chengdu University of Technology*, 28(2), 84–87.
- [4] Yang, Y. B. (2025). Research on college students' return to rural entrepreneurship behavior and influencing factors under the background of rural revitalization. *Agricultural Industrialization*, (4), 26–31.
- [5] Zou, C. J. (2025). Research on college students' employment intentions and influencing factors returning to rural areas in the context of rural revitalization: A case study of Western Guangdong vocational colleges. *Social and Public Welfare*, (4), 68–70.

Research on the Evaluation and Improvement Path of Human Settlements Satisfaction in Ecological Relocation Sites under the Yellow River Strategy—— Taking Liangshan County as an Example

Jiayi Liu*, Linhan Zhang, Lei Liu, Zhuohan Dong, Jingjing Zhou

Shandong Institute of Technology, Yantai, Shandong, 264005, China

**Corresponding author: Jiayi Liu*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: As outlined in the Yellow River Basin Ecological Protection and High-Quality Development Plan, the region faces critical challenges including flood risks, inadequate high-quality development, and insufficient livelihood improvements. Liangshan County has actively implemented ecological relocation projects for residents along the Yellow River in response to national initiatives. This study employs literature review, field investigations, questionnaire analysis, and SPSS data analysis to evaluate residents' satisfaction with their living conditions post-relocation. The research identifies key factors affecting satisfaction levels and explores strategies to enhance residents' sense of fulfillment and well-being. These efforts aim to contribute to ecological conservation and sustainable development in the Yellow River basin while improving local residents' quality of life.

Keywords: Yellow River Basin; Ecological Relocation; Satisfaction of Living Environment; Improvement Path

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.634>

The Yellow River Basin faces challenges including flood risks, lagging high-quality development, and livelihood deficiencies. Due to the extremely high sediment content in the river, governance remains highly challenging with severe water disasters. As a Yellow River basin county, Liangshan County has implemented ecological relocation projects, where resident satisfaction directly impacts project effectiveness. This study focuses on resettlement areas, analyzes factors influencing living satisfaction, proposes optimization strategies, and provides practical references for high-quality development in the Yellow River Basin.

1. Research subjects and methods

This study focuses on Xiaokouluo Town and Zhaogudui Township in Liangshan County, analyzing residents' overall satisfaction with relocation programs and specific aspects including resettlement, livelihood improvement, and social integration. A questionnaire was designed for evaluating satisfaction levels at the Huanghe Xinyuan Community and Cuiping Jiayuan Community in Liangshan County. Statistical analysis software (SPSS) and GIS tools were employed to examine factors influencing satisfaction, assess the effectiveness of living environment improvements, and identify key areas for enhancement. These findings aim to accelerate the stabilization and comprehensive optimization of the socio-economic,

cultural, and ecological development framework in relocation sites^{[1][2]}.

2. Research content

2.1 Relocation Project Overview

The Huanghe Xinyuan Community, located in Xiaolukou Town of Liangshan County, commenced construction in December 2017. A 300-square-meter Huanghe Memory Exhibition Hall was built on the third floor of the service center to preserve Yellow River culture. The Cuiping Jiayuan Community in Zhaogudui Township of Liangshan County serves as a key infrastructure and urban-rural integration project. Construction began in September 2018, featuring 112 relocated housing complexes that accommodated 7,373 residents, while significantly enhancing educational resources and promoting integrated urban-rural development. The ecological relocation initiative along the Yellow River consistently adheres to ecological and economic principles, integrating resource utilization protection, productive construction, and ecological conservation to harmonize economic benefits with environmental sustainability^[3].

2.2 Sample structure

In this survey, 460 questionnaires were distributed and 363 returned. After validity screening, 312 valid responses were selected for statistical analysis and research. The participants comprised 163 males and 149 females, maintaining a gender ratio of approximately 1.1:1. Age distribution showed: 98 adolescents (31%) aged 0-18, 65 middle-aged adults (21%), and 149 seniors (48%). As the survey was conducted offline, respondents were predominantly aged 55 and above.

2.3 Construction of resident satisfaction index system in the study area

This questionnaire establishes a satisfaction evaluation system for relocated residents' living environment, with primary indicators covering natural ecological conditions, material infrastructure, socio-cultural environments, and economic development. The framework comprises three tiers: 4 primary indicators, 10 secondary indicators, and 24 tertiary indicators. Designed around 22 metrics, the survey employs a 5-point satisfaction scale (1-5 points) to quantify residents' subjective preferences. The detailed indicator system is presented in Table 2-1.

Table 2-1 Resident satisfaction index and average score of each index in the study area

Target layer A	supporting layer B	Average score	Classification level C	Average score	Indicator layer D	Average score
Relocation residents' satisfaction with living environment	Natural ecological environment (B1)	4.01	Sanitary and environmental conditions (C1)	3.85	D1 Safety of drinking water	3.70
					D2 level of waste collection	4.00
			Agricultural ecological environment (C2)	4.05	D3 Production sewage treatment	4.00
					D4 Agricultural mechanization level	4.10
			State of the natural environment (C3)	4.17	D5 River and lake pollution treatment	4.01
					D6 Vegetation coverage	4.21
					D7 Natural disaster preparedness	4.30
	Material facilities environment (B2)	4.34	Public service facility conditions (C4)	4.44	D8 Education facilities level	4.45
					D9 Standard of medical facilities	4.46
					D10 Cultural facilities level	4.40
			Individual living conditions (C5)	4.37	D11 Location of the premises	4.40
					D12 Housing comfort	4.33
			Infrastructure supply (C6)	4.20	D13 Accessibility	4.19
					D14 Commercial facilities level	4.15
					D15 Network communication level	4.27

Target layer A	supporting layer B	Average score	Classification level C	Average score	Indicator layer D	Average score
Relocation residents' satisfaction with living environment	Social and cultural environment (B3)	4.16	Cultural development environment (C7)	4.30	D16 Type of cultural activities	4.10
					D17 State of neighborhood relations	4.42
					D18 Social and moral standards	4.39
	economic development environment (B4)	3.89	Social security environment (C8)	4.02	D19 Level of democratic participation	3.81
					D20 Social security level	4.23
			Employment environment conditions (C9)	3.79	D21 Employment location conditions	3.76
					D22 Employment of farmers	3.81
			Income and consumption level (C10)	3.98	D23 Family income level	3.97
					D24 Price and consumption levels	3.98

2.4 Satisfaction analysis of residents in the study area

2.4.1 Analysis of the scores of four first-level indicators

As shown in Table 2-1, residents' average satisfaction scores for different environments are as follows: natural ecological environment (4.01 points), material facilities environment (4.32 points), social and cultural environment (4.16 points), and economic development environment (3.89 points). Notably, the material facilities environment received the highest satisfaction score, while the economic development environment had the lowest. Detailed results are presented in Table 2-1.

2.4.2 Statistical analysis of satisfaction with natural ecological environment

Regarding farmland land circulation, the "Party Branch + Cooperative" model is adopted where residents contribute their farmland as shares, with ownership remaining collectively owned, resulting in an additional income of approximately 1,300 yuan per mu (about 667 m²). For housing allocation, resettlement area prices are determined according to demolition compensation agreements, while any excess area is purchased at market rates. During the initial phase of relocation projects, residents' preferences for floor configurations were surveyed, offering options including multi-story buildings (4+1 and 5+1 layouts) and high-rise structures (11 stories). In terms of natural ecological environment, vegetation coverage scored highest among three indicators (4.21), while drinking water safety received the lowest score (3.70). 15.5% of residents rated it as average. The community maintains 100% tap water supply, ensuring convenient access to water resources. Property management is self-managed, complemented by high vegetation coverage.

2.4.3 Statistical analysis of environmental satisfaction with material facilities

In terms of physical infrastructure, medical facilities scored the highest (4.46) among the three sub-indicators, while commercial facilities ranked lowest (4.15). 92% of residents expressed satisfaction or high satisfaction with the environment. The new community has effectively addressed four major challenges in daily life by providing a 1,000-square-meter clinic space, organizing regular free clinics, and offering free medical consultations and health guidance.

2.4.4 Statistical analysis of social and humanistic environment satisfaction

In terms of social and cultural environment, the third-level indicators showed the highest score in neighborhood relations (4.42) while the lowest in democratic participation (3.81). The overwhelming majority of residents expressed satisfaction with the community's cultural environment, demonstrating strong public recognition of its development. Huanghe Xinyuan Community actively organizes cultural activities to enrich residents' spiritual lives. Neighborhood disputes are resolved through a tiered process: building managers → grid officers → community → government. The community features the "Old Ma" Mediation Studio where the Party Secretary personally handles conflicts. Cuiping Jiayuan Community adopts a multi-level approach—property management → community → village cadres → government—to systematically resolve disputes, effectively addressing conflicts.

2.4.5 Statistical analysis of satisfaction with economic development environment

In terms of economic development environment, the three-level indicators show employment location conditions scored 3.76, household employment levels 3.81, family income levels 3.97, and price consumption levels 3.98. Among residents, 30% expressed general satisfaction, 1.84% dissatisfaction, and 0.16% strong dissatisfaction. The economic environment significantly impacts residents' livelihoods, requiring attention from community governments. To address employment issues, the community has actively established social-enterprise partnerships, created job opportunities, formed a "Two New" alliance group, and developed public welfare positions.

2.5 Entropy analysis

2.5.1 Steps

Step 1: Data standardization

forward pointer :

$$X'_{ij} = \frac{X_{ij} - \min(X_{ij})}{\max(X_{ij}) - \min(X_{ij})}$$

Negative indicators:

$$X'_{ij} = \frac{\max(X_{ij}) - X_{ij}}{\max(X_{ij}) - \min(X_{ij})}$$

Step 2: Calculate the proportion of each indicator

$$p_{ij} = \frac{X'_{ij}}{\sum_{i=1}^n X'_{ij}}$$

Step 3: Calculate information entropy

$$e_j = -k \sum_{i=1}^n p_{ij} \ln(p_{ij})$$

Step 4: Calculate the utility value of information

$$d_j = 1 - e_j$$

Step 5: Calculate weights

$$w_j = \frac{d_j}{\sum_{j=1}^m d_j}$$

Step 6: Calculate the composite score

$$S_i = \sum_{j=1}^m w_j \times X'_{ij}$$

2.5.2 Results analysis

The entropy value method analyzed the information entropy (e), information utility value (d), and weight coefficients (w) of primary and secondary indicators to determine their relative importance in overall satisfaction. The results showed that employment location conditions had the highest weight (8.22%), followed by farmers' employment levels (8.06%), indicating that employment opportunities and work location convenience have the greatest impact on residents' satisfaction. Price consumption level (7.09%) carried a relatively high weight, highlighting living costs as a key factor. Water safety (6.87%) and household income level (5.72%) also ranked high, demonstrating that infrastructure and income significantly contribute to satisfaction. Specific findings are detailed in Table 2-2.

Table 2-2 Summary of weight calculation results by entropy method

Item	weight coefficient w	Item	weight coefficient w
D1 Safe drinking water for life	6.87%	D13 Traffic accessibility	3.91%
D2 level of waste collection	4.57%	D14 Commercial facilities level	3.98%
D3 Production sewage treatment	3.43%	D15 Network communication level	2.78%
D4 Agricultural mechanization level	2.70%	D16 Type of cultural activities	4.36%
D5 River and lake pollution treatment	4.03%	D17 Neighborhood relations	3.24%
D6 Vegetation coverage	2.10%	D18 Social and moral standards	4.24%
D7 Natural disaster preparedness	2.93%	D19 Level of democratic participation	5.50%
D8 Education facilities level	2.68%	D20 Social security level	2.62%
D9 Medical facilities level	2.65%	D21 Employment location conditions	8.22%
D10 Sports and recreation facilities	2.53%	D22 Farmer employment level	8.06%
D11 Location of the house	2.68%	D23 Family income level	5.72%
D12 House comfort	3.11%	D24 Price consumption level	7.09%

2.5.3 Satisfaction weighted score

In order to use the entropy method to comprehensively evaluate satisfaction, we set 5 levels as follows:

Table 2-3 Satisfaction rating scale

Composite index score	1 below	1-2	2-3	3-4	4-5
satisfaction evaluation	range	Need improvement	same as	good	outstanding

According to the weighted score of entropy method, the comprehensive average score of satisfaction of 312 samples is 4.045, which belongs to the “excellent” rating (4-5 points). On the whole, the resettlement site has achieved good effects in ecological protection and community development, which improves residents’ sense of happiness and gain, provides a practical basis for similar projects, and points out the key areas for continuous improvement.

4. Current problems in the Yellow River ecological relocation research area

Feng Li’s (2023) research reveals that China’s Yellow River Basin ecological governance faces challenges in achieving coordinated outcomes across multiple dimensions, including unified leadership among stakeholders, interdepartmental coordination, and regulatory tool selection preferences^[4]. Sun Fuhua, Pan Deng, and Shang Zelong (2023) further demonstrate that satisfaction levels in residential relocation, livelihood resettlement, and rights protection directly influence overall satisfaction with the resettlement process^[5].

According to the investigation and analysis of Huanghe Xinyuan community and Cuiping Home Community, this paper analyzes the following problems:

4.1 Infrastructure and living environment:

The Huanghe Xinyuan Community, situated in a low-lying area prone to water accumulation, occasionally experiences severe water shortages in high-rise buildings due to pressure issues. Both communities face substandard tap water quality and delayed sewage treatment. Additionally, medical facilities remain inadequate, with only a community clinic available while lacking large hospitals and specialized medical institutions. This situation makes it difficult to meet residents’ daily healthcare

needs, particularly for emergency care and specialized treatments.

4.2 Community Relations and Development:

The current situation regarding residents' participation in community governance manifests three key issues: First, excessive intervention by local governments has weakened community self-governance capabilities; second, there exists a lack of effective communication between communities and residents; third, residents demonstrate limited capacity to participate in community governance^[6]. The random housing allocation system in Cuiping Jiayuan Community leads to minimal neighbor interaction, frequent conflicts, and inefficient mediation processes. While public satisfaction with community democratic participation remains high, challenges persist including information asymmetry and low engagement levels. Research by scholars Dong Feilong and Wu Hongchen (2024) on post-relocation residents' satisfaction with livelihood benefits in Dongming Yellow River floodplain areas revealed slightly higher dissatisfaction rates regarding employment^[7]. Both Huanghe Xinyuan Community and Cuiping Jiayuan Community face severe aging populations and demonstrate weak sustainable development potential.

4.3 Public services and resources:

Educational resources are scarce and uneven in quality, the number of schools is limited, teaching facilities are old, teachers are weak, extracurricular tutoring and interest classes are scarce; employment and entrepreneurship support is weak, overall employment opportunities are scarce, the attraction to highly educated and skilled talents is insufficient, and the support for entrepreneurs is small.

5.Strategies and recommendations

5.1 Optimize infrastructure and living environment

We will comprehensively upgrade the water supply system through a rainwater-sewage separation project. Drawing on Shanghai's successful experience and considering the low-lying terrain of residential areas, we will construct new main stormwater pipelines and renovate drainage facilities to enhance flood prevention and drainage capabilities. To address water shortages in high-rise buildings, we will install additional pressure booster systems and optimize the distribution network layout to ensure stable water supply for residents in elevated buildings.

The water plant has upgraded its water supply pipelines using new materials and purification equipment to enhance water quality standards. A long-term water quality monitoring system has been established with smart management technology for real-time tracking. Community medical facilities have been strengthened through updated equipment and improved service quality. An efficient referral network has been created in collaboration with nearby major hospitals to ensure timely emergency care and specialized treatment. The pharmaceutical supply chain has been optimized through partnerships with drug manufacturers to guarantee sufficient medication availability.

5.2 Promoting harmonious development of the community and residents' participation

Communities should strategically plan public spaces by developing cultural and recreational plazas with comprehensive sports and cultural facilities. Regularly organize community enhancement initiatives such as cultural festivals and family-friendly activities to foster neighborhood interaction. To address neighborhood relations, host diverse social events like Neighborhood Festivals and interest groups to enhance communication opportunities. Establish regular discussion forums and exchange meetings to create two-way communication channels. Pay special attention to the needs of vulnerable groups including seniors and children through personalized services. Set up online and offline suggestion boxes to encourage residents' active participation in community decision-making and management processes.

Accelerate industrial development by upgrading furniture parks through intelligent transformation, introducing advanced production lines to enhance product quality and value-added capabilities. The government will invest in large-scale cultivation of specialty agricultural products, encouraging public participation with technical guidance and market access support. Strengthen brand building by promoting local specialties through digital platforms, attracting young talent back to rural communities for employment and entrepreneurship. This initiative aims to alleviate community aging issues while fostering sustainable development.

5.3 Improve the level of public services and resource security

Increase investment in education by expanding schools and kindergartens, upgrading teaching facilities, and attracting high-quality teachers. Establish deep collaborations with leading institutions to conduct regular teacher-student exchange programs that enhance educational quality. Diversify extracurricular activities through art, sports, science, and technology enrichment classes to promote students' all-round development. Develop an educational resource sharing platform to enable online access to premium learning materials.

Establish a dedicated entrepreneurship support fund to provide financial assistance for startups. Conduct entrepreneurship training programs with expert guidance to enhance entrepreneurs' capabilities. Develop preferential policies such as tax reductions and venue rental discounts to attract highly educated professionals and skilled talents to the community. Build an employment and entrepreneurship service platform that publishes job listings and offers career counseling services.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Dong, F. L., Wu, H. C., Yu, Q., et al. (2024). Post-relocation resident satisfaction survey in Yellow River floodplain areas under rural revitalization: A case study of Dongming County (the first county of the Yellow River's inflow into Shandong Province). *Journal of Smart Agriculture*, 4(13), 54–57.
- [2] Feng, L. (2023). Ecological regulation strategies and improvement measures for river basins under the implementation of the Yellow River Protection Law: A quantitative analysis based on legal policy texts. *Journal of Arid Land Resources and Environment*, 37(7), 190–196.
- [3] Ren, Y. W., Yuan, G. B., & Ji, F. H. (1993). A study on ecological resettlement in the Three Gorges Reservoir Area. *Agricultural Modernization Research*, (1), 27–29.
- [4] Si, L. X. (2023). Resident participation in relocation community governance in Yellow River floodplain areas [Master's thesis, Shandong University].
- [5] Sun, F. H., Pan, D., Shang, Z. L., et al. (2023). Analysis of factors affecting satisfaction in resettlement of water conservancy project migrants in Jiangsu Province. *Water Resources Economics*, 41(5), 78–83+100.
- [6] Wang, H. M. (2022). Research on the impact of rural resettlement community construction in Yellow River floodplain areas on residents' subjective well-being [Doctoral dissertation, Beijing Forestry University].
- [7] Wu, D., Geng, H., & Wang, X. L. (2024). Adaptability evaluation and optimization strategies for human settlements in relocation resettlement areas: A case study of Linxiang District, Lincang City. *Journal of Changsha University of Science and Technology (Natural Science Edition)*, 21(2), 133–146.

The Impact of Technological Innovation on Environmental Governance in the Logistics Industry

Yanan Zheng*, Panlong Sheng

School of Public Administration, Shandong Technology And Business University, Yantai, 264005, China

**Corresponding author: Yanan Zheng*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This article uses relevant data from 30 provinces, autonomous regions, and municipalities in China from 2014 to 2023 as research samples to empirically test the impact of technological innovation on logistics industry environmental governance. The results show that: (1) the benchmark regression results show that technological innovation has a positive impact on logistics industry environmental governance. (2) The results of the mediation effect test show that new quality productivity and market mechanisms play a partial mediating role in the relationship between the two. (3) Heterogeneity tests indicate that technological innovation has a more significant impact on the environmental governance of the logistics industry in the eastern region than in the central and western regions.

Keywords: Technological Innovation; Logistics Industry; Environmental Governance; New Quality Productivity; Market Mechanism

Published: Sept 13, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.635>

Introduction

With the deepening of globalization and the explosive growth of e-commerce, modern logistics has become a critical infrastructure supporting efficient socio-economic operations, reaching unprecedented scales and complexities. This transportation-dependent industry is inevitably closely linked to energy consumption and environmental emissions. According to assessments by the United Nations Environment Programme (UNEP), transportation-related carbon dioxide emissions account for a significant proportion, particularly in freight logistics, where its environmental impact increasingly becomes an unavoidable bottleneck in sustainable development^[1]. Traditional logistics management and environmental governance models are predominantly characterized by “end-of-line solutions” or difficult trade-offs between efficiency and environmental protection. Their strategies for addressing environmental challenges demonstrate insufficient timeliness and depth, making governance effectiveness prone to stagnation.

In this era, cutting-edge technological clusters represented by big data analytics, AI-driven decision support, IoT real-time monitoring, automated equipment applications, and new energy power technologies are profoundly reshaping the operational logic and environmental interactions within the logistics industry. The precision insights and optimization potential embedded in these advanced technologies provide innovative pathways for transforming environmental governance paradigms. Empowered by technology, logistics systems have achieved unprecedented operational visualization and holistic optimization—from micro-level real-time vehicle path planning and multimodal transport coordination to macro-

level network design and green energy deployment strategies—achieving an unprecedented integration of technology and environmental objectives. Consequently, carbon intensity, air pollutant emissions, and total resource consumption in logistics processes have been systematically reduced. A new form of green logistics productivity, centered on intelligentization, is rapidly taking shape. It should be emphasized that this technology-driven governance transformation represents not merely an upgrade of specific emission reduction tools, but a comprehensive leap in the logistics industry's ecological niche and developmental logic. This transition profoundly reveals the empowering value of technological innovation for green development, while also requiring us to conduct in-depth analysis and systematic evaluation of the internal mechanisms and practical effects of technology-enhanced environmental governance. Only through such efforts can the logistics industry secure strategic initiative in high-quality development amidst the global green and low-carbon transition wave.

1. Literature review

The logistics industry serves as a cornerstone sector supporting national economic operations^[2-3], while maintaining supply chain resilience, it has also triggered significant energy consumption and pollutant emissions. Current research generally regards technological innovation as the key pathway to reconcile efficiency improvements in logistics with environmental protection. Systematic academic understanding reveals that technology demonstrates multidimensional penetration in reshaping governance paradigms and optimizing environmental performance within logistics systems. In transportation, advanced digital applications show the most notable effect on reducing carbon footprints. Intelligent dispatching systems leverage big data and AI algorithms to integrate real-time order information, road network data, weather conditions, and vehicle status, enabling global dynamic route planning. This not only reduces idle rates but also substantially enhances route efficiency, with empirical evidence demonstrating substantial emission reduction potential^[4]. Meanwhile, advancements in green energy vehicle technologies are progressively replacing traditional fossil fuel power chains. Multiple domestic and international case studies confirm that hydrogen fuel cell trucks and electric trucks show scalable application potential in short-haul cargo collection and urban collaborative delivery, effectively reducing nitrogen oxides (NOx) and fine particulate matter (PM2.5) emissions^[5-7]. Notably, debates persist in this field, with scholars proposing critical reflections on the carbon accounting boundaries of electric vehicles' entire life cycle and infrastructure adaptability^[8].

The intensification and automation of logistics storage operations have profoundly transformed energy structures and land-use efficiency. Automated three-dimensional warehouses, equipped with intelligent stacker cranes, shuttle vehicles, and high-speed sorting systems, achieve exponential improvements in space utilization. This not only reduces land requirements but also decreases average energy consumption per storage operation^[9]. Smart logistics park management systems utilize IoT sensors to precisely regulate cold storage temperatures and equipment status, while integrating distributed energy solutions like rooftop photovoltaic panels. These innovations significantly reduce overall indirect environmental costs in operational processes^[10].

Innovative technologies for packaging focus on closed-loop management of material flows. Lightweight designs and the substitution of traditional high-density polyethylene (HDPE) packaging with renewable bio-based materials have become research hotspots. Empirical studies demonstrate that modified cellulose and polylactic acid (PLA) exhibit exceptional value in significantly reducing packaging pollution loads^[11]. More importantly, fundamental innovations in logistics information system architectures drive environmental governance toward global optimization. The integrated logistics environment platform combining big data, artificial intelligence, and cloud computing enables real-time monitoring of energy consumption, emissions, and waste throughout the entire supply chain, providing data-driven support for precise decision-making^[12].

The academic community has reached a consensus: Technological innovation systematically reduces environmental externalities in the industry by restructuring operational models across logistics sectors. However, the practical penetration of these technologies remains constrained by cost pressures, standardization barriers, and policy coordination levels. Exploring the compatibility between green technologies and market incentive mechanisms will be the key direction for future research breakthroughs.

2. Research hypotheses

2.1 Technological innovation and environmental governance of logistics industry

Technological innovation is recognized as a pivotal driver for advancing green transformation and environmental governance in the logistics sector^[13]. Theoretically, it optimizes logistics operations through multidimensional approaches, effectively reducing environmental footprints. At the technological application level, intelligent path planning and vehicle scheduling systems powered by big data analytics, IoT, and AI dynamically capture real-time multi-source data including road conditions and order information. This enables scientific optimization of transport routes, loading efficiency, and driving speeds, significantly cutting ineffective mileage while enhancing output efficiency per unit of transportation resources. These innovations directly reduce fuel consumption and emissions. On the equipment front, the industrial adoption of new energy vehicles like electric trucks and hydrogen-powered trucks fundamentally replaces traditional fossil fuels with clean energy. By shifting carbon emissions at their source, these solutions achieve substantial reductions in logistics-related carbon footprints. With the ongoing development of charging/hydrogen refueling infrastructure and improvements in battery endurance, their emission-reduction potential will continue to grow.

At the meso-level operational management, the establishment of blockchain-powered logistics traceability platforms and digital supply chain management systems has significantly enhanced information transparency and collaborative capabilities among enterprises across supply chain nodes. These systems not only enable precise monitoring of resource flow paths to optimize warehouse layouts and inventory levels, thereby reducing redundant storage energy consumption, but also encourage companies to adopt eco-friendly packaging and collaborate on co-loading operations. Through resource sharing, these practices effectively mitigate systemic environmental burdens. On a macro level, technological innovation profoundly reshapes logistics industry structures and organizational models, giving rise to innovative business formats like shared logistics platforms and “Internet+” logistics. Leveraging digital capabilities, these models facilitate the integration and efficient coordination of social logistics resources, consolidating fragmented transportation demands while substantially improving facility utilization rates. This evolution objectively achieves optimized overall transportation demand and large-scale low-carbon operations through systematic resource optimization.

Based on the above theoretical analysis, this study puts forward hypothesis 1: Technological innovation has a significant positive promoting effect on environmental governance in logistics industry.

2.2 On the mediating role of new qualitative productive forces

The core characteristics of new-quality productivity manifest as an industrial paradigm transformation driven by data elements, supported by advanced technologies, and aimed at enhancing total factor productivity^[14]. Within this research framework, it serves as a crucial intermediary bridging technological innovation and environmental governance. Theoretically, technological innovations such as AI algorithms, clean energy equipment, and digital twin systems first stimulate the formation of new-quality productivity through restructuring the structure of productive factors. For instance, IoT technology collects real-time data on transportation energy consumption and emissions, while AI-optimized engines dynamically adjust logistics routes, transforming traditional experience-driven models into algorithm-driven decision-making systems. This process drives qualitative upgrades in labor elements (e.g., driver operational efficiency), work objects (e.g., cargo consolidation methods), and working tools (e.g., new energy vehicles) within logistics systems, forming a new productivity combination centered on “data + computing power + green technology”. The emergence of new-quality productivity signifies a profound transformation in logistics resource utilization—from scale expansion to lean operations, and from reliance on factor inputs to technology-driven empowerment. Building on this foundation, new-quality productivity generates environmental governance effectiveness by reconstructing logistics paradigms. Its core mechanisms are manifested in two aspects: First, data intelligence-driven precise supply-demand matching (e.g., shared cloud warehouse systems) and dynamic resource scheduling (e.g., network-wide collaborative transportation networks) systematically reduce vehicle idling rates, warehouse vacancy rates, and packaging waste. On the other hand, the high-intensity application of new energy equipment technologies (such as large-scale operation of hydrogen fuel cell trucks) requires support from advanced infrastructure maintenance capabilities (like smart hydrogen refueling station networks) and green supply chain management

systems (including real-time carbon footprint tracking). This exemplifies the industrial organization-level manifestation of new-quality productivity. The resulting digitalized, collaborative, and low-carbon logistics ecosystem directly reduces both energy intensity and total emissions per unit of logistics service.

Based on the above theoretical analysis, this study puts forward hypothesis 2: new quality productivity plays a significant mediating role between technological innovation and environmental governance of logistics industry.

2.3 The mediating role of market mechanisms

The impact of technological innovation on environmental governance in the logistics industry can only achieve scale effects through effective market mechanisms. Market mechanisms transform technological innovation potential into practical drivers for environmental governance through three dimensions: price signals, competitive pressure, and institutional incentives. This mediating role fundamentally reshapes the behavioral logic of micro entities and industrial structures, guiding technological innovations to unleash systemic value in green development. Theoretical analysis shows that technological innovation primarily triggers market transmission through the mechanism of green premium formation. When IoT real-time monitoring technology is applied to transportation vehicles, it enables precise quantification of energy consumption and emission data per shipment, allowing enterprises to internalize environmental cost accounting. This data supports verifiable carbon footprints, thereby establishing a differentiated pricing basis in carbon emission trading markets. Logistics companies gain carbon quota surpluses by adopting low-emission technologies (e.g., hydrogen-powered trucks), with direct transactional benefits significantly enhancing the return on investment for eco-friendly technology adoption and stimulating equipment renewal initiatives. Meanwhile, end consumers' willingness to pay premium for low-carbon logistics (e.g., "green delivery" options on e-commerce platforms) further motivates enterprises to build clean technology moats. This market demand-driven technological iteration forms a positive feedback loop under competitive market pressures.

The deeper mediating mechanism manifests through the restructuring of competitive order dynamics. Digital platforms like intelligent logistics matching systems dismantle information barriers in traditional transportation markets, enabling real-time algorithmic matching between cargo orders and optimal low-carbon carriers. The dramatic increase in transport pricing transparency compels enterprises to optimize management and upgrade technologies to reduce unit costs. Green technologies, with their cost-effective advantages in fuel efficiency and penalty reduction, have evolved from optional solutions into essential competitive requirements. Government-led green subsidies and environmental tax reductions further amplify this effect—such as subsidies for urban joint distribution center construction, which incentivize companies to consolidate fragmented transportation resources while simultaneously reducing regional traffic pollution. This synergy between institutional frameworks and technological innovation shifts environmental governance from passive compliance to proactive value creation.

Based on the above theoretical analysis, this study puts forward hypothesis 3: market mechanism plays a significant mediating role between technological innovation and environmental governance of logistics industry.

3. Study design

3.1 Data sources and selection

This paper selects the relevant data of 30 provinces, autonomous regions and municipalities in China from 2014 to 2023 as the research sample, and conducts tail trimming on the sample data. The data sources are provincial statistical yearbooks, Wind database and CNRDS database.

3.2 Variable definitions

3.2.1 Interpretation of variables

Technological innovation (denoted as TI). Following the approach of Zou Zhiming and Chen Xun^[15], we selected the number of patent grants and adopted logarithmic transformation as an indicator to measure the technological innovation level of each province.

3.2.2 The variable to be explained

Environmental governance in the logistics industry (denoted as EG). Following the approach of Friday's seventh^[16], the global entropy weighting method was adopted for measurement based on the environmental governance indicators

constructed by them.

3.2.3 Moderating variables

The first mediating variable in this paper is new quality productivity (denoted as New). Referring to the evaluation system of Lu Jiang et al.^[17], the development level of new quality productivity is measured by principal component analysis.

The second mediating variable in this paper is the market mechanism (denoted as MM), which is measured according to Guo Liting's^[18].

3.2.4 Control variables

In this paper, urban and rural residents income gap (Ingap), government intervention ability (Govn), industrial structure (Stru), urbanization level (Lr) and other variables are taken as control variables.

3.3 Model construction

3.3.1 Benchmark regression models

To test hypothesis 1, we construct the following model,

$$EGit = \beta_0 + \beta_1 TIit + mCit + \tau_i + \mu_t + \varepsilon_{it} \quad (1) \quad (1)$$

Among them, EGit is the explained variable, representing environmental governance, i represents province, t represents year, TIit is the explanatory variable, representing technological innovation, Cit is a series of control variables, where μ_t is the time fixed effect, τ_i is the individual fixed effect of province, and ε_{it} is the random disturbance term.

3.3.2 Mediating effect model

To test hypothesis 2 and hypothesis 3, we construct mediation effect models (2) and (3), (4) and (5) respectively.

$$Newit = \gamma_0 + \gamma_1 TIit + mCit + \tau_i + \mu_t + \varepsilon_{it} \quad (2) \quad (2)$$

$$EGit = \delta_0 + \delta_1 TIit + \delta_2 Newit + mCit + \tau_i + \mu_t + \varepsilon_{it} \quad (3) \quad (3)$$

$$MMit = \gamma_0 + \gamma_1 TIit + mCit + \tau_i + \mu_t + \varepsilon_{it} \quad (4) \quad (4)$$

$$EGit = \delta_0 + \delta_1 TIit + \delta_2 MMit + mCit + \tau_i + \mu_t + \varepsilon_{it} \quad (5) \quad (5)$$

Newit and MMit are the new quality productivity and market mechanism respectively, and other variables are the same as model (1).

4. Empirical results and analysis

4.1 Benchmark regression results

The regression results of the benchmark model are shown in column (1) of Table 1. The positive regression coefficient of technological innovation indicates that technological innovation plays a positive role in promoting environmental governance in the logistics industry, and hypothesis 1 is verified.

Table 1 Results of benchmark test regression and mediation effect regression

variable	EG	EG	New	EG	MM
	(1)	(2)	(3)	(4)	(5)
TI	2.29*** (6.81)	1.57** (2.47)	1.32*** (5.16)	1.25*** (3.86)	2.16*** (4.26)
New		2.74*** (4.87)			
MM				1.49*** (3.69)	
_cons	1.391* (1.85)	2.31* (1.92)	3.54*** (2.87)	1.87 (1.12)	2.46* (1.67)
N	300	300	300	300	300
controlled variable	YES	YES	YES	YES	YES
The province and time are fixed	YES	YES	YES	YES	YES
Adj-R2	0.916	0.932	0.873	0.864	0.816

4.2 Moderator variable test

The regression results of the mediating effects between new-quality productivity and market mechanisms are presented in columns (2) and (3), and columns (4) and (5) of Table 1. In column (2), the coefficient of new-quality productivity on environmental governance in the logistics industry is significantly positive. In column (3), technological innovation shows a significant positive correlation with new-quality productivity. This indicates that new-quality productivity partially mediates the relationship between technological innovation and environmental governance in the logistics industry, further validating Hypothesis 2. Similarly, Hypothesis 3 has also been preliminarily tested.

To further confirm the mediating effects of new quality productivity and market mechanism, this study employed two testing methods: Bootstrap and Sobel. The results showed that both direct and indirect effect coefficients were significantly positive, indicating that the analysis of mediating effects between new quality productivity and market mechanism was robust.

4.3 Robustness tests

4.3.1 Replace the core explanatory variables

This study employs a method of replacing the core explanatory variable measurement approach to ensure the robustness of research findings. Following Ma Jinli's ^[19] methodology, technological innovation is measured by the logarithm of per capita patent grants per province (denoted as TII). As shown in Column (1) of Table 2, all regression coefficients remain significantly positive at the 1% level, indicating that Research Hypothesis 1 remains valid after adopting the revised core explanatory measurement approach.

4.3.2 Lagged two explanatory variables

This paper refers to the method of Ban Yunchao et al. ^[20] and adopts the method of replacing the explanatory variables with two periods of lag. The regression results are shown in column (2) of Table 2, and the regression coefficients are positive and significant at the level of 1%, so hypothesis 1 of this study is still valid.

Table 2 Regression results of robustness test

variable	EG	EG
	(1)	(2)
TII	2.85*** (5.68)	
L2.TI		3.54* (1.76)
_cons	3.25* (1.89)	4.43*** (4.19)
N	300	300
controlled variable	YES	YES
The province and time are fixed	YES	YES
Adj-R2	0.927	0.919

4.3.3 Endogeneity tests

This study employs the one-period lagged core explanatory variable as instrumental variables (IV), which satisfies both correlation and exogeneity assumptions. The over-identification test rejects the weak instrument hypothesis through the SW-F test, confirming valid instrument variables. As shown in Table 3, the Anderson LM statistic rejects the insufficient identification hypothesis at the 5% significance level. The F-test for first-stage regression yields a value significantly greater than 10, while the Sargan statistic reaches 8.546, failing to reject the null hypothesis, thereby confirming exogeneity. Second-stage regression results demonstrate that the coefficient of technological innovation is significantly positive, with its significance and sign consistent with the benchmark regression. This indicates that Hypothesis 1 remains supported after controlling for endogeneity.

Table 3 Endogeneity tests

variable	TI	EG
	First	Second
	(4)	(6)
<i>LTI</i>	0.72*** (5.84)	
TI		1.59*** (3.96)
N	300	300
controlled variable	YES	YES
The province and time are fixed	YES	YES
Adj-R2		0.894

4.4 Heterogeneity tests

The impact of technological innovation on environmental governance in the logistics industry may vary across regions due to differences in their endowments. This study examines the relationship between technological innovation and environmental governance in logistics from a geographical perspective, categorizing China's regions into three zones: eastern, central, and western. As shown in columns (1), (2), and (3) of Table 4, technological innovation has a more significant impact on environmental governance in eastern China compared to central and western regions. This disparity may stem from the eastern region's advanced economic development and higher technological capabilities, which amplify the effect of technological innovation on environmental governance in logistics.

Table 4 Regression results of heterogeneity test

Variables	EG (east)	EG (central section)	EG (west)
	(1)	(2)	(3)
<i>TI</i>	0.28*** (5.59)	0.24** (2.49)	0.26* (1.94)
_cons	4.27* (1.89)	1.59 (0.57)	2.32* (1.63)
N	132	99	99
controlled variable	YES	YES	YES
The province and time are fixed	YES	YES	YES
Adj-R2	0.915	0.863	0.785

5 Conclusions and recommendations

5.1 Conclusions

This study employs panel data from 30 Chinese provinces, autonomous regions, and municipalities between 2014 and 2023 to investigate the impact of technological innovation on environmental governance in the logistics sector. The findings reveal three key conclusions: (1) Technological innovation significantly enhances environmental governance within the logistics industry; (2) New-quality productive forces and market mechanisms partially mediate the relationship between technological innovation and environmental governance in logistics; (3) Eastern China demonstrates more pronounced positive effects of technological innovation on environmental governance in its logistics sector compared to central and western regions.

5.2 Recommendations

First, based on empirical research revealing the key drivers and impact pathways of technological innovation in China's

logistics industry environmental governance, future policy design should emphasize targeted measures and mechanism coordination to maximize innovation dividends. The primary strategy is to implement regional differentiated empowerment. Given that eastern regions demonstrate more significant catalytic effects in technological innovation, they should be encouraged to fully leverage their pioneering advantages in digitalization and intelligentization. Priority should be given to promoting deep integration of emerging technologies like artificial intelligence, big data, and IoT in green warehousing, smart scheduling, and multimodal transport, aiming to establish benchmark technology-intensive green logistics demonstration zones. Simultaneously, efforts should intensify to guide advanced technologies, management models, and spillover effects to orderly transfer and diffuse to central and western regions. The central government and developed areas can enhance the intelligence and informatization levels of logistics infrastructure in central and western regions, as well as professional talent reserves, through fiscal transfers, tax incentives, and establishing paired technical support platforms. This will help resolve bottlenecks constraining technological innovation efficiency, thereby driving coordinated regional development and overall enhancement of green governance capabilities.

Second, it is imperative to strengthen the synergistic efforts between two key intermediary pathways: new productive forces and market mechanisms. As new productive forces constitute an effective intermediary, policies should explicitly position the R&D, transformation, and application of green technologies in logistics as a strategic direction for developing new productive forces. Significantly increase fiscal support for research and development of low-energy-consuming equipment (such as electric trucks, hydrogen fuel cell vehicles), recyclable packaging materials, intelligent warehousing systems, and high-efficiency path optimization algorithms. Build an integrated ecosystem combining “industry, academia, research, application, and finance” to accelerate technological iteration and industrialization. Simultaneously, fully leverage the mediating efficacy of market mechanisms. It is urgent to expedite the establishment and deepening of a national carbon emission trading market, explore incorporating logistics transportation into mandatory emission control, significantly increase pollution emission costs, and establish a robust cost-driven mechanism. Deepen green finance practices by encouraging financial institutions to develop diversified financing tools such as green credit and green bonds tailored for the logistics industry, providing tangible cost advantages for enterprises adopting advanced clean technologies. Improve the green logistics standards system and certification framework to enhance the market recognition and premium pricing power of eco-labels, guiding consumers to choose environmentally friendly logistics services, thereby effectively bridging the supply side of technological innovation with the demand side of market needs.

Third, strengthening foundational support and environmental safeguards for technological application is indispensable. It is crucial to enhance comprehensive support throughout the entire process of new technology adoption in logistics enterprises, particularly SMEs. This requires integrated measures including fiscal incentives, financial support, and information services to reduce initial investments and risks during digital transformation and green upgrades. Continuous efforts should focus on improving nationwide logistics infrastructure through digitalization, standardization, and green connectivity. Key priorities include unifying interface standards for information platforms and establishing robust data-sharing mechanisms, thereby providing stable physical and digital foundations for large-scale implementation of advanced technologies. The legal framework must be updated promptly to reflect evolving technological demands, with enhanced legal protections for data security, platform economy regulation, and innovation outcomes. Clear demarcation of environmental protection responsibilities will create a stable and predictable institutional environment that maximizes the potential of technological innovation within green governance frameworks.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Ban, Y. C., Han, D., & Xia, Y. Z. (2025). Research on the impact mechanism of high-quality development in logistics

- driven by digital transformation: Based on panel data from 30 Chinese provinces and municipalities. *Logistics Science & Technology*, 48(10), 59-64.
- [2] Bao, W. Z., & Shi, K. Q. (2025). Green finance, green technology innovation and low-carbon development of circulation industry. *Journal of Financial Development Research*, (3), 68-73.
 - [3] Bonsu, N. O. (2020). Towards a circular and low-carbon economy: Insights from the transitioning to electric vehicles and net zero economy. *Journal of Cleaner Production*, 256, 120659.
 - [4] Cao, C. K., Han, D., Huang, J. P., et al. (2025). The impact of digital transformation on total factor productivity in listed logistics enterprises: Based on the mediating role of new quality productivity and green innovation. *Logistics Science & Technology*, 48(10), 108-113.
 - [5] Cheng, C., Han, Y., & Ren, X. (2023). Analysis of technological innovation on provincial green development levels of logistics industry in China. *Environmental Science and Pollution Research*, 30(18), 53020-53036.
 - [6] Frey, H. C. (2018). Trends in onroad transportation energy and emissions. *Journal of the Air & Waste Management Association*, 68(6), 514-563.
 - [7] Guo, L. T. (2016). Market mechanisms, political connections, and debt financing: An empirical study of SME board listed companies. *International Business (Journal of the University of International Business and Economics)*, (2), 151-160.
 - [8] Han, X., & Han, X. Y. (2025). Research on the path and policies of technological innovation driving the development of aviation manufacturing industry. *China Science and Technology Forum*, (3), 77-85.
 - [9] Han, Y. X., Han, D., & Zeng, F. X. (2025). Temporal-spatial evolution and impact analysis of new productivity empowerment in green logistics for high-quality development. *Logistics Science & Technology*, 48(8), 66-73.
 - [10] Huang, Y. T., & Lin, C. P. (2025). Research on new quality logistics talent cultivation in higher vocational education under the 'In-Turn-Out' three-step method. *Logistics Science & Technology*, 48(7), 181-184.
 - [11] Lu, J., Guo, Z. A., & Wang, Y. P. (2024). Development level of new productive forces, regional disparities and enhancement pathways. *Journal of Chongqing University (Social Sciences Edition)*, 30(3), 1-17.
 - [12] Ma, J. L. (2025). Digital finance, technological innovation and green agricultural productivity. *Statistics and Decision*, 41(8), 148-153.
 - [13] Ma, W. J., Zhang, H. Z., & Zhang, L. L. (2025). Comprehensive empowerment or partial empowerment? A study on the asymmetric impact of digital transformation on green innovation. *System Engineering Theory and Practice*. Advance online publication. <http://kns.cnki.net/kcms/detail/11.2267.n.20250224.2001.017.html>
 - [14] Molina, M. J., & Molina, L. T. (2004). Megacities and atmospheric pollution. *Journal of the Air & Waste Management Association*, 54(6), 644-680.
 - [15] Qasim, U., Osman, A. I., Al-Muhtaseb, A. H., et al. (2021). Renewable cellulosic nanocomposites for food packaging to avoid fossil fuel plastic pollution: A review. *Environmental Chemistry Letters*, 19, 613-641.
 - [16] Wang, X. M., & Zhong, X. Y. (2024). Exploring and practicing industry-education integration model for cultivating practical logistics management professionals under the new liberal arts framework. *Logistics Science & Technology*, 47(21), 153-155+177.
 - [17] Zhan, S. W., & Jing, H. R. (2024). Constraints and optimization strategies for rural green logistics systems under total pollutant discharge control. *Logistics Science and Technology*, 47(22), 53-55+63.
 - [18] Zhang, X., Lu, X. Y., Hu, X. H., et al. (2025). Dynamic incentives for low-carbon transportation in network freight under heterogeneous subsidies. *Industrial Engineering and Management*, 30(2), 80-90.
 - [19] Zhou, J. (2023). Interactive effects of the Yangtze River Delta integrated market and environmental governance: An empirical analysis using a spatially associated equations model. *Journal of Resources and Environment in the Yangtze River Basin*, 32(6), 1165-1175.
 - [20] Zou, Z. M., & Chen, X. (2023). The impact of foreign direct investment on technological innovation and high-quality economic development: Mechanisms and the mediating role of environmental regulation. *Research Management*, 44(2), 165-175.

Research on the Efficiency Evaluation of Company A's Financial Shared Service Center

Caiyu Song*

School of Business, Guilin University of Electronic Science and Technology, Guilin, 541004, China

*Corresponding author: Caiyu Song, 1163766652@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Against the backdrop of the widespread global application of financial shared services and domestic policies driving enterprises' digital transformation, Company A, an enterprise in the energy industry, established a Financial Shared Service Center (FSSC) in 2016 to address issues such as inconsistent accounting, cumbersome processes, and weak risk control in the traditional decentralized financial model. Adhering to the principles of comprehensiveness, systematicness, goal-orientation, and feasibility, this paper combines the Analytic Hierarchy Process (AHP) to establish an evaluation framework consisting of 4 first-level indicators ("Strategic Planning", "Information System", "Organizational Personnel", and "Process Management") and 16 second-level indicators. After scoring by over 10 experts from Company A, constructing a judgment matrix, and conducting a consistency test (all CR values < 0.1), it is determined that "Process Management" and "Information System" have relatively high weights, while indicators such as "Process Effectiveness" are core second-level indicators. The study finds that only the "Strategic Planning" dimension of Company A's FSSC meets the standards, while there are shortcomings in the three dimensions of "Information System" (e.g., subpar system efficiency), "Organizational Personnel" (e.g., insufficient personnel management quality), and "Process Management" (e.g., imbalanced process effectiveness). Based on this, optimization proposals are put forward from three aspects: information system integration, improvement of organizational personnel assessment and incentives, and process reconstruction with risk control. These proposals provide references for the improvement of Company A's FSSC and similar practices in the energy industry.

Keywords: FSS; AHP; Evaluation Indicator System; Effectiveness Evaluation; Energy Industry

Published: Sept 15, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.592>

1.Introduction

Amid the wave of global economic integration and digital transformation, the scale expansion and diversified development of enterprise groups have driven continuous innovation in their financial management models. As an innovative financial management model, the Financial Shared Service Center (FSSC) consolidates repetitive and standardized financial operations scattered across various business units, enabling resource integration, cost reduction, and efficiency improvement. Since the 1980s, when General Electric Company of the United States established the first FSSC, this model has been widely adopted worldwide. According to the 2024 Global Shared Services Survey Report released by Deloitte, 78% of enterprises globally have implemented financial shared services.^[1] Among them, 70% of enterprises reported achieving cost reduction through shared services, and 65% believed that the efficiency of financial processes had been improved.

In China, with the advancement of economic restructuring and high-quality development, policies have continuously promoted enterprises' digital transformation and innovation in financial management. In 2024, the Ministry of Finance revised and issued the Accounting Informatization Work Standards (Finance and Accounting [2024] No. 11) and the Basic Functions and Service Standards for Accounting Software (Finance and Accounting [2024] No. 12), which took effect on January 1, 2025. These standards explicitly require enterprises to strengthen the development of accounting informatization and enhance the digital and intelligent level of financial management, providing policy guidance and standardized guarantees for the development of FSSCs.

As a key enterprise in the energy industry, Company A's business covers power generation, transmission, distribution, and related services, with a large-scale organizational structure and complex business system. Faced with the deepening of energy system reform, the rapid expansion of new energy businesses under the "dual carbon" goal, and the requirements for refined and intelligent financial management in the construction of a new energy system, the traditional decentralized financial model has exposed numerous drawbacks. For instance, inconsistent financial accounting standards among subsidiaries make it difficult to integrate group financial data, and the accuracy and timeliness of data cannot be guaranteed; financial processes are cumbersome with excessive approval links, leading to long processing cycles for businesses such as expense reimbursement and fund settlement, which affects operational efficiency; risk control is decentralized, and the ability to identify, early warn, and respond to financial risks is insufficient, failing to meet the operational needs of strong supervision and high risks in the energy industry. To break through these bottlenecks, Company A fully launched informatization initiatives in 2016, gradually building and putting into operation an FSSC that covers core financial businesses including expense reimbursement, accounts payable, fund settlement, and tax accounting. The goal is to improve the efficiency of financial operations and strengthen group control capabilities through centralized and standardized management.

As a key enterprise in the energy industry, Company A's business covers power generation, transmission, distribution, and related services, with a large-scale organizational structure and complex business system. Faced with the deepening of energy system reform, the rapid expansion of new energy businesses under the "dual carbon" goal, and the requirements for refined and intelligent financial management in the construction of a new energy system, the traditional decentralized financial model has exposed numerous drawbacks. For instance, inconsistent financial accounting standards among subsidiaries make it difficult to integrate group financial data, and the accuracy and timeliness of data cannot be guaranteed; financial processes are cumbersome with excessive approval links, leading to long processing cycles for businesses such as expense reimbursement and fund settlement, which affects operational efficiency; risk control is decentralized, and the ability to identify, early warn, and respond to financial risks is insufficient, failing to meet the operational needs of strong supervision and high risks in the energy industry. To break through these bottlenecks, Company A fully launched informatization initiatives in 2016, gradually building and putting into operation an FSSC that covers core financial businesses including expense reimbursement, accounts payable, fund settlement, and tax accounting. The goal is to improve the efficiency of financial operations and strengthen group control capabilities through centralized and standardized management.

From an academic research perspective, evaluating the operational effectiveness of FSSCs is a key link to ensure their continuous optimization and value creation. Traditional evaluation methods mostly focus on the analysis of financial indicators (e.g., cost reduction rate, process efficiency improvement), which cannot fully reflect the multi-dimensional operational status of FSSCs in terms of process optimization, technical support, personnel capabilities, service quality, and risk control. In recent years, the Analytic Hierarchy Process (AHP)—an effective multi-criteria decision-making and comprehensive evaluation method—has been gradually applied in the field of enterprise management. Proposed by American operations researcher Thomas L. Saaty in the 1970s, AHP decomposes complex problems into a target layer, criterion layer, and alternative layer, constructs a judgment matrix, and calculates the relative importance weights of elements at each layer. This realizes the combination of qualitative and quantitative analysis, providing a scientific basis for multi-factor decision-making.

At present, research on applying AHP to the evaluation of FSSC operational effectiveness is still in the exploratory stage. Particularly in the energy industry, due to the uniqueness of its business (e.g., asset intensiveness, strong production

continuity, and significant policy impact), existing research results cannot fully meet the needs of industry-specific characteristics. Therefore, this study takes Company A's FSSC as the research object and innovatively constructs a comprehensive evaluation model based on AHP. By systematically sorting out the key influencing factors of FSSC operations and using AHP to determine the weights of each factor, this study aims to accurately identify the advantages and shortcomings of Company A's FSSC operations, provide targeted strategies for its continuous optimization, and at the same time offer theoretical and practical references for FSSC practices in the energy industry and other similar industries. This enriches and improves the theoretical and methodological system for evaluating FSSC operational effectiveness.

2. Construction of the Operational Effectiveness Evaluation System for Company A's FSSC

2.1 Construction Principles

Comprehensiveness Principle: An FSSC encompasses multiple capabilities. In constructing the indicator system, all key dimensions of the FSSC should be covered to ensure that the evaluation system can objectively and comprehensively reflect the operational status of the FSSC.^[2]

Systematic Principle: In establishing the evaluation indicator system, systematic thinking should be followed to ensure logical relevance among various evaluation dimensions and form a complete evaluation system.

Goal-orientation Principle: The construction of the FSSC-AHP model must be guided by the enterprise's strategic goals. The selected indicators should clarify the development stage of the FSSC, ensuring that the evaluation results can be used to analyze current development deficiencies and provide valuable references for enterprise management decisions.

Feasibility Principle: The selection of indicators should consider the feasibility of practical operation. In the actual evaluation process, indicator design should emphasize quantifiability, prioritizing indicators that can be measured through objective data. Additionally, the accessibility of data should be considered, and indicators that are important but difficult to obtain data for should be avoided. This ensures that the model can be smoothly implemented under the enterprise's existing resource conditions.

2.2 AHP Hierarchical Analysis Evaluation Model

AHP is a structured decision-analysis tool. It first decomposes complex decision-making problems into multiple layers, including the target layer and criterion layer. Then, by constructing a judgment matrix, it determines the relative importance among factors at each layer. Next, it calculates the weights of each factor and conducts a consistency test to ensure the rationality of weight distribution. This method helps decision-makers understand problems more clearly and make decisions based on more comprehensive information.

2.3 Framework of the Evaluation Indicator System

By synthesizing research by domestic and foreign scholars on the key factors of FSSCs, this paper identifies the core construction elements of FSSCs: high alignment with strategic planning, high-standard business processes, a reasonable organizational structure, and a diverse and cutting-edge information system.^{[3][4]} Based on this, the paper sets "Strategic Planning", "Information System", "Organizational Personnel", and "Process Management" as first-level indicators, which are further subdivided into four aspects: efficiency, quality, cost, and risk. By assigning different weights to each dimension and summing the scores of each dimension according to the weights, the final operational effectiveness evaluation result can be obtained. Based on questionnaires and in-depth interviews, the operational effectiveness of Company A's FSSC can be evaluated using 4 first-level key process area dimensions and 16 second-level subordinate indicators. These include: Strategic Planning (A) with Cost Adaptability (A1), Service Quality (A2), Operational Efficiency (A3), and Risk Resilience (A4); Information System (B) with Cost Rationality (B1), System Quality (B2), System Efficiency (B3), and System Security (B4); Organizational Personnel (C) with Human Resource Cost Adaptability (C1), Personnel Management Quality (C2), Personnel Effectiveness (C3), and Personnel Risk (C4); and Process Management (D) with Process Cost Adaptability (D1), Process Quality (D2), Process Effectiveness (D3), and Process Risk (D4). For details, see Table 1.

Table1: Evaluation Index System for Operational Effectiveness of Company A's Financial Shared Service Center

First-level Indicators	Code	Second-level Indicators	Code
Strategic Planning	A	Cost Adaptability	A1
		Service Quality	A2
		Operational Efficiency	A3
		Risk Resilience	A4
Information System	B	Cost Rationality	B1
		System Quality	B2
		System Efficiency	B3
		System Security	B4
Organizational Personnel	C	Human Resource Cost Adaptability	C1
		Personnel Management Quality	C2
		Personnel Effectiveness	C3
		Personnel Risk	C4
Process Management	D	Process Cost Adaptability	D1
		Process Quality	D2
		Process Effectiveness	D3
		Process Risk	D4

3.Weight Allocation of Evaluation Indicators and Effectiveness Analysis of Company A's FSSC-AHP Model

3.1 Weight Allocation of Evaluation Indicators for Company A's FSSC-AHP Model

To clarify the weight of each indicator, more than 10 enterprise experts from Company A were invited to score the importance of each indicator during the research process. The scoring results were then validated and summarized within the company, and a judgment matrix $S = (u_{ij})_{p \times p}$ was constructed. The final judgment matrices for indicators at all levels are shown in Table 2.

Table2: Judgment Matrices of Indicators at All Levels

First-level Indicators	A	B	C	D
A	1			
B	-	1		
C	-	-	1	
D	-	-	-	1

In Tables 3 to 8, W_i represents the weight of each indicator. To determine whether the judgment matrix has satisfactory consistency, the Consistency Index (CI) should be compared with the Random Index (RI). The Consistency Ratio (CR) is calculated as $CR = CI/RI$. When $CR = 0$, the judgment matrix has excellent consistency; when $CR < 0.1$, the consistency is good; otherwise, the consistency of the judgment matrix is poor, and the values in the matrix should be revised until $CR < 0.1$.

Table3: Judgment Matrix, Weight Allocation and Consistency Test of First-level Indicators

Criterion Layer	Strategic Planning (A)	Information System (B)	Organizational Personnel (C)	Process Management (D)	Weight (W)	CI	CR
Strategic Planning (A)	1	1/2.3589	1/2.0567	1/2.6451	0.151	0.04	0.045
Information System (B)	2.3589	1	1/0.8563	1/1.3614	0.262		
Organizational Personnel (C)	2.0567	0.8563	1	1/1.5126	0.236		
Process Management (D)	2.6451	1.3614	1.5126	1	0.351		

Table4: Judgment Matrix, Weight Allocation and Consistency Test of Second-level Indicators for Strategic Planning (A)

Strategic Planning (A)	Cost Adaptability (A1)	Service Quality (A2)	Operational Efficiency (A3)	Risk Resilience (A4)	Relative Weight of Second-level Indicators(%)	CI	CR
Cost Adaptability (A1)	1	2.1	0.9	2.8	31.5	0.028	0.031
Service Quality (A2)	1/2.1	1	0.429	1.333	15.2		
Operational Efficiency (A3)	1/0.9	2.333	1	3.111	43.8		
Risk Resilience (A4)	1/2.8	0.75	0.322	1	9.5		

Table5: Judgment Matrix, Weight Allocation and Consistency Test of Second-level Indicators for Information System (B)

Information System (B)	Cost Rationality (B1)	System Quality (B2)	System Efficiency (B3)	System Security (B4)	Relative Weight of Second-level Indicators(%)	CI	CR
Cost Rationality (B1)	1	0.45	0.38	1.9	14.8	0.023	0.026
System Quality (B2)	1/0.45	1	0.844	4.222	28.5		
System Efficiency (B3)	1/0.38	1.185	1	5	47.2		
System Security (B4)	1/1.9	0.237	0.2	1	9.5		

Table6: Judgment Matrix, Weight Allocation and Consistency Test of Second-level Indicators for Organizational Personnel (C)

Organizational Personnel(C)	Human Resource Cost Adaptability(C1)	Personnel Management Quality(C2)	Personnel Effectiveness (C3)	Personnel Risk (C4)	Relative Weight of Second-level Indicators(%)	CI	CR
Human Resource Cost Adaptability (C1)	1	0.32	1.8	0.45	15.8	0.031	0.034
Personnel Management Quality (C2)	1/0.32	1	5.625	1.406	52.5		
Personnel Effectiveness (C3)	1/1.8	0.178	1	0.25	9.8		
Personnel Risk (C4)	1/0.45	0.711	4	1	21.9		

Table7: Judgment Matrix, Weight Allocation and Consistency Test of Second-level Indicators for Process Management (D)

Process Management (D)	Process Cost Adaptability (D1)	Process Quality (D2)	Process Effectiveness (D3)	Process Risk (D4)	Relative Weight of Second-level Indicators(%)	CI	CR
Process Cost Adaptability (D1)	1	0.48	0.21	1.8	11.8	0.025	0.028
Process Quality (D2)	1/0.48	1	0.438	3.75	22.7		
Process Effectiveness (D3)	1/0.21	2.286	1	8.571	55.2		
Process Risk (D4)	1/1.8	0.267	0.117	1	10.3		

Table8: Summary Table of Weights

First-level Indicators	Weight of First-level Indicators(%)	Second-level Indicators	Relative Weight of Second-level Indicators(%)	Comprehensive Weight of Second-level Indicators(%)
Strategic Planning (A)	15.1	Cost Adaptability (A1)	31.5	4.76
		Service Quality (A2)	15.2	2.29
		Operational Efficiency (A3)	43.8	6.61
		Risk Resilience (A4)	9.5	1.43
Information System (B)	26.2	Cost Rationality (B1)	14.8	3.88
		System Quality (B2)	28.5	7.47
		System Efficiency (B3)	47.2	12.37
		System Security (B4)	9.5	2.49
Organizational Personnel (C)	23.6	Human Resource Cost Adaptability (C1)	15.8	3.73
		Personnel Management Quality (C2)	52.5	12.39
		Personnel Effectiveness (C3)	9.8	2.31
		Personnel Risk (C4)	21.9	5.17
Process Management (D)	35.1	Process Cost Adaptability (D1)	11.8	4.14
		Process Quality (D2)	22.7	7.97
		Process Effectiveness (D3)	55.2	19.38
		Process Risk (D4)	10.3	3.62

3.2 Analysis of Company A's FSSC-AHP Model

Ten experienced experts (managers and above) from Company A's FSSC evaluated the indicator value system layer, and each expert scored the indicators at the indicator layer. The scoring results are shown in Table 9.

Table 9: Summary Table of Scores and Target Values of Second-level Indicators

First-level Indicators	Second-level Indicators	Relative Weight of Second-level Indicators(%)	Comprehensive Weight of Second-level Indicators(%)	Current Score	Internal Target Value
Strategic Planning (A)	Cost Adaptability (A1)	31.5	4.76	3.8	3.5
	Service Quality (A2)	15.2	2.29	3.6	3.5
	Operational Efficiency (A3)	43.8	6.61	3.7	3.5
	Risk Resilience (A4)	9.5	1.43	3.6	3.5
Information System (B)	Cost Rationality (B1)	14.8	3.88	2.8	3.5
	System Quality (B2)	28.5	7.47	2.7	3.5
	System Efficiency (B3)	47.2	12.37	2.5	3.5
	System Security (B4)	9.5	2.49	3.6	3.5

First-level Indicators	Second-level Indicators	Relative Weight of Second-level Indicators(%)	Comprehensive Weight of Second-level Indicators(%)	Current Score	Internal Target Value
Organizational Personnel (C)	Human Resource Cost Adaptability (C1)	15.8	3.73	3.6	3.5
	Personnel Management Quality (C2)	52.5	12.39	2.6	3.5
	Personnel Effectiveness (C3)	9.8	2.31	2.8	3.5
	Personnel Risk (C4)	21.9	5.17	3.6	3.5
Process Management (D)	Process Cost Adaptability (D1)	11.8	4.14	2.7	3.5
	Process Quality (D2)	22.7	7.97	2.6	3.5
	Process Effectiveness (D3)	55.2	19.38	2.4	3.5
	Process Risk (D4)	10.3	3.62	3.6	3.5

3.3 Result Analysis of Company A's FSSC-AHP Model

Based on the comparison between the scores of the second-level indicators and the internal target values, the “Strategic Planning” dimension fully meets the standards and requires no additional attention; however, the three core dimensions of “Information System”, “Organizational Personnel”, and “Process Management” have multiple indicators that fail to meet the standards.

3.3.1 Information System Layer: Insufficient Core Operational Capabilities and Limited Support for Business Efficiency

The three core indicators of “System Efficiency”, “System Quality”, and “Cost Rationality” under the Information System all fail to meet the targets, covering the entire “efficiency-quality-cost” chain. This reflects insufficient overall adaptability and operational stability of the system. From an operational perspective, the lack of a unified coordination mechanism among multiple systems forces cross-platform operations for business processing, increasing redundant links and directly reducing processing efficiency; the poor alignment between system functions and business needs makes it impossible to adapt to specific business scenarios, requiring manual supplementary operations, which not only reduces processing quality but also increases hidden costs; at the same time, the unbalanced allocation of system operation and maintenance resources leads to idle functions occupying costs and insufficient support for core needs, further exacerbating the vicious cycle of “poor system user experience-weak business support capabilities” and failing to meet the basic requirements for the efficient operation of financial shared services.

3.3.2 Organizational Personnel Layer: Imperfect Management System and Underutilized Personnel Value

The two key indicators of “Personnel Management Quality” and “Personnel Effectiveness” under Organizational Personnel fail to meet the standards, and “Personnel Management Quality”—as a core dimension—shows a significant gap. This exposes the dual shortcomings of the management system in “development support-capability stimulation”. From a mechanism perspective, the lack of a clear design for career development paths, vague promotion standards, and a single-level structure leave employees without guidance for growth and insufficient sense of professional belonging; the performance appraisal and incentive system focuses on single quantitative indicators, ignoring qualitative capabilities and collaborative contributions, and the small incentive gap makes it difficult to stimulate employees’ initiative and innovation. Against this backdrop, personnel effectiveness is naturally limited: on the one hand, work efficiency is lower than the target, with long processing times for core businesses; on the other hand, professional capabilities are poorly aligned with business needs, with low mastery rates of key skills and excessive business error rates, preventing the effective conversion of personnel value into operational advantages of the FSSC.

3.3.3 Process Management Layer: Imbalanced End-to-End Operation and Insufficient Business Flow Efficiency and Value

The three indicators of “Process Effectiveness”, “Process Quality”, and “Process Cost Adaptability” under Process Management all fail to meet the standards, covering the entire life cycle of process operation. Moreover, “Process Effectiveness”—as a high-weight dimension—shows the largest gap, highlighting systematic problems in process design and management. From a process perspective, redundant node settings, excessive cross-departmental approval levels, and lack of time-limit control result in business flow cycles far exceeding the target, leading to low processing efficiency for core businesses; process design fails to fully consider the characteristics of industry-specific businesses, and there is a lack of standardized norms for handling exceptional scenarios, resulting in large differences in processing methods, which not only reduces process compliance but also increases error rates; at the same time, the imbalance between process operation costs and value output leads to increased labor costs from redundant nodes and hidden losses from process delays, with cost inputs not effectively converted into business value, failing to support the refined operational needs of the FSSC.

4. Optimization Plan for Company A’s FSSC

4.1 Optimization at the Information System Layer: Accelerate Data Migration and Eliminate System Redundancy

Multi-platform data migration should follow the principles of “safety first, accuracy and efficiency” and establish a full-process management and control system. First, conduct an inventory of data assets across multiple platforms, clarify the scope of core and non-core data, and develop a classified migration strategy based on business characteristics and data value. Priority should be given to ensuring the migration of data related to strategic businesses (e.g., new energy financial data).

During the migration implementation, it is necessary to establish operational standards of “unified standards and controllable quality”: unify data formats and calibers to ensure compatibility between migrated data and existing systems; establish a data verification mechanism to conduct multiple rounds of verification from dimensions such as integrity, accuracy, and consistency, avoiding data deviations that affect business continuity; at the same time, develop emergency plans to address risks such as system failures and data loss that may occur during migration, ensuring the smooth progress of migration work.

System integration should aim to “eliminate redundancy and improve collaboration” and build an integrated system architecture: promptly clean up and take offline migrated platforms to free up hardware and operation and maintenance resources; sort out the functions of existing systems, eliminate redundant functions that are disconnected from business needs and have extremely low usage rates, and optimize system performance; achieve real-time synchronization and interconnected sharing of business data and financial data by connecting data interfaces of various systems, eliminating data silos and providing technical support for the efficient operation of financial shared services.

4.2 Optimization at the Organizational Personnel Layer: Improve the Assessment System and Stabilize the Talent Team

The optimization of the performance appraisal system should adhere to the principles of “comprehensiveness and objectivity, clear orientation, and effective incentives” and build a multi-dimensional evaluation system. In designing appraisal dimensions, break through the limitations of traditional single quantitative indicators, integrate qualitative and quantitative indicators such as data application contributions, business department satisfaction, and team collaboration, and fully cover employees’ performance in business processing, value creation, and service quality. Special emphasis should be placed on strengthening the strategic relevance of key performance indicators for core positions.

The formulation of appraisal standards should follow the principles of “scientific rationality and dynamic adjustment”: combine the characteristics of energy financial shared services and strategic goals to clarify the evaluation standards and weights of each indicator; establish a dynamic optimization mechanism for appraisal standards, and regularly revise appraisal indicators and standards based on business development, strategic adjustments, and market changes to ensure that the appraisal system always adapts to the enterprise’s development needs.

The design of the incentive mechanism should focus on “differentiation and long-term effectiveness”, break the equalitarianism, and establish an incentive system closely linked to performance: widen the incentive gap between employees

of different performance levels, highlighting the incentive intensity for outstanding employees and core talents; improve the long-term incentive mechanism, linking employee performance to career development, salary growth, and training opportunities to enhance employees' sense of belonging and loyalty; at the same time, establish smooth performance feedback channels, promptly feedback appraisal results to employees, help employees clarify improvement directions, and improve employee satisfaction and retention rates.

4.3 Optimization at the Process Management Layer: Standardize Process Settings and Improve Operational Efficiency

Process optimization should take “streamlining and efficiency, compliance and controllability” as the core and follow the logic of “systematic sorting-problem diagnosis-reconstruction and optimization-continuous improvement”. First, comprehensively sort out existing business processes, identify problems such as redundant nodes, overlapping responsibilities, and delayed approvals in processes based on the characteristics of energy financial shared services, and clarify the focus and direction of process optimization.

Process reconstruction should follow the principles of “standardization and modularization”: integrate overlapping links, streamline unnecessary approval levels, optimize process paths, and improve business processing efficiency; design modular process templates for different business types (e.g., conventional accounting, special project financial processing) to ensure that processes adapt to various business scenarios; at the same time, establish process standards and norms, clarify the division of responsibilities, operational requirements, and time-limit standards for each link, and reduce human operational deviations.

Risk prevention and control should be integrated into the entire life cycle of processes, and a management and control mechanism of “pre-event prevention, in-event monitoring, and post-event improvement” should be established: embed compliance verification nodes and risk early warning mechanisms in process design to prevent business risks in advance; promptly detect and intervene in process abnormalities by monitoring process operation data in real time; regularly conduct process compliance audits and effectiveness evaluations, summarize problems and experiences, and continuously optimize the process system to ensure the standardized and efficient operation of processes and improve the quality and risk control capabilities of financial shared services.

5. Conclusion

5.1 Summary

This study focuses on the FSSC of Company A in the energy industry and conducts research on the evaluation and optimization of operational effectiveness combined with AHP. First, against the backdrop of a global FSSC application rate of 78% and domestic policies driving the proportion of A-share listed companies with FSSCs to rise to 45% by the end of 2024, this study takes Company A's FSSC—launched in 2016 and covering multiple core financial businesses—as the research object, aiming to address issues such as inconsistent accounting standards, cumbersome processes, and weak risk control in the company's traditional decentralized financial model.

Following the principles of comprehensiveness, systematicness, goal-orientation, and feasibility, the study constructs an AHP evaluation model, establishing 4 first-level indicators (“Strategic Planning”, “Information System”, “Organizational Personnel”, and “Process Management”) and 16 second-level indicators. After scoring by over 10 experts from Company A, constructing a judgment matrix, and conducting a consistency test (all CR values < 0.1), it is determined that “Process Management” (35.1%) and “Information System” (26.2%) are first-level indicators with relatively high weights, while “Process Effectiveness” (19.38%) and “Personnel Management Quality” (12.39%) are core second-level indicators.

The current situation evaluation shows that only the “Strategic Planning” dimension of Company A's FSSC meets the standards, while there are obvious shortcomings in the three dimensions of “Information System” (e.g., subpar system efficiency and quality), “Organizational Personnel” (e.g., insufficient personnel management quality and effectiveness), and “Process Management” (e.g., imbalanced process effectiveness and quality). Based on this, the study proposes optimization plans from three aspects: information system (data migration and system integration), organizational personnel (improvement of assessment and incentive mechanisms), and process management (process reconstruction and risk control), providing

references for the improvement of Company A's FSSC and similar practices in the energy industry.

5.2 Research Limitations

Limitations in Research Sample and Scope: The study only takes the FSSC of Company A—a single energy enterprise—as the research object and does not include cases of enterprises with other scales and business structures in the industry. The single sample leads to insufficient industry universality of the research conclusions, making it difficult to fully reflect the common problems and differentiated characteristics of FSSC operations among different types of enterprises in the energy industry.

Insufficiencies in Evaluation Indicators and Data Dimensions: Although the evaluation indicators cover four core dimensions, they do not fully integrate the financial characteristics of new energy businesses under the “dual carbon” goal in the energy industry to design special indicators; data acquisition relies on scores from internal enterprise experts and internal target values, lacking comparisons with external industry benchmark data, making it impossible to accurately judge the competitiveness of Company A's FSSC in the industry.

Insufficiencies in the Implementability and Effect Verification of Optimization Plans: The proposed optimization plans are mainly based on theoretical design and do not formulate detailed implementation paths for resource investment, time cycles, and potential risks of plan implementation; moreover, no mechanism for tracking and verifying the effects after plan implementation is established, making it impossible to quantitatively evaluate the actual improvement effect of optimization measures on FSSC operational effectiveness.

Lack of a Dynamic Evaluation Perspective: The study adopts a static evaluation method and does not consider the impact of dynamic factors such as enterprise business expansion, policy changes (e.g., adjustments to new energy policies), and technological iteration (e.g., the in-depth application of AI in the financial field) on FSSC operations. This makes it difficult to achieve long-term and dynamic monitoring and evaluation of FSSC operational effectiveness.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Chen, J. L. (2024). Research on the Operation Optimization of Z Company's Financial Shared Service Center under the Digital Background [Master's Thesis]. Xi'an Shiyou University. DOI: 10.27400/d.cnki.gxasc.2024.000627.
- [2] Yang, J. J. (2023). Research on the Development of Single - function Shared Service Centers to Multi - function Shared Service Centers in China. *Business Information*, (20), 134 - 137.
- [3] Xing, X. (2023). Research on the Optimization of Performance Evaluation of TJ Bridge Construction Company's Financial Shared Service Center [Master's Thesis]. Xi'an Shiyou University. DOI: 10.27400/d.cnki.gxasc.2023.000280.
- [4] Zhang, W., & Sheng, S. C. (2022). Research on the Capability Maturity Evaluation of Financial Shared Service Centers - A Case Study of G Company. *Economist*, (11), 71 - 74.

Unveiling the Gaze: Patriarchal Power and Female Resistance in Disgrace

Xiaoyu Chen*, Chuan Shi

Sichuan Minzu College, Sichuan, 626001, China

*Corresponding author: Xiaoyu Chen, chenxiaoyu@student.usm.my

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This paper examines the mechanisms of the male gaze in J.M. Coetzee's *Disgrace*, situating its female characters within intersecting structures of power, surveillance, and resistance. Drawing on Michel Foucault's concept of disciplinary power and Jacques Lacan's theory of the gaze, this study argues that Soraya, Melanie, and Bev Shaw occupy distinct positions within patriarchal visual regimes. Soraya is exoticized and disciplined through an orientalist gaze that renders her a fetishized object; Melanie is ensnared in a web of male desire that simultaneously constructs and erases her agency; and Bev Shaw disrupts the gaze by embracing an aesthetic of desexualized visibility, resisting conventional femininity. Each character, in turn, enacts subversive strategies—withdrawal, silence, and counter-surveillance—that unsettle patriarchal authority. By foregrounding the interplay between gaze, power, and female subjectivity, this paper expands feminist readings of *Disgrace*, highlighting the novel's interrogation of gendered oppression and agency in post-apartheid South Africa.

Keywords: Coetzee; *Disgrace*; Gendered Representation; Male Gaze; Resistance

Published: Sept 15, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.589>

1.Introduction

J.M. Coetzee is widely recognized for his moral inquiries and sophisticated narrative techniques. His works critically engage with race, colonial legacies, and power structures in South Africa, with *Disgrace* standing as a pivotal exploration of gender, race, and authority in post-apartheid society. Awarded the 1999 Booker Prize, the novel interrogates shifting power dynamics and moral ambiguities, situating Coetzee as a global literary figure whose work transcends national and historical boundaries. While *Disgrace* has been extensively analyzed through the lenses of race, power, and morality, the representation of female subjectivity remains an area of ongoing debate. The novel's three central female characters—Soraya, Melanie, and Bev Shaw—are entangled in a network of patriarchal surveillance and control, each negotiating distinct forms of objectification and agency. Their experiences illuminate the persistence of gendered oppression in post-apartheid South Africa while also revealing strategies of resistance.

Gaze theory provides a crucial framework for understanding these dynamics. Drawing on Foucauldian notions of disciplinary power and Lacanian psychoanalysis, this paper examines how *Disgrace* constructs a patriarchal surveillance system through its protagonist, David Lurie. Soraya, positioned within an economy of male desire, experiences both eroticization and surveillance as a sex worker. Melanie, as Lurie's student, is rendered an object of his gaze, with her silence and withdrawal exposing the power asymmetry in their relationship. Bev Shaw, while less overtly subjected to Lurie's erotic gaze, remains

marginalized within the broader socio-structural hierarchy, her unconventional femininity both subverting and reinforcing patriarchal norms.

Crucially, these women do not remain passive within these power structures. Soraya asserts control by reclaiming her privacy and severing ties with Lurie. Melanie's silence and eventual departure function as acts of passive defiance, challenging Lurie's authority. Bev Shaw, through her care for injured animals, constructs an alternative ethical paradigm that resists traditional forms of patriarchal validation. Their distinct modes of resistance, though varying in form, collectively illustrate the complexities of female agency under patriarchal domination.

By unveiling the mechanisms of patriarchal surveillance in *Disgrace*, this paper deepens feminist interpretations of Coetzee's work. The first section establishes the theoretical framework, situating the analysis within Foucault's concept of disciplinary power, Lacan's notion of the gaze, and bell hooks' oppositional gaze. The second section, Findings and Discussions, conducts a close textual analysis of Soraya, Melanie, and Bev Shaw, scrutinizing how each character negotiates oppression and resistance under patriarchal surveillance. The final section concludes by synthesizing the theoretical and analytical insights, highlighting the novel's contribution to feminist critiques of gaze and power in post-apartheid South Africa. Through this analysis, this study contributes to broader discussions on gendered power relations, agency, and resilience in Coetzee's literary corpus.

1.2 Research Objectives

The primary objective of this study is to systematically identify and expose how the male gaze in Coetzee's *Disgrace* operates through discourse, disciplinary practices, and institutionalized surveillance to regulate the female body and subjectivity, thereby constructing a gendered field of oppression. A further aim is to comparatively analyze the distinct positions of Soraya, Melanie, and Bev Shaw within this gaze regime, tracing and interpreting how their diverse strategies—ranging from compliance and silence to counter-gaze and ethical care—generate forms of everyday resistance and agency within specific contexts. Finally, by situating the textual analysis within Michel Foucault's theory of disciplinary power, Jacques Lacan's concept of the gaze, and bell hooks' notion of the oppositional gaze, the study seeks to evaluate how Coetzee's narrative in the post-apartheid context illuminates the intersecting mechanisms of gender, race, and power, thereby contributing fresh theoretical and critical insights into female subjectivity, modes of resistance, and gaze criticism in postcolonial literature.

2. Theoretical Framework

The concept of the gaze, central to visual culture studies, extends beyond the mere act of looking to encompass mechanisms of power and the construction of subjectivity. Michel Foucault (2002) argues that the gaze functions as an instrument of surveillance and discipline, compelling individuals to internalize power structures and engage in self-regulation. In *Discipline and Punish* (Foucault, 1975), he introduces the Panopticon as a model of modern disciplinary power, emphasizing that:

“The Panopticon was destined to spread throughout society. It makes power more economic and effective. It does this to develop the economy, spread education, and improve public morality, not to save society. The Panopticon represents the subordination of bodies that increases the utility of power while dispensing with the need for a prince” (Foucault, 1975).

Here, Foucault underscores how surveillance ceases to be a direct act of repression and instead becomes an omnipresent mechanism that structures behavior. Under constant observation, individuals unconsciously regulate their own actions, demonstrating how power operates without the need for overt coercion.

Expanding on this, Foucault's *The Birth of the Clinic* (2002) introduces the “medical gaze,” wherein physicians, by observing, classifying, and documenting patients, integrate individuals into a system of knowledge and power. This fusion of power and knowledge, he argues, does not merely facilitate the treatment of disease but establishes a discourse that categorizes and regulates subjects. Within patriarchal structures, this gaze extends beyond institutional settings, shaping gendered dynamics of power. Women, traditionally positioned as objects of the gaze, become defined and controlled through societal norms that dictate their visibility and subjugation.

Gaze and Subjectivity

While Foucault's analysis focuses on the disciplinary aspects of the gaze, Jacques Lacan introduces a psychoanalytic dimension that reveals its role in shaping subjectivity. In *The Four Fundamental Concepts of Psycho-Analysis* (2018), Lacan

argues that the gaze is intricately linked to desire. Since the subject's desire is fundamentally the desire of the Other, the gaze structures how individuals perceive themselves in relation to external forces.

Two key Lacanian concepts—*dompte-regard* (taming the gaze) and *trompe-l'œil* (optical illusion)—highlight how the gaze mediates subjectivity. *Dompte-regard* immerses the observer into a visual field, fostering identification, whereas *trompe-l'œil* produces perceptual deception, intensifying the subject's engagement. These mechanisms resonate with Lacan's notion of *objet petit a*, the unattainable object of desire that signifies the subject's inherent lack. In the context of visual representation, the subject, upon perceiving an idealized image, projects their desires onto it, reinforcing their sense of lack.

This framework provides insight into the gendered dynamics of the gaze. Women in patriarchal societies often function as *objet petit a*, positioned as the site of male desire while simultaneously being denied full subjectivity. In *Disgrace*, Soraya, Melanie, and Bev Shaw each navigate this dynamic, occupying positions where they are both observed and, to varying extents, resist their objectification. By engaging with Lacanian theory, we can analyze how these women negotiate visibility, power, and agency within the novel's patriarchal structures.

The Oppositional Gaze and the Potential for Resistance

The oppositional gaze, rooted in black feminist thought and conceptualized by Bell Hooks (2008), serves as a critical tool for resisting hegemonic visual culture and reclaiming subjectivity. It challenges dominant ideological structures that have historically marginalized black women, allowing them to interrogate and deconstruct power relations embedded in representation. By rejecting passive spectatorship, the oppositional gaze transforms looking into an act of resistance, redefining subjectivity beyond imposed norms. Central to its function is the disruption of the traditional gendered and racialized dynamics of looking. Rejecting the phallogocentric framework that positions women as passive objects, the oppositional gaze enables marginalized individuals to refuse identification with dominant visual paradigms. This rejection not only dismantles oppressive ways of seeing but also affirms alternative modes of self-representation, creating a space for subjectivity and empowerment. Beyond its critique of visual structures, the oppositional gaze operates as a broader mechanism of self-definition and cultural transformation. By resisting imposed narratives, women reclaim their subjectivity and participate in reshaping discourse. This act of seeing differently becomes both a political intervention and a means of asserting presence, challenging exclusionary ideologies while envisioning new possibilities for representation and empowerment.

Foucault's theory of power emphasizes that power is not merely repressive but rather permeates social structures, shaping individuals through discourse, discipline, and governance. However, he also argues that power relations always contain the potential for resistance, whereby individuals may counter established power structures by refusing to be seen, deliberately misusing rules, or engaging in what he terms "counter-conduct."

In *Discipline and Punish* (1975), Foucault employs the Panopticon prison model to illustrate how modern power operates through ubiquitous surveillance, leading individuals to internalize self-discipline. However, those under surveillance are not entirely passive; they may undermine power by deliberately evading observation, obscuring their identities, or minimizing their visibility. This strategy of "refusing to be seen" thus becomes a crucial means of resisting disciplinary power.

Additionally, individuals may subvert power by deliberately misusing rules, appearing to comply while resisting, or strategically exploiting regulations to disrupt the disciplinary system. This form of resistance is evident across various domains, including authoritarian regimes, healthcare systems, and legal institutions. For instance, prisoners may manipulate bureaucratic legal procedures to challenge prison authorities, while queer activism often employs exaggerated performances of gender norms to expose their inherent contradictions. Such tactical resistance not only contests existing norms but also reveals that power is neither absolute nor immutable; rather, it can be appropriated and subverted.

Foucault further develops the possibilities of resistance in *Security, Territory, Population* (2007), where he introduces the concept of "counter-conduct," referring to individuals' rejection of dominant social norms and the construction of alternative ways of living as a form of resistance against governmental power. Examples include rejecting institutionalized marriage, withdrawing from mainstream medical systems, or establishing autonomous communities to create spaces outside the control of hegemonic power. Unlike direct revolutionary or violent opposition, this decentralized mode of resistance is more

pervasive, emphasizing the dissolution of power's influence through everyday practices.

In the context of *Disgrace*, the female characters' resistance can be understood through the lens of counter-conduct. Soraya, for instance, reclaims her autonomy by withdrawing from Lurie's intrusive gaze, refusing to participate in his fantasy. Melanie, though subjected to gendered oppression, disrupts Lurie's narrative control through her silence and refusal to conform to his expectations. Bev Shaw, rather than engaging in direct confrontation, constructs an alternative ethical framework based on care, positioning herself outside traditional patriarchal and capitalist systems. Each of these acts, in their own way, mirrors Foucault's notion of counter-conduct—forms of subtle but persistent resistance that challenge dominant modes of power.

Thus, while the disciplinary gaze in *Disgrace* operates as a mechanism of patriarchal control, the female characters' resistance—whether through oppositional looking, silence, withdrawal, or the creation of alternative value systems—demonstrates that power is never absolute. Instead, through everyday acts of defiance, they carve out spaces of agency and subjectivity within an oppressive framework.

This theoretical framework integrates Foucault's analysis of disciplinary power, Lacan's insights into subjectivity, and hooks' concept of the oppositional gaze to examine how *Disgrace* critiques patriarchal hierarchies. By situating the female characters within this framework, we can explore how they navigate and resist the gaze, challenging male-dominated structures of power and asserting their own forms of agency. Ultimately, this analysis highlights how Coetzee's novel not only exposes the mechanisms of oppression but also reveals the multifaceted ways in which women negotiate subjectivity within—and against—systems of control.

3. Findings and Discussions

3.1 Findings

The findings indicate that Coetzee's *Disgrace* constructs a complex network of patriarchal surveillance and desire through David Lurie's gaze, positioning Soraya, Melanie, and Bev Shaw in distinct yet interconnected forms of objectification. Soraya is exoticized and commodified, but her eventual withdrawal and oppositional gaze reclaim her autonomy. Melanie is initially entrapped within Lurie's narrative of desire, yet her silence, refusal to engage, and eventual denunciation transform her into an active agent challenging institutional and patriarchal authority. Bev Shaw resists categorization altogether, subverting conventional ideals of femininity and introducing an "ethical gaze" grounded in care and responsibility rather than consumption. Together, these women reveal that although the male gaze functions as a disciplinary mechanism, its authority is neither total nor uncontested. Through compliance as strategy, silence as defiance, and counter-gazes rooted in ethics, they enact multifaceted forms of resistance, thereby destabilizing dominant power relations and reconfiguring the possibilities of female subjectivity in post-apartheid South Africa.

3.2 Discussions

The Objectified Body and the Orientalist Gaze

In *Disgrace*, Soraya, a South African Muslim woman engaged in sex work, is explicitly classified as "Exotic" by Discreet Escorts. This label not only underscores her commodification within the sex trade but also reflects the construction of identity through the white male gaze. Although Lurie expresses "complete satisfaction" with Soraya, this satisfaction is contingent upon his ability to mold her into an object of his desire through acts of gazing, fantasizing, and exerting control. The Soraya he perceives is thus a projection, fundamentally distinct from her actual self. His reliance on her presence as a means of alleviating the monotony of his life is evident in the narrator's remark: "Without the Thursday interludes, the week is as featureless as a desert" (Coetzee, 1999, p. 9)." This analogy highlights Soraya's instrumentalization, reducing her to an object that fills the void in Lurie's otherwise barren existence, rather than recognizing her as an autonomous individual.

The Orientalist Gaze and the Commodification of Soraya

Soraya's exoticized image is accentuated in the opening chapter of the novel. Lurie's description of her appearance is imbued with Orientalist undertones: "She has honey-colored skin, long black hair, and dark, liquid eyes" (Coetzee, 1999, p. 3). These features not only endow her with an air of mystery but also render her a visual object meant for gaze and consumption. As Edward Said argues in *Orientalism* (1977), Eastern women are frequently constructed within Western discourse as mysterious

and submissive objects. This construction closely aligns with Lurie's mode of looking at Soraya, reinforcing a dynamic in which she is reduced to an aestheticized and consumable presence rather than recognized as an autonomous subject.

The act of gazing is not neutral; it is an assertion of dominance. As Michel Foucault (1975) posits, subjects under constant observation internalize the gaze, leading to self-regulation. Under Lurie's scrutiny, Soraya passively conforms to his expectations, demonstrating the dynamics of discipline and control. Lurie's authority over Soraya is evident in his ability to dictate her physical appearance: "Not liking the stickiness of the makeup, he asked her to wipe it off. She obeyed and has never worn it since" (Coetzee, 1999, p. 5). This moment exemplifies how male dominance is exercised through the gaze. Lurie's preferences not only regulate Soraya's outward presentation but also shape her behavioral patterns, reinforcing her subordinate position within their relationship. At its core, the male gaze functions as a mechanism of control, not only reducing women to objects of male desire but also legitimizing and perpetuating patriarchal authority. As Laura Mulvey (2013) argues in *Visual Pleasure and Narrative Cinema*, the male gaze structures female representation in ways that render women passive and subservient to male fantasies, thereby sustaining asymmetrical gender power dynamics. Within this framework, Soraya is not merely objectified but also deprived of subjectivity, as Lurie's control over her appearance signifies a broader assertion of dominance over her body. This depiction underscores how power relations are inscribed and reinforced through the act of gazing, positioning women as subjects to be shaped and regulated by male authority.

Compliance as a Strategy of Resistance

Soraya's mild temperament and apparent compliance lead Lurie to mistakenly believe in the existence of an emotional connection between them. He assumes that this sentiment is reciprocated to some extent: "To some degree, he believes, this affection is reciprocated. Affection may not be love, but it is at least its cousin. Given their unpromising beginnings, they have been lucky, the two of them: he to have found her, she to have found him" (Coetzee, 1999). However, this supposed "luck" is merely Lurie's self-delusion. He fails to recognize that Soraya's compliance is not necessarily genuine acceptance but rather a strategic performance that allows her to navigate a system where power is asymmetrically distributed. Her apparent submission recalls James C. Scott's (2004) concept of "public and hidden transcripts", which differentiates between outward performances of obedience and covert forms of resistance. In this framework, Soraya's willingness to comply with Lurie's requests may be read not as internalized subordination but as a survival tactic—an effort to maintain control over her own circumstances while avoiding direct confrontation.

Her compliance, therefore, is not absolute. She resists male control not through overt rebellion but by setting boundaries and severing ties. When Lurie attempts to intrude into her private life and break established boundaries, she decisively terminates their relationship, refusing to be incorporated into his sphere of control. This rejection is not merely an individual decision but an act of "counter-conduct", as Foucault (2007) conceptualizes it—a subtle yet effective mode of resistance that refuses to conform to hegemonic expectations.

The Oppositional Gaze: Reclaiming Subjectivity

A pivotal moment occurs when Lurie encounters Soraya on St. George's Street with her two sons. Unconsciously, he follows them: "Then one Saturday morning everything changes... It is Soraya, unmistakably, flanked by two children, two boys" (Coetzee, 1999, p. 7). As their gazes meet through the glass, Soraya's look is no longer passive: "For an instant, through the glass, Soraya's eyes meet his" (Coetzee, 1999, p. 7)." This moment marks a critical shift in power dynamics. Her gaze is not merely the result of an accidental encounter but an assertion of awareness and refusal. At that moment, she ceases to be a passive object of observation and instead asserts her subjectivity, drawing clear boundaries and rejecting further scrutiny.

Bell Hooks (2008) conceptualizes the oppositional gaze as a direct challenge to dominant power structures. In this context, Soraya's gaze functions as an act of resistance—it disrupts Lurie's sense of control, denies his fantasy, and reclaims her autonomy. Her gaze not only fractures the power dynamics of observation but also asserts her agency in defining her own identity. Unlike earlier moments in the novel, where she is subjected to Lurie's gaze, here she actively returns the gaze, destabilizing his authority.

Soraya's assertion of subjectivity extends beyond this moment of visual resistance. Ultimately, she reconstructs her autonomy by completely severing ties with Lurie. Her refusal to engage further with him marks a decisive break from his influence,

challenging the structures that sought to define her solely through the lens of white male desire. As Hamid Dabashi (2020) argues, the colonial gaze is not merely an act of looking but a mechanism of power control, and those being observed can resist this control by returning the gaze. Soraya's glance challenges Lurie, transforming her from a passive object of observation into an active subject who disrupts the power dynamics of the gaze.

Soraya's resistance demonstrates that even within constrained social structures, marginalized individuals can challenge power relations through subtle yet effective means. Her gaze not only resists the white male gaze but also symbolizes the reshaping of female subjectivity within intricate social dynamics. By applying Dabashi's concept of "the colonial gaze and resistance", we can more comprehensively understand how Soraya reconstructs her subjectivity amid the dual oppression of male and colonial gazes. Her rejection of Lurie, her act of looking back, and her refusal to remain within his sphere of influence collectively embody a form of resistance that reclaims agency and redefines power relations.

The Predicament of Gaze Under Male Desire

After these events, David attempts to seduce one of his students, Melanie Isaacs. The situation eventually escalates into sexual violence, leading to David's dismissal from the university due to the scandal involving Melanie.

David Lurie's gaze upon Melanie Isaacs is not merely an act of looking but an exercise of power, reflecting both the structural dominance of men within patriarchal hierarchies and the asymmetries of class relations. While on the surface, gazing appears to be a mundane, everyday act, it is, in fact, a mechanism through which power is enacted and legitimized. As Foucault (2016) emphasizes in *Discipline and Punish*, modern power is not solely imposed from above by legal institutions but is diffused through micro-mechanisms—discipline, surveillance, and behavioral norms—that shape individuals into compliant subjects. Within the university system, Lurie wields authority not only as a male but also as a professor, positioning Melanie as a vulnerable figure within this disciplinary structure. His gaze upon her is thus not simply an expression of desire but a manifestation of institutionalized power.

Gaze and Misinterpretation: The Romanticization of Coercion

Lurie deliberately misreads Melanie's body language, interpreting it as an affirmation of his own desires and using this misinterpretation to justify his transgressions. However, Melanie's silence, resistance, and eventual accusation signify a struggle for female subjectivity. She refuses to be reduced to a passive object of the male gaze.

Although Melanie Isaacs is not explicitly positioned as an object of display like Soraya, she nonetheless functions as a vessel for Lurie's desire. While the means of pursuit differ—monetary transaction for Soraya and poetic seduction for Melanie—the underlying objective remains the same: the possession of the female body. Lurie's relentless attempts to lure Melanie demonstrate a strategic exertion of power, veiled under the guise of artistic and intellectual engagement. His invocation of Shakespeare's sonnet—"From fairest creatures we desire increase, that thereby beauty's rose might never die" (Coetzee, 1999, p. 16)—ostensibly elevates Melanie to an idealized status, yet as Beauvoir argues in *The Second Sex* (2014), the glorification of women as muses or divine figures serves only as another form of objectification, denying them subjectivity. Lurie reinforces this idea when he asserts: "A woman's beauty does not belong to her alone—it is part of the bounty she brings into the world." (Coetzee, 1999, p. 16) This statement reflects the patriarchal assumption that female beauty is a public commodity rather than an intrinsic personal attribute. From their initial encounter, Lurie's gaze inscribes Melanie within a framework of visual consumption, positioning her as an object of male desire:

"Her hair is damp from the rain. He gazes at her, clearly captivated. She lowers her eyes, offering that same evasive yet perhaps slightly coquettish smile." (Coetzee, 1999, p. 6)

Here, the description of Melanie's smile as "coquettish" reveals Lurie's interpretative bias—his tendency to misread neutral or indifferent gestures as invitations, thereby constructing a self-serving narrative that justifies his pursuit. This process aligns with what Laura Mulvey describes in *Visual Pleasure and Narrative Cinema* (2013) as the active/male and passive/female binary, wherein "the determining male gaze projects its fantasy onto the female figure, which is styled accordingly" (2013). Within this paradigm, women are not perceived as autonomous beings but rather as spectacles designed for male visual pleasure, reinforcing patriarchal structures of dominance. The narrative technique of *Disgrace*—which frequently employs free indirect discourse—further complicates the reader's perception by immersing us in Lurie's distorted gaze. For example,

in the following passage:

“She smiles back, bobbing her head, her smile sly rather than shy. She is small and thin, with close-cropped black hair, wide, almost Chinese, cheekbones, large, dark eyes. Her outfits are always striking. Today she wears a maroon miniskirt with mustard-colored sweater and black tights; the gold baubles on her belt match the gold balls of her earrings.” (Coetzee, 1999, p. 9)

The detailed description of Melanie’s appearance—her clothing, accessories, and body—is not an objective portrayal but rather Lurie’s perspective, framing her within a discourse of eroticization. This process aligns with Mulvey’s argument that women in visual culture are coded for “strong visual impact” and exist within a paradigm of “to-be-looked-at-ness” (2013), a process that denies their subjectivity while enabling the male viewer’s active role in shaping the narrative.

Silence as Resistance: The Politics of Non-Compliance

Melanie’s silence serves not only as an indication of victimization but also as an act of resistance. Rather than responding to Lurie’s coercive pursuit, she chooses withdrawal—skipping class, ignoring phone calls, and refusing to reply to messages. This refusal to engage with Lurie’s discourse can be understood through Judith Butler’s (2011) argument in *Bodies That Matter*: discourse is both constitutive and normative, meaning that refusing to respond signifies a rejection of the performative force of the other’s speech, constituting a form of “deconstructive” resistance.

Moreover, Melanie’s eventual denunciation of Lurie is not merely an exposure of his misconduct but a reclaiming of her right to speech. Butler’s concept of speakability is particularly relevant here—the ability to speak and be heard is determined by social power structures. By formally accusing Lurie, Melanie transitions from a passive victim to an active accuser, compelling Lurie to confront his loss of power.

Theatrical Performance as Reclamation of Subjectivity

Melanie’s participation in the student theatrical performance plays a crucial role in both her academic progress and personal development. As a key milestone in her education, the performance signifies her perseverance in completing her studies despite the trauma she has experienced. Within this space, she demonstrates increased confidence and agency, marking a shift in her self-perception. No longer the passive, silent student seen through Lurie’s gaze, she emerges as an individual capable of shaping her own identity. This transformation is evident not only on a psychological level but also in her performance itself:

“Melanie has kept her part as Gloria, the novice hairdresser... She is altogether more sure of herself than before—in fact, good in the part, positively gifted.” (Coetzee, 1999, p. 91)

This passage explicitly illustrates Melanie’s evolution—she is no longer a passive object of observation but an assertive performer shaping her own presence on stage. Her transformation aligns with Judith Butler’s (2011) argument in *Gender Trouble* that gender identity is continuously constructed and reconstituted through social performances. Melanie’s command over her theatrical role signifies not only her control over her stage presence but also her broader reclamation of agency. Meanwhile, Lurie attempts to maintain his gaze upon Melanie, yet his vision is rendered powerless: “The auditorium of the student union is in darkness. Unnoticed, he takes a seat in the back row...” (Coetzee, 1999, p. 93)

The darkness not only conceals Lurie’s presence but also symbolizes the erosion of his power to define Melanie through his gaze. Unlike earlier moments when his perspective shaped her image, she now determines how she is viewed and understood through the structured performance of the public stage. On stage, she is no longer Lurie’s object of desire but an independent artistic creator.

Nevertheless, Lurie’s attempt to voyeuristically observe Melanie’s performance suggests his lingering desire for control. Yet, this act of secret surveillance ultimately fails—Melanie’s boyfriend detects his presence and warns him to leave. This moment marks a pivotal shift: once women become aware of and reject the male gaze, it loses its authority and legitimacy (Mulvey, 2013). Lurie’s secretive observation, instead of reinforcing his dominance, reduces him to a powerless, marginalized spectator lurking in the shadows.

Furthermore, as John Stuart Mill (1966) emphasizes, women’s autonomy is intrinsically linked to their ability to define themselves beyond patriarchal constraints. The theatrical stage provides Melanie with such a space, where she is no longer confined within Lurie’s narrative but actively rearticulates her identity through performance. This aligns with Butler’s (2011)

argument that subjectivity is constituted through performative acts, suggesting that Melanie's theatrical role is not merely an artistic endeavor but an embodied assertion of selfhood. By stepping into a role of her own choosing, she challenges the structures that previously sought to confine her, demonstrating that agency can be reclaimed through acts of self-representation.

The Collapse of the Male Gaze

Lurie's gaze, initially an instrument of control, ultimately collapses as Melanie reclaims her self-representation. Through silence, denunciation, and theatrical performance, she transitions from an object of male desire into an autonomous subject, disrupting the patriarchal script that sought to define her. Her ability to control her narrative—both in her refusal to conform to Lurie's expectations and in her theatrical role—suggests the potential for female agency within oppressive structures.

However, *Disgrace* does not present a simplistic narrative of empowerment. While Melanie's resistance disrupts Lurie's authority, the novel also reveals the enduring challenges faced by women in reclaiming their subjectivity within a patriarchal system. Ultimately, her story underscores the tensions between subjugation and resistance, silence and speech, objectification, and self-representation—tensions that remain unresolved but deeply illuminating in the novel's critique of power.

Subverting the Male Gaze – A Radical Female Figure

Bev Shaw presents a female figure that fundamentally disrupts conventional representations of women in *Disgrace*. Unlike Soraya and Melanie, who are initially framed within Lurie's aestheticized and objectifying gaze, Bev neither conforms to traditional standards of female attractiveness nor submits to the male gaze's disciplining power. Instead, she engages in what Bell Hooks (2008) terms an "oppositional gaze"—a gaze that actively resists hegemonic structures of gendered and racialized power. While hooks' concept primarily addresses Black women's resistance to white patriarchal dominance, it can be productively extended to Bev's character, as she refuses to be subsumed into Lurie's habitual mode of visual and sexual possession. Through her pragmatic approach to both sexuality and care work, Bev disrupts Lurie's assumptions about female desirability and passivity, positioning herself as one of the novel's most autonomous female figures.

Lurie's descriptions of Bev underscore his inability to aestheticize her in the same way he does Soraya or Melanie. He notes her lack of conventional femininity, remarking:

"She is lying under the blanket with only her head sticking out. Even in the dimness there is nothing charming in the sight. Slipping off his underpants, he gets in beside her, runs his hands down her body. She has no breasts to speak of. Sturdy, almost waistless, like a squat little tub." (Coetzee, 1999)

His physical assessment reflects his ingrained male gaze, which attempts to categorize and evaluate women based on their visual appeal. However, unlike the women Lurie has previously pursued, Bev does not exist within this framework of desire. Her sexual encounter with Lurie is not framed in terms of romance or seduction but rather as a pragmatic act, one that she initiates without deference to his aesthetic preferences. Her lack of concern for conforming to Lurie's expectations unsettles him, marking a shift in power dynamics.

While Lurie initially attempts to assimilate Bev into his habitual framework of sexual conquest, she refuses to become a passive object of observation. Instead, she asserts her subjectivity through her work at the animal clinic, where she takes on the responsibility of caring for abandoned and suffering animals. This role transcends traditional gender expectations, as her engagement with life and death decisions disrupts the conventional association of women with passive caregiving. As Carol J. Adams (2018) argues in *The Sexual Politics of Meat*, the treatment of animals and the objectification of women are deeply intertwined within patriarchal structures. In contrast to Lurie's objectifying gaze, which seeks to possess and consume, Bev's engagement with animals is one of ethical responsibility rather than control. Her actions introduce what might be termed an "ethical gaze"—one that is desexualized, rooted in care rather than domination.

This ethical gaze not only defines Bev's own subjectivity but also serves as a catalyst for Lurie's transformation. Initially, Lurie approaches his work at the clinic with detachment, yet under Bev's guidance, he begins to engage with the suffering of animals in a way that forces him to confront his own moral limitations. Bev's refusal to conform to Lurie's expectations—whether as a sexual object or as a traditional caregiver—forces him to recognize a mode of relationality that is not predicated on possession or power. Her gaze, unlike Lurie's, is not about consumption but about recognition and responsibility.

Ultimately, Bev Shaw emerges as the novel's most ethically autonomous female figure. While her physical appearance and sexuality do not conform to patriarchal ideals, she subverts these structures not by rejecting intimacy altogether but by redefining its terms. She does not allow herself to be passively consumed by Lurie's gaze but instead asserts control over her own narrative. Unlike Melanie, whose silence serves as resistance, or Soraya, who commodifies her own body within the structures of patriarchal exchange, Bev actively destabilizes the power dynamics of the gaze itself. Her subjectivity is not constructed through desirability but through action—through her work, her choices, and her refusal to be defined by male desire.

In this sense, Bev represents a radical challenge to the novel's broader meditation on power, sexuality, and autonomy. While Lurie's gaze attempts to categorize, possess, and define, Bev's counter-gaze resists such reductions, asserting a form of female agency that transcends both aesthetic and patriarchal constraints. Through her pragmatic approach to sexuality and her ethical engagement with care, Bev reconfigures the terms of subjectivity, positioning herself not as an object of desire but as an autonomous moral agent.

Conclusion

Coetzee's *Disgrace* interrogates the complexities of post-apartheid South African society through its portrayal of female characters, who navigate the intersections of patriarchal, racial, and sociopolitical oppression. While they remain subjects of the male gaze, they also exhibit resilience and subjectivity in varying degrees. Through the lens of Lacanian psychoanalysis, Foucauldian discourse theory, and bell hooks' critique of the gaze, this study demonstrates that women's subjugation is not immutable but can be contested through counter-gazes, discursive reconstruction, and acts of self-determination. Although Coetzee refrains from prescribing definitive solutions, his narrative compels a critical reevaluation of power structures, gendered discourse, and the precarious position of women in postcolonial societies.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Adams, C. J. (2018). The sexual politics of meat. In *Living with contradictions* (pp. 548-557). Routledge.
- [2] Butler, J. (2011). *Bodies that matter: On the discursive limits of sex*. Routledge.
- [3] Coetzee, J. M. (1999). *Disgrace*. Secker & Warburg. <https://books.google.de/books?id=fvdjAAAAMAAJ>
- [4] Dabashi, H. (2020). *Reversing the colonial gaze: Persian travelers abroad* (Vol. 10). Cambridge University Press.
- [5] De Beauvoir, S. (2014). The second sex. In *Classic and Contemporary Readings in Sociology* (pp. 118-123). Routledge.
- [6] Foucault, M. (2002). *The birth of the clinic*. Routledge.
- [7] Foucault, M. (2007). *Security, territory, population: Lectures at the Collège de France, 1977-78*. Springer.
- [8] Foucault, M. (2016). *Discipline and punish*. In *Social theory re-wired* (pp. 319-329). Routledge.
- [9] Foucault, M. (1975). *Discipline and punish* (A. Sheridan, Trans.). Paris, FR: Gallimard.
- [10] Hooks, B. (2008). The oppositional gaze: Black female spectators. In *Black looks*. Routledge.
- [11] Horsley, R. A. (2004). *Hidden transcripts and the arts of resistance: Applying the work of James C. Scott to Jesus and Paul* (Vol. 48). Brill.
- [12] Mill, J. S. (1966). *The subjection of women*. Springer.
- [13] Miller, J. A., & Lacan, J. (2018). *The four fundamental concepts of psycho-analysis*. Routledge.
- [14] Mulvey, L. (2013). Visual pleasure and narrative cinema. In *Feminism and film theory* (pp. 57-68). Routledge.
- [15] Said, E. W. (1977). Orientalism. *The Georgia Review*, 31(1), 162-206.

Tibetan Women's Identification with the Sense of Community for the Chinese Nation: A Case Study of Wind

Xiaoyu Chen*, Chuan Shi

Sichuan Minzu College, Sichuan, 626001, China

*Corresponding author: Xiaoyu Chen, chenxiaoyu@student.usm.my

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This article investigates Tibetan women's identification with the consciousness of the Chinese national community through the characterization of Samdan and Gelak in Alai's novel *Wind*. Samdan, marginalized by bodily stigmatization and social exclusion, reconstructs her subjectivity and achieves emotional integration into the community through maternal experience and the revaluation of life. Gelak positioned between traditional ethics and modern lifestyles, embodies an active form of identification with the national community through her resilience and sense of responsibility. Their lived experiences reveal the complex intersections of gender, ethnicity, and social structures, while also illustrating how minority women contribute to strengthening national belonging through everyday practices. By analyzing these female figures, this study deepens the understanding of minority women's experiences and offers literary insights into the cultivation of a shared the sense of community for the Chinese nation.

Keywords: The Sense of Community for the Chinese Nation; Ethnic Identity; Tibetan Women; Alai; *Wind*; Samdan and Gelak

Published: Sept 15, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.588>

1.Introduction

In the contemporary strategic context of consolidating the awareness of the Chinese national community, minority literature and its criticism must move beyond the simplistic "ethnic-symbolic" representations and instead delve into the values of a "diverse yet unified" national community through in-depth exploration and artistic expression. Alai, as an eminent Tibetan writer, consistently combines profound "ethnic representation" with broad "cross-ethnic imagination": his works are rooted in the folk culture and regional memory of the Gyalrong Tibetan areas, while simultaneously addressing universal issues arising in the process of China's modernization through Tibetan narratives. This creative orientation allows his works to retain a strong ethnic character while transcending the limitations of a single ethnic perspective, thereby manifesting universal humanistic concerns. It is precisely this characteristic of "writing China from Tibet" that renders his works an important literary vehicle for bridging ethnic cultural identity and national identity (Wang, 2022), providing a paradigmatic case for studying the representation of Chinese national community consciousness in literature.

Within Alai's literary corpus, Tibetan female characters often play dual roles as both "cultural inheritors" and "intercultural mediators." From Zhuoma's witnessing of the decline of the Tusi system in *Red Poppies* to Amas Jiong's steadfast guardianship of ecological and cultural values in *Mushroom Circle*, the fate of women forms a central lens through which Alai observes historical change and reflects on cultural interaction (Deji Cao, 1998). These female figures not only

carry the deep-seated memory of ethnic culture but also demonstrate remarkable adaptability and creativity amid social transformations. By narrating individual female experiences, Alai effectively translates the abstract concept of community consciousness into tangible lived experience, avoiding the “tourist gaze” of exoticizing the other’s culture (Said, 1978) and enabling readers to grasp the complexity and necessity of community-building through concrete character trajectories.

Scholarly research on the relationship between Alai’s creative works and Chinese national community consciousness has produced substantial findings, primarily focusing on two directions: first, emphasizing his historical narratives (e.g., *Red Poppies*) in their macro-level expression of national identity and historical reflection (Zeng, 2019; Wu, 2006); second, analyzing the communal ethics and critiques of modernization embedded in his ecological writing (e.g., *Three Cordyceps and Mushroom Circle*) (Zhou, 2018). These studies reveal, from various perspectives, the intrinsic connection between Alai’s work and community consciousness, providing a critical theoretical foundation for the present study. However, most existing research approaches the topic from a macro-level lens, offering limited exploration of the specific narrative mechanisms at the micro-level.

Existing scholarship predominantly adopts holistic or thematic perspectives, often neglecting how female characters—and particularly their identity narratives—embody community consciousness in concrete narrative terms. Many studies treat female figures merely as annotations for macro-level thematic arguments, failing to fully articulate the constructive power inherent in their embodied experiences, emotional trajectories, and acts of agency. This gap provides the entry point for the present research. This study argues that female identity narratives are a crucial dimension for understanding how the “diverse yet unified” concept of community takes root in Alai’s works and necessitates close textual analysis to elucidate their distinctive narrative strategies and cultural functions.

1.2 Research Objectives

Building on the aforementioned research gaps, this study aims to investigate the relationship between the narrative construction of Tibetan female identities and the concrete articulation of the sense of community for the Chinese nation through close textual analysis. Specifically, this research addresses three core questions: First, how does Samdan’s “body narrative interweaving divinity and demonism” embody the folkloric and cultural heritage of the Gyarong Tibetan region while concretely representing the core value of “pluralistic coexistence” within the Chinese national community? Second, how does Gelak’s “transgressive narrative challenging gender taboos” reflect Alai’s creative characteristic of “cross-ethnic imagination,” dynamically demonstrating Tibetan women’s dual identification with both ethnic and national identities? Third, in light of Alai’s practice of writing in Chinese and his engagement with national identity consciousness, what unique role do Tibetan female identity narratives play in the construction and dissemination of the sense of community for the Chinese nation?

2. Materials and Methods

Materials

This study selects the film *Wind* (Based on *The Bastard Child Gelak* by Alai) as the core case for analysis, given its irreplaceable representative value within Alai’s literary corpus. Its significance lies in three aspects. First, the narrative concentration: the film focuses on two marginal figures—Samdan (an unwed mother) and her daughter Gelak—whose intertwined fates serve as a microcosm of survival within the cultural interstices of the Jiarong Tibetan region. Their life trajectories reveal the dilemmas and choices individuals face amid cultural encounters, transforming grand narratives of identity into tangible lived experiences. Second, the cultural interaction: the film reconstructs traditional Tibetan gender taboos (e.g., the prohibition against women ascending sacred mountains), while simultaneously highlighting Han-Tibetan cultural dynamics through characters such as Zhang Luosang, a Han-Tibetan descendant, and the enlightenment offered by Han teachers. These dual perspectives underscore the historical inevitability and contemporary dynamics of interethnic interaction (Ma, 2018). Third, the fusion of faith and ideas: Alai organically integrates Bön animistic beliefs (e.g., Samdan’s sensitivity to nature) with modern egalitarian values rooted in Han cultural discourse. The identity formation of both Samdan and Gelak thus becomes a vivid example of the interweaving between “ethnic culture” and “national mainstream culture” (Shi, 2013). Rather than a superficial cultural layering, this process demonstrates a negotiation of differences toward value

consensus, embodying the intrinsic logic of the “pluralistic unity” of the Chinese national community.

Methods

To address the research questions, this study employs close textual analysis as its primary method. The analysis proceeds in three steps. First, key narrative elements—including dialogue, bodily depictions, symbolic motifs such as “sacred mountains” and “tsampa,” and recurring cultural codes—are systematically examined to trace how identity and community consciousness are articulated. Second, symbolic patterns are thematically coded and contextualized within the socio-cultural realities of the Jiarong Tibetan region, including gender discipline, folk belief, and historical Han-Tibetan interaction. Third, the cinematic adaptation is analyzed for its audiovisual strategies—such as framing, performance, and sound design—that mediate or amplify the textual representation of women’s identity and community belonging. By combining narrative and filmic analysis, the study aims to uncover how the film translates abstract notions of community consciousness into embodied experiences, particularly through the voices and struggles of Tibetan women.

3. Theoretical Framework

In examining the interaction between minority women’s identities and the consciousness of the Chinese national community, it is necessary to draw upon major theories in sociology and cultural studies to uncover the mechanisms through which identity and collective consciousness are generated. This study builds its theoretical framework primarily on three approaches—social construction theory, cultural identity theory, and the theory of the “imagined community.” Together, these perspectives provide an effective interpretative lens for understanding how Tibetan women’s identity narratives intertwine with the construction of collective consciousness in Alai’s works.

3.1 Social Construction Theory

Berger and Luckmann (1966), in *The Social Construction of Reality*, argue that social reality does not exist naturally but is continuously constructed through human interactions, institutions, and linguistic representations. This perspective offers a crucial vantage point for analyzing the identity of Samdan and Gelak. Their female identities are not solely determined by biological sex but are reshaped within the intersection of local cultural regulations in the Jiarong Tibetan region (such as the taboo against women entering sacred mountains) and national discourses emphasizing equality and education. This constructive process positions individual identity at the convergence of cultural traditions and state recognition, thereby providing a concrete pathway for the embodiment of the sense of community for the Chinese nation (Ma, 2018).

3.2 Cultural Identity Theory

Hall (1996) emphasizes that cultural identity is neither fixed nor singular, but rather fluid, multiple, and dynamically shaped within historical contexts and social relations. Applied to the analysis of *Wind*, this theory elucidates how Samdan and Gelak negotiate their identities amid cultural interactions. As an unmarried mother, Samdan bears the weight of gender taboos and stigmatization within traditional society, yet through her engagement with nature, she manifests a cultural power that transcends gendered discipline. Gelak, on the other hand, gradually develops a dual sense of identity through exposure to modern ideas and education provided by Han teachers. These processes reveal both the tension and generative potential of cultural identity, demonstrating that women are not merely passive carriers of a single ethnic culture, but active agents in constructing identity.

3.3 Theory of the Imagined Community

Anderson (1991) posits that the nation is an “imagined political community” sustained through the construction of cultural symbols, narratives, and shared memories. From this perspective, *Wind* situates the local narratives of the Jiarong Tibetan region within the broader framework of the Chinese nation conceived as a “pluralistic unity.” Through the individual experiences of Samdan and Gelak, the novel presents scenes of Sino-Tibetan cultural exchange and interactions of beliefs and ideas. These depictions not only reflect the complexities of cultural identity but also enable readers and viewers to imagine and identify with a national community that transcends ethnic differences. Such a “local-to-national” narrative logic constitutes a key mechanism in the formation of the sense of community for the Chinese nation (Shi, 2013).

In summary, social construction theory highlights the interactive generation of identity, cultural identity theory underscores its fluidity and multiplicity, and the theory of the imagined community reveals the cultural construction of national belonging.

Collectively, these three perspectives complement one another and provide a robust analytical framework for investigating how Tibetan women's identity narratives in Alai's works contribute to the formation of Chinese national community consciousness.

4. Findings and Discussions

4.1 Findings

The analysis reveals that female narratives in Alai's works collectively embody a multilayered negotiation of identity and community. Samdan's embodied experience demonstrates how stigmatized bodies become a microcosm of communal "plural coexistence," while Gelak's narrative of breakthrough reflects the tension and reconciliation between ethnic identity and national belonging. At the same time, Alai's adoption of Chinese writing grants women's stories the function of a cultural bridge, linking local traditions with the broader national community. Together, these findings highlight how women's struggles and representations serve not only as individual expressions of survival but also as symbolic mediations of collective identity and cultural integration.

4.2 Discussions

From the very beginning of the novel, Samdan's body is inscribed with the label of "demonic," as her act of bearing a child out of wedlock is perceived as a violation of traditional Tibetan marital ethics (Alai, 2001). Her "unstable mental state" further stigmatizes her as an ominous figure. This process of "bodily stigmatization" essentially represents the ethical mechanism through which traditional Tibetan society disciplines and regulates the female body. Such discipline is not an abstract principle but rather operates through everyday micro-practices: villagers deploy gossip and epithets such as "unclean" or "inauspicious" to pass moral judgment on her; they exclude her from material distribution, thereby imposing implicit economic sanctions; and they even attempt to expel her from the village space, thus enforcing physical segregation. As Foucault (1977) argues in *Discipline and Punish*, the body is a crucial site of power, where disciplinary techniques inscribe ideology upon the individual. In *Wind*, Samdan's body becomes a "disciplinary carrier" of traditional ethics, with villagers continuously inscribing and reinforcing the label of "demonic" upon her body through these micro-practices, thereby safeguarding the boundaries of traditional order. This logic bears a parallel to *Red Poppies*, where the *tusi* system delineates human value through the classification of "bone rank," both functioning through mechanisms of categorization and exclusion to consolidate power structures.

However, Alai does not render such disciplinary practices as absolute. The episode in which several elder women secretly provide aid to Samdan reflects a form of empathetic recognition embedded within Tibetan culture. According to Gele's (2002) ethnographic study of the Jiarong Tibetan region, which historically functioned as a core area of the "Han-Tibetan corridor," the long-standing cultural plurality of the region has fostered an enduring tension within Tibetan ethical systems that allows space for the inclusion of heterogeneity. This inclusivity is evident in the grassroots ethic of mutual assistance: although many women remain publicly silent under collective pressure, some clandestinely leave *tsampa* at Samdan's door. Such gestures extend beyond acts of charity; they represent a silent resistance to rigid disciplinary norms and reveal the community's capacity for self-regulation rooted in survival wisdom. This dynamic underscores that the value of "pluralistic coexistence" is not an externally imposed concept but an inherent potential within local cultural traditions.

Samdan's body also embodies a distinctive dimension of "sacredness." She demonstrates an intuition that transcends ordinary perception, such as the ability to "smell the coming of snow" and accurately predict sudden shifts in weather (Alai, 2001). In moments of extreme deprivation, she exhibits an almost obsessive guardianship of life—for instance, reserving the last mouthful of *tsampa* for her daughter Gelak while subsisting on wild vegetables herself. This "sacredness" does not originate from institutionalized symbols of Tibetan Buddhism but is instead deeply rooted in the Bon tradition of the Jiarong region. Bon posits that "all things have spirit," regarding mountains, rivers, vegetation, wind, rain, and thunder as animate entities, and designates women as unique mediators between nature and humanity (Shi, 2013). Samdan's heightened sensitivity to the natural world reflects precisely this animistic worldview: her body functions as a receptor of natural forces, while her maternal resilience in preserving life resonates with the Bon cosmology, which emphasizes the sanctity of life, cyclical regeneration, and transformation. As Alai himself has emphasized in his reflections on creative practice, his works draw

inspiration not from institutionalized religion but primarily from Bon traditions and oral folk culture (Wu, 2006). The figure of Samdan emerges as a literary embodiment of this creative orientation.

Gelak challenges the taboo that “women cannot ascend the sacred mountain to perform rituals,” thereby demonstrating a form of critical adherence to her ethnic culture. Her stance of “believing in the sacred mountain but not in gender restrictions” reflects Alai’s dialectical approach to cultural tradition (Alai, 2001). This narrative resonates intertextually with the figure of the shaman Dorje in *Hollow Mountain*, as both characters seek a balance amid the tension between tradition and modernity. Such balance is not a simple compromise but rather a reflective reconstruction: it honors the cultural heritage while simultaneously interrogating and rejecting its unreasonable elements, embodying the internal dialectics of cultural development. Through this narrative strategy, the work avoids the reductive binary of cultural conservatism versus radical modernism, instead presenting the complexity of cultural innovation. Anderson’s (1991) notion of the “imagined community” emphasizes the constructed nature of cultural identity. Gelak’s act of questioning can thus be understood as a process of deconstructing and reconstructing the traditional gender order: she retains the cultural essence of the sacred mountain belief while discarding the outdated, discriminatory gender restrictions. In this process, the individual is not a passive recipient of cultural tradition but an active participant in its reinterpretation and innovative transformation through conscious thought and choice.

Gelak’s process of identity transgression is closely intertwined with the dissemination of Han Chinese modernist values. Through her interactions with a Han Chinese teacher, she becomes exposed to state-endorsed cultural principles, such as gender equality. Alai emphasizes that “Mandarin serves as a communication tool shared across multiple ethnic groups,” a perspective validated within Gelak’s narrative, as language functions as a medium for cultural transmission and facilitates the awakening of her national consciousness. Drawing on Anderson’s (1991) theoretical framework of “language–print capitalism–national imagination,” Gelak’s acceptance of modern values marks the expansion of her identity from that of a “Tibetan girl” to a member of the broader Chinese nation. This formation of national identification is not imposed externally; rather, it emerges organically through cultural interaction, reflecting the intrinsic logic underpinning the construction of Chinese national community consciousness.

Gelak’s successful participation in the sacred mountain ritual carries symbolic significance that transcends individual narrative. The villagers’ shift from opposition to tacit acceptance, and even to actively offering khatas, reflects the Tibetan community’s receptivity to the integration of ethnic culture with state-sanctioned mainstream culture. This collective attitudinal transformation aligns with the discourse that national identification is fundamental to enduring social stability, and it demonstrates that the construction of community consciousness requires not only changes at the individual psychological level but also recognition and enactment at the societal collective level. This process illustrates the adaptability of traditional culture under the pressures of modernity, as well as the complex social mechanisms involved in forming communal awareness. Drawing on Honneth’s (1995) theory of recognition, the villagers’ acceptance of Gelak effectively constitutes an acknowledgment of the state-endorsed value of gender equality, signaling the translation of communal consciousness from abstract ideology into collective practice. The unification of ethnic identity and national identity thus not only facilitates individual acts of identity negotiation but also promotes the concretization of communal consciousness at the grassroots level. Through this narrative, the work vividly demonstrates how Chinese national community consciousness is realized in everyday cultural practices, offering a compelling literary example for understanding the mechanisms of community formation.

Conclusion

Wind materializes Chinese national community consciousness through the “embodied narrative” of Samdan and the “emancipatory narrative” of Gelak. The dual characteristics of “demonic” and “divine” embodied in Samdan are rooted in the Bon traditions and local wisdom of the Gyarong Tibetan region, while simultaneously reflecting the pragmatic logic of Han-Tibetan cultural interactions. Gelak’s gendered resistance dynamically constructs a dual identification with both ethnic and national identity, signifying the translation of communal consciousness from abstract ideology into lived practice. Tibetan women’s identity narratives play four interrelated roles in shaping community consciousness: first, as “concrete carriers,” they render communal values tangible through individual experiences, challenging stereotypes; second, as “emotional

connectors,” they evoke cross-ethnic empathy by transmitting shared values such as motherhood and human dignity; third, as “cultural bridges,” they facilitate cultural integration amid the interaction of tradition and modernity; and fourth, as “agents of practice,” individual actions catalyze collective conceptual change, embedding communal awareness into social life. Alai’s use of the Chinese language and his “cross-ethnic imagination” further empower these Tibetan women’s narratives, enabling them to transcend ethnic boundaries and serve as pivotal mediators of community values. His works combine the distinctiveness of ethnic culture with universal humanistic values, thereby fostering identity integration through intercultural engagement. This narrative strategy offers valuable insights into how minority literature can actively contribute to the construction and reinforcement of Chinese national community consciousness.

Funding

This research was supported by the Kangba Culture Research Center of Sichuan Minzu College under the project titled “A Study on the Representation and Construction of the Sense of Community for the Chinese Nation in Contemporary Minority Literature from the Perspective of Alai’s Novels” (Project No. KBFH2513).

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Alai. (2001). *The Bastard Child Gelak*. In Alai wenji: Zhong duanpian xiaoshuo juan [Collected works of Alai: Volume of novellas and short stories]. Renmin Wenxue Chubanshe.
- [2] Anderson, B. (1991). *Imagined communities: Reflections on the origin and spread of nationalism* (Rev. ed.). Verso.
- [3] Berger, P. L., & Luckmann, T. (1966). *The social construction of reality: A treatise in the sociology of knowledge*. Anchor Books.
- [4] Cao, D. (1998). Understanding Alai. *Journal of Southwest Minzu University (Philosophy and Social Sciences Edition)*, (6), 59–62.
- [5] Foucault, M. (1977). *Discipline and punish: The birth of the prison* (A. Sheridan, Trans.). Pantheon Books.
- [6] Gele, L. (2002). *On the origin and formation of Tibetan culture and its relations with surrounding ethnic groups*. Zhongshan University Press.
- [7] Hall, S. (1996). *Questions of cultural identity*. SAGE Publications.
- [8] Honneth, A. (1995). *The struggle for recognition: The moral grammar of social conflicts*. Polity Press.
- [9] Ma, R. (2018). *Minzu yu shehui fazhan* [Ethnicity and social development]. Social Sciences Academic Press.
- [10] Said, E. W. (1978). *Orientalism*. Pantheon Books.
- [11] Shih, S. (2013). *Xizang wenming dongxiang fazhanshi* [History of the eastward development of Tibetan civilization]. Sichuan People’s Publishing House.
- [12] Wang, R. (2022). Ethnic representation and cross-cultural imagination in Alai’s literary works. *Journal of Hainan University (Humanities and Social Sciences Edition)*, 40(1), 134–143.
- [13] Wu, D. (2006). Ethnicity, power, and survival: A polysemous reading of Alai’s *Dust Settles*. *Journal of South-Central University for Nationalities (Humanities and Social Sciences Edition)*, 26(5), 155–159.
- [14] Zeng, L. (2019). On national identity and significance in Alai’s novels. *Guizhou Social Sciences*, (8), 17–22.
- [15] Zhou, X. (2018). Cultural rooting and dispersed narrative: On Alai’s novels. *Journal of Southwest Minzu University (Humanities and Social Sciences Edition)*, 39(12), 176–183.

Home-Country Institutional Pressure and Foreign Divestment: Evidence from Developed-Country Multinationals in China

Qihu Wang*, Yue Gong, Yilan Gao

School of Economics & Management, Shanghai Institute of Technology, 201418, China

*Corresponding author: Qihu Wang, ecustwangqihu@163.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In recent years, advanced economies have increasingly adopted restrictive outward-investment measures, creating unprecedented institutional pressures on developed-country multinational enterprises (DMNEs). Yet DMNEs' responses, particularly foreign divestment decisions, remain heterogeneous and underexplored. Building on the institution-based view and investment opportunity perspective, this study investigates how home-country institutional pressure influences DMNEs' divestment from China and how investment opportunities moderate this relationship. Using a panel dataset of DMNEs listed in China from 2018 to 2024, we find that home-country institutional pressure significantly increases foreign divestment, and that this effect is amplified when firms face abundant investment opportunities. These findings extend international business research by (1) positioning home-country institutional pressure as an active driver rather than a background condition of DMNE strategy, and (2) identifying investment opportunities as a critical boundary condition shaping firm responsiveness. The study also offers managerial and policy insights into managing strategic choices under rising geopolitical and institutional constraints.

Keywords: Home-country Institutional Pressure; Investment Opportunities; DMNEs; Institution-based View; Foreign Divestment

Published: Sept 15, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.580>

1.Introduction

Fueled by escalating concerns over national and economic security, advanced economies have undergone a paradigmatic shift in their investment policy regimes—from market-oriented liberalism to intervention-oriented nationalism (Cui et al., 2023; Luo, 2022; Luo & Van Assche, 2023). Over the past decade, the incidence of outward foreign direct investment (OFDI)-specific restrictions has increased by nearly one third, with national security-based screening mechanisms becoming the most distinctive feature of the emerging regulatory landscape (UNCTAD, 2024). Since 2020, the United States has introduced a series of measures to monitor and regulate OFDI, culminating in an August 2023 executive order to review investments in sensitive national security-related technologies. In January 2024, the European Commission likewise proposed a framework to scrutinize OFDI in critical sectors such as advanced semiconductors and biotechnology. These institutional shifts carry profound implications for developed-country multinational enterprises (DMNEs), yet their strategic responses have been strikingly heterogeneous. For instance, Intel and Advanced Micro-Fabrication Equipment Inc. (AMEC), both operating in the advanced-semiconductor ecosystem and subject to similar U.S. OFDI scrutiny, pursued divergent strategies in China: Intel scaled down its Dalian packaging venture in 2020, whereas AMEC deepened its commitments by expanding its Shanghai

headquarters and ramping up local etch-equipment capacity in 2025. Such divergence poses a salient theoretical puzzle: under comparable home-country institutional pressure, why do some DMNEs divest while others sustain or expand their foreign operations?

Existing research has sought to address this puzzle by drawing on institutional theory and related perspectives. Specifically, studies on DMNEs have predominantly examined how firms respond to host-country institutional pressures, emphasizing that heterogeneous firm characteristics—such as resource endowments, strategic intent, and experiential learning—are key drivers of divergent strategic outcomes (Kostova et al., 2008; Meyer & Peng, 2016; Oliver, 1991). Research on divestment further underscores the role of host-country conditions, including political risk, liability of foreignness, and economic growth, in shaping exit decisions (Benito, 2005; Berry, 2010; Schmid & Morschett, 2020). However, these studies largely treat DMNEs' home-country institutions as stable background conditions rather than dynamic forces directly influencing their OFDI choices. Moreover, the burgeoning literature on investment screening has concentrated primarily on inward FDI (Evenett, 2019; Chan & Meunier, 2022), leaving underexplored how recent home-country regulatory interventions affect DMNEs' strategies. This creates a critical gap: despite intensifying home-country institutional pressures, we lack a systematic understanding of why DMNEs facing comparable constraints display heterogeneous divestment behaviors abroad.

This study addresses this gap by integrating institutional pressure theory with the investment opportunity perspective. We argue that firms with abundant investment opportunities are more inclined to comply with home-country institutional pressures by choosing divestment or withdrawal, whereas firms with limited opportunities are more likely to resist and sustain their host-market presence. By testing this argument using DMNEs' divestment behavior in China, this research contributes to the international business literature in three ways. First, it addresses a critical gap in IB research on DMNEs: prior studies often treat home-country institutions as a stable background condition rather than an active driver of DMNEs' strategies (Peng, 2002; Peng et al., 2008). Our findings show that home-country institutional pressures can exert contingent and decisive effects on DMNEs' divestment decisions, thereby extending the application of the institution-based view in the study of DMNEs' internationalization. Second, it extends divestment research by identifying investment opportunities as a critical boundary condition (Benito, 2005; Dai et al., 2017). Third, it provides managerial and policy implications by explaining why firms like Apple diversify away while others like Intel deepen commitments under similar geopolitical tensions.

2.Theoretical Background and Hypotheses

2.1 Foreign Divestment and Antecedents

Foreign divestment has attracted growing scholarly attention in recent years, as firms increasingly reconfigure their global portfolios in response to both internal constraints and external shocks (Sethuram & Gaur, 2024). According to UNCTAD (2024), the incidence of OFDI-specific restrictions has risen by nearly one-third over the past decade across both developed and developing economies, intensifying pressures on multinational enterprises (MNEs) to reconsider their international presence. Although divestment is sometimes seen as the “mirror image” of foreign entry, scholars emphasize that it is not merely a reversal but a distinct strategic decision with its own antecedents (Benito, 2005; Ameyaw, Panibratov, & Ameyaw, 2023). This raises the question of what factors can determine firms' foreign divestment decisions.

Some scholars focus on firm-specific antecedents to explain why certain MNEs divest while others sustain their foreign subsidiaries. Empirical research shows that poor financial performance and low profitability increase the likelihood of divestment (Berry, 2013; Chung et al., 2010; Han, 2021). Organizational factors such as managerial decision-making, strategic misalignment, or lack of internal commitment have also been highlighted as triggers of divestment (Brauer, 2006). Collectively, these findings indicate that divestment is not simply a market-driven outcome but is strongly shaped by firm-level capabilities and constraints. Other scholars emphasize environmental factors that drive divestment decisions. Host-country political instability, policy unpredictability, and weak institutional environments substantially increase exit risks for foreign subsidiaries (Gonchar & Greve, 2022; Tang, 2023). Market-related conditions, such as economic downturns, shrinking demand, or intensified local competition, have also been identified as critical drivers of divestment (Berry, 2013; Dittmar & Shivdasani, 2003; Park et al., 2021; Tan, 2022). In emerging markets, in particular, foreign subsidiaries face greater institutional fragility and abrupt regulatory shifts, which exacerbate their vulnerability and shorten their life cycles

(Ameyaw et al., 2023). These studies underscore that divestment decisions are shaped not only by firm-level conditions but also by the turbulence of host-country environments. However, as Ameyaw et al. (2023) note, existing foreign divestment from emerging markets research has primarily concentrated on host-country antecedents of divestment, while the role of home-country factors remains comparatively underexplored.

Although both firm-specific and environmental factors help scholars identify the antecedents of foreign divestment, relying on only one of the two would be insufficient to capture the phenomenon's complexity (Schmid & Morschett, 2020). On the one hand, firm-level resources and strategies shape how MNEs perceive and respond to external shocks. On the other hand, environmental turbulence can amplify or attenuate firm-specific vulnerabilities, leading to divergent divestment outcomes under similar conditions. Thus, combining the insights of both perspectives can enhance our knowledge of the antecedents of foreign divestment (Sethuram & Gaur, 2024; Ameyaw et al., 2023). In this study, we integrate these two perspectives to examine how home-country institutional pressures and firm investment opportunities jointly influence DMNEs' divestment behavior in China.

2.2 Home-country Institutional Pressure and DMNEs' Foreign Divestment

The institution-based view (Peng et al., 2008) emphasizes that firms' international strategies are shaped not only by market considerations but also by institutional frameworks. Institutions can act as both enablers and constraints of cross-border investment, guiding the "rules of the game" that firms must comply with. While extant studies on foreign divestment have primarily highlighted host-country drivers (e.g., market downturns, institutional instability), emerging research underscores the growing role of home-country institutions in shaping firms' location strategies (Sethuram & Gaur, 2024). In particular, recent developments such as OFDI screening, export controls, and national security-driven industrial policies illustrate that home governments have become active players in regulating where and how DMNEs can operate abroad (Cui et al., 2023; Luo & Van Assche, 2023).

Home-country institutional pressure manifests through formal mechanisms such as legislation, sanctions, and investment restrictions, as well as informal political expectations that condition firms' strategic choices (Witt, 2019). These pressures increase the compliance costs and risks associated with maintaining foreign subsidiaries in politically sensitive host markets. For example, U.S. technology firms operating in China have faced increasing scrutiny under the CHIPS and Science Act, which restricts further expansion and incentivizes re-shoring (Luo, 2022). Such institutional constraints not only limit firms' operational autonomy but also alter their cost-benefit assessments of staying abroad versus divesting. As a result, DMNEs facing stronger home-country pressures are more likely to consider divestment as a way to secure legitimacy at home and avoid political or legal sanctions.

Moreover, home-country institutional pressures may carry coercive and normative legitimacy effects (Oliver, 1991). On the coercive side, firms may be legally compelled to exit certain foreign markets to comply with new restrictions. On the normative side, alignment with national security and industrial policies may improve firms' legitimacy in the eyes of policymakers and domestic stakeholders. Thus, complying with divestment pressures not only reduces regulatory and reputational risks but also positions firms favorably in securing home-market resources, such as subsidies or preferential access to government contracts (Luo, 2022). Taken together, these arguments suggest that DMNEs subject to stronger home-country institutional pressures will be more inclined to divest their foreign subsidiaries, even if such decisions contradict short-term economic logic. Accordingly, we propose the following hypothesis:

Hypothesis 1: Home-country institutional pressure is positively associated with DMNEs' foreign divestment.

2.3 Impact of Investment Opportunities on Linkage between Home-country Institutional Pressure and DMNEs' Foreign Divestment

Investment opportunities refer to the availability of viable and profitable projects that firms can pursue to achieve future growth (Bates, 2005; Carpenter & Guariglia, 2008). In the international business context, investment opportunities reflect firms' strategic flexibility. The strategic flexibility afforded by multinational investment opportunities allows firms to adapt to environmental uncertainties, much like real options that can be exercised when conditions are favorable (Lee & Makhija, 2009). Conversely, a lack of such opportunities may reinforce path dependence, constraining a firm's strategic responses

in host markets. Thus, investment opportunities fundamentally shape firms' sensitivity to institutional constraints and their strategic responses.

When home-country institutional pressures rise, firms are confronted with the dilemma of whether to comply by divesting or to resist and continue operations abroad. The ability to divest from a host market in response to home-country pressures is significantly conditioned by a firm's portfolio of investment opportunities. Firms possessing a broader array of real options—such as diversified international investments or viable alternative projects—exhibit greater strategic flexibility. This flexibility allows them to more readily reallocate resources away from pressured markets towards opportunities promising higher returns or better alignment with home-country expectations, thereby mitigating the opportunity cost of divestment. The value of such flexibility in enabling adaptive responses to external shocks, including potentially coercive pressures, is underscored by research in international business (Lee & Makhija, 2009). Divestment, in this case, becomes a relatively less costly option, as the opportunity cost of foregone growth in the host country is mitigated by attractive alternatives elsewhere.

By contrast, firms with limited investment opportunities may perceive divestment as more costly, since withdrawing from an existing market reduces their already scarce growth avenues. Consequently, these firms may resist home-country institutional pressures and sustain their host-country presence despite heightened risks, in order to preserve rare growth opportunities. This implies that the positive effect of home-country institutional pressure on DMNEs' divestment is stronger when investment opportunities are abundant, but weaker when such opportunities are scarce. Accordingly, we propose the following hypothesis:

Hypothesis 2: Investment opportunities positively moderate the relationship between home-country institutional pressure and DMNEs' foreign divestment, such that the relationship is stronger when investment opportunities are abundant.

3.Methods

3.1 Research Context: DMNEs Operating in China

We took DMNEs operating in China as our research sample for three reasons. First, home-country institutional pressures have intensified in recent years, especially in advanced economies. According to the World Investment Report 2024 published by UNCTAD, developed countries have increased their restrictions on OFDI by nearly one-third over the past decade (UNCTAD, 2024). Multiple developed economies have established broad screening mechanisms on OFDI under the rationale of “maintaining national and economic security”. Studying DMNEs allows us to capture these changes in home-country institutional pressures and test our theoretical predictions about their effects on divestment. Second, many of these restrictive measures explicitly target DMNEs' investments in China. For instance, the United States' National Critical Capabilities Defense Act (NCCDA) of 2022 introduced a new regulatory mechanism to review U.S. enterprises' investments and business activities in specific countries, including China, citing national security concerns. This confirms that China provides a critical setting for examining FDI-related issues such as foreign divestment (Kim et al., 2010). In addition, as one of the largest recipients of FDI globally, China hosts a substantial proportion of DMNEs' subsidiaries, which further increases the relevance of this context (UNCTAD, 2024). Third, to avoid the confounding effect of cross-country variation in host-country characteristics on foreign divestment, we relied on divestment cases from DMNEs in a single host country within a specific period. In summary, China, with its high concentration of DMNEs' investments, offers an ideal setting for collecting such data and testing our hypotheses.

3.2 Data Collection

We selected listed firms operating in China between 2018 and 2024 whose ultimate controllers are nationals of developed countries as the initial research sample. Data on home-country institutional pressures were collected from the UNCTAD Investment Policy Monitor database, while firm-level divestment and financial data were primarily obtained from the CSMAR database. After excluding firms with missing values on key variables, the final sample consisted of 335 firm-year observations.

3.3 Measures

Dependent variable: Foreign divestment. Following prior research (Boddeyn, 1979; Ameyaw et al., 2023), we measure foreign divestment as the annual reduction in the equity ownership share held by foreign ultimate controllers in their Chinese

listed subsidiaries.

Independent variable: Home-country institutional pressure. We measure home-country institutional pressure as the ratio of the cumulative stock of restrictive investment measures issued by a firm's home country by the end of year t to the total stock of investment measures issued by that country by the same year. We use a stock-based rather than a flow-based indicator for three main reasons. First, institutional pressures are cumulative and exhibit memory effects: once restrictive measures are enacted, they usually remain in effect, thereby creating "layered institutional constraints." A stock measure captures the full scope of historical institutional restrictions that firms face, while a flow measure only accounts for newly introduced measures in a given year, potentially underestimating long-term constraints. Second, multinational firms make strategic and compliance decisions with reference to "all currently binding regulations" rather than only newly enacted measures. Thus, the stock-based ratio better reflects firms' actual perceptions and decision logic. Third, a stock measure mitigates short-term volatility that may arise from policy cycles or temporary political shocks, thereby improving stability and comparability. The investment measures are compiled in the UNCTAD Investment Policy Monitor, which records official measures taken by UN member states that affect OFDI. They are classified into two categories according to their potential effects: facilitating measures (e.g., liberalization, promotion, incentives) and restrictive measures (e.g., operational limitations).

Moderating variable: Investment opportunities. Following Szewczyk et al. (1996) and Carpenter & Guariglia (2008), we use Tobin's Q as a proxy for investment opportunities. Tobin's Q is calculated as market value of equity divided by (total assets – intangible assets – goodwill). This measure directly reflects the capital market's expectations about the availability of projects with positive net present value. A Q value greater than 1 indicates that the market perceives the firm to have profitable investment opportunities, with higher values implying greater expected returns from marginal investments.

Control variables. In line with Soule et al. (2014), we control for a range of firm- and country-level variables. At the firm level, we control for: (1) firm age, measured as the natural logarithm of years since establishment; (2) firm size, measured as the natural logarithm of total assets at year-end; (3) leverage, defined as the ratio of total liabilities to total assets at year-end; and (4) ROA, measured as net income divided by the average balance of total assets. At the country level, we control for: (5) host-country GDP, measured as the natural logarithm of annual GDP; and (6) host-country GDP per capita, measured as the natural logarithm of annual GDP per capita.

3.4 Model Specification

To address unobserved firm heterogeneity and avoid omitted variable bias, we employed a panel fixed-effects model, as suggested by the Hausman test which rejected the random-effects assumption. Firm-clustered robust standard errors were used to correct for potential autocorrelation and heteroskedasticity, thereby ensuring consistent estimates and valid statistical inference. The baseline empirical model is specified as follows:

$$\text{Foreign divestment}_{i,t} = \alpha_0 + \alpha_1 \text{Home-country institutional pressure}_{i,t} + \sum \alpha_i \text{Controls}_{i,t} + \sum \text{Industry} + \sum \text{Year} + \varepsilon_{i,t}$$

$$\text{Foreign divestment}_{i,t} = \alpha_0 + \alpha_1 \text{Home-country institutional pressure}_{i,t} + \alpha_2 \text{Investment opportunities}_{i,t} + \alpha_3 \text{Home-country institutional pressure}_{i,t} \times \text{Investment opportunities}_{i,t} + \sum \alpha_i \text{Controls}_{i,t} + \sum \text{Industry} + \sum \text{Year} + \varepsilon_{i,t}$$

where i denotes the firm, t denotes the year, $\text{Controls}_{i,t}$ is the set of control variables, $\sum \text{Industry}$ and $\sum \text{Year}$ capture industry and year fixed effects, respectively, $\varepsilon_{i,t}$ is the error term.

4. Results

Table 1 shows the descriptive statistics (e.g., means, standard deviations, minimum and maximum) and correlations of all the variables. The mean value of divestment is 1.939 with a standard deviation of 8.609, indicating that divestment activities dominate among foreign firms in China, with substantial variation across firms. On average, firms reduced their equity holdings to a notable extent during the observation period, suggesting that divestment constitutes a common and non-

trivial strategic response rather than an isolated phenomenon. At the same time, the relatively large dispersion in divestment indicates heterogeneous firm-level responses to external institutional environments, consistent with prior findings that divestment is highly path- and context-dependent (Benito, 1997; Ameyaw et al., 2023). The mean value of home-country institutional pressure is 0.912, reflecting the intensification of restrictive FDI measures imposed by developed economies in recent years. Moreover, the distribution of investment opportunity suggests that many firms in the sample faced substantial investment opportunities, which provides an important condition to examine how firm-level strategic options may interact with home-country institutional pressures in shaping divestment behavior. Other variables also fall within reasonable ranges and are generally consistent with prior studies.

Table 1 Descriptive statistics and correlations

Variables	1	2	3	4	5	6	7	8	9
1 Foreign divestment	1.000								
2 Home-country institutional pressure	0.019	1.000							
3 Investment Opportunities	0.093*	-0.112**	1.000						
4 Firm age	-0.133**	0.009	-0.101**	1.000					
5 Firm size	0.057	-0.021	0.035	-0.002	1.000				
6 Leverage	-0.025	-0.083*	-0.147***	0.043	0.281***	1.000			
7 ROA	0.003	0.010	0.287***	0.121**	0.050	-0.187***	1.000		
8 Host-country GDP	0.013	0.027	0.055	0.010	-0.256***	-0.050	-0.092*	1.000	
9 Host-country GDP per capita	0.051	0.061	0.073	-0.059	-0.051	-0.196***	0.045	0.102**	1.000
Mean	1.939	0.912	2.432	2.786	21.701	0.283	0.054	11.061	11.626
S.D.	8.609	0.100	1.804	0.339	0.931	0.173	0.106	0.605	0.373
Min	-40.900	0.500	1.046	1.609	19.507	0.027	-1.156	8.780	10.479
Max	82.090	1.000	20.436	3.555	24.842	0.976	0.427	11.861	12.338

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 2 reports the regression results. Model 1 includes only the control variables. Model 2 introduces home-country institutional pressure, and the coefficient is positive and significant ($\alpha_1 = 11.277$, $p < 0.05$), suggesting that stronger home-country institutional pressure is associated with greater foreign divestment in China. Thus, Hypothesis 1 is supported. Model 3 adds the moderating variable (investment opportunities), and Model 4 further incorporates the interaction term between home-country institutional pressure and investment opportunities. The coefficient of the interaction term is positive and significant ($\alpha_3 = 5.173$, $p < 0.05$), indicating that the effect of home-country institutional pressure on divestment is stronger for firms with greater investment opportunities. Therefore, Hypothesis 2 is also supported.

Table 2 Results of the panel fixed-effects regression analysis

Variables	Model 1	Model 2	Model 3	Model 4
Firm age	-20.941 (21.946)	-19.551 (22.639)	-15.171 (22.479)	-16.023 (22.658)
Firm size	-0.099 (2.747)	-0.126 (2.867)	1.780 (3.582)	1.860 (3.610)
Leverage	-13.502 (8.595)	-13.079 (8.857)	-17.663* (9.176)	-17.151* (9.212)
ROA	13.023 (13.076)	10.464 (12.692)	3.066 (14.593)	1.971 (14.585)
Host-country GDP	3.697 (11.773)	3.907 (12.039)	2.784 (11.415)	2.099 (11.279)
Host-country GDP per capita	10.699 (15.994)	10.747 (16.099)	9.826 (15.626)	9.583 (15.539)
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Home-country institutional pressure		11.277** (5.634)	14.986** (6.742)	-2.780 (9.392)
Investment Opportunities			0.957 (0.591)	-3.667* (2.102)
Home-country institutional pressure× Investment Opportunities				5.173** (2.594)
Constant	-98.228 (301.425)	-115.484 (308.664)	-148.922 (311.633)	-122.250 (306.633)
N	335	310	310	310
R ²	0.086	0.097	0.115	0.123

Note: Robust standard errors are reported in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5. Discussion

5.1 Theoretical Contributions

This study makes three main contributions to international business (IB) and strategy research. First, it enriches the institution-based view of international business by repositioning home-country institutional pressure from a relatively passive background condition (Peng, 2002; Peng et al., 2008) to an active driver of DMNEs' international strategies. While prior divestment research has concentrated on host-country turbulence or firm-level inefficiencies (Benito, 2005; Ameyaw et al., 2023), our findings demonstrate that restrictive FDI measures enacted by advanced economies can decisively shape DMNEs' divestment behaviors abroad. In doing so, the study extends the application of institutional theory to explain not only market entry and expansion but also market exit and withdrawal decisions.

Second, the study contributes to the literature on foreign divestment by identifying investment opportunities as a key boundary condition that moderates firms' responsiveness to home-country pressures. Existing research has acknowledged that firms' heterogeneous responses to institutional pressures stem from internal resources and strategic orientations (Kostova et al., 2008; Meyer & Peng, 2016; Oliver, 1991), yet has largely overlooked the constraining or enabling role of investment opportunities. By showing that firms with greater investment opportunities are more inclined to reallocate resources away from China under home-country institutional pressure, we integrate the opportunity-based perspective (Chandra et al., 2012)

with institutional explanations of foreign divestment. This integration highlights that divestment is not merely a compliance-driven response but also a strategic reconfiguration of global portfolios in light of both institutional constraints and growth opportunities.

Third, this research advances the broader literature on DMNEs by shedding light on their heterogeneous strategic adaptation under geopolitical uncertainty. Our findings explain why firms facing comparable home-country restrictions—such as Intel scaling down in China versus AMD deepening its local commitments—nonetheless diverge in their divestment propensities. By uncovering the interactive role of institutional pressure and investment opportunities, we offer a more nuanced explanation of DMNEs' internationalization strategies in a period of rising geo-economic interventionism (Cui et al., 2023; Luo & Van Assche, 2023).

5.2 Managerial and Policy Implications

For managers of DMNEs, our findings underscore the importance of incorporating home-country institutional dynamics into international risk management. Managers should recognize that restrictive OFDI measures can materially alter the viability of host-country operations. Accordingly, firms may need to build greater flexibility in their global portfolios, diversify exposure across regions, and proactively identify investment opportunities that allow for smoother reallocation of capital in response to shifting institutional pressures.

From a policy perspective, our findings carry implications not only for policymakers in advanced economies but also for the Chinese government as a host-country regulator. While home-country restrictions are outside China's control, their impacts can be mitigated through policies aimed at stabilizing foreign investors' confidence. For instance, by enhancing regulatory transparency, reducing administrative barriers, and expanding market access in sectors less affected by geopolitical restrictions, China can lower the perceived risks of sustained operations. Moreover, offering tailored incentives or partnership opportunities to foreign investors can help anchor long-term commitments, thereby buffering the destabilizing effects of external institutional shocks. Such measures are aligned with China's broader agenda of stabilizing foreign investment and can help maintain the attractiveness of its market despite rising geo-economic frictions.

5.3 Limitations and Future Directions

This study is not without limitations, which open avenues for future research. First, our empirical setting focuses on DMNEs operating in China. While this context provides an ideal natural laboratory due to the concentration of restrictive FDI scrutiny, future studies should explore whether our findings generalize to other host-country contexts, particularly emerging economies with different institutional profiles. Second, our operationalization of home-country institutional pressure is based on UNCTAD's investment policy database, which captures formal regulatory measures. Future work could extend this by incorporating informal political pressures, such as geopolitical tensions, media discourse, or lobbying activities, to obtain a more comprehensive measure of institutional constraints. Third, although we theorize investment opportunities as the central moderating factor, other firm-level mechanisms—such as ownership structures, resource endowments, or prior divestment experience—may also condition the impact of institutional pressures. Examining these contingencies could enrich our understanding of the heterogeneity in divestment responses.

Overall, this study contributes to the growing stream of research on foreign divestment by advancing an institutionally embedded and opportunity-sensitive perspective. By unpacking how home-country institutional pressures interact with firm-level strategic considerations, we provide novel insights into the complex drivers of DMNEs' divestment behavior and open new directions for future research in international business.

Conclusion

Our study examines the effect of home-country institutional pressure on DMNEs' foreign divestment and investigates how investment opportunities moderate this relationship. We find that institutional pressure from the home country significantly increases the likelihood of divestment, and this effect is amplified when firms possess abundant investment opportunities. The findings can deepen our theoretical understanding of DMNEs' strategic adaptation under geopolitical tension and offers practical insights for policymakers and managers navigating today's increasingly restrictive global investment environment.

Funding

Shanghai Philosophy and Social Science Planning Project (grant number: 2023EGL001).

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Ameyaw, A. K., Panibratov, A., & Ameyaw, A. S. (2023). Foreign divestment from emerging markets: A systematic literature review, integrative framework, and research agenda. *European Management Journal*, 41(6), 1134-1152.
- [2] Bates, T. W. (2005). Asset sales, investment opportunities, and the use of proceeds. *The Journal of Finance*, 60(1), 105-135.
- [3] Benito, G. R. (2005). Divestment and international business strategy. *Journal of Economic Geography*, 5(2), 235-251.
- [4] Berry, H. (2013). When do firms divest foreign operations? *Organization Science*, 24(1), 246-261.
- [5] Boddewyn, J. J. (1979). Foreign divestment: magnitude and factors. *Journal of International Business Studies*, 10(1), 21-26.
- [6] Brauer, M. (2006). What have we acquired and what should we acquire in divestiture research? A review and research agenda. *Journal of management*, 32(6), 751-785.
- [7] Carpenter, R. E., & Guariglia, A. (2008). Cash flow, investment, and investment opportunities: New tests using UK panel data. *Journal of banking & finance*, 32(9), 1894-1906.
- [8] Chan, Z. T., & Meunier, S. (2022). Behind the screen: Understanding national support for a foreign investment screening mechanism in the European Union. *The Review of International Organizations*, 17(3), 513-541.
- [9] Chandra, Y., Styles, C., & Wilkinson, I. F. (2012). An opportunity-based view of rapid internationalization. *Journal of International Marketing*, 20(1), 74-102.
- [10] Chung, C. C., Lee, S. H., Beamish, P. W., & Isobe, T. (2010). Subsidiary expansion/contraction during times of economic crisis. *Journal of International Business Studies*, 41(3), 500-516.
- [11] Cui, V., Vertinsky, I., Wang, Y., & Zhou, D. (2023). Decoupling in international business: The 'new' vulnerability of globalization and MNEs' response strategies. *Journal of International Business Studies*, 54(8), 1562-1576.
- [12] Dai, L., Eden, L., & Beamish, P. W. (2017). Caught in the crossfire: Dimensions of vulnerability and foreign multinationals' exit from war-afflicted countries. *Strategic Management Journal*, 38(7), 1478-1498.
- [13] Dittmar, A., & Shivdasani, A. (2003). Divestitures and divisional investment policies. *The Journal of Finance*, 58(6), 2711-2744.
- [14] Evenett, S. J. (2019). Protectionism, state discrimination, and international business since the onset of the Global Financial Crisis. *Journal of International Business Policy*, 2(1), 9-36.
- [15] Gonchar, K., & Greve, M. (2022). The impact of political risk on FDI exit decisions. *Economic Systems*, 46(2), 100975.
- [16] Han, X. (2021). Risk management, legitimacy, and the overseas subsidiary performance of emerging market MNEs. *International Business Review*, 30(4), 101732.
- [17] Kim, T. Y., Delios, A., & Xu, D. (2010). Organizational geography, experiential learning and subsidiary exit: Japanese foreign expansions in China, 1979-2001. *Journal of Economic Geography*, 10(4), 579-597.
- [18] Kostova, T., Roth, K., & Dacin, M. T. (2008). Institutional theory in the study of multinational corporations: A critique and new directions. *Academy of Management Review*, 33(4), 994-1006.
- [19] Lee, S. H., & Makhija, M. (2009). Flexibility in internationalization: is it valuable during an economic crisis?. *Strategic Management Journal*, 30(5), 537-555.
- [20] Luo, Y. (2022). Illusions of techno-nationalism. *Journal of international business studies*, 53(3), 550-567.
- [21] Luo, Y., & Van Assche, A. (2023). The rise of techno-geopolitical uncertainty: Implications of the United States CHIPS and Science Act. *Journal of international business studies*, 54(8), 1423-1440.
- [22] Meyer, K. E., & Peng, M. W. (2016). Theoretical foundations of emerging economy business research. *Journal of*

- International Business Studies, 47(1), 3-22.
- [23] Oliver, C. (1991). Strategic responses to institutional processes. *Academy of Management Review*, 16(1), 145-179.
- [24] Park, J. Y., Lew, Y. K., & Park, B. I. (2021). An organismic approach to multinational enterprise failure. *Management Decision*, 59(1), 18-31.
- [25] Peng, M. W. (2002). Towards an institution-based view of business strategy. *Asia Pacific journal of management*, 19(2), 251-267.
- [26] Peng, M. W., Wang, D. Y., & Jiang, Y. (2008). An institution-based view of international business strategy: A focus on emerging economies. *Journal of international business studies*, 39(5), 920-936.
- [27] Schmid, D., & Morschett, D. (2020). Decades of research on foreign subsidiary divestment: what do we really know about its antecedents?. *International Business Review*, 29(4), 101653.
- [28] Sethuram, S., & Gaur, A. (2024). Foreign divestment: the missing piece in international business scholarship. *Journal of International Business Studies*, 55(8), 1038-1047.
- [29] Soule, S. A., Swaminathan, A., & Tihanyi, L. (2014). The diffusion of foreign divestment from Burma. *Strategic Management Journal*, 35(7), 1032-1052.
- [30] Szewczyk, S. H., Tsetsekos, G. P., & Zantout, Z. (1996). The valuation of corporate R&D expenditures: Evidence from investment opportunities and free cash flow. *Financial Management*, 105-110.
- [31] Tan, H. (2023). Declining industries in emerging economies and firms' strategies. *critical perspectives on international business*, 19(2), 234-252.
- [32] Tang, R. W. (2023). Institutional unpredictability and foreign exit– reentry dynamics: The moderating role of foreign ownership. *Journal of World Business*, 58(2), 101389.
- [33] United Nations Conference on Trade and Development. (2024). *World investment report 2024: Investment facilitation and digital government*. United Nations.
- [34] Witt, M. A. (2019). De-globalization: Theories, predictions, and opportunities for international business research. *Journal of International Business Studies*, 50(7), 1053–1077.

The Effect of Readability of Listed Company Prospectuses on IPO Breaks: Evidence from the Shanghai Stock Exchange in China

Ruining Li^{1*}, Jiangjiao Duan²

University of Shanghai Science and Technology, School of Management, Shanghai, 200000, China

*Corresponding author: Ruining Li, 12295827002@163.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Using text analysis methods, this study analyzed the prospectuses of A-share listed companies on the Shanghai Stock Exchange that went public between 2014 and 2024, retrieved from the SSE website. By constructing readability metrics through an indicator-based approach, the relationship between the readability of Chinese text and the occurrence of initial public offering breaks on the first trading day was examined. The research found that, after controlling for industry and time fixed effects, there was a negative correlation between the readability of listed companies' prospectuses and the incidence of IPO breaks. This relationship was mediated through underwriter behavior. After a series of robustness checks, the above conclusion remained valid. Further research revealed that the degree of negative correlation between prospectus readability and IPO price breaks differed before and after the implementation of the registration-based IPO system, as well as when classified by the nature of listed enterprises. This finding provides a new perspective for research on factors influencing IPO pricing, which is beneficial for regulatory agencies to further standardize the information disclosure content of listed companies' prospectuses and also conducive to the development of capital markets.

Keywords: The Readability of Prospectus; IPO Break; Information Asymmetry

Published: Sept 15, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.595>

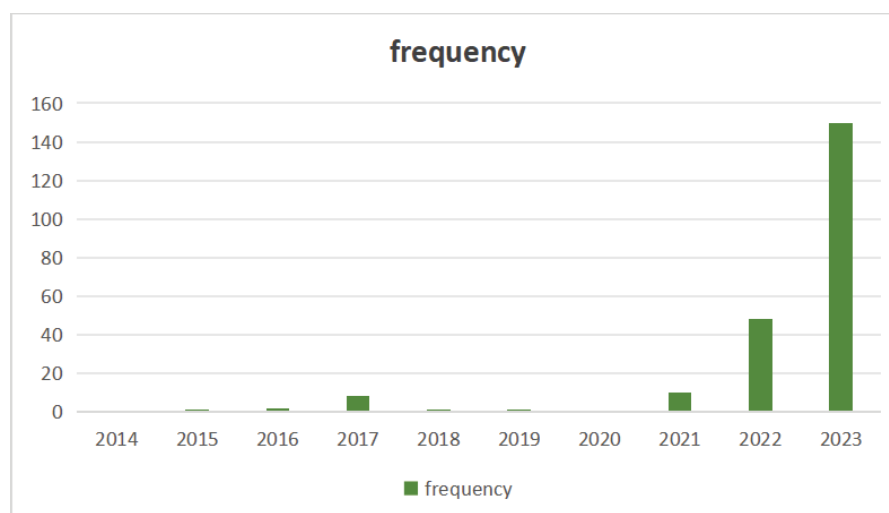
1.Introduction

The IPO system imparts vitality and resilience to the capital market, facilitating its ability to better serve the real economy. Under the backdrop of the comprehensive registration-based IPO reform, the adoption of market-oriented inquiry and underwriting mechanisms has resulted in greater freedom in the pricing of new shares, leading to prevalent phenomena such as IPO breaks. After a stock is issued, its price fluctuations are influenced by factors such as the market supply-demand relationship, investor sentiment, and company-related information. If the issuance price in the primary market is too high, or if the trading price in the secondary market is too low, it can lead to the stock's price falling below its issuance price, known as an IPO break. Figure 1 introduces the IPO breaks on the first day of enterprises listed on the Shanghai Stock Exchange.

Under the registration-based IPO system, the primary channel for information disclosure by listed companies during the IPO period is the prospectus. A prospectus is a document issued by a joint-stock company when offering shares, which discloses relevant matters related to the issuance and serves as an invitation to non-specific investors to purchase or sell shares. On the one hand, the prospectus is an important reference for underwriters in IPO pricing. If the IPO price is set too high and

the stock price subsequently returns to a reasonable level, it may lead to a situation where the stock price falls below the offering price. On the other hand, the prospectus is also a significant source of information for investors to understand the operating conditions of listed companies. If the readability of the prospectus is poor, investors may not be able to fully obtain the information disclosed by the listed company (Yu, 2022), leading to an increase in information asymmetry (Arnold et al., 2010), which ultimately affects the price in the secondary stock market and may result in IPO breaks.

Figure1 the IPO breaks on the first day of enterprises on the SSE



Source: iFinD database

When investors obtain information about a company through a prospectus, they may face the issue of information asymmetry (Hanley and Hoberg, 2012). Complex information disclosure can impair investors' judgment, exclude them from the stock market, reduce investor participation, and gradually widen the gap among stock market participants (Tan et al., 2015). The increased cost and difficulty of obtaining information exacerbate the degree of information asymmetry in the IPO market (Grossman and Stiglitz, 1980; Bloomfield, 2002; Asay et al., 2018). Enhancing the readability of prospectuses can help mitigate information asymmetry. Fazzari et al. (1988) argue that problems such as information asymmetry exist in the market, rendering capital markets imperfect. In the process of stock issuance, the readability of the prospectus affects the degree of information asymmetry, thereby influencing IPO pricing (Li et al., 2018). In China's stock market, retail investors constitute a large proportion. Consequently, an increase in information asymmetry raises their cost of information processing (Dyck et al., 2008), leading to a decrease in demand for the stock. This causes a decline in prices in the secondary market and increases the ratio of IPO breaks. Therefore, this paper examines the impact of prospectus readability on IPO breaks based on information asymmetry.

Since the implementation of the registration-based IPO system, the number of IPO breaks in China's stock market has gradually increased. However, existing literature on pricing issues in the stock market has primarily focused on underpricing (Liu et al., 2011; Dan Bernhardt et al., 2022; Laura et al., 2023), with limited studies on IPO breaks. Since the implementation of the registration-based IPO system in 2019, the number of IPO breaks has increased significantly in the STAR Market. Therefore, research on stock pricing cannot be limited solely to underpricing. The research in this paper can effectively fill the gap in this field.

Specifically, this paper adopts the method of text analysis, taking the prospectuses of A-share listed companies on the Shanghai Stock Exchange from 2014 to 2024 as the analysis object, and using the index method as a measure of readability to investigate the relationship between the readability of Chinese financial texts and the break of stocks. The higher the readability of the textual information in the prospectus, the lower the likelihood of IPO breaks. This conclusion remains valid after robustness testing. Furthermore, this paper also concludes that the relationship between the readability of a listed company's prospectus and IPO breaks is mediated through the behavior of underwriters. Companies with higher readability of prospectuses tend to have more accurate stock pricing after listing, which more truly reflects their intrinsic value. This is

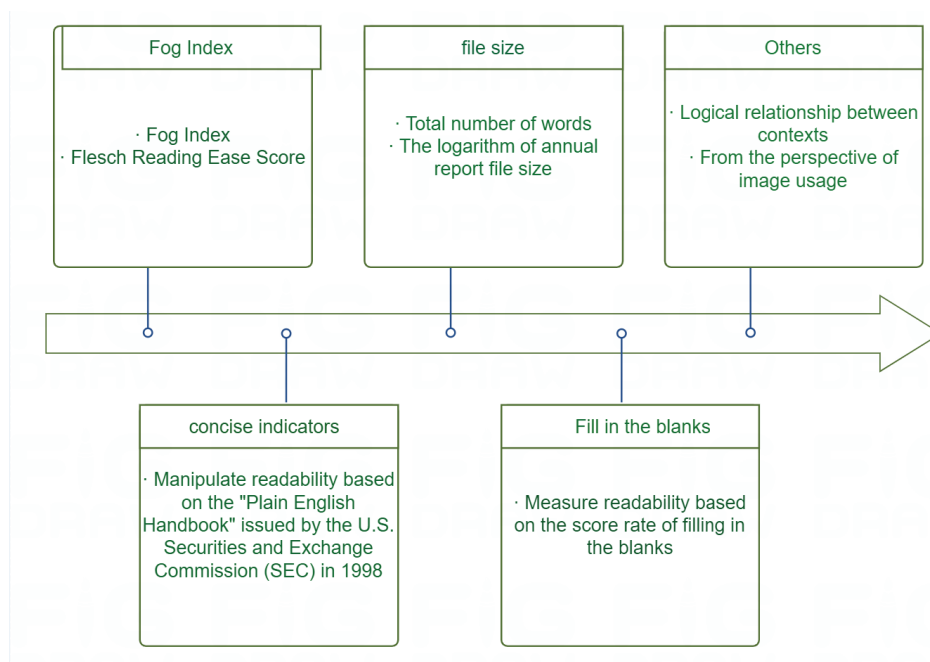
also conducive to the full play of the role of direct financing in the capital market, improving the efficiency of capital use, and leading to better performance of listed companies and less break ratio of stocks.

The main contributions of this paper are embodied in the following aspects: Firstly, our model delineates the transmission process through which the readability of prospectuses affects IPO breaks, and constructs readability indicators using both textual and metric methods, applying text mining techniques to the construction of these indicators. Secondly, for the first time, we identify the readability of prospectuses as a major factor leading to IPO breaks in the stock market, analyzing the impact of different actors on stock prices from the perspective of information asymmetry. Finally, we conduct regression analysis using the Logistic model, which serves as a valuable supplement to research on China's stock market, which is still in the stage of emerging capital markets.

2.Literature review and hypothesis

So far, a set of more established financial readability measures has been introduced, such as the Fog Index, Flesch Kincaid Indices, and Flesch Reading Ease, among others (Li, 2008; Biddle et al, 2009; Leavy et al, 2011). Li (2008) was the first to apply the Misty Index to measure the readability of listed companies' annual reports. Dale and Chall (1949) defined readability from the perspective of communication effectiveness. They proposed that readability refers to the sum of all interacting factors in a given text that affect whether readers can read, understand, and be interested in it at an optimal speed. Klare et al. (1955), on the other hand, defined text readability as the ease or difficulty of reading a text due to its writing style. Baker and Kare (1992) used the complexity and length of the text to measure the readability of annual reports, and found that annual reports are very difficult for most investors to understand, requiring people with a college education or above to comprehend their content. Loughran and McDonald (2014) argued that in the composition of the Fog Index, the average sentence length is difficult to measure, and the definition of complex vocabulary does not conform to the characteristics of financial texts, so this index cannot effectively measure the readability of financial texts. Lingli Yu (2020) finally introduced a model tailored specifically for Chinese readability, potentially enhancing the comprehension of information disclosure in the Chinese market. Haiyu Yan (2024) utilizes AR indicator to explain the readability of MD&A. Figure 2 introduces the methods for measuring text readability up to now.

Figure2 the methods for measuring text readability up to now



The above discussion primarily focuses on the measurement of annual report readability. Many scholars have also explored the impact of annual report readability, with Management's Discussion and Analysis (MD&A) and financial statement notes being widely used in readability studies. Li (2008) investigated the relationship between the readability of MD&A and corporate earnings. Rjiba (2021) believes that when the disclosure tone is more negative or ambiguous, the impact of annual

report complexity on equity costs is greater. Minkwan Ahn (2023) has found that sustainability reports with higher readability tend to provide more company-specific information in the financial market.

It can be observed that the readability of information disclosure content can be influenced by the management of listed companies. If the management obscures information disclosure content to cover up poor business performance (Lo et al, 2017), then the readability of the company's information disclosure content will decrease (Merkle Davies et al., 2011), increasing the degree of information asymmetry between listed companies and investors (Rameezdeen and Rajapakse, 2007). The relationship between the readability of annual reports and the profitability of listed companies has become a research direction for many scholars (Courtis, 1998), aiming to analyze whether there is any potential for manipulation by management. Subramanian et al. (1993) examined that firms with superior operating results tend to have more readable annual reports. A study conducted by Bushee et al. (2018) concluded that when firms are performing well, managers tend to be more proactive in disclosing information. Bai et al. (2019) concluded that in English-speaking countries, listed companies with less readable annual reports experience delayed stock price movements, leading to a higher risk of future stock price crashes. Hasan (2020) argued that the readability of disclosures in financial reports is significantly and positively correlated with the managerial competence of executives of listed firms.

The phenomenon of IPO breaks was first discovered by Stigler (1964) when studying industrial enterprises. Subsequently, scholars researching stock market performance successively uncovered this abnormal phenomenon and attributed it to a relatively high degree of uncertainty. Benveniste (1989), referencing the US book-building pricing mechanism, proposed an optimal pricing mechanism selection model, and argued that the main reason for IPO breaks is the information asymmetry between securities underwriters and investors.

Therefore, the rationale for IPO breaks lies in the information asymmetry existing in the market, and the readability of the prospectus significantly influences this information asymmetry. Here, we propose the first hypothesis:

H1: The higher the readability of the prospectus of a listed company, the lower the occurrence rate of IPO breaks on the first day.

As China's capital market gradually becomes more market-oriented, the number of IPO breaks has increased. Currently, research on "IPO breaks" phenomenon is still not thorough enough, and this study aims to fill that gap. Based on early research on IPO breaks, Stoll and Curley (1970) examined the price trends of 205 U.S. stocks and found that they exhibited a long-term downward trend. Sung Gyun Mun and Jang Soo Cheong (2019) concluded that restaurant businesses with lower profitability would bear greater financial burdens, ultimately leading to IPO breaks until they were delisted.

The phenomenon of IPO breaks is due to investors being overly optimistic about the stock's valuation and unreasonable pricing at the time of issuance, resulting from an excessively high pricing of the stock (Derrien and Kent, 2003). Khurshed (2009) found that issuers of stocks tend to increase the offering price in order to raise more funds, and as a result, they may release related false information, which leads to IPO breaks in the later stages. Kevin K. (2016) conducted a study on IPOs and found that the conducts of underwriters significantly influenced pricing decisions. Therefore, it can be concluded that overpricing by underwriters is one of the main factors contributing to the phenomenon of IPO breaks for listed companies. The prospectus is the primary channel for underwriters to obtain information about a company's operations. When the degree of information asymmetry between the company and the market increases, the pricing set by the underwriter may deviate from the true value of the stock. Motivated by the desire to earn higher underwriting fees, underwriters have an incentive to increase the IPO price (Cook et al., 2006), ultimately resulting in an overpriced IPO and a break of the issue price.

Therefore, it can be concluded that overpricing by underwriters is one of the important factors contributing to the phenomenon of IPO breaks for listed companies. Based on this, we propose the second hypothesis:

H2a: The readability of the prospectus can influence the incidence rate of IPO breaks by affecting the behavior of underwriters in the primary market.

When investors decide whether to purchase a stock, they first refer to the prospectus of the stock. If the prospectus is highly readable, investors can more easily obtain relevant information about the company, thereby making a judgment on whether the stock is worth investing in (Boulton et al., 2011, Hong et al., 2014). Conversely, if the prospectus is less readable,

investors may have limited access to officially disclosed information (Yu, 2022) or limited access to information about the listed company through other channels (Tetlock, 2007). This may lead investors to be cautious in purchasing the stock (Daniel, Hirshleifer, & Subrahmanyam, 1998; Hirshleifer, 2001), reducing the demand for it (Zhang, 2006a; Zhang, 2006b), and ultimately causing the stock price to fall.

Therefore, the sentiment of secondary market investors is also one of the important factors influencing the underpricing of listed companies' stocks. Based on this, we propose the third hypothesis:

H2b: The readability of the prospectus will influence the incidence rate of IPO breaks by affecting the sentiment of secondary market investors.

3. Data and methodology

3.1 Sample acquisition and screening

This paper selects relevant data and prospectuses of all listed companies on the Main Board and STAR Market of the Shanghai Stock Exchange from 2014 to 2024 as the research objects. The financial data of listed companies and IPO market data used in the research are sourced from the CSMAR database and iFinD database. The prospectuses used in this paper were batch-downloaded from the designated sections of the Main Board and STAR Market of the Shanghai Stock Exchange using a Python web crawler program. The initial sample comprises 1,358 listed companies.

The initial sample underwent the following processing: all ST and *ST listed companies were excluded; due to the specificity of financial listed companies, they were also excluded; additionally, 80 companies with prospectuses that could not be correctly parsed due to encryption or coding issues were removed, resulting in a final set of 1,232 observations. This paper utilizes Python to conduct statistics on these prospectuses, including information such as word count, average sentence length, whether they contain a directory, and total number of pages.

3.2 Definition of variables

3.2.1 Dependent variable

In empirical analysis, Y can be defined as a binary variable indicating whether a stock has experienced IPO break, with $Y=1$ representing that the stock has suffered from an IPO break and $Y=0$ indicating that the stock has not experienced an IPO break, as shown in Equation (1).

$$Y = \text{Logit}(BD) = \ln\left(\frac{BD}{1-BD}\right) \quad (1)$$

The explained variable, denoted as BD , is calculated based on the logit model and represents the odds of a newly listed stock experiencing an IPO break, as shown in Equation (2).

$$BD = \frac{\exp(\bar{y})}{1 + \exp(\bar{y})} \quad (2)$$

3.2.2 Independent variables

The formula-based readability metrics consist of two calculations. The first is based on the readability measurement model proposed by Senter and Smith (1967). This metric employs two of the most fundamental and crucial indicators for measurement. Here, the AR metric is inversely correlated with readability; a higher value indicates that the text is more difficult to understand and less readable. Therefore, for consistency in the interpretation of the specification, the negative value of this indicator is used to represent the readability of the text. The construction of this indicator is shown in (3).

$$AR = -[4.17 * (\text{Vocabulary length} / \text{Word count}) + 0.39 * (\text{Word count} / \text{Sentence Count}) - 21.43] \quad (3)$$

Secondly, we utilize the Flesch-Kincaid (FK) formula to assess the readability of a text based on the reading ability required by the intended audience. This indicator measures the ease of reading, where a higher score indicates lower requirements for reading ability. To ensure consistency in interpretation, we multiply the FK score by (-1) , so that a higher absolute value corresponds to lower readability. The construction of this modified indicator is illustrated in (4).

$$FK = -[0.39 * (\text{Word count} / \text{Sentence Count}) + 11.8 * (\text{Vocabulary length} / \text{Word count}) - 15.9] \quad (4)$$

3.2.3 Control variables

The control variables selected for this study comprise the logarithmic value of total sponsorship fees(BJ), the logarithmic value of assets raised(RM), the industry price-earnings ratio on the listing date(PE), the logarithmic value of pre-listing company's total assets(TA), return on assets(ROA), the pre-listing company's gearing ratio(AD), the turnover rate on the first day of listing(TR), a dummy variable indicating whether the company is state-owned(XZ), and another dummy variable indicating whether the company is ranked in the top ten of equity underwriters(SY). Additionally, control for the year (Year) and industry (Industry) effects.

Table 1 Variable definition table.

Variable type	Variable name	Variable symbol	Variable definition
Dependent variables	the ratio of IPO breaks occurrences	BD	$BD = \exp(\bar{y}) / (1 + \exp(\bar{y}))$
Independent variables	Readability measures1	AR	$-\ln[4.17 * (\text{Vocabulary length} / \text{Word count}) + 0.39 * (\text{Word count} / \text{Sentence Count}) - 21.43]$
	Readability measures2	FK	$-\ln[0.39 * (\text{Word count} / \text{Sentence Count}) + 11.8 * (\text{Vocabulary length} / \text{Word count}) - 15.9]$
	total sponsorship fees	BJ	he logarithmic value of total sponsorship fees
Control variable	Total assets raised	RM	the logarithmic value of assets raised
	Price Earnings Ratio	PE	he industry price-earnings ratio on the listing date
	pre-listing company's total assets	TA	the logarithmic value of pre-listing company's total assets
	return on assets	ROA	Return on assets before the company went public
	Pre-listing gearing ratio	AD	the pre-listing company's gearing ratio
	the turnover rate	TR	the turnover rate on the first day of listing
	Nature of business	XZ	Whether it is a state-owned enterprise, 1 for yes, 0 for no
	Underwriter reputation	SY	Whether the equity underwriters are ranked in the top ten, yes 1, no 0
	Year	Year	Annual fixed effects
	industry	Industry	industry fixed effect

3.2.4 Model construction

This study employs the Logistic model for regression analysis. Given that the sample consists of only one observation per IPO company, namely the prospectus, it is not feasible to control for individual fixed effects. Instead, the study controls for industry and year effects. The baseline regression model is shown in Equation (5).

$$\text{Logit}(BD) = \ln\left(\frac{BD}{1-BD}\right) = \beta_0 + \beta_1 x_1 + \cdots + \beta_i x_i + \varepsilon_{i,t} + \text{Year} + \text{Industry} \quad (5)$$

In this model, BD represents the incidence of IPO breaks, β_0 is the coefficient of the constant term in the regression, x_i denotes the factors influencing IPO breaks, and β_i represents the regression coefficient for the i th variable. Based on the Logistic regression model, the regression models constructed with the incidence of IPO breaks as the dependent variable are presented in Equations (6) and (7).

$$BD = \beta_0 + \beta_1 AR + \beta_2 BJ + \beta_3 RM + \beta_4 PE + \beta_5 TA + \beta_6 ROA + \beta_7 AD + \beta_8 TR + \beta_9 XZ + \beta_{10} SY + \text{Year} + \text{Industry} + \varepsilon_{i,t} \quad (6)$$

$$BD = \beta_0 + \beta_1 FK + \beta_2 BJ + \beta_3 RM + \beta_4 PE + \beta_5 TA + \beta_6 ROA + \beta_7 AD + \beta_8 TR + \beta_9 XZ + \beta_{10} SY + Year + Industry + \varepsilon_{i,t} \quad (7)$$

4. Results

4.1 Empirical analysis

4.1.1 Descriptive statistics

This paper utilizes web crawling technology to obtain the prospectuses of listed companies on the Shanghai Stock Exchange. After excluding all ST, *ST, and financial companies, it employs Python software to calculate the total number of pages, total number of words, total number of tables, total number of images, and total number of sentences in these prospectuses, as shown in Table 2.

Table 2 Data Overview of Prospectuses

	Max	Min	Mean
Pages	2800	300	497.41
Words	713442	319	264389.83
Tables	653	142	247.70
Images	15081	0	263.61
Sentences	7587	35	2807.53

Table 3 presents the descriptive statistics of the data. The standard deviation of the AR, FK, and BD indicators for the broken group are 0.331, 0.248, and 0.136 respectively, while for the unbroken group, they are 0.340, 0.259, and 0.212, suggesting that the relatively large volatility in the readability of prospectuses from listed companies that have experienced IPO breaks explains why the mean value for the broken group is relatively low.

Table 3 Summary statistics.

	(1)	(2)		(3)		(4)		(5)	
variables	Obs	Mean		Std.		Min		Max	
Group	N	broken group	unbroken group	broken group	unbroken group	broken group	unbroken group	broken group	unbroken group
BD	1,222	0.923	0.822	0.136	0.212	0.172	0.121	1.000	1.000
AR	1,231	-3.787	-3.759	0.331	0.340	-4.451	-4.681	-2.349	-2.917
FK	1,231	-5.113	-5.092	0.248	0.259	-5.650	-5.806	-4.159	-4.480
BJ	1,231	0.318	0.791	1.297	1.949	0	0	6.215	6.397
RM	1,231	11.99	11.20	0.637	0.783	10.81	9.749	14.61	13.82
PE	320	32.55	30.66	16.06	15.01	1	3.130	75.12	71.72
TA	1,223	20.01	20.59	1.325	1.165	17.28	18.38	24.19	24.52
ROA	1,223	-0.0444	0.0860	0.327	0.0934	-1.738	-0.303	0.514	0.361
AD	1,224	54.45	36.09	38.69	25.72	0	0	211.6	98.70
TR	1,232	0.0801	0.0640	0.0430	0.0732	5.00e-05	3.00e-05	0.148	0.184
XZ	1,232	0.0698	0.119	0.256	0.324	0	0	1	1
SY	1,232	0.698	0.527	0.462	0.499	0	0	1	1

4.1.2 Correlation analysis

Given the large number of variables in this paper, there may exist strong correlations among them, which can lead to the issue of multicollinearity. To prevent this issue, a correlation analysis is conducted prior to regression. First, the correlation coefficients between variables are calculated using Stata software. As shown in Table 4, the correlation coefficients between the control variables are all below 0.4, indicating that the correlations among the control variables are weak, and there is no issue of multicollinearity.

Table 4 Correlation analysis.

Variables	BD	AR	FK	BJ	RM	PE	TA	ROA	AD	TR	XZ	SY
BD	1											
AR	-0.67***	1										
FK	-0.67***	0.98***	1									
BJ	-0.007	-0.013	-0.02	1								
RM	0.08	0.16***	0.16***	-0.09*	1							
PE	0.106	-0.07	-0.06	0.08	0.02	1						
TA	-0.34***	0.18***	0.18***	-0.01	0.37***	-0.17	1					
ROA	0.01	-0.07	-0.08	0.01	-0.19***	-0.08	0.001	1				
AD	-0.05	0.07	0.08	-0.03	0.22***	-0.04	0.20***	-0.29***	1			
TR	-0.09	-0.02	-0.01	-0.02	0.19***	0.06	-0.38***	-0.12***	0.11***	1		
XZ	-0.25***	0.08	0.08	0.004	0.17***	-0.06	0.39**	-0.04	0.08	-0.04	1	
SY	-0.15***	0.03	0.03	-0.01	0.23***	0.05	0.10**	-0.097*	0.12***	0.08	0.04	1

4.1.3 regression

Based on the regression results presented in Table 5, the overall R-squared values for the two models are 0.821 and 0.813, respectively, indicating that these models have good fit effects. Furthermore, the P-values for both models are 0.000, suggesting that they are statistically significant overall, and the regression results are reliable. When the readability indicator for companies is AR, the AR indicator passes the test at the 1% significance level, and the regression coefficient is negative, which aligns with the expected hypothesis. The higher the readability of a listed company's prospectus, the lower the proportion of IPO breaks.

It should be noted that the readability indicator is designed such that a lower score indicates higher readability. For the convenience of our research, the original indicator was multiplied by (-1). Therefore, when the text readability is higher, the score of the readability indicator is also higher. This conclusion is consistent with the expected hypothesis H1, which states that the higher the readability of a listed company's prospectus, the lower the incidence of IPO breaks.

Table 5 Regression results

VARIABLES	(1)	(2)
	BD	BD
AR	-0.421*** (-22.65)	
FK		-0.541*** (-21.94)
BJ	-0.002	-0.002

VARIABLES	(1) BD	(2) BD
	(-0.52)	(-0.52)
RM	0.115***	0.115***
	(14.71)	(14.40)
PE	-0.000	-0.000
	(-0.49)	(-0.44)
TA	-0.070***	-0.071***
	(-13.40)	(-13.21)
ROA	-0.011	-0.009
	(-0.47)	(-0.40)
AD	0.000	0.000
	(0.89)	(0.88)
TR	-1.237***	-1.245***
	(-11.84)	(-11.67)
XZ	-0.054***	-0.053***
	(-3.59)	(-3.47)
SY	-0.049***	-0.050***
	(-4.53)	(-4.44)
Constant	-0.559***	-1.731***
	(-3.26)	(-8.36)
Observations	320	320
R-squared	0.821	0.813
Industry FE	YES	YES
Year FE	YES	YES

Note(s): t-statistics are in parentheses. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

Source(s): Authors' work

4.2 Mediation effect analysis

4.2.1 conduct of underwriters

The behavior of underwriters can be represented by taking the logarithm of the total underwriting fee (CX) (Lewellen, 2010). IPO pricing behavior can be viewed as a form of information transmission, where underwriters' judgments on IPO prices reflect their assessments of the companies. The prospectus of a company serves as the primary basis for underwriters to assess the operating conditions of a company that is soon to be listed. Therefore, the readability of the prospectus will affect the degree to which underwriters can obtain information, further influencing the IPO price.

If the readability of a company's prospectus is low, underwriters will have limited access to relevant information about the company, leading to deviations in IPO pricing from its accurate value. In such cases, underwriters may intentionally raise the offering price for their own benefit. Once the stock is traded in the secondary market and its price returns to a rational level, an IPO break will occur. Therefore, we consider the behavior of underwriters as a transmission mechanism through which the readability of the prospectus affects IPO breaks. Improving the readability of the prospectus can reduce the degree of information asymmetry, enabling underwriters to price IPOs more accurately and thus lowering the incidence of IPO breaks.

The mechanism test employs a two-step approach, with the model setup as shown in Equations (8) and (9).

$$CX = e_1 + cAR(FK) + \beta_1 Controls + Industry + Year + \varepsilon_{it} \quad (8)$$

$$BD = e_2 + aCX + \alpha Controls + Industry + Year + \varepsilon_{it} \quad (9)$$

4.2.2 investor sentiment

Investor sentiment can be represented by the turnover rate (TR). On the one hand, if the readability of a listed company's prospectus is low, investors have limited access to specific company information, which can lead to decreased investment in that stock. On the other hand, if online media obtain limited information from the prospectus (Guldiken et al, 2017) or even convey inaccurate information to investors (Arnold et al, 2010), this can also result in reduced demand for the stock (Wang and Wu, 2015), causing a price decline in the secondary market. Therefore, investor sentiment in the secondary market can serve as a transmission mechanism for the impact of prospectus readability on IPO breaks. Enhancing the readability of the prospectus reduces the degree of information asymmetry in the market, allowing secondary investors to access more information about the relevant company and increasing their demand for the listed company's stock, as illustrated in Equations (10) and (11).

$$TR = e_1 + cAR(FK) + \beta_1 Controls + Industry + Year + \varepsilon_{it} \quad (10)$$

$$BD = e_2 + aTR + \alpha Controls + Industry + Year + \varepsilon_{it} \quad (11)$$

We can represent this transmission mechanism in Figure 3.

Figure 3 transmission mechanism

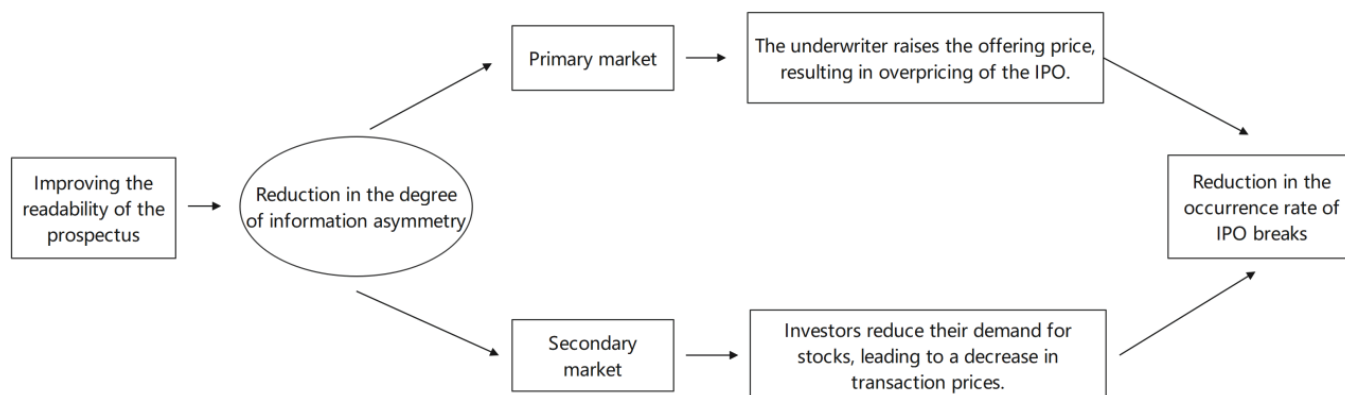


Table 6 Mediation effect results

VARIABLES	(1) CX	(2) CX	(3) BD	(4) TR	(5) TR	(6) BD
AR	-0.061** (-2.33)			-0.015*** (-3.22)		
FK		-0.078** (-2.27)			-0.019*** (-3.22)	
CX			0.053*** (2.72)			
TR						-0.358*** (-3.18)
ROA	-0.049 (-0.65)	-0.050 (-0.66)	0.077 (1.51)	-0.014 (-1.04)	-0.014 (-1.05)	0.070 (1.38)
AD	-0.000 (-0.52)	-0.000 (-0.53)	-0.000 (-1.53)	-0.000 (-0.98)	-0.000 (-0.99)	-0.000* (-1.69)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	CX	CX	BD	TR	TR	BD
RM	0.577*** (45.68)	0.577*** (45.66)	0.011 (0.78)	-0.002 (-0.92)	-0.002 (-0.91)	0.040*** (4.78)
SY	0.028 (1.57)	0.028 (1.57)	-0.071*** (-5.88)	0.000 (0.02)	0.000 (0.02)	-0.069*** (-5.76)
Constant	1.509*** (7.42)	1.344*** (5.29)	0.135 (1.13)	-0.045 (-1.27)	-0.087** (-1.99)	0.235** (2.06)
Observations	1,222	1,222	1,221	1,222	1,222	1,221
R-squared	0.763	0.762	0.101	0.498	0.498	0.103
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

Note(s): t-statistics are in parentheses. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

Source(s): Authors' work

As stated in columns (1), (2), and (3) of Table 6, underwriter behavior can induce a negative correlation between the readability of the prospectus and IPO breaks. However, as derived from columns (4), (5), and (6), investor sentiment does not support this negative correlation. Therefore, with Hypothesis H2a confirmed, we can draw the following conclusion from the regression results: Through a two-step analysis, we can infer that an increase in the readability of the prospectus reduces the behavior of underwriters deliberately raising the issue price to obtain higher underwriting fees. This alleviates the degree of information asymmetry in the market, leading to more reasonable IPO issue prices and thus reducing the incidence of IPO breaks.

4.2.3 Bootstrap Test

Based on the results presented in Table 7, we can observe that the confidence intervals are all negative, with no numbers falling between positive and negative, or zero within these intervals. Therefore, we can conclude that there is a mediation effect: the readability of listing companies' prospectuses influences the occurrence of IPO breaks through the mechanism of underwriters' behavior.

Table 7 Bootstrap Test

	coefficient	std. err.	z	P> z	[95% conf. interval]	
_bs_1	0.0140258	0.0038252	3.67	0.000	0.0065287	0.021523
_bs_2	-0.4519545	0.0137623	-32.84	0.000	-0.478928	-0.424981
_bs_3	-0.4379287	0.0140974	-31.06	0.000	-0.465559	-0.4102983

4.3 Robustness analysis

Robustness test can be divided into four parts.

4.3.1 Only the last four years of sample data were retained

The STAR Market has experienced a large quantities breaks in IPOs since 2021 and has become the most affected area of A-share IPOs, shattering the perception that IPOs are always profitable. We can also clearly observe from Figure 1 that the occurrence rate of IPO breaks in the past four years is significantly higher than that in previous years. Therefore, only data from after 2021 is retained for the regression analysis, and the results are presented in Table 9 column(1) and column(2). As a result, we can draw a similar conclusion to our previous analysis. Specifically, the readability measures AR and FK coefficients have increased, indicating that in the last four years, the readability of financial statements has had a more pronounced impact on the incidence rate of IPO breaks for listed companies.

4.3.2 Add other control variables

We have incorporated the logarithm of total underwriting fees(LnCX) and net cash flow per share(LL) into the model to account for the influence of prospectus readability on the probability of breaks for listed companies. Based on the regression results, we can conclude that the model fits well, and after controlling for industry and time fixed effects, the readability of listed companies' prospectuses exhibits a negative correlation with the incidence of IPO breaks among listed companies. The results are presented in column(3) and column(4).

4.3.3 Substitution of explanatory variables

Readability can also be measured using a text-based method, which involves counting six standardized indicators: the presence or absence of a table of contents, the page number (standardized), the total number of words (standardized), the average sentence length (standardized and isotropic), the number of sentences (standardized and multiplied by 10), and the number of words (standardized). All text analysis is conducted within a Python environment, and the specific steps include: The first step is the preprocessing of prospectuses, converting all PDF files into TXT format. The second step involves obtaining data such as the total number of words and sentences in each prospectus, and calculating the average sentence length. The third step is to construct readability indicators by summing the standardized data results to calculate the final readability indicator value. The results are shown in Table 8.

Table 8 Textual Readability Metrics

Transaction Code	contents	page number	number of words	number of sentences	average sentence length	readability
600025	1	0.1972	0.4050	0.1277	0.9997	2.7296
600032	1	0.2244	0.6520	0.1392	0.9996	3.0152
.....
689009	1	0.038	0.6154	0.1245	0.9997	2.7776

According to column(5), we can conclude that, at the 10% significance level, a higher readability of a listed company's prospectus is associated with a lower incidence of break of the company's stock.

4.3.4 PSM test

The PSM test results are shown in column(6) and column(7), in order to avoid the possibility of endogenous disturbances in the model, the readability metrics AR as well as the median FK are used as benchmarks in this study. The data table greater than the median is labeled as 1 otherwise 0, which is indicated by the readability AR1 and FK1. Meanwhile, 1:1 nearest-neighbor matching is performed without replacement, and the samples with successful matches are returned again, and we can still conclude that after controlling for the fixed effects of industry and time, the readability of listed firms' prospectuses is responsibly correlated with the incidence of IPO breaks.

Table 9 Robustness analysis

VARIABLES	(1) BD	(2) BD	(3) BD	(4) BD	(5) BD	(6) BD	(7) BD
readability					-0.114* (-1.89)		
AR	-0.425*** (-22.67)		-0.423*** (-22.43)				
AR1						-0.176*** (-13.02)	
FK		-0.547***		-0.544***			

VARIABLES	(1) BD	(2) BD	(3) BD	(4) BD	(5) BD	(6) BD	(7) BD
		(-21.93)		(-21.72)			
FK1							-0.179*** (-13.57)
BJ	-0.001 (-0.39)	-0.001 (-0.40)	-0.002 (-0.53)	-0.002 (-0.53)	-0.007 (-1.28)	-0.001 (-0.22)	-0.003 (-0.64)
RM	0.118*** (14.68)	0.117*** (14.34)	0.107*** (7.51)	0.106*** (7.31)	0.114*** (8.34)	0.107*** (10.74)	0.115*** (10.79)
PE	-0.000 (-0.34)	-0.000 (-0.30)	-0.000 (-0.40)	-0.000 (-0.36)	0.000 (0.61)	0.000 (0.63)	0.000 (0.04)
TA	-0.071*** (-13.28)	-0.071*** (-13.08)	-0.070*** (-12.54)	-0.070*** (-12.34)	-0.084*** (-8.68)	-0.076*** (-11.23)	-0.082*** (-11.49)
ROA	-0.011 (-0.47)	-0.009 (-0.40)	-0.013 (-0.57)	-0.012 (-0.50)	0.049 (0.92)	-0.011 (-0.32)	-0.010 (-0.32)
AD	0.000 (0.71)	0.000 (0.70)	0.000 (0.90)	0.000 (0.88)	0.000 (0.70)	0.000 (1.24)	0.000 (0.51)
TR	-1.245*** (-11.77)	-1.254*** (-11.60)	-1.243*** (-11.87)	-1.251*** (-11.70)	-1.226*** (-6.89)	-1.215*** (-9.02)	-1.258*** (-9.04)
XZ	-0.056*** (-3.67)	-0.055*** (-3.54)	-0.051*** (-3.37)	-0.050*** (-3.24)	-0.042* (-1.66)	-0.052*** (-2.89)	-0.030 (-1.61)
SY	-0.051*** (-4.60)	-0.051*** (-4.50)	-0.049*** (-4.43)	-0.049*** (-4.34)	-0.058*** (-3.16)	-0.044*** (-3.04)	-0.045*** (-3.14)
LnCX			0.012 (0.71)	0.013 (0.74)			
LL			0.004 (0.90)	0.004 (0.89)			
Constant	-0.688*** (-4.36)	-1.870*** (-9.50)	-0.594*** (-3.38)	-1.773*** (-8.40)	1.542*** (5.46)	1.100*** (6.61)	1.131*** (6.65)
Observations	317	317	320	320	320	340	342
R-squared	0.822	0.814	0.822	0.814	0.504	0.676	0.679
Industry FE	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES

Note(s): t-statistics are in parentheses. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively.

Source(s): Authors' work

5. Conclusion

This empirical study examines the relationship between the readability of listing prospectuses and the occurrence of IPO breaks among listed companies. Through Logistic model analysis, it is found that there is a negative correlation between the

readability of listing prospectuses and the incidence rate of IPO breaks. Taking the listing prospectuses of companies listed from 2014 to 2024 as the analysis sample, we employed text mining methods to construct readability indicators and verified the hypothesis through empirical analysis. The theoretical and practical significance of this paper are as follows:

Firstly, the model and empirical results of this paper indicate that the readability of prospectuses affects the incidence rate of IPO breaks in the stock market. When underwriters set IPO prices, they refer to the listing prospectus. An increase in readability can reduce the deviation of IPO prices from their intrinsic value, thereby decreasing the occurrence of IPO breaks and contributing to the stability of the stock market. Therefore, the higher the readability of the listing prospectus, the lower the incidence rate of IPO breaks. This conclusion demonstrates that high readability plays a crucial role in reducing the factors that contribute to instability in the stock market. This paper not only provides a reference for research on IPO breaks among listed companies in emerging capital markets but also offers new insights for promoting the stable development of the stock market.

Secondly, this study utilizes Python for text mining to construct readability indicators based on textual methods, enriching the research on the measurability of readability in financial information disclosure in Chinese text. Previous studies mostly used the Fog Index to measure readability, which is suitable for English text. However, this study provides a more accurate and reasonable measurement of readability, offering a reference for readability research in Chinese text.

Lastly, for government departments, it is crucial to further standardize the information disclosure content in listing prospectuses of listed companies (Coffee, 1984). Improving the readability of listing prospectuses holds dual significance. On one hand, it assists underwriters in accurately pricing IPOs for listed companies (Carter et al., 1998); on the other hand, it reduces information asymmetry between companies and investors, enhancing the transparency of the capital market. Furthermore, for investors, the reduced cost of obtaining information from the stock market attracts more participants. Enhanced market liquidity facilitates accurate pricing of listed companies' stock trading prices, reducing the occurrence of market anomalies, and ultimately promoting the stable development of the Chinese stock market.

The limitation of this paper is that it does not consider the impact of the pandemic on IPO breaks. Since the outbreak of the pandemic in 2019, the phenomenon of IPO breaks has gradually increased. Therefore, this factor should be taken into account in subsequent research. This paper focuses on the first-day breaks, while the impact of investor sentiment in the secondary market on stock trading prices is limited. Future research can extend the period of IPO breaks, which will allow for a deeper influence of investor sentiment on stock trading prices and facilitate further research.

Funding

no

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Yu, Z. (2022), "Financial report readability and accounting conservatism", *Journal of Risk and Financial Management*, Vol. 15 No. 10, p. 454, Doi: 10.3390/jrfm15100454.
- [2] Daniel, K., Hirshleifer, D., & Subrahmanyam, A. (1998), "Investor psychology and security market under- and overreactions", *Journal of Finance*, 53(6), 1839–1885.
- [3] Hirshleifer, D. (2001), "Investor psychology and asset pricing", *Journal of Finance*, 56(4), 1533–1597.
- [4] Zhang, X. F. (2006a), "Information uncertainty and stock returns", *Journal of Finance*, 61(1), 105–137.
- [5] Zhang, X. F. (2006b), "Information uncertainty and analyst forecast behavior", *Contemporary Accounting Research*, 23(2), 565–590.
- [6] Boulton, T. J.; S. B. Smart; and C. J. Zutter., (2011), "Earnings Quality and International IPO Underpricing", *Accounting Review*, 86, 485–505.
- [7] Hong, H. A.; M. Hung; and G. J. Lobo., (2014), "The Impact of Mandatory IFRS Adoption on IPOs in Global Capital Markets." *Accounting Review*, 89, 1365–1397.

- [8] Dale, E., and J. S. Chall., (1949), "The concept of readability", elementary English, Pages: 19-26.
- [9] Tinker, M. A., G. R. Klare, (1955), "Review of Know Your Reader", Journal of Educational Psychology, 46(5), 318–319.
- [10] Eugene Baker, H. and Kare, D.D., (1992), "Relationship Between Annual Report Readability and Corporate Financial Performance", Management Research News, Vol. 15 No. 1, pp. 1-4.
- [11] Stigler, G. J., (1964), "Public regulation of the securities markets", Bus. Law., 19, 721.
- [12] François Derrien, Kent L. Womack, (2003), "Auctions vs. Bookbuilding and the Control of Underpricing in Hot IPO Markets", The Review of Financial Studies, Volume 16, Issue 1, Pages 31–61.
- [13] Marc Goergen, Arif Khurshed, Luc Renneboog, (2009), "Why are the French so different from the Germans? Underpricing of IPOs on the Euro New Markets", International Review of Law and Economics, Volume 29, Issue 3, Pages 260-271.
- [14] Kevin K. Boeh, Craig Dunbar, (2016), "Underwriter deal pipeline and the pricing of IPOs", Journal of Financial Economics, Volume 120, Issue 2, Pages 383-399, ISSN 0304-405X.
- [15] Fazzari S, Hubbard R G, Petersen B. (1988), "Investment, financing decisions, and tax policy", The American economic review, 78(2): 200-205.
- [16] Li, R., Liu, W., Liu, Y. and Tsai, S.-B. (2018), "IPO underpricing after the (2008), financial crisis: a study of the Chinese stock markets", Sustainability, Vol. 10 No. 8, p. 2844.
- [17] Dyck, A., Volchkova, N. and Zingales, L. (2008), "The corporate governance role of the media: evidence from Russia", The Journal of Finance, Vol. 63 No. 3, pp. 1093-1135.
- [18] Dan Bernhardt, Kostas Koufopoulos, Giulio Trigilia,(2022), "Separating equilibria, underpricing and security design", Journal of Financial Economics, Volume 145, Issue 3, Pages 788-801, ISSN 0304-405X.
- [19] Xiaoding Liu, Jay R. Ritter, (2011), "Local underwriter oligopolies and IPO underpricing", Journal of Financial Economics, Volume 102, Issue 3, Pages 579-601, ISSN 0304-405X.
- [20] Laura Xiaolei Liu, Ruichang Lu, Ann E. Sherman, Yong Zhang, (2023), "IPO underpricing and limited attention: Theory and evidence", Journal of Banking & Finance, Volume 154, 106932, ISSN 0378-4266.
- [21] Arnold, T., Fishe, R. P., & North, D., (2010), "The effects of ambiguous information on initial and subsequent IPO returns", Financial Management, 39(4), 1497-1519.
- [22] Hanley, K. W., and G. Hoberg,(2012), "Litigation risk, strategic disclosure and the underpricing of initial public offerings", Journal of Financial Economics ,103:235–54.
- [23] Hun-Tong Tan, Elaine Ying Wang, Bo Zhou, (2015), "How Does Readability Influence Investors' Judgments? Consistency of Benchmark Performance Matters", The Accounting Review. 90 (1): 371–393.
- [24] Bloomfield R. J., (2008), "Discussion of annual report readability, current earnings, and earnings persistence", Journal of Accounting and Economics, 45):248 ~ 252.
- [25] Grossman S. J., Stiglitz J. E., (1980), "On the impossibility of informationally efficient markets", American Economic Review, 70): 393 ~ 408.
- [26] H. Scott Asay, Robert Libby, Kristina Rennekamp, (2018), "Firm performance, reporting goals, and language choices in narrative disclosures", Journal of Accounting and Economics, Volume 65, Issues 2–3, Pages 380-398.
- [27] Li F. (2008), "Annual report readability, current earnings, and earnings persistence", Journal of Accounting and Economics, 45 (2/3): 221-247.
- [28] Biddle,G. C., G. Hilary, and R. S. Verdi, (2009), "How Does Financial Reporting Quality Relate to Investment Efficiency?", Journal of Accounting and Economics, 48(2-3): 112-131.
- [29] Lehavy, R., F. Li, and K. Merkley, (2011), "The Effect of Annual Report Readability on Analyst Following and the Properties of Their Earnings Forecasts", Accounting Review , 86(3): 1087-1115.
- [30] LOUGHRAN, T. and MCDONALD, B. (2014), "Measuring Readability in Financial Disclosures", The Journal of Finance, 69: 1643-1671.
- [31] Haiyu Yan, (2024), "Environmental information disclosure, earnings quality and the Readability and Emotional

- Tendencies of Management Discussion and Analysis”, *Finance Research Letters*, Volume 60,104913,ISSN1544-6123.
- [32] Lingli Yu and Q. Cao and Yunhan Mou and Hongyu Du, (2020), “Chinese FOG Index: the Readability of Information Disclosure in Chinese Listed Companies”, *Proceedings of the 2020 5th International Conference on Mathematics and Artificial Intelligence*.
- [33] Hatem Rjiba, Samir Saadi, Sabri Boubaker, Xiaoya (Sara) Ding, (2021), “Annual report readability and the cost of equity capital”, *Journal of Corporate Finance*, Volume 67, 101902, ISSN 0929-1199.
- [34] Minkwan Ahn, Doowon Jung, Jeong-Taek Kim, Woo-Jong Lee, Hee-Yeon Sunwoo,(2023), “Do more readable sustainability reports provide more value-relevant information to shareholders?”, *Finance Research Letters*,Volume 57,1 04154, ISSN 1544-6123.
- [35] Lo, K., F. Ramos, and R.Rogo, (2017), “Earnings Management and Annual Report Readability”, *Journal of Accounting and Economics*, 63 (1): 1 - 25.
- [36] Merkl-Davies D M, Brennan N M, McLeay S J., (2011), “Impression management and retrospective sense-making in corporate narratives”, *Accounting, Auditing & Accountability Journal*, (2011), 24(3): 315-344.
- [37] Rameezdeen, R., and C. Rajapakse. 2007. “Contract Interpretation: The Impact of Readability”, *Construction Management and Economics*, 25(7) : 729-737.
- [38] Courtis, J.K., (1998), “Annual report readability variability: tests of the obfuscation hypothesis”, *Account. Audit. Account*, J. 11 (4), 459–472.
- [39] Subramanian, R., Insley, R. G., & Blackwell, R. D. (1993), “Performance and Readability: A Comparison of Annual Reports of Profitable and Unprofitable Corporations”, *The Journal of Business Communication*, 30(1), 49-61.
- [40] BUSHEE, B.J., GOW, I.D. and TAYLOR, D.J., (2018), “Linguistic Complexity in Firm Disclosures: Obfuscation or Information?”, *Journal of Accounting Research*, 56: 85-121.
- [41] Mostafa Monzur Hasan, (2020), “Readability of Narrative Disclosures in 10-K Reports: Does Managerial Ability Matter?”, *European Accounting Review*, 29:1, 147-168.
- [42] Minkwan Ahn, Doowon Jung, Jeong-Taek Kim, Woo-Jong Lee, Hee-Yeon Sunwoo,(2023), “Do more readable sustainability reports provide more value-relevant information to shareholders?”, *Finance Research Letters*, Volume 57, 104154, ISSN 1544-6123.
- [43] Xuelian Bai, Yi Dong & Nan Hu, (2019), “Financial report readability and stock return synchronicity”, *Applied Economics*, 51:4, 346-363.
- [44] Mun G S, Jang S., (2019), “Restaurant firms’ IPO motivations and post-IPO performances”, *International Journal of Contemporary Hospitality Management*, 31(9): 3484-3502.
- [45] Stoll HR, Curley AJ., (1970), “Small Business and the New Issues Market for Equities”, *Journal of Financial and Quantitative Analysis*, 5(3):309-322.
- [46] François Derrien, Kent L. Womack, (2003), “Auctions vs. Bookbuilding and the Control of Underpricing in Hot IPO Markets”, *The Review of Financial Studies*, Volume 16, Issue 1, Pages 31–61.
- [47] Lawrence M. Benveniste, Paul A. Spindt, (1989), “How investment bankers determine the offer price and allocation of new issues”, *Journal of Financial Economics*, Volume 24, Issue 2, Pages 343-361.
- [48] Marc Goergen, Arif Khurshed, Luc Renneboog, (2009), “Why are the French so different from the Germans? Underpricing of IPOs on the Euro New Markets”, *International Review of Law and Economics*, Volume 29, Issue 3, Pages 260-271.
- [49] Lewellen, J., Nagel, S., & Shanken, J.,(2010), “A skeptical appraisal of asset pricing tests”, *Journal of Financial economics*, 96(2), 175-194.
- [50] Guldiken, O., Tupper, C., Nair, A. and Yu, H. (2017), “The impact of media coverage on IPO stock performance”, *Journal of Business Research*, Vol. 72, pp. 24-32.
- [51] Arnold, T., Fishe, R.P.H. and North, D. (2010), “The effects of ambiguous information on initial and subsequent IPO returns”, *Financial Management*, Vol. 39 No. 4, pp. 1497-1519.

- [52] Wang, C.Y. and Wu, J.W. (2015), "Media tone, investor sentiment and IPO pricing", *Journal of Financial Research*, Vol. 9, pp. 174-189.
- [53] Cook, D.O., Kieschnick, R. and Ness, R.A.V. (2006), "On the marketing of IPOs", *Journal of Financial Economics*, Vol. 82 No. 1, pp. 35-61.
- [54] Tetlock, P.C. (2007), "Giving content to investor sentiment: the role of media in the stock market", *The Journal of Finance*, Vol. 62 No. 3, pp. 1139-1168.
- [55] Senter, R. J., & Smith, E. A. ,(1967), "Automated readability index (pp. 1-14)", Technical report, DTIC document.
- [56] Coffee, J. C., Jr. (1984), "Market failure and the economic case for a mandatory disclosure system", *Virginia Law Review*, 70:717-53.
- [57] Carter R B, Dark F H, Singh A K., (1998), "Underwriter reputation, initial returns, and the long-run performance of IPO stocks", *Journal of Finance*, 53(1): 285-311.

Research on Marketing Strategy of Tea Wine Products of DJ Wine Industry

Wei Wang*

Jiangxi University of Software and Professional Technology, Nanchang, Jiangxi, 330000, China

*Corresponding author: Wei Wang

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In recent years, the liquor market has developed rapidly, consumers' demand for Baijiu (Chinese liquor) has upgraded, and market competition has become increasingly fierce. Wine-making enterprises, especially small and medium-sized ones, are facing severe challenges and urgently need scientific development strategies. This paper takes the tea wine products of DJ Wine Industry Co., Ltd. as the research object. Through on-the-spot investigation, it deeply analyzes its development overview and marketing status, studies the opportunities and threats in the external environment, as well as the advantages and disadvantages of the enterprise itself, and finds problems such as vague positioning, inappropriate pricing, poor channels, and single promotion methods. The study uses STP theory to segment, select and accurately position the target market of tea wine products; with the help of 4P theory, it optimizes the marketing strategy from four aspects: product, price, channel and promotion. At the same time, combined with the macro and micro environment of the company, it systematically adjusts the marketing status and strategy. This research aims to tailor a scientific and comprehensive marketing plan for DJ Wine Industry's tea wine products, helping it formulate a perfect marketing plan according to its actual situation, improve market competitiveness and share, and achieve sustainable development. The research results can not only provide reference for DJ Wine Industry, but also offer new ideas and methods for similar liquor enterprises to optimize marketing strategies, formulate sales plans, and promote the development of China's liquor industry.

Keywords: Tea Wine; Marketing; 4P Theory

Published: Sept 22, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.607>

1.Introduction

To improve the marketing strategies of small and medium-sized Baijiu enterprises in China, and help them make full use of marketing strategy tools in the development process, so as to increase market share, expand enterprise scale and improve enterprise profits, this paper takes DJ Wine Industry Co., Ltd. as an example. In 1995, the company was just a wine workshop with only four workers, who brewed bulk Baijiu with sorghum and wheat, mainly sold through door-to-door and in-store purchases. After continuous development and expansion, the founder made research, development and innovation on the wine body, and developed a new type of tea-flavored Baijiu, which is a distilled Baijiu product fermented with pure tea leaves. With an alcohol content of 52 degrees, it belongs to high-alcohol liquor. The tea wine is colorless, with a sweet tea aroma when tasted. DJ Wine Industry Co., Ltd. was founded in 2017, with a current staff size of 160 people. By the end of 2024, its business volume had reached 20 million yuan. Its main business model is to provide OEM (original equipment manufacturing) of wine products for tea enterprises. However, the OEM business has thin profits and slow growth, which

is not as good as other large brands and independent brand wine enterprises. At present, DJ Wine Industry Co., Ltd. has put forward a To C marketing strategy to face consumers directly, while retaining the OEM business, and making every effort to develop its own brand to fully enter the consumer market. Facing the rapid growth of the Baijiu consumption market today, the competition among large, medium, small and micro wine enterprises is extremely fierce. This paper hopes to provide reference for small, medium and micro wine enterprises in marketing strategy through the research on the marketing strategy of DJ Wine Industry's tea wine products.

2.Domestic and Foreign Literature Review and Theoretical Basis

2.1 Domestic and Foreign Literature Review

Relevant research on marketing generally holds that an enterprise's competitiveness in the market is closely linked to its market sales capability, and market sales play a key role in a company's development. Yu Tao (2022) argues that if the pace of technological progress fails to keep up with the changing needs of consumers in the market, relying solely on technological advancement is insufficient to secure a company's market advantage. Therefore, companies must clearly define their positioning and prioritize meeting customer needs in their operations. Only in this way can overall operational costs be reduced and the company's market competitiveness be enhanced to a greater extent, which requires improving the company's market research and sales capabilities. Chen Tao and Zhao Jun (2004) point out that many Chinese companies are still in the transition from traditional to modern marketing models, having not yet formed a genuine marketing system and lacking an understanding of such systems. Xue Zhou (2020) believes that centering on solving customer needs and placing corporate sales at the forefront is becoming increasingly important in a company's development. For research on the fast-moving consumer goods market, foreign studies began much earlier than in China, and many classic marketing theories have been developed. For example, at the American Marketing Association, Neil Borden delivered a speech in 1953 and coined the term "marketing mix". Later, Jerome McCarthy summarized the 4P principle, which refers to "Product", "Price", "Place", and "Promotion", and elaborated on it in **Basic Marketing**. 4P has laid a solid foundation for subsequent analyses of marketing strategies, and most current marketing strategies are based on this idea. In the 1990s, Lauterborn proposed the 4C marketing concept. The difference between 4C and 4P is that 4P stands from the producer's perspective, while 4C stands from the customer's perspective. Iqbal Shaukat (2021) believes that marketing provides a method for developing and promoting a product. Don Schultz, the father of marketing management, told us how to view market competition from a competitive perspective, put forward suggestions for enterprises to formulate sound business strategies, and pointed out that marketing theory is an essential management theory for every company. Marketing lays the foundation for how to develop and sell products, and marketing management proposes new methods for increasing sales through various approaches. In the context of global economic integration, market-oriented operation is an effective means. Some also integrate information technology with marketing strategies. In summary, we can draw the following conclusion: There is a close connection between the development of enterprises and the scientific method of marketing. In today's increasingly fierce market competition, especially small and medium-sized enterprises should pay more attention to marketing. Baijiu enterprises are also an important part of today's enterprises, and Baijiu marketing is an important branch of marketing. Therefore, both large and small Baijiu enterprises attach great importance to marketing methods and actively respond to the ever-changing market changes with the development of the times. Most of the research on enterprise marketing strategies is based on STP theory and 4P marketing theory, using PEST as an analytical tool to analyze enterprise marketing strategies and put forward improvement suggestions. This paper discusses the same marketing strategy for the tea wine products of DJ Wine Industry.

2.2 Theoretical Basis

The 4P marketing concept, namely: Product, Price, Place, and Promotion. 4P was first introduced into enterprise management by the renowned American business management expert Jerome McCarthy in the 1960s and has since occupied a pivotal position in modern enterprise management. It provides an effective method for companies to achieve their market goals and plays a significant role in this process.

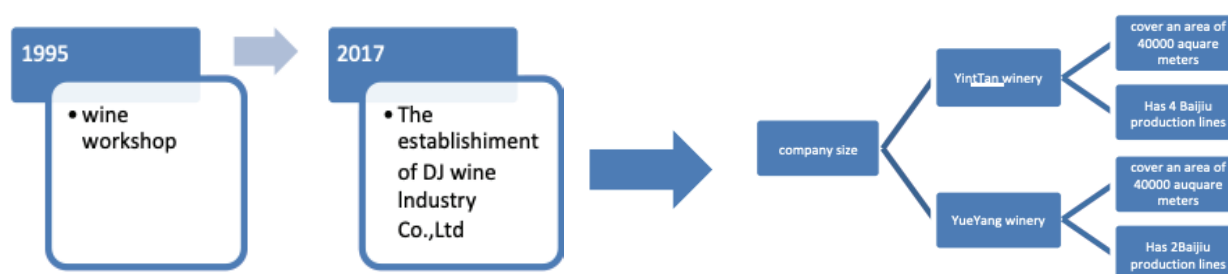
3.DJ Wine Industry's To B Marketing Strategy and Dilemmas

3.1 Overview of DJ Wine Industry Co., Ltd.

The full name of DJ Wine Industry Co., Ltd. is “Guixi Duijin Wine Industry Co., Ltd.” When it was established in 1995, it was a wine workshop with only 4 employees. Initially, it produced bulk Baijiu brewed from sorghum and wheat, mainly sold through door-to-door and in-store purchases. After continuous development and expansion, the founder engaged in research, development and innovation of the wine body and developed a new brewing technology, which is a Baijiu brewing technology for distilled Baijiu fermented from pure tea leaves. Guixi DJ Wine Industry Co., Ltd. was founded in 2017, and its development history is shown in Figure 1. Currently, its main business model is OEM (original equipment manufacturing) of wine products for tea enterprises, and tea wine products are the only liquor products of DJ Wine Industry Co., Ltd. Its main sales markets are Fujian, Jiangxi, Guangdong and Shanghai. At present, as a representative of tea-flavored Baijiu, it occupies a position in the Baijiu market. The wineries are respectively located in Yueyang City, Hunan Province and Yingtan City, Jiangxi Province, with a staff size of 160 people. It has a certain reputation in the Baijiu industry, and the tea-flavored brewing technology has obtained a national patent. By the end of 2024, its business volume had reached 20 million yuan, but all businesses operated in the OEM mode, providing OEM services for major tea enterprises and tea merchants to produce tea-flavored Baijiu. The slow-moving tea in China also brought benefits to DJ Wine Industry in the early stage of its establishment. For tea merchants and enterprises, OEM of tea-flavored Baijiu undoubtedly opened up an extension of their products. For example, Da Hong Pao tea can be used to make wine, becoming Da Hong Pao tea wine. The value chain of the tea wine industry is basically the same as that of general industrial enterprises. In the production of tea wine, consumers play two roles in the value chain of the tea wine industry: they are both recipients and demanders of tea wine products. Currently, in China, the end customers of tea and Baijiu are divided into catering terminals, community retail terminals, supermarket terminals and nightclub terminals. Terminal merchants purchase various required production materials through professional contracting and self-construction, and finally produce and sell them to customers. From the analysis of profit distribution at each stage of the industrial value chain, tea enterprises usually obtain the maximum added value because they have advantages in both manufacturing and marketing; due to the different costs of different packaging materials and equipment, it is relatively difficult to increase product value. However, in China, the mainstream packaging materials for tea Baijiu have established a unified market in China, so their product pricing is relatively stable, and their profitability is at the domestic average level. Tea and Baijiu companies have relatively high profits in the entire industry chain because there is no problem of homogeneity. At the same time, tea merchants and enterprises themselves have perfect sales channels, and tea-flavored Baijiu undoubtedly brings them a new product and can also digest slow-moving tea. These two points enabled DJ Wine Industry Co., Ltd. in the start-up period to obtain many OEM orders. OEM refers to a named manufacturer entrusting another manufacturer to produce goods on its behalf, and the final brand name of the goods still uses that of the named manufacturer. China’s Baijiu industry has a variety of production license qualifications, and many tea enterprises themselves do not have the qualifications and capabilities for Baijiu production, so they can only entrust DJ Wine Industry Co., Ltd. for OEM production. From 2017 to the end of 2024, it maintained its business by relying on technological monopoly and low-cost OEM to attract tea merchants and enterprises. Its sales exceeded 15 million yuan in 2019, but by 2024, the annual sales growth rate had slowed down, fluctuating around 1 million yuan per year. DJ Wine Industry Co., Ltd. has encountered a development bottleneck.

Figure 1 Development History of DJ Wine Industry Co., Ltd.

Source: self-made



3.2 Current Situation of To B Marketing Strategy for Tea Wine Products of DJ Wine Industry Co., Ltd.

The main tea wine products sold by DJ Wine Industry Co., Ltd. are the Daozhengyun tea wine series. This series is divided into 6 single products (see Table 1): Daozhengyun Longjing Tea Wine, Daozhengyun Longjing Tea Wine (green bottle), Daozhengyun White Tea Wine, Daozhengyun Green Tea Wine, Daozhengyun Da Hong Pao Tea Wine, and Daozhengyun Yongchun Yellow Tea Wine. They are originated from Yingtan City, Jiangxi Province, and are tea-flavored distilled Baijiu. Each single product has a capacity of 500ml and an alcohol content of 52%.

Table 1 Main Products Sold by DJ Wine Industry Co., Ltd.

product degree capacity	Daozhengyun Longjing Tea Wine	Daozhengyun Longjing Tea Wine (Green Bottle)	Daozhengyun White Tea Wine	Daozhengyun Green Tea Wine	Daozhengyun Da Hong Pao Tea Wine	Daozhengyun Yongchun Yel- low Tea Wine	Daozhengyun Longhu Hero Tea Wine
degree	52°	52°	52°	52°	52°	52°	52°
capacity	500ml	500ml	500ml	500ml	500ml	500ml	500ml

Source: self-made

The Daozhengyun tea wine series products are mainly distributed through sales channels targeting tea enterprises and merchants, as well as tea lovers, mainly male consumers aged around 30-60. Each product in the Daozhengyun tea wine series has its own unique appearance, and prices are differentiated through different appearances. The bottle of Daozhengyun Longjing Tea Wine is blue, representing preciousness; the golden bottle cap and auspicious cloud patterns stand for wealth and symbolize good luck and auspiciousness; the bamboo joint pattern on the bottom of the bottle represents the power of life and symbolizes longevity and peace. The bottle colors of Daozhengyun White Tea Wine, Green Tea Wine, and Black Tea Wine correspond to their flavors—red for black tea, green for green tea, and white for white tea. Their appearances all feature a water drop bottle design, representing purity and symbolizing beauty and innocence (see Figure 2).

Figure 2 Appearance of Daozhengyun Tea Wine Products

Source: self-made



4. Analysis of Marketing Strategy Environment for Tea Wine Products of DJ Wine Industry Co., Ltd.

4.1 PEST Analysis

The state has formulated a series of industrial policies for liquor enterprises. Table 2 lists the changes in industrial policies from 2012 to 2024. In 2012, due to frequent production safety accidents in the liquor industry, the state intensified supervision over the food safety of liquor. Over these ten years, the introduction of the Eight Provisions has had a great impact on the liquor industry, resulting in a decline in the overall profitability of listed liquor companies. In the two years after the introduction of the Eight Provisions, the wealth loss of first-tier liquor enterprises reached as high as 80.83%. China's liquor industry has been severely impacted, among which the major official consumption forces of well-known brands such as Moutai, Xifeng Wine and Jiugui Wine have been completely suppressed. For a long time, China's liquor industry has been classified as a "restricted" industry. In February 2013, China's "Guidance Catalog for Industrial Structure Adjustment (2011

Edition) (Amendment)" (No. 21 of 2013) continued to include the "liquor industry" in the "restricted" industry. In 2019, the National Development and Reform Commission removed liquor from the "restricted industries", meaning that the liquor industry was officially liberalized.

According to Tianyancha data, as of February 26, 2022, there were a total of 319,000 liquor-related enterprises in China, with 7,712 new enterprises registered throughout the year, among which 283,000 were small and micro enterprises with a registered capital of less than 1 million yuan, accounting for about 88% of the entire industry

Table 2 Changes in Liquor Policies from 2012 to 2022

event time	Relevant conference policies and their impacts
2012	Liquor production enterprises have repeatedly encountered food safety incidents such as industrial alcohol blending, addition of plasticizers, and detection of pesticide residues, leading to increased food safety inspections in the liquor industry.
2012	The newly revised Criminal Law stipulates that drunk driving of motor vehicles shall be convicted of "dangerous driving", and drunk driving has been criminalized. Therefore, one should not drive after drinking, and should not drink when driving.
2013	The state has issued documents to control the production quality of liquor. The State Food and Drug Administration issued the "Notice on Further Strengthening the Supervision and Administration of Liquor Quality and Safety", the Ministry of Commerce issued the "Standards for Circulation Services in the Liquor Industry", and the State Administration of Work Safety issued the "Safety Management Standards for Liquor Enterprises", etc., which have strengthened supervision over the entire process of liquor, including raw material procurement, production process supervision, finished product testing, and label supervision.
2013	Local governments have successively issued alcohol bans. The Standing Committee of the Hainan Provincial Party Committee reviewed and approved the "Regulations on Improving Work Style and Maintaining Close Ties with the Masses", which clearly states that "from now on, official receptions in the province shall be arranged at designated places according to standards and no alcohol shall be served". This is the first local version of the "alcohol ban" after the 18th National Congress of the Communist Party of China.
2018	The "Beverage and Liquor Classification Standards" have been revised to scientifically define traditional solid-state liquor, liquid-state liquor, solid-liquid liquor, formulated liquor or flavor-adjusted liquor, and explicitly stipulate the raw materials, production processes, edible alcohol, food additives, and product traceability standards in the production process of edible liquor.

Source of information : <http://www.woyao9.com/bjzx/181618.html>.

4.2 Economic Environment Analysis

China's economic development model has gradually shifted from high energy consumption and high emissions to low energy consumption and high efficiency. Nationwide, efforts are being made to promote industrial transformation and upgrading, with a number of new industries and new business forms emerging in the economic development, and the industry continues to transform and develop new drivers of growth. High-tech industries such as artificial intelligence, biomedicine, intelligent manufacturing, and 5G will play a leading role in future economic development. The COVID-19 pandemic at the end of 2019 also had an impact on the world economy and caused a great impact on China's import and export trade. The integration of world trade has both advantages and disadvantages for our liquor industry. On the one hand, due to the continuous opening of the market, a large number of foreign liquor companies have poured into China, which has caused a huge impact on the development of our liquor industry. In particular, with the entry of internationally renowned wine brands and the large-scale introduction of wine, the development of the domestic liquor industry is facing huge competitive pressure. In addition, due to the opening of the market, our liquor industry has also gained some advanced brewing technologies and management experience, which has created favorable conditions for our liquor industry to go global. At present, our liquor has a low share and popularity in the world, and is still in the initial stage of entering the world. It is still a long way for China's liquor industry to explore the international market and enhance its international popularity. Worldwide, with the rise of trade protectionism and the outbreak of the pandemic around the world, China's macro-economy has gradually formed a new

development pattern with the domestic big cycle as the main body and the domestic and international dual cycles promoting and reinforcing each other, which also provides a major historical opportunity for China's consumption upgrading. Under the current industrial structure, how to achieve high-quality development has become an increasingly concerned issue for major liquor enterprises. From the market to products, and then to customers, all are constantly updating. Liquor, breweries, and rice wine are facing an era where low-end products withdraw and high-end products rise. The development of the beverage industry has also entered a "four new" period: low-end products withdraw, high-end products rise vigorously; new consumers have more aesthetic views and more demands; in the new retail industry, the interaction between customers and brands is getting deeper and the relationship is getting closer, with high-quality value, new corporate culture, and new brand culture. In the process of China's new round of industrial transformation and upgrading, the demand for the traditional industry of brewing is getting higher and higher. At the same time, the continuous improvement of environmental protection standards has also prompted the brewing industry to carry out technological transformation and improvement in terms of sewage discharge.

4.3 Socio-Cultural Environment Analysis

For thousands of years, alcohol has been generally endowed with various cultural connotations, symbolizing rituals of life, respect, and noble personalities. Chinese people have an indelible affection for the white wine they have tasted, so they traditionally still prefer to drink and consume white wine. However, with the advancement of globalization, economic development, and improvement in people's quality of life, the white wine market is constantly undergoing new changes. With modernization, globalization, and urbanization, people's consumption concepts have changed. They have higher and higher requirements for products, including white wine, as well as for foreign wines and soft drinks. People are strongly influenced by publicity, thinking that drinking white wine is outdated, while drinking red wine and foreign wine is fashionable and elegant. Due to changes in people's material lifestyle and the continuous improvement of their requirements for health, the consumption of white wine is increasingly inclined to high-end, which also affects the sales of low-end white wine to a certain extent. In the context of globalization, urban culture has risen worldwide, and cities are the most influential in the world. European and American spirits, Japanese and Korean wines, etc., have entered China and are favored by urban young people. For example, urban bars mainly serve imported foreign wines, with their unique bartending techniques and integration of European and American cultures, which are favored by young people. The increasing variety of beverage choices provided by restaurants has formed competition with white wine. After 2000, Korean dramas became popular all over China, and Korean cuisine also began to prevail in China, which is deeply loved by young people. Sake also appears in Korean movies and TV dramas, which is the reason for the rise of Korean sake in China. In addition, Korean sake has a low alcohol content, which is favored by some consumers who are not used to high-alcohol wines. Sake quickly entered the Chinese market and can be bought in major supermarkets and convenience stores, which has a strong impact on the low-end white wine market. However, Chinese white wine is also striving to go global, and a number of famous brands are gradually moving towards the world. For example, in 2017, Chinese Yanghe cocktail won the London "LCBA" award and gained high popularity in London. However, the current international recognition of Chinese white wine is still very low. International consumers' understanding of Chinese white wine is not sufficient, especially in terms of its quality, traditional brewing technology, alcohol content, and price, which has created great obstacles for Chinese white wine to enter the world market.

5.Improvement of 4P To C Marketing Strategy for Tea Wine Products of DJ Wine Industry Co., Ltd.

5.1 Enhance product layout

Launch low-priced products to meet the demand of the low-end market. According to the questionnaire survey, 27.66% of the surveyed customers would choose liquor around 100 yuan (see Table 3), and 38.3% of the surveyed consumers often buy liquor priced between 100-300 yuan. The tea wine products produced by DJ Winery have always been mainly medium and high-end series, targeting the consumer groups of medium and high-end liquor. Facing the huge middle-income and low-income groups in China, the tea wine products lack low-end products below 100 yuan per bottle and mid-end products priced between 100-300 yuan. Therefore, products priced below 100 yuan and between 100-300 yuan can be added to the

Daozhengyun series of tea wine currently produced with Longjing, Dahongpao, green tea and white tea. This can enrich the product line of DJ Wine Industry Co., Ltd., diversify its products, and provide higher-quality products and services for the majority of working-class customers. It will expand the overall market share of DJ Wine Industry Co., Ltd., and the addition of low and mid-end products will also play a certain role in boosting high-end tea wine. In the interviews with key people, Manager A of the entrusted processing party said that the repurchase rate of tea wine is very high and it is gradually being liked by consumers. Dealer G, an employee of DJ Wine Industry Co., Ltd., said that the current price range of tea wine products is relatively high, with no low and mid-end products. Some consumers who have the willingness to buy eventually give up due to the price range, and hope that there will be some low and mid-priced tea wine products to meet the needs of other consumers.

3 Price Ranges of Liquor Frequently Purchased by Consumers

quantity \ option	subtotal	proportion
<100	91	27.66%
100-300	126	38.3%
300-500	67	20.36%
500-1000	36	10.94%
>1000	9	2.74%
Number of valid respondents	329	

Source of information: Self-made

5.2 Highlight product features

The tea wine products of DJ Wine Industry are first distinguished from liquor of other flavors, and second, they aim to establish a healthy brand image. The series of tea wine products OEMed by DJ Wine Industry do not have advertising slogans that highlight product features. As shown in Figure 3, the advertising slogan of Daozhengyun series tea wine products is “Pure tea brewing, national patented product”. It is necessary to further design advertising slogans with the theme of great health. On the other hand, in terms of distinguishing internal single products, at present, they are mainly matched in terms of color and tea raw materials, and there is no distinction based on the characteristics and values of each single product. For example, green tea and Longjing tea, Longjing tea itself is a type of green tea, and the category attributes are relatively confusing. It is necessary to have differences in outer packaging and bottle body in addition to color.

Figure 3 Daozhengyun Series Tea Wine

Source of information: Self-made



5.3 Launch of new products

First, attention should be paid to gift-giving consumption demand. The demand for gifts with a unit price of 100-300 yuan is a necessary part of the national liquor consumption market, and it can promote the sales of dealers and other products to a certain extent, which can not only occupy the market but also encourage dealers participating in tea wine distribution. Since Daozhengyun Longjing Tea Wine (1,688 yuan/bottle), Daozhengyun Green Tea Wine (1,688 yuan/bottle), and Daozhengyun Drop-shaped Bottle Green Tea Wine (588 yuan/bottle) do not meet the gift-giving needs of the low-end market, product innovation is required. A low-priced variety can be derived from Daozhengyun Green Tea Wine, and its green packaging design is also in line with the characteristics of the green and healthy brand. Secondly, the wedding banquet market in the low-end market is also a sector that cannot be ignored. Regarding China's wedding banquet concept, people still prefer festive red. At present, among all Daozhengyun tea wine products, only Daozhengyun Black Tea Wine in a drop-shaped bottle (588 yuan/bottle), as shown in Figure 4, is available, which is relatively single in product and its price does not meet the low-end wedding banquet market. Therefore, it is necessary to launch tea wine products with red packaging made from green tea and white tea to supplement, and the price should be in line with the consumption level of the working class.

Figure 4 Daozhengyun Drop-shaped Bottle Series Tea Wine

Source of information: Self-made



Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Chen, S. Y. (2016). Research on brand marketing strategy of Zhejiang Guyue Longshan [In Chinese]. *Rural Economy and Science-Technology*, 27(17), 190–191. <https://doi.org/10.3969/j.issn.1007-7103.2016.17.100>
- [2] Chen, T., & Zhao, J. J. (2004). Research on marketing channel conflict and management strategy of Chinese enterprises. *Business Economics and Management*, (6), 4–7. <https://doi.org/10.14134/j.cnki.cn33-1336/f.2004.06.001>
- [3] China General Chamber of Commerce, & National Commercial Information Center. (2022, January 18). Annual analysis of the operation of the consumer goods market in 2021 . Retrieved May 8, 2023, from <http://www.cncic.org/zxxz/934.jhtml>
- [4] China National Radio. (2022, July 14). China's wine industry achieved 868.7 billion yuan in sales revenue in 2021, now in a critical stage of industrial adjustment . Retrieved May 8, 2023, from https://economy.cnr.cn/jiujia/20220714/t20220714_525920121.shtml
- [5] Espejel, J., & Fandos, C. (2009). Wine marketing strategies in Spain. *International Journal of Wine Business Research*,

- 21(4), 367–380. <https://doi.org/10.1108/17511060911004917>
- [6] Fang, S. W. (2022). Research on marketing strategies of Chinese sauce-aroma white wine in the new environment . *Business Culture*, (14), 52–53. <https://doi.org/10.3969/j.issn.1006-4117.2022.14.022>
- [7] Gao, S. (2015). Research on marketing strategies of Fengxiang classic Xifeng wine [Master's thesis, Xi'an University of Technology]. CNKI. <https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201601&filename=1015363987.nh>
- [8] Ge, J. X. (2022). Research on the current situation and strategies of new media marketing in baijiu enterprises . *China Market*, (33), 117–118. <https://doi.org/10.13939/j.cnki.zgsc.2022.33.117>
- [9] Geng, X. Q. (2022). Analysis of digital marketing strategies for baijiu enterprises . *Market Modernization*, (8), 48–50. <https://doi.org/10.14013/j.cnki.scxdh.2022.08.020>
- [10] Iqbal, S. (2021). Marketing management with global and international perspective. *Journal of Investment and Management*, 10(3), 106–115.
- [11] Ko, J.-Y., Yoo, B.-K., & Lee, Y.-Y. (2009). Wine marketing strategies of 5-star hotel restaurants in Seoul using the Delphi technique. *Journal of Tourism Sciences*, 33(3), 11–30.
- [12] Latusi, S., Zerbini, C., Maestripieri, S., & Luceri, B. (2018). Wine marketing: Consumer persuasion through the region of origin. *Wine Economics and Policy*, 7(2), 12–20.
- [13] Lu, T. H. (2006). Report on Chinese consumer behavior . China Social Sciences Press.
- [14] Lu, Y. (2010). Research on marketing innovation path under economic transformation . *Science and Technology Management Research*, 30(23), 15–16. <https://doi.org/10.3969/j.issn.1000-7695.2010.23.004>
- [15] Spence, C. (2019). Multisensory experiential wine marketing. *Food Quality and Preference*, 71, 93–100. <https://doi.org/10.1016/j.foodqual.2018.07.001>
- [16] Wang, G. Z., & Wang, W. (2019). Analysis of customized marketing strategies for baijiu . *Liquor-Making Science & Technology*, (8), 139–142. <https://doi.org/10.13746/j.njkj.2019146>
- [17] Wang, L. (2019). Research on the construction of omni-channel marketing model for baijiu enterprises . *Journal of Shanxi Institute of Energy*, 32(2), 76–78.
- [18] Wang, L. (2023). Research on marketing strategies of baijiu enterprises in the new market environment . *Time-Honored Brand Marketing*, (1), 41–43.
- [19] Wang, L. J. (2013). Customer relationship model based on Confucian values . *Management World*, (2), 87–88. <https://doi.org/10.19744/j.cnki.11-1235/f.2013.02.010>
- [20] Xue, Z. (2022). A brief discussion on the relationship between marketing strategy and enterprise strategy . *China Economic and Trade Herald*, (4), 75–77.
- [21] Yang, B. Z. (2011). Innovation of enterprise marketing strategy . *Business Strategy*, (5), 76–78.
- [22] Yang, X. Q. (2008). Marketing strategy of Kaifeng time-honored brands based on SWOT analysis . *Contemporary Economy*, (1), 94–95.
- [23] Yao, S. M. (2019). Research on marketing strategies of baijiu production enterprises . *Business News*, (26), 113–114.
- [24] Yu, T. (2022). Research on marketing strategy management and innovation . *Enterprise Management*, (9), 141–143.
- [25] Zhang, L. (2021). Optimization of the marketing management system based on cloud computing and big data. *Complexity*, 2021, Article 9977. <https://doi.org/10.1155/2021/99977>
- [26] Zhu, K. (2011). Research on cultural marketing in the baijiu industry . *Modern Marketing (Academic Edition)*, (1), 38.
- [27] Zhu, L. (2023). Research on baijiu marketing strategies . *Marketing Industry*, (1), 65–67.

Bridging Structural Causal Inference and Machine Learning: The S-DIDML Estimator for Heterogeneous Treatment Effects

Yile Yu^{1*}, Anzhi Xu²

1.School of Education, Zhejiang University of Technology, Hangzhou, 310014, China

2.School of Accounting, Yunnan University of Finance and Economics, Kunming, 650221, China

*Corresponding author: Yile Yu, 302023572139@zjut.edu.cn

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In response to the increasing complexity of policy environments and the proliferation of high-dimensional data, this paper introduces the S-DIDML estimator—a framework grounded in structure and semiparametrically flexible for causal inference. By embedding Difference-in-Differences (DID) logic within a Double Machine Learning (DML) architecture, the S-DIDML approach combines the strengths of temporal identification, machine learning-based nuisance adjustment, and orthogonalized estimation. We begin by identifying critical limitations in existing methods, including the lack of structural interpretability in ML models, instability of classical DID under high-dimensional confounding, and the temporal rigidity of standard DML frameworks. Building on recent advances in staggered adoption designs and Neyman orthogonalization, S-DIDML offers a five-step estimation pipeline that enables robust estimation of heterogeneous treatment effects (HTEs) while maintaining interpretability and scalability. Demonstrative applications are discussed across labor economics, education, taxation, and environmental policy. The proposed framework contributes to the methodological frontier by offering a blueprint for policy-relevant, structurally interpretable, and statistically valid causal analysis in complex data settings.

Keywords: S-DIDML; Methodology; Causal Inference; Difference-in-Differences; Double Machine Learning; Semiparametric Methods

Published: Sept 22, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.609>

1.Introduction

In the social sciences, the pursuit of causal understanding—rather than mere correlation—has long defined the discipline’s scientific ambition. Researchers in various fields endeavor to isolate the effect of a particular treatment or intervention from the myriad of other confounding influences. This is true when assessing the effect of a trade policy on employment, the impact of educational reform on student performance, or the consequences of environmental regulations on firm productivity. At the core of these efforts lies causal inference, which seeks to address the fundamental question: It is imperative to consider what the outcome would have been in the absence of the treatment. Economics, political science, education, and public policy have increasingly embraced quasi-experimental designs to approximate this elusive counterfactual.^[1] Among them, the Difference-in-Differences (DID) framework has become a canonical tool.^[2] It leverages temporal and group-based variation to identify causal effects under a critical “parallel trends” assumption.^[3] The appeal of DID lies in its structural interpretability, transparency, and policy relevance, making it a mainstay in top journals and institutional evaluations alike. However, the

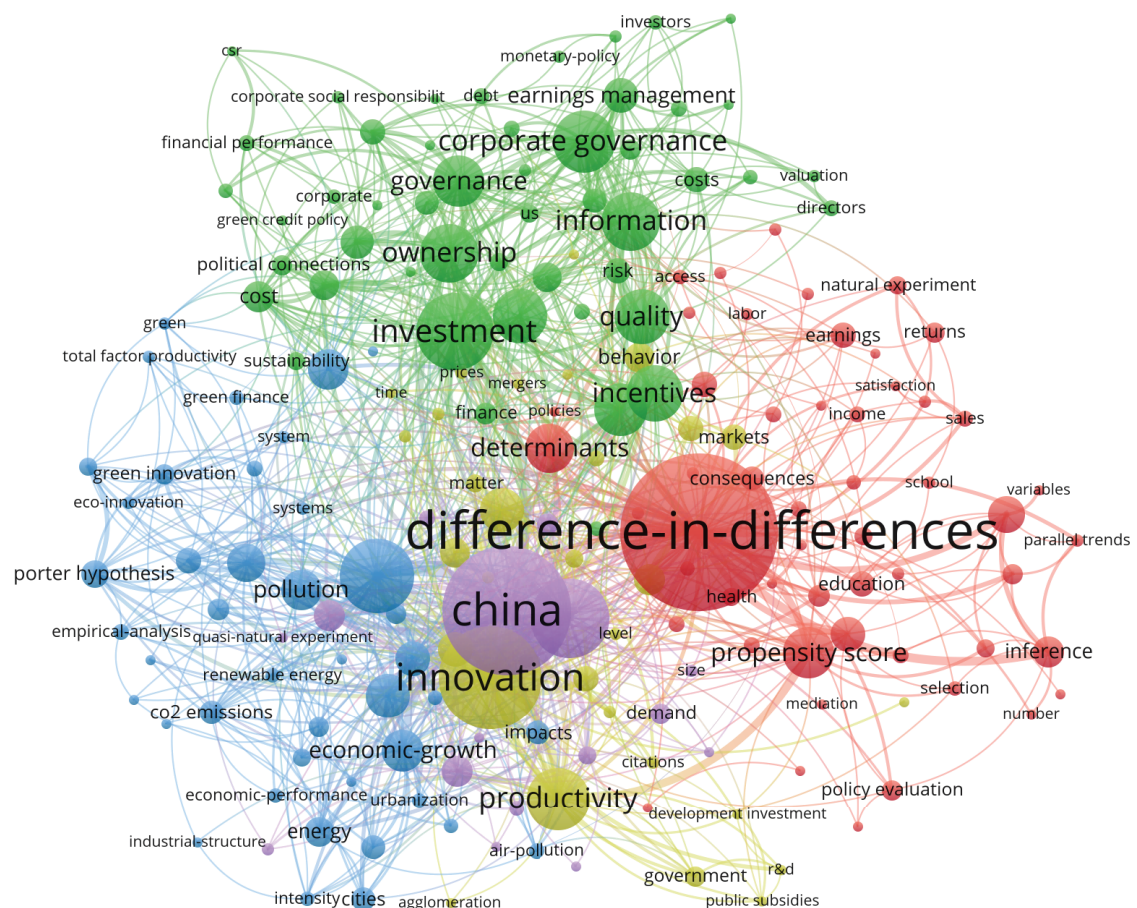
rise of high-dimensional data environments—where researchers can access hundreds of covariates from administrative records, digital platforms, or satellite imagery—has exposed the limitations of traditional causal tools.^[4] Conventional DID approaches, often implemented via linear fixed effects models, may falter in the presence of nonlinear confounding, covariate imbalance, or heterogeneous treatment response.^[5] In such settings, machine learning (ML) offers promising tools to flexibly model complex data structures, select relevant variables, and improve predictive accuracy.^[6] Yet, ML methods themselves are often prediction-oriented and lack the structural discipline needed for causal interpretation.^[7] Bridging the divide between structure-driven identification and data-driven flexibility has become a central challenge for contemporary empirical research.^[8] In response, a growing literature—most notably Double/Debiased Machine Learning (DDML)—has attempted to integrate the strengths of both paradigms.^[9] This paper situates itself within this growing effort to reconcile causal structure and machine learning innovation, focusing particularly on the evolution of DID and its modern extensions.^[10] Through a comprehensive review and methodological synthesis, we propose a new estimator—S-DIDML that structurally embeds DID within a residualized ML framework, enabling robust and interpretable causal inference in high-dimensional settings.^[11]

2.Literature Mapping and Bibliometric Review

2.1 The Evolution and Diversification of Difference-in-Differences in Social Science Research

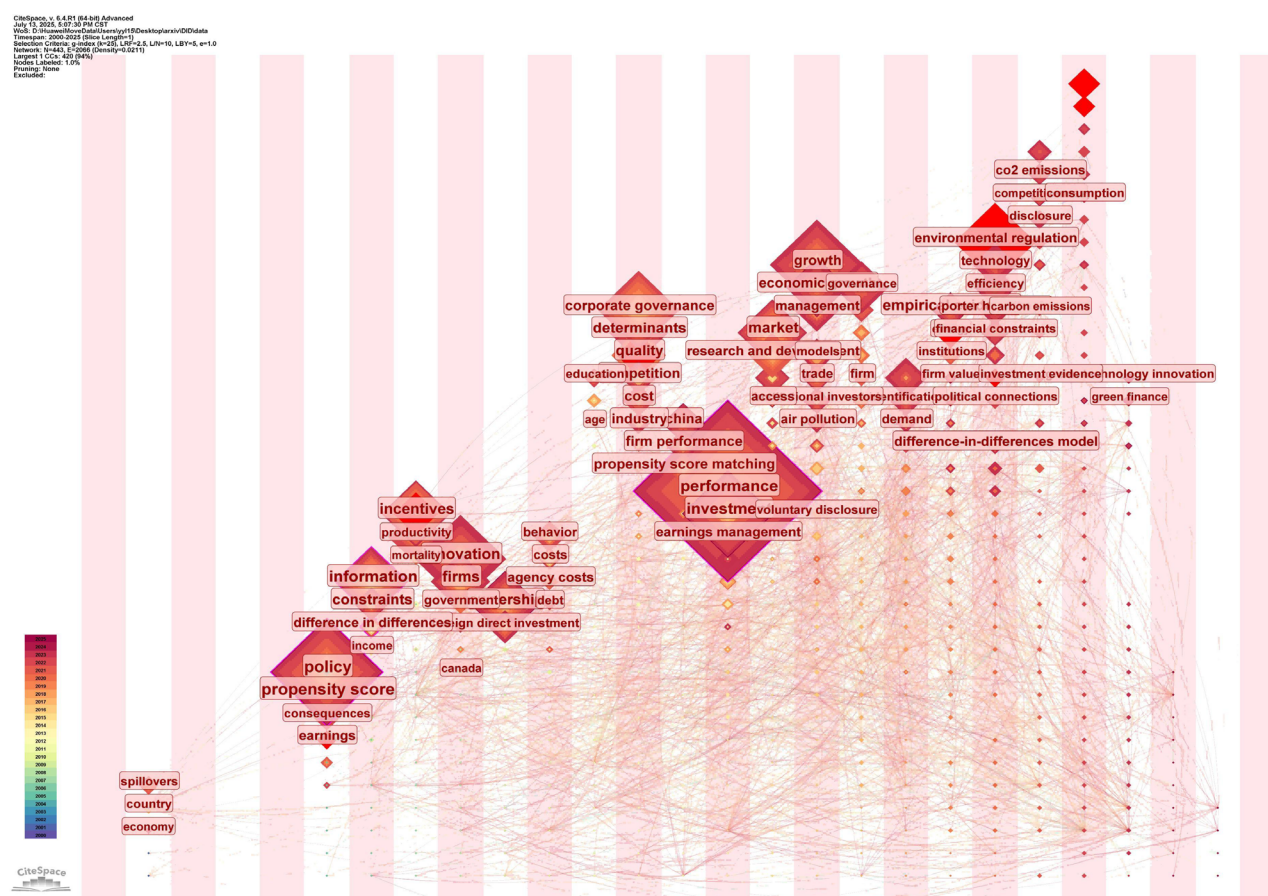
Over the past three decades, the Difference-in-Differences (DID) approach has evolved from a relatively simple econometric tool to a cornerstone methodology for causal inference in applied social sciences.^[12] First widely adopted in labor economics and public policy evaluation (Ashenfelter & Card, 1985), DID methods are now routinely employed to assess the causal impacts of reforms and shocks across domains such as education, environmental regulation, corporate governance, and innovation policy.^[13] The conceptual strength of DID lies in its structural identification strategy, which exploits longitudinal

Figure 1 Co-occurrence clustering map of keywords in DID-related research



variation between treatment and control units, assuming parallel trends in the absence of treatment.^[14] Our bibliometric analysis of 500 articles indexed in Web of Science (2000–2024) reveals an exponential growth in DID-related publications, especially after 2010. This growth reflects the method's diffusion beyond economics into interdisciplinary domains, including political science, environmental studies, and development research. The VOSviewer keyword co-occurrence map (Figure 1) illustrates how DID research has clustered around several thematic poles: green and environmental economics, anchored by terms such as pollution, green finance, and Porter hypothesis; corporate governance and financial policy, focused on ownership, incentives, and earnings management; innovation and productivity analysis, with keywords like urbanization, China, and total factor productivity; and public policy and human capital evaluation, integrating DID with propensity score methods, education, and healthcare outcomes. The temporal cluster visualization from CiteSpace (Figure 2) suggests a clear trajectory of conceptual evolution.^[15] Early DID studies (pre-2005) were tightly linked to labor market outcomes and macroeconomic shocks.^[16] However, since 2015, the frontier has shifted toward applications in environmental regulation, technological innovation, and firm behavior under asymmetric information, often in the context of emerging markets such as China.^[17] These newer applications frequently involve complex multi-treatment environments, time-varying exposures, and heterogeneous policy responses across sectors—conditions that test the limits of classical DID assumptions. Methodologically, DID estimation has undergone substantial refinement.^[18] Influential work by Abadie (2005) extended DID into the semiparametric domain, allowing for richer covariate structures via matching.^[19] More recently, Callaway and Sant'Anna (2021) and Sun and Abraham (2021) introduced robust estimators for staggered adoption designs, correcting for treatment timing heterogeneity that plagues two-way fixed effects models.^[20] These innovations address several longstanding concerns: violation of parallel trends across heterogeneous units; bias under dynamic treatment effects and anticipation; and negative weighting in TWFE regression models. Despite these advances, traditional DID remains fundamentally limited in high-dimensional settings. Most DID implementations rely on linearity assumptions and low-dimensional covariate control, which become fragile when dealing with hundreds of potential confounders from administrative records, digital platforms,

Figure 2 Temporal evolution diagram of keywords in DID-related research



or geospatial data. Additionally, classical DID is typically estimated at the average treatment effect (ATE) level, with little consideration for treatment effect heterogeneity (HTE) across firms, regions, or demographic groups. Recent attempts to augment DID with machine learning techniques—particularly in pre-processing stages using propensity score estimation, kernel matching, or covariate balancing—remain largely modular rather than integrative.^[21] They seldom modify the core identification strategy or link to formal orthogonalization procedures, as found in Double Machine Learning (DML) frameworks.^[22] In summary, DID has achieved a remarkable degree of empirical relevance and institutional acceptance across disciplines.^[23] However, the emerging landscape of complex, high-dimensional policy environments exposes critical limitations in classical DID frameworks.^[24] To remain a credible tool for modern causal analysis, DID methods must evolve in two key directions: (1) integration with flexible, data-adaptive modeling approaches capable of handling nonlinearities and latent confounding, and (2) preservation of structural interpretability, ensuring that causal parameters remain transparent and policy-actionable.^[25] This methodological tension motivates the development of S-DIDML, a new estimator introduced in this study that embeds DID within a double residualized machine learning framework.^[26] S-DIDML retains the core logic of temporal comparison while incorporating high-dimensional learning and orthogonalized estimation.^[27] As we will show, this approach offers a principled and scalable path toward heterogeneity-aware, high-dimensional causal inference grounded in quasi-experimental logic.^[28]

2.2 The Rise of Double/Debiased Machine Learning: From Orthogonalization to High-Dimensional Causal Inference

In response to the growing need for reliable causal inference in high-dimensional settings, the past decade has witnessed the rapid rise of Double Machine Learning (DML) and Debiased Machine Learning (DDML) frameworks.^[29] Rooted in the econometric concept of orthogonalized moment equations and powered by modern machine learning-based nuisance parameter estimation, these methods have substantially expanded the empirical frontier for researchers dealing with complex treatment assignment, heterogeneity, and large-scale observational data.^[30] DML and its variants provide a principled way to separate the prediction task (nuisance estimation) from the estimation of causal effects, by leveraging Neyman orthogonality, sample-splitting, and cross-fitting to obtain asymptotically valid estimators even in the presence of flexible, nonparametric models.^[31] The bibliometric analysis of 178 core papers indexed in Web of Science (2016–2024) confirms the explosive growth of this literature.^[32] The VOSviewer co-occurrence network (Figure 3) centers around key themes including causal inference, Neyman orthogonality, cross-fitting, efficiency, and heterogeneous treatment effects, all closely linked with practical implementation strategies such as lasso, random forest, double robustness, and partially linear models.^[33] Meanwhile, the CiteSpace temporal map (Figure 4) highlights a condensed knowledge burst in 2019–2022, during which seminal works formalized inference after machine learning (Chernozhukov et al.^[34], 2018), introduced double/debiased orthogonal estimation (Newey & Robins, 2018), and developed scalable estimators for average and conditional treatment effects (Athey & Wager, 2019; Farrell et al., 2021). These methods have now been codified into a general paradigm: use ML to estimate nuisance components, and then debias the effect estimator via orthogonalization. At the theoretical level, DDML builds on semiparametric efficiency theory, combining flexible first-stage ML tools (e.^[35]g., penalized regression, tree-based ensembles, deep nets) with second-stage doubly robust score functions. Estimators are designed to satisfy conditions such as local robustness, asymptotic linearity, and root-n convergence, making them particularly suited for policy evaluation under approximate sparsity or nonlinear selection. A critical innovation is the use of cross-fitting to mitigate overfitting bias in high-capacity learners, enabling the use of complex models like neural networks or gradient boosting within a valid inferential framework. In empirical applications, DDML has rapidly diffused into fields such as health economics, education policy, taxation, and labor market discrimination, often in the context of heterogeneous treatment effects or partial identification.^[36] For instance, Athey, Tibshirani, and Wager (2019) propose Causal Forests to estimate treatment effects conditional on covariates, while Chernozhukov et al.^[37] (2020) extend DDML to quantile regression and instrumental variables. These contributions have redefined the scope of credible causal inference, enabling researchers to shift from estimating a single average treatment effect toward recovering rich heterogeneity structures and distributional effects, all while preserving valid statistical inference. Nevertheless, current DDML applications still face several constraints.^[38] First, many frameworks are

Figure 3 Keyword co-occurrence clustering map of DDML-related research

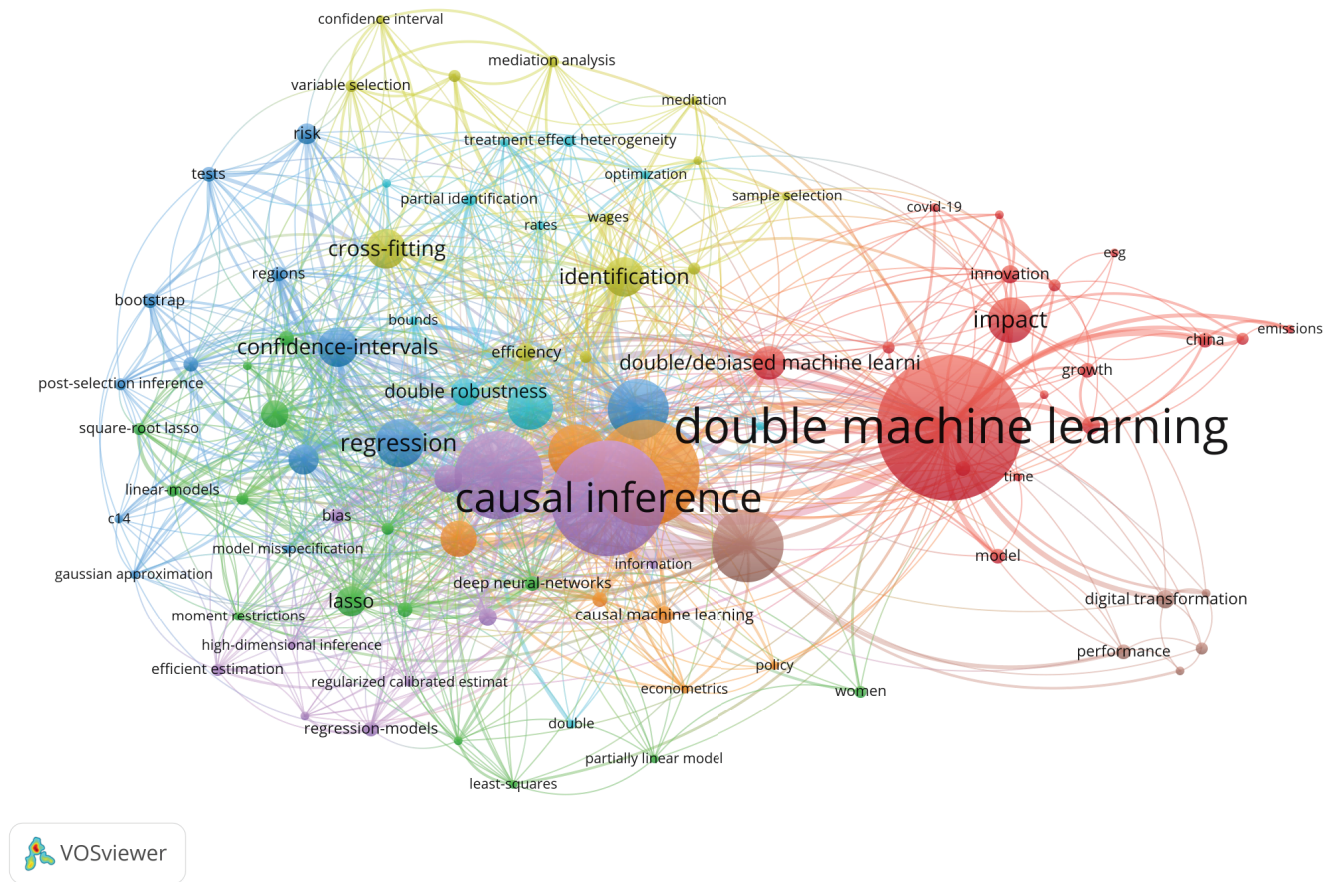
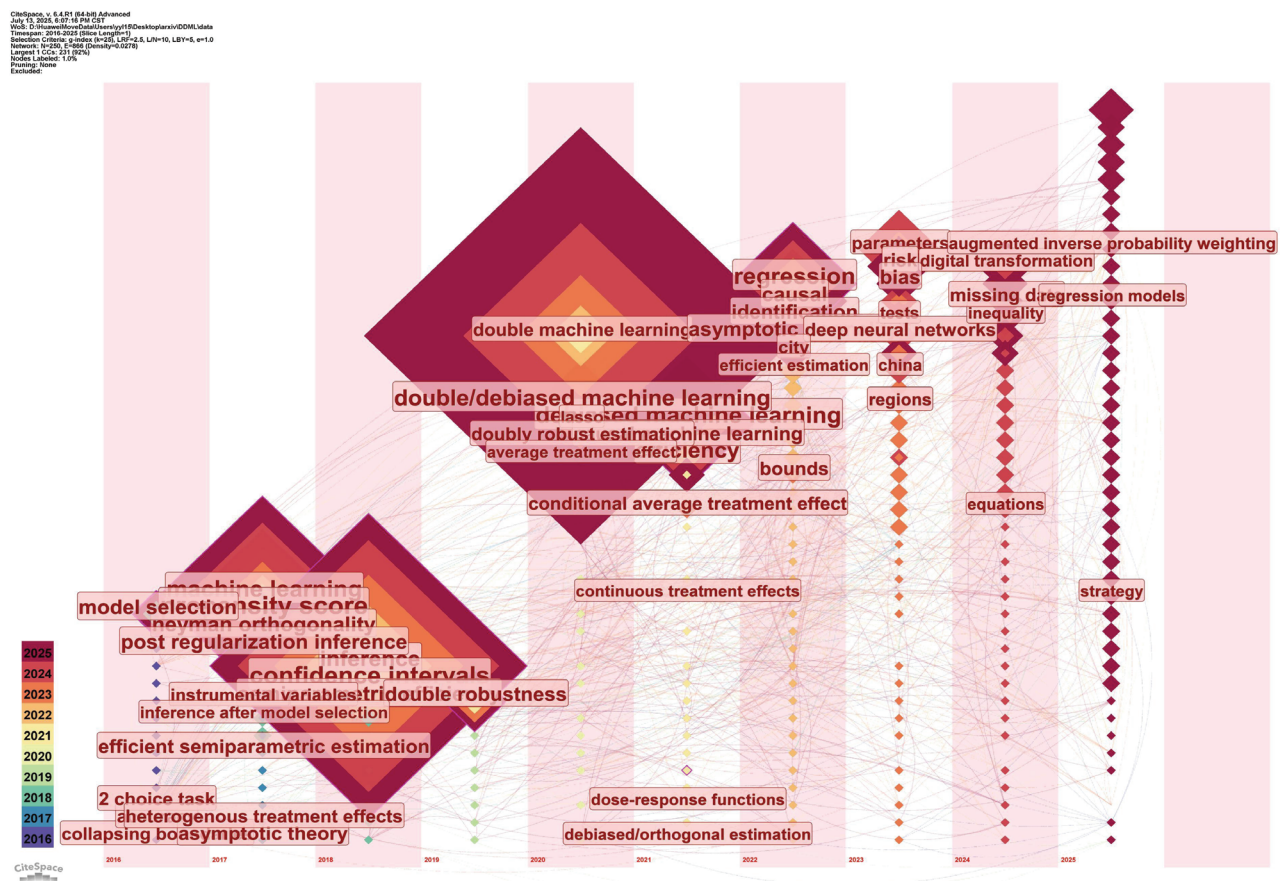


Figure 4 Temporal evolution diagram of keywords related to DDML research



cross-sectional or static, lacking explicit integration with panel designs, staggered treatments, or temporal structures typical of Difference-in-Differences research.^[39] Second, the adoption of ML within causal inference remains primarily focused on prediction-quality improvements rather than structural causal modeling.^[40] There is limited attention to embedding domain-specific identification strategies (e.g., timing, policy eligibility rules, group heterogeneity) within the estimation process. Finally, while DML allows for flexible controls, it does not by itself address the interpretability challenge: the black-box nature of some ML learners can obscure the causal estimand and undermine transparency in applied policy contexts. These challenges underscore the necessity of an integrative approach—one that unifies the structure-driven identification logic of quasi-experimental designs with the data-adaptive capacity of machine learning. The S-DIDML framework proposed in this paper is precisely such an effort. By embedding the Difference-in-Differences design into a DDML architecture, we enable researchers to retain structural interpretability while achieving statistical robustness in high-dimensional, dynamic, and heterogeneous settings.

2.3 Structural Causal Inference Meets Machine Learning: Toward a Unified Framework for Transparent and Scalable Policy Evaluation

The increasing availability of high-dimensional observational data has amplified the need for causal inference methods that are both structurally interpretable and computationally scalable. This has led to a surge in research endeavors at the intersection of structural causal inference and machine learning (ML), with a focus on preserving the clarity of model-based identification strategies while leveraging the flexibility and generalization capabilities of ML algorithms. Conventional econometric models rely heavily on parametric assumptions, while pure machine learning (ML) approaches optimize prediction without providing inference guarantees. In contrast, this hybrid literature aims to formalize data-adaptive structural estimators that are consistent, efficient, and interpretable for policy evaluation. A comprehensive review of 62 high-impact publications (2015–2024) from Web of Science reveals that this integration effort is centered on several converging themes. As demonstrated in the VOSviewer map (Figure 5), the predominant themes encompass causal inference, propensity score matching, double robust estimation, instrumental variables, and generalized random forests, frequently intersecting with applied domains such as healthcare, education, energy policy, and digital platforms. In terms of methodology, big data analytics, deep learning, bias reduction, and heterogeneous treatment effects are frequently mentioned alongside fundamental statistical terms such as efficiency, identification, and confidence intervals. Concurrently, the CiteSpace timeline (Figure 6) underscores three significant phases in the field's intellectual trajectory: an initial predilection for efficient semiparametric estimation (2015–2018), a transition to policy-aware machine learning models (2019–2021), and a recent proliferation of causal machine learning for complex treatment regimes (2022–2024). A prominent line of research focuses on integrating graphical causal models or potential outcomes frameworks into machine learning (ML) pipelines. For instance, Louizos et al. (2017) introduced Causal Effect Variational Autoencoders, which utilize latent variable modeling to disentangle treatment effects from confounding. In their 2017 publication, Shalit et al. put forward a proposal for the use of Counterfactual Regression Networks in the context of learning individualized treatment effects under the condition of a covariate shift. These architectures signify a substantial departure from the conventional black-box prediction paradigm, marking a transition toward model-aware architectures that demonstrate a heightened level of respect for treatment assignment mechanisms. Concurrently, within the econometrics tradition, researchers such as Pearl (2009) and Bareinboim & Pearl (2016) advocate for structural causal diagrams (SCMs) that formalize identification via do-calculus. These diagrams provide a framework for integrating data with domain knowledge to estimate causal parameters under selection bias or mediation. The synthesis of these approaches has resulted in the development of highly effective new estimators. It is noteworthy that generalized random forests (Athey et al., 2019) facilitate the estimation of conditional average treatment effects (CATE) through a partition-based approach. Additionally, causal boosting and meta-learners (e.g., T-learner, X-learner) adapt conventional ensemble learners to optimize policy evaluation tasks. These innovations frequently demonstrate superior performance in terms of bias-variance tradeoffs when confronted with classical regression models, particularly in scenarios where treatment effects exhibit significant heterogeneity and intricate interactions are prevalent. However, this emerging body of literature also reveals significant tensions between structural rigor and algorithmic complexity. First, while machine learning (ML) tools excel at

Figure 5 DDML & DID Co-occurrence Cluster Map of Key Research Terms

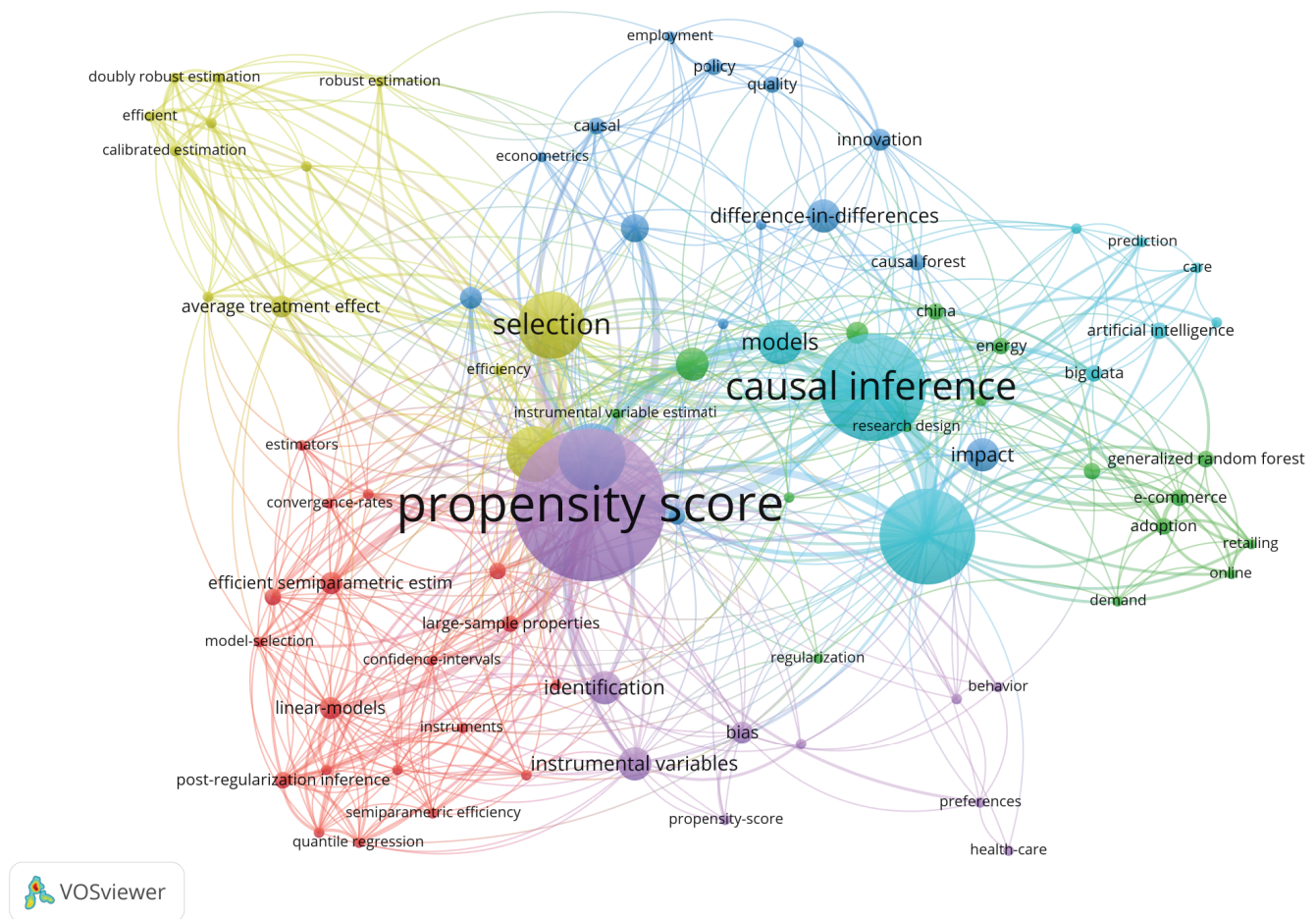
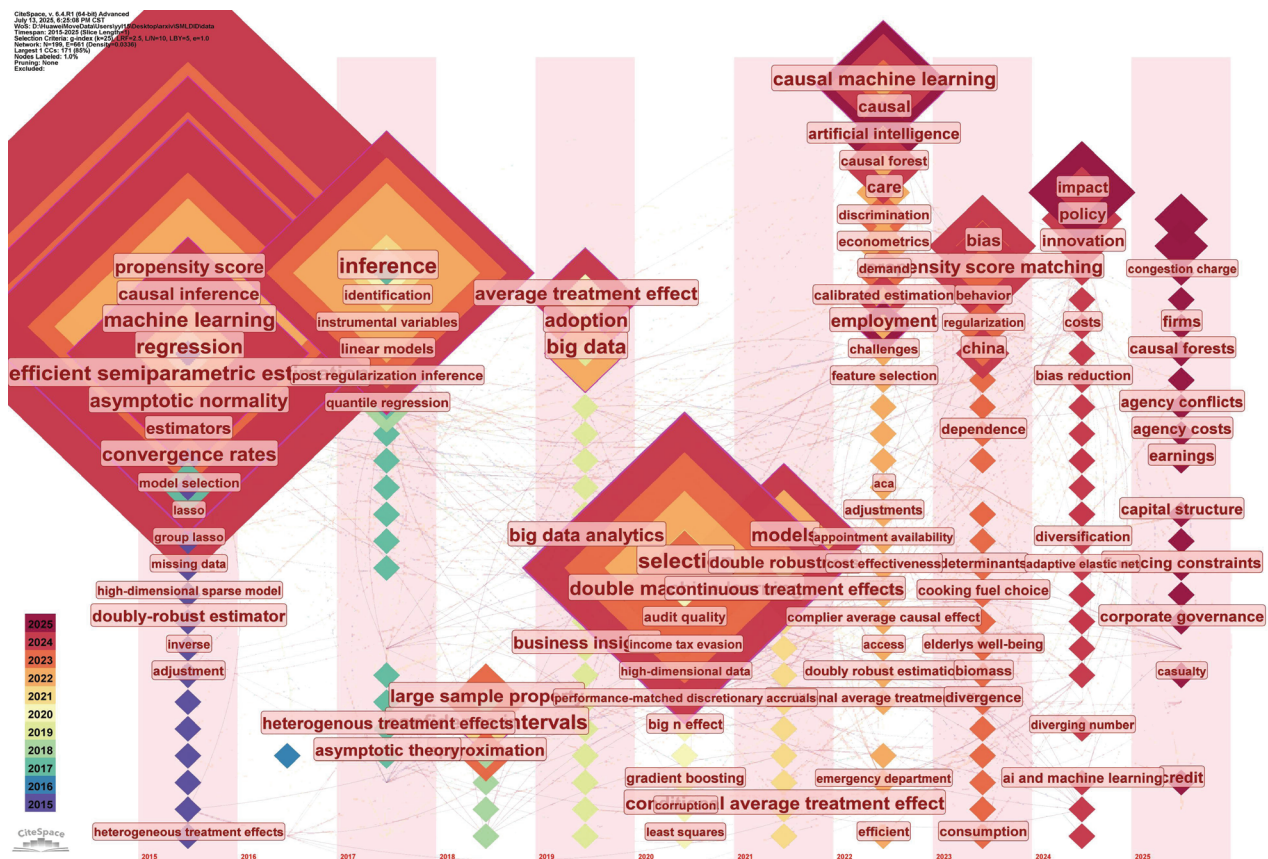


Figure 6 Keyword Temporal Evolution Diagram of DDML&DID Integration Research



approximating nuisance functions, they often lack explicit representation of causal assumptions. This hinders the evaluation of identification strength and the falsification of key assumptions (e.g., unconfoundedness). Secondly, structural models offer transparency and counterfactual interpretability; however, they are computationally fragile in high-dimensional settings, particularly under limited overlap or weak instruments. The absence of a unifying inferential theory further complicates the integration of frequentist inference with black-box learners, particularly in the context of interpreting uncertainty surrounding causal estimates. The proposed S-DIDML framework in this paper addresses these gaps by integrating difference-in-differences identification logic, double machine learning estimation, and domain-aware structural assumptions into a unified design. The model maintains clear identification through the use of parallel trends logic and temporal contrasts, enhancing estimation robustness using orthogonalized residualization and cross-fitting. Additionally, it enables high-dimensional adjustment through the implementation of supervised machine learning. Consequently, S-DIDML makes a significant contribution to the extant literature by offering a transparent, scalable, and statistically valid framework for policy evaluation with heterogeneous effects and complex treatments.

3.Gaps and Research Needs

A brief commentary is provided in the following table 1.

Table 1 Comparison Table of Characteristics of Different Methods

Method category	Core limitations	Performance	References
Machine learning(ML)	Lack of interpretability and structural modeling capability	Black-box models are difficult to interpret causal pathways; lack economic behavioral constraints or theoretical assumptions; and are non-analyzable for decision-making processes.	Breiman (2001); Chernozhukov et al. (2018); Molnar (2022)
Difference-in-Differences (DID)	Unable to handle high-dimensional covariates and complex heterogeneity structures	High-dimensional conditions lead to model instability; Assumptions (such as parallel trends) are difficult to verify; Unable to naturally identify multi-group, multi-time-point heterogeneous effects	Goodman-Bacon (2021); Roth et al. (2022)
Double/Debiased ML (DML/DDML)	Lack of structural embedding and multi-period adaptability	Assuming cross-sectional data is being processed, it is difficult to handle multi-period policies and temporal dynamics; divorced from the context of economic theory, the explanatory power is weak.	Chernozhukov et al. (2018); Imai & Kim (2021); Kennedy (2022)
HTE Estimation	Structural interpretation is lacking, and the mechanism transparency is low.	Causal Forests / Meta-Learners can detect heterogeneity but cannot explain the source of differences; they are prone to producing a “mechanism void” in policy interpretation bias.	Wager & Athey (2018); Künzel et al. (2019); Heckman & Vytlačil (2005)

3.1Machine Learning in Causal Inference: Challenges of Interpretability and Weak Structural Assumptions

Machine learning (ML) techniques have exhibited remarkable success in high-dimensional prediction tasks. However, their application in causal inference is encumbered by fundamental limitations, particularly with regard to interpretability and structural grounding. This tension stems from the fact that the majority of supervised machine learning (ML) algorithms are designed to maximize predictive accuracy rather than to ensure causal identifiability. This phenomenon, as famously articulated by Pearl (2009), is often referred to as “the algorithmization of association, not causation.” A significant challenge is that machine learning (ML) models generally operate under agnostic data-generating assumptions, exhibiting a lack of

a clear mapping to domain-relevant structural models. As Athey and Imbens (2019) emphasize, “machine learning excels at reducing prediction error but often leaves causal structure unspecified,” which means treatment effects may be detected without being explainable in terms of mechanisms, counterfactual logic, or institutional design. To illustrate, while tree-based learners, such as random forests or gradient boosting, are capable of detecting treatment heterogeneity, they lack the capacity to discern whether this heterogeneity is attributable to observed policy variation, unmeasured confounding, or spurious interactions. The absence of structural constraints in machine learning (ML) introduces a secondary risk, which is the impediment of credible identification of causal parameters. In contrast to parametric econometric models, which explicitly encode assumptions such as exclusion restrictions, monotonicity, or sequential ignorability, machine learning (ML) models frequently estimate flexible functions without the use of guiding restrictions. As Louizos et al. (2017) have noted, this can result in high-variance estimators or misleading results, particularly when treatment assignment is non-random or when confounding is only partially observed. Furthermore, when machine learning (ML) is applied in a naive manner in causal contexts, it frequently violates the orthogonality conditions necessary for valid inference, unless careful debiasing or orthogonal score construction is employed (Chernozhukov et al., 2018). Interpretability is a closely related concern. As Kitson (2025) emphasizes, while techniques such as SHAP or LIME offer local approximations for black-box models, they “do not constitute structural explanations of the data-generating process” and cannot substitute for a formal causal model. The dearth of counterfactual semantics and policy-relevant parameters in standard machine learning (ML) frameworks engenders challenges in substantiating findings for regulatory, legal, and institutional decision-making. Collectively, these limitations point to a broader epistemological issue: without structural assumptions, causal statements derived from machine learning (ML) risk being descriptive rather than explanatory. This weakens the scientific value of such analyses, particularly in social science domains that rely heavily on theoretical grounding, historical context, and institutional realism. In order to address these concerns, the extant literature proposes a combination of machine learning (ML) with formal structural inference frameworks, such as Structural Equation Models (SEMs) (Pearl, 2009), structural score functions (Newey & Robins, 2018), or graphical causal modeling (Bareinboim & Pearl, 2016). However, these integrations remain in their infancy and have yet to be widely adopted in empirical work, particularly in policy evaluation with staggered or longitudinal designs.

3.2 Limitations of Classical Difference-in-Differences: Covariate Dimensionality and Identification Fragility

The Difference-in-Differences (DID) framework has become a foundational method in the field of applied econometrics for estimating causal effects from observational panel data. The study’s fundamental appeal stems from its use of an intuitive identification strategy, which involves the comparison of outcome trends between treated and control groups. This approach is predicated on the assumption of parallel trends in the absence of treatment. However, despite its widespread use, recent theoretical and empirical developments have highlighted critical limitations of DID, particularly in the face of high-dimensional covariates, treatment timing heterogeneity, and violations of baseline assumptions. A primary concern pertains to the management of covariates and the issue of model misspecification. In the field of data science and statistics, traditional DID (Diffusion Interrupted Difference) models are typically estimated using two-way fixed effects (TWFE) regression. In this estimation method, control variables are either excluded or incorporated linearly. In practice, this limitation restricts the capacity of DID to adjust for nonlinear, time-varying, or high-dimensional confounders—precisely the kinds of complexities that are prevalent in modern administrative, firm-level, or geospatial data. As Abadie (2005) observed, even moderate deviations from parametric assumptions in the outcome model can result in biased estimates. The magnitude of these risks is amplified under two conditions: first, when the covariate space expands, and second, when interactions between covariates and treatment status are neglected. Furthermore, as demonstrated by Goodman-Bacon (2021), the implementation of TWFE in staggered adoption settings can result in the negative weighting of treatment effects, thereby introducing bias and compromising the interpretability of causal relationships. This phenomenon occurs because the estimator aggregates over comparisons across different timing groups, some of which may act as implicit controls for others. In such cases, the estimate no longer represents a clear causal contrast between treated and untreated units, especially if treatment effects are dynamic or heterogeneous across cohorts. These insights have contributed to the development of more robust DID estimators, such

as those proposed by Callaway and Sant'Anna (2021), which explicitly account for variation in treatment timing and allow for group-time-specific treatment effects. A further challenge lies in the robustness to trend violations. Although DID is often justified by informal graphical checks or pre-trend tests, these approaches suffer from low power and subjective interpretation. Roth (2023) offers a critique of the overreliance on pre-trends as a robustness diagnostic and proposes formal methods to account for uncertainty in parallel trend assumptions. The author demonstrates that even mild violations can substantially alter inference. Furthermore, in numerous policy contexts—including rolling interventions or gradually implemented regulations—the concept of a singular pre-treatment trend is often deemed implausible, necessitating more adaptable and data-driven trend modeling methodologies. The conventional DID framework is inadequate in addressing high-dimensional settings, where the number of potential covariates exceeds the sample size. In such circumstances, linear fixed-effects models may become unstable or inapplicable, and post-hoc covariate balancing or matching procedures may fail due to poor overlap or extreme weights. Attempts to augment the difference-in-difference (DID) method with machine learning for pre-processing (e.g., via propensity score estimation) are often modular rather than integrative. This failure to embed machine learning (ML) into the estimation stage or maintain orthogonality necessary for valid inference has been observed in many cases. While DID remains a powerful identification tool, its classical implementations face substantial limitations in modern empirical settings characterized by high-dimensional data, staggered treatments, heterogeneous effects, and limited trend credibility. These limitations have motivated the development of structurally grounded, machine-learning-enhanced DID frameworks—such as the S-DIDML estimator proposed in this study—that preserve the logic of temporal comparison while enhancing robustness, flexibility, and theoretical coherence.

3.3 Double Machine Learning: Weak Integration with Economic Structure and Limited Temporal Flexibility

Double Machine Learning (DML) has emerged as a powerful framework for causal inference in high-dimensional settings. By leveraging orthogonal moment conditions, sample-splitting, and cross-fitting, DML enables consistent estimation of treatment effects even when nuisance functions (e.g., propensity scores or outcome regressions) are estimated using complex, flexible machine learning methods (Chernozhukov et al., 2018). However, despite its strong statistical foundation, DML remains structurally minimalistic and temporally constrained, making it ill-suited for many empirical contexts encountered in economic policy research. A salient limitation pertains to DML's predilection for cross-sectional or static treatment settings. The majority of DML implementations are developed under the assumption of a single treatment decision per unit. This limitation precludes the application of these methods to scenarios such as multi-period treatments, staggered adoption, or event-time heterogeneity, which are common in education, tax, environmental, or labor policy studies. As Imai and Kim (2021) have demonstrated, the application of DML in panel data contexts can result in biased estimates if the temporal structure of treatment assignment and potential outcomes is not adequately considered. This limitation restricts the applicability of standard DML in real-world settings where treatments unfold over time and responses are dynamic. Additionally, while DML offers flexibility in estimating nuisance functions, it does not inherently ensure structural interpretability. The majority of DML applications are implemented without integrating formal economic assumptions—such as rational behavior, instrumental monotonicity, policy discontinuities, or selection mechanisms—into the estimation architecture. Consequently, DML estimators have the capacity to discern local causal effects, yet they frequently lack a comprehensive explanation of their theoretical underpinnings or their economic ramifications. Heckman and Pinto (2019) contend that such “structure-free” approaches carry the risk of producing effects that are “statistically significant but policy-irrelevant,” particularly in domains that necessitate behavioral modeling or institutional contextualization. The efficacy of DML's inference guarantees is contingent upon the fulfillment of specific orthogonality and rate conditions. However, these conditions may become ineffective in settings characterized by low overlap, intricate treatment interactions, or feedback loops over time. For instance, Kennedy (2022) demonstrates that conventional cross-fitting and orthogonalization procedures may exhibit suboptimal performance when the treatment assignment mechanism itself is endogenous to outcomes (e.g., performance-based subsidies or policy-induced behavioral changes). This further underscores the necessity for structural restrictions to ensure causal stability and policy extrapolation. Another practical challenge lies in embedding DML within quasi-experimental designs,

such as regression discontinuity, instrumental variables, or difference-in-differences frameworks. Recent endeavors have sought to expand the DML framework to encompass instrumental variables (Chernozhukov et al., 2022) and event studies (Roth and Sant'Anna, 2023). However, these approaches remain in their nascent stages and frequently exhibit the ambiguity and opacity characteristic of traditional structural designs. The tension between statistical optimality and domain-specific identification logic remains unresolved. Collectively, these limitations suggest that while DML is a powerful statistical tool, its effectiveness in economic and social science applications depends on its integration with structural frameworks that reflect timing, group heterogeneity, policy rules, and institutional mechanisms. In the absence of such integration, DML faces the potential to evolve into a technically sophisticated yet substantively opaque estimation strategy.

Figure 7 Matrix heatmap estimation diagram of characteristics for various research methods

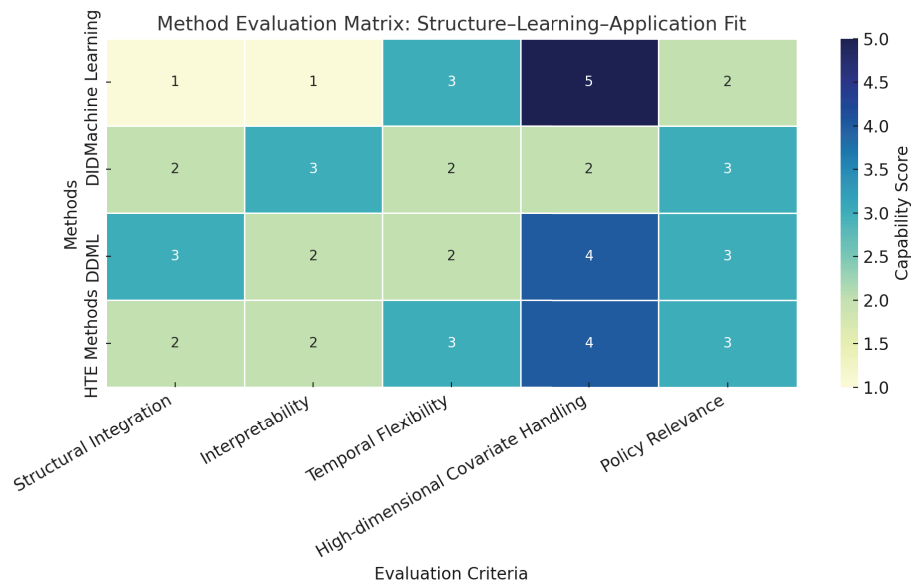
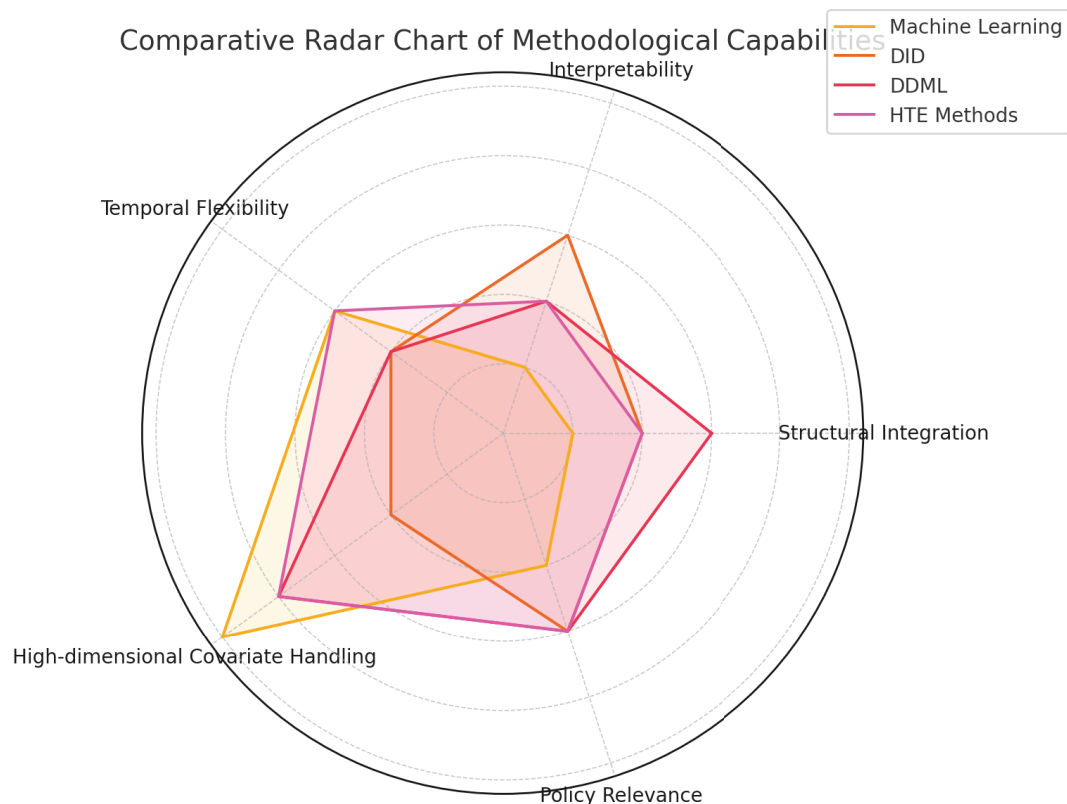


Figure 8 Radar estimation diagram of the characteristics of various research methods



4. The S-DIDML Framework

The S-DIDML framework is constructed as a five-step semiparametric estimation pipeline, designed to combine the temporal identification logic of Difference-in-Differences (DID) with the residualization and orthogonalization principles of Double Machine Learning (DML). This design enables robust causal inference in high-dimensional, staggered-treatment settings while preserving interpretability grounded in structural counterfactual logic.

Step 1: Policy Exposure Encoding and Panel Structuring

The initial step involves transforming raw data into a well-defined panel format. Treatment exposure variables D_{it} are encoded to reflect group-level policy adoption, including information on timing and staggered rollout. Cohort indicators $g(i)$ and time indicators t are constructed, enabling the identification of treatment dynamics across subgroups and time periods. This step reproduces the structural basis of traditional DID under staggered adoption scenarios.

Step 2: High-dimensional Nuisance Estimation via Machine Learning

To control for confounding in high-dimensional settings, flexible machine learning models are used to predict the outcome and treatment assignment based on covariates. Specifically, two nuisance functions are estimated:

$$g(X_{it}) \approx E[Y_{it}|X_{it}], m(X_{it}) \approx E[D_{it}|X_{it}]$$

These models are fitted using cross-fitting to ensure orthogonality and to mitigate overfitting. A wide range of supervised ML methods (e.g., random forests, boosting, neural networks) can be applied at this stage, depending on the structure of X_{it} .

Step 3: Double Residualization of Outcome and Treatment Variables

Following estimation, the observed variables are residualized as follows:

$$\tilde{Y}_{it} = Y_{it} - \hat{g}(X_{it}), \tilde{D}_{it} = D_{it} - \hat{m}(X_{it})$$

This double residualization process yields outcome and treatment variables that are orthogonal to the high-dimensional covariates X_{it} , thereby satisfying the Neyman orthogonality condition necessary for valid second-stage inference.

Step 4: Structural DID Estimation on Residualized Quantities

The core causal effect is estimated by regressing the residualized outcome \tilde{Y}_{it} on the residualized treatment indicator \tilde{D}_{it} , while incorporating group and time fixed effects. This regression preserves the cohort-time structure of DID and allows for dynamic, group-specific treatment effects:

$$\tilde{Y}_{it} = \tau_{g,t} \tilde{D}_{it} + \alpha_g + \lambda_t + \varepsilon_{it}$$

Depending on the empirical setting, estimators such as Callaway–Sant’Anna (2021) or Sun & Abraham (2021) can be employed to estimate average or event-time treatment effects.

Step 5: Aggregation, Uncertainty Quantification, and Robustness Checks

Estimated group-time treatment effects $\tau_{g,t}$ are aggregated into overall ATT or dynamic treatment effect curves. Standard errors are obtained using cross-fitting-compatible variance formulas or nonparametric bootstrap methods. Finally, robustness is assessed via falsification tests (e.g., placebo interventions), checking for pre-trend violations, and assessing overlap conditions.

5. Demonstrative Literature Applications: Where S-DIDML Can Be Used

The S-DIDML framework is not only theoretically robust but also practically versatile. Its design enables immediate adoption in several streams of empirical literature, especially where conventional DID or DDML frameworks face limitations due to high-dimensional covariates, staggered policy timing, or heterogeneity in treatment effects. Below, we outline four thematic domains where S-DIDML can provide substantial improvements in causal identification and inference quality.

5.1 Labor Economics: Evaluating Active Labor Market Policies (ALMPs)

Many ALMP evaluations rely on DID or event-study approaches (e.g., Kluve, 2010; Card et al., 2018), often using limited covariates due to multicollinearity concerns. However, modern administrative labor datasets now include thousands of features (firm size, tenure, dynamic local shocks). S-DIDML allows for robust estimation of heterogeneous effects of job subsidies or training programs across firms, sectors, or worker types, while maintaining structural interpretability of ATT.

5.2 Education Policy: School Reform, Curriculum Changes, and Tracking

Educational reforms (e.g., extending school years, STEM incentives, curriculum realignments) are often evaluated via DID with state or district fixed effects. However, treatment rollout is usually staggered, and student-level data are high-dimensional. By orthogonalizing outcomes with rich baseline test scores, socio-demographics, and parental inputs, S-DIDML enables dynamic treatment effect estimation at both cohort and demographic subgroup levels.

5.3 Fiscal and Tax Policy: Estimating Behavioral Responses with Administrative Tax Data

Tax policy changes (e.g., earned income tax credits, marginal rate changes) exhibit rich staggered designs but require flexible modeling of income dynamics, deductions, and family structure. Traditional regression-based DID models are poorly suited for such settings. S-DIDML accommodates high-dimensional pre-tax characteristics and allows for precise subgroup inference on labor supply elasticities or compliance behavior.

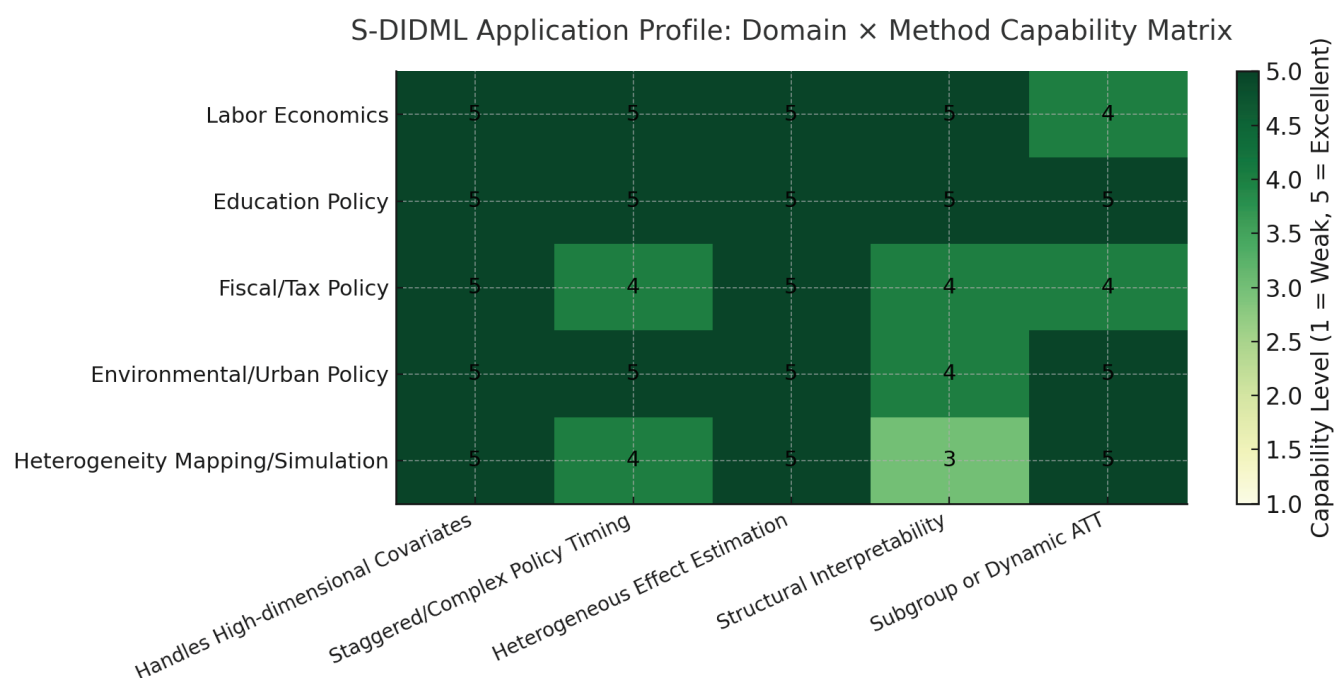
5.4 Environmental and Urban Policy: Evaluating Green Subsidies and Urban Interventions

Many environmental interventions (e.g., subsidies for electric vehicles, zoning regulations, pollution controls) are staggered and differ in intensity across space and time. Treatment heterogeneity is fundamental, and the policy environment is often rich in covariates (weather, geography, firm-level pollution histories). S-DIDML can flexibly estimate subgroup effects (e.g., by income decile or industry), while adjusting for spatial autocorrelation and nonlinearity.

5.5 Opportunities in Heterogeneity Mapping and Welfare Simulation

Beyond direct ATT estimation, S-DIDML can be embedded into policy simulation pipelines, enabling credible counterfactual mapping of treatment gains across the covariate space. For instance, it can assist in identifying which demographic groups benefit most from job guarantees or minimum wage hikes, using machine learning for heterogeneity partitioning while ensuring DID identification integrity.

Figure 9 Matrix heatmap estimation diagram of S-DIDML framework applications across different domains



6. Conclusion

This paper introduces the S-DIDML framework—a structural, semiparametric estimator designed to bridge the interpretability of Difference-in-Differences (DID) methods with the high-dimensional flexibility of Double Machine Learning (DML). In doing so, we aim to provide applied researchers in economics and the social sciences with a unified, theoretically grounded, and computationally feasible approach to estimating heterogeneous treatment effects in staggered policy contexts. We began by identifying a set of unresolved challenges in modern causal inference: the limited interpretability of pure machine learning estimators, the instability of conventional DID methods under high-dimensional controls, and the restricted scope of existing DDML estimators in handling multiple treatment periods or complex policy rollout. Through an extensive literature review

across DID, DDML, and structural ML, we demonstrated the methodological need for an integrated solution. To address these limitations, S-DIDML proposes a five-step estimation pipeline: (1) panel structuring and treatment timing encoding, (2) flexible nuisance estimation using ML, (3) double residualization for Neyman orthogonality, (4) structural DID regression for interpretable group-time effects, and (5) aggregation and robustness analysis. Each step is modular, theoretically motivated, and designed for transparency and scalability. We articulated the framework's principles—structural identification, orthogonality, and semiparametric adaptability—and illustrated its potential across key empirical domains including labor policy, education, taxation, and environmental regulation. Furthermore, we engaged critically with its current limitations, such as reliance on overlap, lack of interference modeling, and the need for unified subgroup inference. These issues mark important frontiers for future research in causal machine learning. S-DIDML is not intended to replace either traditional quasi-experimental methods or deep learning-based prediction tools. Instead, it acts as a conceptual and computational bridge: retaining causal interpretability grounded in economic theory, while leveraging the modeling capacity of modern ML for complex data environments. As empirical researchers face ever-larger datasets and increasingly heterogeneous policy designs, such hybrid frameworks are crucial for producing credible, robust, and policy-relevant insights. We envision S-DIDML not as a fixed model but as a flexible blueprint—one that invites further theoretical refinement, software development, and empirical adaptation. Its goal is not merely to improve estimation, but to foster a new generation of structurally informed, statistically rigorous causal inference in the high-dimensional era.

Funding

This research is supported by the project ‘Path of Government Financial Input Restructuring to Promote High Quality Development of Education’(Project No.2025279)of the Canal Cup Extracurricular Academic Science and Technology Fund for College Students of Zhejiang University of Technology.

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Abadie, A. (2021). Using synthetic controls: Feasibility, data requirements, and methodological aspects. *Journal of Economic Literature*, 59(2), 391–425. <https://doi.org/10.1257/jel.20201405>
- [2] Athey, S., & Imbens, G. (2017). The state of applied econometrics: Causality and policy evaluation. *Journal of Economic Perspectives*, 31(2), 3–32. <https://doi.org/10.1257/jep.31.2.3>
- [3] Callaway, B., & Sant’Anna, P. H. C. (2021). Difference-in-differences with multiple time periods. *Journal of Econometrics*, 225(2), 200–230. <https://doi.org/10.1016/j.jeconom.2020.12.001>
- [4] Sant’Anna, P. H. C., & Zhao, J. (2020). Doubly robust difference-in-differences estimators. *Journal of Econometrics*, 219(1), 101–122. <https://doi.org/10.1016/j.jeconom.2020.06.003>
- [5] Sun, L., & Abraham, S. (2021). Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *Journal of Econometrics*, 225(2), 175–199. <https://doi.org/10.1016/j.jeconom.2020.09.006>
- [6] Chernozhukov, V., et al. (2018). Double/debiased machine learning for treatment and structural parameters. *The Econometrics Journal*, 21(1), C1–C68. <https://doi.org/10.1111/ectj.12097>
- [7] Kennedy, E. H. (2022). Semiparametric theory and empirical processes in causal inference. *Annual Review of Statistics and Its Application*, 9, 151–176. <https://doi.org/10.1146/annurev-statistics-040220-112545>
- [8] Nie, X., & Wager, S. (2021). Quasi-oracle estimation of heterogeneous treatment effects. *Biometrika*, 108(2), 299–319. <https://doi.org/10.1093/biomet/asaa076>
- [9] Imai, K., & Kim, I. S. (2021). When should we use unit fixed effects regression models for causal inference with longitudinal data? *American Journal of Political Science*, 65(2), 448–466. <https://doi.org/10.1111/ajps.12523>
- [10] Roth, J. (2023). Pre-test with care: How to test for parallel trends with multiple groups. *Review of Economics and Statistics*. https://doi.org/10.1162/rest_a_01207
- [11] Angrist, J. D., & Pischke, J.-S. (2009). *Mostly harmless econometrics: An empiricist’s companion*. Princeton University

Press.

- [12] Wooldridge, J. M. (2021). *Introductory Econometrics: A Modern Approach* (7th ed.). Cengage Learning.
- [13] Belloni, A., Chernozhukov, V., & Hansen, C. (2014). Inference on treatment effects after selection among high-dimensional controls. *Review of Economic Studies*, 81(2), 608–650. <https://doi.org/10.1093/restud/rdt044>
- [14] Doudchenko, N., & Imbens, G. (2016). Balancing, regression, difference-in-differences and synthetic control methods: A synthesis. NBER Working Paper No. 22791.
- [15] Borusyak, K., Jaravel, X., & Spiess, J. (2023). Revisiting event study designs. *Econometrica*, 91(1), 65–95. <https://doi.org/10.3982/ecta20695>
- [16] Callaway, B., Goodman-Bacon, A., & Sant’Anna, P. H. C. (2023). Difference-in-differences with a continuous treatment. *Journal of Econometrics*. <https://doi.org/10.1016/j.jeconom.2023.105417>
- [17] Athey, S., Tibshirani, J., & Wager, S. (2019). Generalized random forests. *Annals of Statistics*, 47(2), 1148–1178. <https://doi.org/10.1214/18-AOS1709>
- [18] Künzel, S. R., Sekhon, J. S., Bickel, P. J., & Yu, B. (2019). Metalearners for estimating heterogeneous treatment effects using machine learning. *PNAS*, 116(10), 4156–4165. <https://doi.org/10.1073/pnas.1804597116>
- [19] Hill, J. (2011). Bayesian nonparametric modeling for causal inference. *Journal of Computational and Graphical Statistics*, 20(1), 217–240. <https://doi.org/10.1198/jcgs.2010.08162>
- [20] Imbens, G. W., & Rubin, D. B. (2015). *Causal inference for statistics, social, and biomedical sciences: An introduction*. Cambridge University Press.
- [21] Roth, J., Sant’Anna, P. H. C., Bilinski, A., & Poe, J. (2022). What’s trending in difference-in-differences? NBER Working Paper No. 31506.
- [22] Duflo, E., Glennerster, R., & Kremer, M. (2008). Using randomization in development economics research. *Handbook of Development Economics*, 4, 3895–3962.
- [23] Hastie, T., Tibshirani, R., & Friedman, J. (2009). *The elements of statistical learning* (2nd ed.). Springer.
- [24] Oprescu, M., & Zhu, Y. (2023). Selective machine learning for heterogeneous treatment effect estimation. *Journal of Causal Inference*, 11(1). <https://doi.org/10.1515/jci-2022-0021>
- [25] Wager, S., & Athey, S. (2018). Estimation and inference of heterogeneous treatment effects using random forests. *Journal of the American Statistical Association*, 113(523), 1228–1242. <https://doi.org/10.1080/01621459.2017.1319839>
- [26] Schmidheiny, K., & Siegloch, S. (2019). On event studies and distributed-lags in two-way fixed effects models. IZA Discussion Paper No. 12088.
- [27] de Chaisemartin, C., & D’Haultfœuille, X. (2020). Two-way fixed effects estimators with heterogeneous treatment effects. *American Economic Review*, 110(9), 2964–2996. <https://doi.org/10.1257/aer.20181169>
- [28] Xu, Y. (2017). Generalized synthetic control method: Causal inference with interactive fixed effects models. *Political Analysis*, 25(1), 57–76. <https://doi.org/10.1017/pan.2016.2>
- [29] Kasy, M., & Sautmann, A. (2021). Adaptive treatment assignment in experiments for policy choice. *Econometrica*, 89(1), 113–132. <https://doi.org/10.3982/ECTA17443>
- [30] Ben-Michael, E., Feller, A., & Rothstein, J. (2021). The augmented synthetic control method. *Journal of the American Statistical Association*, 116(536), 1789–1803. <https://doi.org/10.1080/01621459.2021.1929245>
- [31] Hazlett, C. (2020). Regression discontinuity and heteroskedasticity. *Political Science Research and Methods*, 8(3), 551–566.
- [32] Varian, H. R. (2014). Big data: New tricks for econometrics. *Journal of Economic Perspectives*, 28(2), 3–28.
- [33] Breiman, L. (2001). Statistical modeling: The two cultures. *Statistical Science*, 16(3), 199–231.
- [34] Knaus, M. C., Lechner, M., & Strittmatter, A. (2021). Machine learning estimation of heterogeneous labor market impacts of COVID-19 policies. *Labour Economics*, 72, 102054. <https://doi.org/10.1016/j.labeco.2021.102054>
- [35] Bryan, G., Karlan, D., & Nelson, S. (2021). Commitment devices. *Annual Review of Economics*, 13, 561–583. <https://doi.org/10.1146/annurev-economics-082420-112136>

- [36] Rubin, D. B. (1974). Estimating causal effects of treatments in randomized and nonrandomized studies. *Journal of Educational Psychology*, 66(5), 688–701.
- [37] Heckman, J. J., & Vytlačil, E. (2007). Econometric evaluation of social programs, part I: Causal models, structural models and econometric policy evaluation. *Handbook of Econometrics*, 6, 4779–4874.
- [38] Pearl, J. (2009). *Causality: Models, reasoning, and inference* (2nd ed.). Cambridge University Press.
- [39] Heckman, J. J., Pinto, R., & Savelyev, P. A. (2013). Understanding the mechanisms through which an influential early childhood program boosted adult outcomes. *American Economic Review*, 103(6), 2052–2086.
- [40] Imbens, G. W. (2020). Potential outcome and directed acyclic graphs: An overview. *AEA Papers and Proceedings*, 110, 358–361. <https://doi.org/10.1257/pandp.20201008>

A Concise Algorithm for Calculating the Number of Microstates in a Bose System

Chuan Shi*, Jun Wen

Shu Li Yu Tong Ji Xue Yuan, Sichuan Minzu College, Kangding, Sichuan, 626001, China

*Corresponding author: Chuan Shi, 2239409663@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: By introducing a model of “small balls separated by boards”, this paper transforms the method for solving the number of microstates of a Bose system and presents an algorithm that is more concise than the one provided in textbooks. Studies have shown that “Thermodynamics·Statistical Physics” is a relatively difficult specialized course; learners often encounter concepts that are hard to understand and complex calculations during their study. However, the calculation method for the number of microstates of a Bose system presented in Wang Zhicheng’s book is not concise enough and tends to raise questions among students. Through analysis, this paper points out the shortcomings of the calculation method in Wang Zhicheng’s book. By elaborating on the concise algorithm proposed by the authors, it clearly demonstrates that this algorithm makes the calculation process of the number of microstates of a Bose system more intuitive and can avoid some doubts existing in textbooks. Finally, the physical connotation of the number of microstates of the Bose system can also be clearly observed through our algorithm.

Keywords: Thermodynamic and Statistical Physics; Number of Microstates; Boltzmann System

Published: Sept 22, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.597>

1.Introduction

In the study of Statistical Physics, distribution and microstates are difficult points for students. It is very important to understand and master the derivation method of the number of microstates. However, in the actual teaching process, some students think that the calculation process of the number of microstates of the Bose system in Wang Zhicheng’s book “Thermodynamics·Statistical Physics” is difficult to understand^[1], and there are several doubtful points that need to be clarified. Therefore, it is necessary to propose a more concise method for calculating the number of microstates of the Bose system. As early as 1997, someone proposed a method for calculating the number of microstates of a classical system different from that in textbooks^[2]. In 2003, Song Weicai used the metaphor of “people checking into a hotel” to understand the calculation of the number of microstates of the Bose system in textbooks and provided an explanation for the unreasonable parts of the algorithm in textbooks^[3]. In 2019, Lan Shanquan proposed two different algorithms for the distributions of the three systems, but they were still not concise enough^[4]. In 2025, Li Yuanchang et al. solved the problem of the thermodynamic probability of N gas molecules distributed in the left and right halves of a rectangular container and quantitatively verified Boltzmann’s statistical explanation of the microscopic nature of the second law of thermodynamics^[5]. These works reflect the importance of solving the number of microstates of the system^{[6][7]}. On this basis, we propose a concise and intuitive method for calculating the number of microstates of the Bose system based on previous studies^[8].

2. The classical method for calculating the number of microstates of a Bose system

First, it is necessary to calculate the number of possible ways for a_l particles to occupy ω_l quantum states at the energy level ϵ_l . Use ①, ②, ... to represent each quantum state, and \circ to represent each particle. Arrange them in a row, with the leftmost position fixed as quantum state ①. Since there are a total of $\omega_l + a_l - 1$ quantum states and particles except quantum state ①, there are $(\omega_l + a_l - 1)!$ ways to arrange them. Then, divide by the number of mutual exchanges between all particles $a_l!$ and the number of mutual exchanges between quantum states $(\omega_l - 1)!$, so there are $(\omega_l + a_l - 1)!/[a_l!(\omega_l - 1)!]$ possible ways. Multiply the results of each energy level, and the number of microstates corresponding to the distribution $\{a_l\}$ of the Bose system is obtained [1]

$$\Omega_{B.E} = \prod_l \frac{(\omega_l + a_l - 1)!}{a_l!(\omega_l - 1)!}$$

Although the above conclusion appears in textbooks, there are several doubtful points that need to be clarified: (1). Why should the number of arrangements be divided by the number of mutual exchanges between quantum states $(\omega_l - 1)!$? If the arrangement remains the same after the exchange of quantum states, does it mean that each quantum state at the same energy level is indistinguishable? Is this contradictory to the assumption that the degeneracy is ω_l ? 2. The number of arrangements of ω_l quantum states should also be $\omega_l!$ instead of $(\omega_l - 1)!$. The explanation in the book is that the leftmost position is fixed as quantum state ①, but what is the reason? No explanation is given in the textbook. The above problems easily cause doubts among students, so is there a better method to solve this problem?

3. A Concise Algorithm

Consider a_l identical particles occupying ω_l quantum states at the energy level ϵ_l . For ease of understanding, we can model this as placing a_l indistinguishable small balls into ω_l boxes and arranging them in a row, where each such arrangement represents a way of particles occupying each quantum state. For example, the arrangement in Figure 1 shows that 1 particle is occupied on quantum state 1, 3 particles on quantum state 2, and 2 particles on quantum state 3. Since there is no limit to the number of particles occupying a single quantum state in a Bose system, there is no limit to the relative values of a_l and ω_l . In this model, there is also no limit to the number of small balls in each box. To eliminate the influence of exchanging boxes (quantum states) on the arrangement of this problem, we equate the model to using $\omega_l - 1$ boards to separate a_l small balls. This is because $\omega_l - 1$ boards are needed to divide the small balls into ω_l groups (Figure 2). Similarly, the arrangement in Figure 2 shows that 1 particle is occupied on quantum state 1, 3 particles on quantum state 2, and 2 particles on quantum state 3. Therefore, Figure 1 and Figure 2 represent equivalent problems. Now let's look at Figure 2: even if the boards are exchanged, it will not affect the distribution of small balls in each corresponding quantum state. In other words, although the ω_l quantum states at the energy level ϵ_l are not identical, the boards separating these quantum states in this model can be regarded as identical. This is because whether the partitions are the same or not does not affect the grouping of small balls; the partitions only serve to make the grouping clearer.

Figure1: particle occupying on quantum state

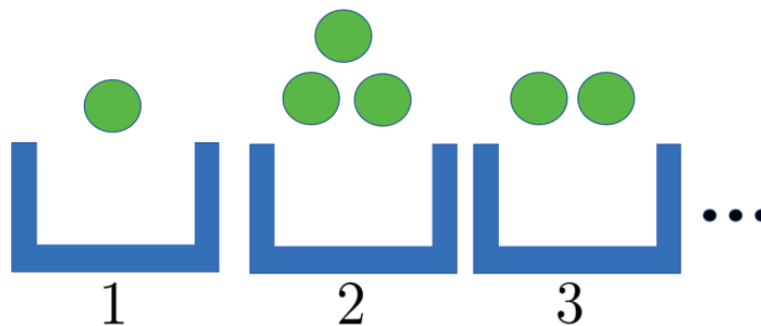
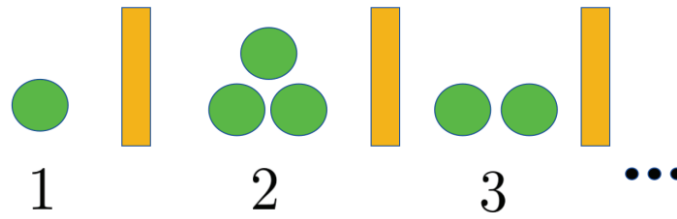


Figure2: our equivalengt model



Next, this model can be used to directly calculate the number of microstates of the Bose distribution. Number the a_l small balls as $1, 2, 3, \dots, a_l$, and number the $\omega_l - 1$ boards as $1, 2, 3, \dots, \omega_l - 1$. Then arrange them in a row. Exchanging the relative positions of the partitions and the small balls is equivalent to rearranging the system composed of the small balls and the boards. Thus, the total number of small balls plus boards (the number of particles plus the number of quantum states) is $a_l + \omega_l - 1$, and there are $(\omega_l + a_l - 1)!$ ways to arrange them. Since the small balls are completely identical (particles in a Bose system are indistinguishable), we should also divide by the number of mutual exchanges between the small balls (particles) $a_l!$ and the number of mutual exchanges between the boards $(\omega_l - 1)!$ (obviously, exchanging the boards will not change the distribution of particles in different quantum states). Therefore, there are $(\omega_l + a_l - 1)! / [a_l!(\omega_l - 1)!]$ possible ways for a_l particles to occupy ω_l quantum states at the energy level ϵ_l . Similarly, since this is the arrangement method for one energy level, the results of each energy level are finally multiplied. Therefore, the number of microstates corresponding to the distribution $\{a_l\}$ of the Bose system is calculated as follows

$$\Omega_{B.E} = \prod_l \frac{(\omega_l + a_l - 1)!}{a_l!(\omega_l - 1)!}$$

This calculation result is consistent with the result in Wang Zhicheng's book, but it is more concise and will not cause misunderstandings among readers.

4. Discussion

By introducing the model of “inserting boards among small balls”, we propose a completely new method for calculating the number of microstates of a Bose system. This method can avoid the problems existing in the method from Wang Zhicheng's textbook, such as:

The textbook does not clearly state whether the quantum states at the same energy level are indistinguishable. This premise is of great importance. If the quantum states are distinguishable, the calculation result does not need to be divided by the number of mutual exchanges between quantum states, which contradicts the calculation result in the textbook; if the quantum states are indistinguishable, this is inconsistent with the basic assumption of the Bose system (that quantum states are distinguishable). However, in our algorithm, the boards that separate these quantum states can be regarded as identical, and exchanging the boards will not affect the distribution of small balls in each corresponding quantum state, thus avoiding this problem.

2. The textbook does not provide a reason for fixing the leftmost end of the arrangement as quantum state ①. Based on this, the textbook gives the arrangement of the remaining quantum states as $(\omega_l - 1)!$, and this process is very forced and unconvincing. Our algorithm exactly requires using $\omega_l - 1$ boards to separate a_l small balls (because dividing a_l small balls into ω_l groups requires $\omega_l - 1$ boards), and the arrangement of $\omega_l - 1$ boards is exactly $(\omega_l - 1)!$ with no contradictions.

Conclusion

By introducing the “boards inserting into small balls” model, we propose a new calculation method that can well avoid these problems. This method is not only simple in the calculation process but also helps teachers and students better understand the physical connotation of the Bose distribution. In conclusion, by introducing the model of inserting boards among small balls to replace the original arrangement, we propose a completely new and concise algorithm for calculating the number of

microstates of a Bose system. Compared with the algorithm in the textbook, our algorithm avoids the confusion caused by directly arranging particles and quantum states. Furthermore, it has the advantages of a simple calculation process and easier understanding. We have reason to believe that mastering this algorithm can help teachers and students better understand the physical connotation of the Bose distribution.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Wang, Z. C. (2013). Thermodynamics and statistical physics. Higher Education Press.
- [2] Sun, J. J. (1997). Supplementary notes on the calculation method of microstate number. *Journal of Shenyang Normal University Educational Science Edition*, (5), 25-26.
- [3] Song, W. C. (2003). Microstate number of Bose systems. *Guangxi Physics*, (3), 35-36.
- [4] Lan, S. Q. (2019). Algorithms for calculating microstate numbers in thermodynamics and statistical physics. *Journal of Chifeng University (Natural Science Edition)*, 35(11), 31-32. <https://doi.org/10.13398/j.cnki.issn1673-260x.2019.11.011>
- [5] Li, Y. C., Liu, Y. L., Liu, P., Lü, Y. J., & Li, J. G. (2025). Strict proof of Boltzmann's microscopic interpretation of the second law of thermodynamics using Stirling's formula. *College Physics*, 44(2), 45-50. <https://doi.org/10.16854/j.cnki.1000-0712.240395>
- [6] Gao, Y. C. (2010). A brief discussion on the simple statistics of Boltzmann, Fermi, and Bose systems. *Public Communication of Science & Technology*, (23), 139-140.
- [7] Hao, A. M., & Lu, T. H. (2023). Study on deriving the microstate number of identical particle systems using combinations. *Journal of Baicheng Normal University*, 37(2), 110-114.
- [8] Hou, J. X. (2022). Is the small-particle correction for the most probable distribution necessary? *College Physics*, 41(12), 1-3, 7. <https://doi.org/10.16854/j.cnki.1000-0712.220272>

A Study on Ethnic Identity and National Identity in “Sui Feng Piao San”

Chuan Shi¹, Xiaoyu Chen²

1. Shu Li Yu Tong Ji Xue Yuan, Sichuan Minzu College, Kangding, Sichuan, 626001, China

2. Sichuan Minzu College, Kangding, Sichuan, 626001, China

*Corresponding author: Chuan Shi, 2239409663@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In previous studies on ethnic minorities, there has been insufficient exploration of the correlation between ethnic identity and national identity. To address this gap, this paper adopts the method of textual analysis on Alai's novel “Sui Feng Piao San” and proposes a three-stage model of “ethnic group - nation” dual composite identity. The study finds that the ethnic identity of the characters in Alai's works exhibits the characteristic of dynamic reconstruction, while being influenced by both the traditional culture of their own ethnic group and national ideology. Furthermore, the characters in the novel have unique paths of identity construction. The research findings on contemporary ethnic minority literature further confirm this point. Finally, the results of this study can provide a brand-new perspective for subsequent research on Alai.

Keywords: Group Ideology; National Ideology; Alai

Published: Oct 12, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.631>

1. Introduction

1.1 Research Background and Significance

Alai is a well-known ethnic minority writer. His full-length novel “Chen'ai Luoding” is the first work in the history of Tibetan literature to win the Mao Dun Literature Prize, breaking the long-standing limitation of Tibetan literature to regional narratives. Meanwhile, Alai is also a writer who possesses both a sense of ethnic cultural identity, modern national identity, and state consciousness. After winning the prize, he created works such as “Sui Feng Piao San”, “Zhandui”, and “Mogu Quan”, covering various genres including novels and non-fiction works ^[1]. Among these, “Sui Feng Piao San” is set in Tibetan areas and reflects the identity issue of “the symbiosis of ethnic identity and national identity” during the period of ethnic cultural transformation through the survival stories of grassroots individuals, providing a typical textual sample for the study of ethnic identity.

Ethnic identity and national identity have been important theories in the research on ethnic minorities in recent years, and ethnic identity exerts a profound impact on national identity. Guo Lishuang points out that dislocations and contradictions may arise between national identity and ethnic identity. Particularly in multi-ethnic countries during the social transformation period, if planned identity and resistant identity play a dominant role in society, they will challenge the previous legitimate identity—namely, challenging the legitimacy of the original national identity ^[2].

The “deconstruction and reconstruction of identity” in ethnic minority literature is a current hotspot in academic research. However, most existing studies only focus on the interpretation of ethnic identity; even research on Alai has fallen into

interpretive frameworks such as “Tibetan area writing” and “Tibetan civilization identity,” which overshadow the significance of his literary creation for the construction of the connotation of the Chinese nation community^[3]. Fortunately, Alai’s works embody the value pursuit of the diversity of Chinese culture, and his literary creation is of great significance to the construction of the connotation of the Chinese nation community. This paper will study Alai’s novel “Sui Feng Piao San” to explore the in-depth connections between individuals, ethnic culture, and the national community, thereby making up for the deficiencies in existing research.

1.2 Review of Research Status

In a letter to Yi Wenxiang, Alai once stated that he intended to write a full-length novel titled “Gela’s Growth”. Although this full-length novel has not been published to date, we have “Sui Feng Piao San”, whose protagonist is exactly Gela^[4]. The novel mainly centers on the conflicts between Gela and his mother and the external world, presenting the unavoidable pain and disasters faced by individuals in society. There are two layers of society on which Gela and his mother depend for survival: one is Jicun Village, and the other is the world outside Jicun Village, i.e., the new society at that time. These two layers of the external world simultaneously surround and put pressure on Gela and his mother^[5]. Wang Rong argues that Alai roots his literary practice in the land of the Jiarong Tibetan area, and his creations highlight a strong sense of locality and the principle of integration^[1]. Alai is a writer with a sense of ethnic cultural identity, modern national identity, and state consciousness. His choice of “non-mother-tongue writing” style, the expression of national concepts, as well as the specific details and plot settings in his novel narratives, fully demonstrate his awareness of national identity and sense of responsibility to safeguard the national community^[6]. Alai’s choice to deny rather than nostalgia for the feudal serfdom in Tibetan areas reflects his rationality and democratic thoughts^[7]. However, current research still lacks in-depth discussions on the “interactive relationship between ethnic identity and national identity” in “Sui Feng Piao San”.

1.3 Research Methods

This study adopts a threefold approach of “theoretical construction - textual verification - material support.” Based on theories related to ethnic identity and national identity, combined with close reading and cultural research methods, it realizes in-depth integration of theories, texts, and documentary materials. By in-depth interpreting Alai’s novel “Sui Feng Piao San”, integrating ethnic identity theory with research on national identity, this study aims to improve the dual-perspective identity research path of “ethnic group - nation” in ethnic minority literature. From the perspective of literary research, it also provides a reference basis for the inheritance of ethnic culture in contemporary Tibetan areas, the coordinated development of ethnic identity and national identity, and the integration of ethnic cultures.

1.4 Research Objectives

- 1) Theoretical Objective: Integrate ethnic identity theory with research on national identity, and improve the dual-perspective identity research path of “ethnic group - nation” in ethnic minority literature.
- 2) Practical Objective: From the perspective of literary research, provide a reference basis for the inheritance of ethnic culture in contemporary Tibetan areas, the coordinated development of ethnic identity and national identity, and the integration of ethnic cultures.
- 3) Innovative Objective: In-depth analyze the identity dilemmas of grassroots individuals in Tibetan areas amid cultural changes and national development, and reveal the symbiotic logic between ethnic identity and national identity.

2. Theoretical Construction of Ethnic Identity

2.1 Definition of Core Concepts: The Relationship between Ethnic Identity and National Identity

Ethnic Identity The famous British scholar Bronisław Malinowski extended the concept of “ethnic identity” from the term “identity” in the field of ethnology. He believed that an ethnic group or ethnic community consists of a group of people who share the same culture and recognize each other. Ethnic identity also includes four elements: group consciousness, group cognition, attitude, behavior, and sense of belonging. It refers to an individual’s recognition of their own ethnic identity and expresses the individual’s attitude and beliefs towards their ethnic group^[8]. Ethnic identity is the core of the inherent soul of an ethnic group, which is gradually formed in the long-term social changes and historical development. Since no ethnic group can develop without ethnic identity, its connotation is not static^[9].

National Identity National identity refers to the sense of belonging and recognition of members of a country towards the politics, economy, culture, and other aspects of the country to which they belong. It implies that national identity is an elevation of ethnic identity and cultural identity. Existing studies on the definition of “national identity” can be divided into two categories: the first category, from a functional perspective, holds that national identity is a kind of identity consciousness in which an individual belongs to a certain country and has relevant connections with other people in that country; the second category, from a content perspective, argues that national identity is a comprehensive identity confirmation from two dimensions, namely the cultural dimension and the political dimension^[9]. National identity includes an individual’s confirmation of the community to which they belong and has political attributes.

Now we introduce the Interactive Relationship between the Two in Alai’s Novels. In Alai’s view, China is an integrated multi-ethnic national community, a “republic composed of diverse cultures and multiple ethnic groups”^[10], and the Tibetan ethnic group is a member of this cultural community that is larger than an ethnic group. He once said, “Even ethnic minorities do not live an alternative life”^[11]. In Alai’s novels, he often depicts (ethnic) minorities and the nation as a community with a shared future: under his pen, the past history of the Jiarong Tibetan area is always closely linked to the vicissitudes of the nation^[6]. Therefore, in Alai’s novels, ethnic identity and national identity present a relationship of “symbiosis and mutual construction”: ethnic identity is the cultural foundation of national identity, while national identity provides political and developmental guarantees for ethnic identity.

2.2 Dynamic Evolution Logic

By interpreting Alai’s novels, this study proposes a three-stage model of “ethnic group - nation” dual composite identity. The first stage is the “static symbiosis stage”. In the “traditional ethnic society,” individuals form ethnic identity through the cultural inheritance of families and communities; at the same time, they form a simple national identity based on the “national sovereignty subordination relationship” (such as the dependence of chieftains on the central government, as reflected in Zeng Lijun’s discussion on the national identity of the Maiqi Chieftain in “Red Poppies”)^[6]. The two identities are mainly characterized by “stable symbiosis” (for example, the elderly in Jicun Village recognize both their Tibetan identity and their identity as citizens of the nation)^[12].

The second stage is the “conflict adjustment stage”. Changes in the external context, such as the in-depth integration of Han and Tibetan cultures and national institutional reforms, break the original balance of identity. Individuals experience identity confusion due to “cultural differences” and “the tension between ethnic traditions and national development” (such as Enbo’s sense of alienation from ethnic culture and the external world^[12]). They need to resolve conflicts through “active adjustment” (accepting national systems) to achieve the coordination between ethnic identity and national identity.

The third stage is the “integration and elevation stage”. In the coordinated development of the “ethnic group-nation” individuals form a dual composite identity of “ethnic cultural confidence plus firm national identity”—they not only adhere to the foundation of ethnic culture (such as safeguarding Tibetan customs and beliefs) but also actively integrate into national development (such as participating in modernization drive and safeguarding national unity), embodying the “openness” and “integrity” of identity. This is consistent with Zeng Lijun’s statement that “Alai reveals the interconnected and symbiotic state of the destinies of the ethnic group and the nation”^[6].

3. Findings and Discussions

3.1 Research Findings: Interpretation of “Sui Feng Piao San” Based on the Theoretical Framework

By combining the theory of ethnic identity with the framework of national identity and conducting a textual analysis of “Sui Feng Piao San”, this study finds that: against the background of modernization and cultural collision, the ethnic identity of the characters in the work presents the characteristics of dynamic reconstruction—they not only retain their attachment to the traditional culture, religious beliefs, and lifestyle of their own ethnic group but also inevitably encounter the impact of external culture and the influence of national ideology. At the same time, the infiltration of national identity, through means such as education and policies, engages in dialogue and integration with ethnic identity at the individual consciousness level, enabling the characters to explore a unique path of identity construction amid the tension between tradition and modernity, and between locality and the nation. The research results on contemporary Tibetan literature further confirm the complexity

and symbiosis of this dual identity, providing new theoretical support and case basis for understanding identity construction in ethnic minority literature.

3.2 Discussions

(1) Gela: Identity Awakening and Integration in the Trajectory of Individual Life

As the vibrant core character in the novel, Gela's growth process profoundly demonstrates the interweaving of ethnic identity and national identity. Gela was originally an uncivilized child growing up in Jicun Village: "He spent his days bustling about in the forests, tracking the footprints of various animals and skillfully setting all kinds of deadly traps. He had almost become a wild person himself. Every day, he only watched people bustle about from the gaps between the trees"^[12]. Nurtured in the natural and cultural environment of the Jiarong Tibetan area, the language, customs, and beliefs of the Tibetan ethnic group became the foundation of his life, and he had a strong sense of ethnic identity. However, his thoughts began to change in the process of contacting the outside world. For example, when Gela walked out of Jicun Village again: "Gela ran outside the town, slowed down, and with a cunning smile on his face, began to enjoy the things he had just obtained. This Gela was different from the one who stayed motionless in Jicun Village. On the road, the Gela with rich wandering experience was back again. Or rather, the Gela who had grown tired of staying in Jicun Village once again felt the most pleasant aspect of a wandering life"^[12]. "Gela would definitely keep walking like this and never return to the narrow, poor Jicun Village that clouded people's minds"^[12]. At the same time, as Gela grew up and gradually contacted the outside world, he also began to have doubts about the Tibetan ethnic group and the customs and beliefs of Jicun Village: "Gela lay on the ground, surrounded by extreme silence. At that moment, he really wanted to believe that there were flower goblins in this world. But at the same time, he knew that such beautiful mysteries could not exist in this world at all. A world that people were reluctant to live in would not be inhabited by immortals; since goblins had boundless powers, they presumably would not be willing to live here either"^[12]. Gela's dynamic balance and active integration between the two identities embody the symbiotic logic of ethnic and national identity at the individual level.

(2) Enbo: Identity Persistence and Adjustment of a Traditional Guardian

As a steadfast guardian of traditional Tibetan culture, Enbo's daily life and behavioral choices fully demonstrate his profound identification with his ethnic identity: "In his youth, Enbo became a monk under his uncle Jiangcun Gongbu, who was a lama at Wanxiang Temple. In 1956 of the new calendar, he was forced by the government to return to secular life together with Jiangcun Gongbu. He was one of the few people in the village who could read and write. The only person more knowledgeable than him was Lama Jiangcun Gongbu"^[12]. "Enbo was once a monk and believed in fate. He believed that the firecracker was not intentionally thrown by Gela. If Gela had really thrown it, it must have been the mysterious power in the dark that made him do so"^[12]. Even years after returning to secular life, Enbo still maintained his reverence for and guardianship of traditional culture and religious beliefs: "After the rabbit recovered from its illness, Enbo and his family all felt a heavy weight in their hearts. Enbo was once a monk; if it were not for the compelling situation, he would still be devoting himself to Buddhism in the temple"^[12]. He abided by the ancient customs of the Tibetan area, adhered to the traditional production and lifestyle, and held a devout respect and sense of mission to inherit his own ethnic culture. However, Enbo was not conservative and rigid. After his son passed away, Enbo and his wife Le'er Jincuo did not indulge in excessive grief but instead adopted a positive and optimistic attitude towards life: "In Jicun Village, indifference and suspicion between people constituted the main theme of life. Therefore, the overly affectionate relationship between this couple made them outliers. But they had made up their minds to live a good life regardless of others' opinions"^[12]. During the labor in the production team, Enbo also gradually transformed from initial resistance to an optimistic and accepting attitude: "The Enbo who was a monk was dying day by day in his heart, while the Enbo who strived for secular survival was growing day by day." It can be seen that Enbo's attitude of active adjustment while adhering to traditions demonstrates the mutually promoting relationship between ethnic identity and national identity.

Conclusion

The Tibetan ethnic identity in "Sui Feng Piao San" does not exist in isolation but forms a relationship of "symbiosis and mutual construction" with national identity—ethnic identity is based on the culture of Tibetan areas, while national identity

takes the “community with a shared future” as its core, and the two evolve dynamically in the interaction between individual experience and external context. Through his novel writing, Alai not only highlights the unique value of ethnic culture but also conveys a sense of responsibility to safeguard the national community. This writing of the “ethnic group - nation” dual composite identity provides important references for the identity narrative in ethnic minority literature and the development of contemporary nation-states.

Funding

This research was supported by the Kangba Culture Research Center of Sichuan Minzu College under the project titled “A Study on the Representation and Construction of the Sense of Community for the Chinese Nation in Contemporary Minority Literature from the Perspective of Alai’s Novels” (Project No. KBFH2513).

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Wang, R. (2022). On ethnic expression and cross-ethnic imagination in Alai’s literary creation. *Journal of Literary Theory and Criticism*, (01), 134-143. <https://doi.org/10.16532/j.cnki.1002-9583.2022.01.012>
- [2] Guo, L. S., & Fu, C. Y. (2016). Dissolution and reconstruction: The challenges of supranationalism, cultural community and ethnic identity to national identity. *Foreign Social Sciences*, (04), 37-45.
- [3] Li, C. Z. (2021). Alai’s literary path and the consciousness of the Chinese nation community. *Literary Review*, (04), 140-149.
- [4] Chen, Z. J. (2005). Drifting and remaining: An interpretation of Alai’s new work “Sui Feng Piao San”. *Southern Cultural Forum*, (03), 53-57.
- [5] Huang, S. G. (2005). Historical dust and individual pain: A review of Alai’s recent work “Sui Feng Piao San”. *Studies of Ethnic Literature*, (04), 94-97.
- [6] Zeng, L. J. (2019). On the national identity and its significance in Alai’s novel creation. *Guizhou Social Sciences*, (08), 17-22. <https://doi.org/10.13713/j.cnki.cssci.2019.08.003>
- [7] Tang, H. M. (2008). On identity in Alai’s “Red Poppies”. *Journal of South-Central Minzu University (Humanities and Social Sciences Edition)*, (03), 167-170. <https://doi.org/10.19898/j.cnki.42-1704/c.2008.03.035>
- [8] Guo, Q. G. (2011). *An Introduction to Communication*. Beijing: China Renmin University Press.
- [9] Liu, L. L. (2023). Study on the construction of common identity of all ethnic groups in the cultural space of Tongxin County, Ningxia Hui Autonomous Region (Master’s thesis). Lanzhou University. <https://doi.org/10.27204/d.cnki.glzhu.2023.001211>
- [10] Alai. (2015). The frontier of consumer society and frontier literature: A speech at Hubei Provincial Library. *Yangtze Literature and Art*, (11), 150-157.
- [11] Alai, & Sun, X. N. (1998, March 31). Life expression in the depth of history. *China Culture Daily*.
- [12] Alai. (2018). *Sui Feng Piao San [Jicun Epic (Six Volumes)]*. Zhejiang Literature and Art Publishing House.

Optimal Product Pricing and Recovery Strategies in a Two-period Model for Manufacturers with Core Classification and Trade-In-for-New/Reman Policies

Zhe Wang^{1,2,3*}, Peipei Cao¹, Fan Xu¹

1.School of Business, Nanjing Audit University, Nanjing 211815, China

2.Huishang Futures Co., Ltd., Hefei 230009, China

3.School of Management, Hefei University of Technology, Hefei 230009, China

*Corresponding author: Zhe Wang, wangzhe9012@126.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Motivated by the recent policy initiative of the Central Financial and Economic Affairs Commission to promote a new round of equipment upgrading and consumer-goods trade-in programs, we develop a two-period game-theoretic model for a manufacturer endowed with remanufacturing capability. In period 1, the market is partitioned into new and remanufactured products, and the initial market structure is determined by their respective demand shares. In period 2, consumers' trade-in/-for-remanufacturing behavior is disentangled; utility theory is employed to derive demand functions under alternative scenarios. The manufacturer then chooses the sales prices of both new and remanufactured products together with the buy-back price of used new products so as to maximize its total profit. Key findings are as follows. (1) The new-product demand share, the trade-in discount for remanufactured items, and the product's circular value are the three pivotal drivers of pricing strategy. In particular, when the new-product demand share is low, the circular value is high, or the remanufactured-product trade-in discount is large, the optimal buy-back price of new products equals the selling price of remanufactured products. (2) The sales prices of new/remanufactured products and the buy-back price increase with the remanufacturing trade-in discount and consumers' perceived-value discount, decrease with the circular value, and rise with the new-product production cost. (3) The impact of the new product's circular value on pricing depends on the market structure: only when the new-product demand share is high, the trade-in discount is low, and the circular value itself is small will an increase in circular value raise all prices. (4) Under a high remanufactured-product pricing strategy, the buy-back price is U-shaped in the new-product demand share; under a low pricing strategy it increases monotonically. (5) Manufacturer profit increases with the remanufacturing trade-in discount, the circular value, and the perceived-value discount, but decreases with the remanufacturing circular value. A lower new-product demand share and higher production cost reduce total profit; however, once the cost exceeds a critical threshold, profit rebounds. We recommend that manufacturers dynamically adjust pricing, invest in remanufacturing technology, and enhance recovery incentives. Meanwhile, governments should underpin green consumption and the circular economy through supportive policies and effective oversight.

Keywords: Product Segmentation; Trade-in-for-New; Trade-in-for-Reman; Pricing Strategy; Remanufacturing

Published: Oct 12, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.651>

1.Introduction

Remanufacturing refers to the process of restoring discarded products or components to their original performance and quality levels through repair, upgrading, and reassembly, thereby extending their service life and reintroducing them to the market^[1]. Remanufacturing not only protects the environment and improves resource reuse efficiency but also reduces production costs and enhances economic benefits, thus achieving sustainable development. Consequently, the remanufacturing market is experiencing rapid growth. Taking the automotive-parts remanufacturing market as an example, the global market value is expected to increase from approximately USD 61.8 billion in 2023 to USD 119.5 billion by 2032, with a compound annual growth rate of about 9 %^a. As consumers' environmental awareness and acceptance of remanufactured products rise, more and more manufacturers are introducing remanufacturing and establishing remanufactured-product lines to further expand market share. For instance, SAIC Volkswagen has set up its own power-train remanufacturing plant, and Caterpillar, a world-leading construction and mining equipment manufacturer, also provides remanufacturing services for engineering machinery^b. However, substitutability between remanufactured and new products creates a cannibalization effect that forces manufacturers to adjust their pricing strategies. Therefore, how manufacturers should design product-pricing strategies under new-versus-reman product competition is the key question addressed in this paper.

To stimulate consumption of both new and remanufactured products, the Chinese government has launched trade-in-for-new and trade-in-for-reman policies. 'Trade-in-for-new' allows consumers to return an old unit and receive a discount on the purchase of a new product^[2]. Apple, for example, promotes trade-in programs that encourage consumers to return old devices to authorized dealers, thereby boosting sales of new products. Data show that, compared with 2018, Apple's sales in 2019 quadrupled thanks to the trade-in policy^c. 'Trade-in-for-reman' refers to consumers trading in an old unit for a discount on a remanufactured product. Remanufactured products are also called officially refurbished products. Huawei, for instance, offers officially refurbished Mate40 Pro 5G phones on its official website, all of which have passed strict remanufacturing processes to ensure performance comparable to new devices. The trade-in-for-reman policy greatly promotes sales of remanufactured products. According to market-research agency Counterpoint, global shipments of second-hand smartphones—including officially refurbished phones—reached 282.6 million units, an increase of 11.5 % year-on-year^d. In practice, an increasing number of firms have adopted trade-in-for-new and trade-in-for-reman policies as sales strategies to stimulate consumer purchasing behavior. Yet previous studies on new-versus-reman sales strategies rarely consider the coexistence of both incentive policies. Therefore, the first objective of this paper is to uncover how these two sales incentives influence consumer purchasing behavior under new-versus-reman competition.

The introduction of trade-in-for-new/reman policies significantly affects consumer purchasing behavior. Under these policies, strategic consumers care not only about future prices of new and remanufactured products but also about the residual value of their used units and the utility derived from continuing to use them. Consumers' purchasing decisions thus become inherently multi-period dynamic problems. Faced with such complex consumer behavior, manufacturers find it more difficult to set prices for new and remanufactured products. Moreover, the multiplicity of sources for trade-in cores further complicates pricing. Existing studies usually assume that cores come only from originally sold new products, ignoring used remanufactured products. Currently, large quantities of remanufactured products are already in circulation, and firms in practice recycle both used new and used remanufactured units. For example, Apple's AppleCare+ trade-in service allows users to trade in old devices—including officially refurbished ones—toward the purchase of new devices^e. Therefore, the second objective of this paper is to investigate manufacturers' dynamic pricing strategies that simultaneously account for the impacts of trade-in-for-new/reman policies on consumer behavior, the multiplicity of core sources, and product competition.

a <https://www.custommarketinsights.com/report/automotive-parts-remanufacturing-market/>

b <https://www.caterpillar.com/>

c <https://www.qianzhan.com/analyst/detail/329/210205-838290ce.html>

d https://www.thepaper.cn/newsDetail_forward_24934009

e https://www.thepaper.cn/newsDetail_forward_24934009

In summary, this paper simultaneously considers consumers' multi-period purchasing behavior, trade-in-for-new/reman policies, and multiple core sources to study a manufacturer's multi-period dynamic optimal sales-pricing and collection strategies. We construct a two-product, two-period pricing model in which the manufacturer maximizes total profit. Consumers choose between a new and a remanufactured product in period 1; in period 2, consumers who purchased in period 1 may either participate in trade-in-for-new, trade-in-for-reman, or keep their old units. Building on this complex consumer behavior, we construct consumer utility functions that incorporate the remanufactured-product perceived-value discount and collection-price differentials, derive the corresponding demand functions, and solve the model under KKT conditions to obtain optimal pricing decisions under various scenarios. We then conduct sensitivity analyses with respect to key parameters such as the remanufactured-product perceived discount, the proportion of different core types, and the remanufactured-product collection-price discount, and complement the analytical results with numerical simulations. Compared with previous studies, this paper makes several important contributions. First, in a competitive-product setting, we simultaneously consider both trade-in-for-new and trade-in-for-reman policies and explore how these two sales incentives influence consumer purchasing behavior. Second, we account for the multiplicity of core sources—namely, originally sold new and remanufactured products—and examine how different core-mix proportions affect manufacturers' sales and collection pricing when implementing trade-in-for-new and trade-in-for-reman programs. Finally, based on consumers' multi-period dynamic purchasing behavior, we derive optimal pricing strategies under both policies, thereby extending the literature on dynamic collection pricing. The main research questions are as follows:

- (1) How do product competition and core classification affect consumer purchasing behavior under trade-in-for-new/reman policies?
- (2) How should a manufacturer set sales and collection prices for new and remanufactured products when accounting for the combined effects of trade-in-for-new/reman policies on consumer behavior, product competition, and core sources?
- (3) How do key factors such as the proportion of different core types, the remanufactured-product collection-price discount, and consumers' perceived discount on remanufactured products influence the manufacturer's optimal sales and collection pricing strategies and profit?

The remainder of the paper is organized as follows. Section 2 reviews the literature, Section 3 describes the problem and basic assumptions, Section 4 establishes and solves the manufacturer's two-period sales-and-collection pricing model, Section 5 conducts sensitivity analyses of sales and collection pricing strategies, Section 6 provides numerical simulations and supplementary discussions, and Section 7 concludes.

2. Literature Review

Literature closely related to this study can be grouped into three main streams: consumer purchase behavior, product remanufacturing, and sales-incentive strategies.

2.1 Consumer Purchase Behavior

Studies investigating the determinants of consumer purchase behavior toward remanufactured products provide abundant empirical evidence. Some scholars focus on cognitive factors. Wang and Hazen^[4] employ structural equation modeling to examine how cost, quality, and environmental knowledge affect purchase intention; their results show that perceived value positively influences intention, whereas perceived risk exerts a negative effect. Using the theory of planned behavior (TPB), Wang et al.^[5] analyze Chinese consumers and find that attitude, subjective norm, and perceived behavioral control are the main drivers, with perceived inconvenience and perceived risk being negative. Others concentrate on attitudes and behaviors: Wang et al.^[6] demonstrate that attitude, perceived behavioral control, and perceived risk significantly shape remanufactured-product purchase intention. Singhal et al.^[7] corroborate via meta-analysis that attitude, subjective norm, perceived green benefit, and perceived behavioral control are positively related to intention, while perceived risk is negatively related. Product characteristics also matter. Khor and Hazen^[8] apply TPB to Malaysian consumers and reveal a preference for energy-saving remanufactured products. Jun et al.^[9] show that similarity between remanufactured and new products negatively affects new-product purchase intention, with brand reputation moderating this link. Regarding non-economic factors, Alyahya et al.^[10] use fuzzy-set qualitative comparative analysis (FsQCA) and identify moral responsibility as an important

antecedent of remanufactured-product purchase behavior. Collectively, these studies underscore the complexity of consumers' remanufactured-product purchase intention.

To delve deeper into the decision mechanism, researchers construct consumer utility functions that incorporate behavioral traits and preferences to quantify utility levels across purchase options. Christensen and Manser^[11] adopt direct and indirect translog utility functions to derive budget-share equations, demonstrating flexibility and consistency with utility-maximization theory and concluding that the translog form is well suited for preference modeling. Grounded in perceived-risk theory, consumers form distinct initial value expectations when facing product choices. Wang et al.^[12] and Esenduran et al.^[13] build utility functions that capture the choice between new and remanufactured products, noting that remanufactured products suffer a consumer value discount relative to new ones. Dong and Lei^[14] design a two-period utility function that portrays the effects of continuing to use, collecting a rebate, or upgrading to a new product, but their setting considers only new products and ignores the option to buy remanufactured products. Therefore, drawing on prior work, this paper constructs a two-period utility function that simultaneously encompasses three options—buying new, buying remanufactured, and keeping the old unit—and explicitly incorporates the remanufactured-product consumer value discount and collection price, thereby capturing consumers' complex purchase behavior.

2.2 Product Remanufacturing

As remanufacturing has gradually become a key component of firms' product portfolios, the competitive relationship between new and remanufactured products in the marketplace and their pricing have attracted extensive attention. Sun et al.^[15] construct a differentiated-competition model involving a manufacturer, a remanufacturer, and a retailer, and employ theoretical and numerical analyses to examine the impact of third-party remanufacturing on market competition; they point out that consumers' different sensitivities toward new and remanufactured products play a critical role in equilibrium decisions. Guide and Li^[16] use auction experiments to propose a willingness-to-pay model and investigate the self-cannibalization problem when new and remanufactured products are sold simultaneously, showing that commercial products face high cannibalization risk. Abbey et al.^[17] develop a consumer-preference-based pricing model between a new-product manufacturer and a third-party remanufacturer, and study price competition between new and remanufactured products; they find that when remanufactured products enter the market, appropriately raising the new-product price helps reduce profit erosion. Wang et al.^[18] propose a price-and-service competition model involving a traditional manufacturer, a remanufacturer, and a retailer, and explore optimal profits of new and remanufactured products under different game structures. Wu^[19] designs a supply-chain competition model composed of a new-product manufacturer, a remanufacturer, and a retailer, investigates price and service competition between new and remanufactured products, and reveals the equilibrium characteristics of the remanufacturer's effort level as well as its price and service decisions. Although single-period pricing strategies have been well studied, research on multi-period pricing of new and remanufactured products remains scarce^[20, 21].

To reduce the difficulty of remanufacturing, the value and quality of collected used cores have likewise received increasing attention^[22-24]. Fan et al.^[25] provide useful managerial insights into the relationships among a firm's channel choice, consumer acceptance of the direct channel, and the value of used products. Li et al.^[26] propose three collection strategies based on consumers' quality perceptions, examine how the quality-decay coefficients of used and refurbished products and the value of new products affect the choice of collection mode, and offer optimal decisions for collection platforms. Yin et al.^[27] further build a system-dynamics simulation model to compare the impacts of different graded collection mechanisms on used-core collection quality and remanufacturer profit. Van et al.^[28] analyze the economic conditions for remanufacturing based on used-core quality and derive optimal collection strategies under general settings. However, existing studies have not adequately considered how sales and collection strategies are affected when cores originate from both new and remanufactured products. Therefore, this paper incorporates the issue of core sources in trade-in-for-new/reman programs and thoroughly investigates two-period sales and collection pricing strategies.

2.3 Sales-Incentive Strategies

Sales-incentive strategies are key instruments for firms to stimulate product sales, covering pre-sale services, after-sale rebates^[29], subsidies^[30], and celebrity live-streaming sales^[31]. Among new-product promotions, trade-in-for-new has been

widely adopted and studied, and has demonstrated significant effectiveness. Wan et al.^[32] propose three trade-in schemes and examine how quality differences affect collection mode and sales price, showing that trade-in raises the collection rate of used products in many scenarios. Xu et al.^[33] analyze the joint decisions of online/offline channel expansion and logistics choice through a two-period dynamic model, pointing out that trade-in-for-new critically influences corporate strategic choices. Liu et al.^[34] explore a manufacturer's use of a third-party information platform to implement trade-in-for-new, finding that under certain conditions the strategy markedly increases manufacturer profit. Shi et al.^[35] investigate the strategy in the presence of informal recycling competition and show that it improves market share and profit. Researchers have also delved into different trade-in service modes. Wang et al.^[36] employ a manufacturer–retailer game to examine who should offer trade-in under different e-commerce modes; they identify conflicting interests under the reselling mode but a win–win outcome under the agency mode. Tang et al.^[37] use a duopoly-retailer model to study how brand loyalty affects exclusive versus non-exclusive trade-in strategies, showing that the exclusive strategy performs better in markets with low brand loyalty. Yang et al.^[38] compare self-built versus cooperative trade-in modes from an omnichannel perspective and find that the cooperative mode enhances social welfare when consumer waiting costs are low.

Besides trade-in-for-new, trade-in-for-reman has attracted attention as a means to promote remanufactured-product sales. Ma et al.^[39] show that when firms introduce trade-in-for-reman, the reference-quality effect cannot be ignored given quality differences in remanufactured products. Sun and Xu^[40] study pricing decisions in closed-loop supply chains, propose four trade-in-for-reman models, and reveal how firm power, collection channel, and product durability affect profit and market share. Gao and Ding^[41] segment consumers and develop five demand structures and five decision models, concluding that the manufacturer's optimal strategy depends on market structure. Wan and Zou^[42] examine government influence and find that properly set sales subsidies can effectively promote the end-of-life vehicle-remanufacturing industry. Han et al.^[43] investigate how firms use trade-in-for-reman to develop the remanufactured-product market and identify product remanufacturability and government subsidy as key determinants. A few studies simultaneously consider both trade-in-for-new and trade-in-for-reman^[1, 44, 45], but they do not differentiate core sources. Therefore, this paper incorporates both policies and further classifies returned cores into originally sold new products and previously remanufactured products.

2.4 Literature Summary

Extant studies have thoroughly addressed trade-in-for-new, and research on trade-in-for-reman is gradually increasing. However, the foregoing review reveals that further investigation is needed in the following areas.

- (1) Most existing work concentrates on either trade-in-for-new or trade-in-for-reman alone; studies examining both strategies simultaneously are scarce, indicating an insufficient characterization of consumers' complex purchase behavior under combined incentives. Therefore, this paper incorporates the remanufactured-product perceived-value discount and collection-price differentials into the consumer utility function to explore how the two sales incentives jointly influence purchase behavior.
- (2) In used-product collection, few studies classify cores by source. Different core types affect operational management, and although some scholars have considered quality and value, they have not distinguished whether cores originated from new or previously remanufactured products. Hence, this paper examines how the proportion of different core sources influences manufacturers' sales and collection pricing when implementing trade-in-for-new and trade-in-for-reman policies.
- (3) Single-period pricing strategies are well developed, yet multi-period pricing of new and remanufactured products remains under-explored. Accordingly, this paper investigates two-period trade-in-for-new and trade-in-for-reman pricing strategies based on consumers' inherently multi-period dynamic purchase behavior, thereby extending the literature on collection pricing.

3. Problem Description and Basic Assumptions

We consider a manufacturer who possesses both manufacturing and remanufacturing capabilities, produces new and remanufactured products, and offers consumers who already own its products either a trade-in-for-new or a trade-in-for-reman service. New and remanufactured products are indexed by subscripts n and r , respectively. The unit production cost of a new product is c_n , and that of a remanufactured product is c_r . Because remanufacturing saves raw-material input relative to

new production^[46, 47], we have $c_r < c_n$. Consequently, $c_n - c_r$ captures the cost advantage of remanufacturing^[48, 49]. To simplify computations without loss of generality, we set $c_r = 0$ ^[50, 51]. The circular values of new and remanufactured products are denoted by s_n and s_r , respectively, with $c_n > s_n > s_r > 0$ ^[32, 52]. The unit selling prices of new and remanufactured products are p_r and p_n , and the unit buy-back prices are r_r and r_n , satisfying $\phi r_n = r_r$. To ease calculations, let $\phi \in (0, 1)$ denote the buy-back price discount the manufacturer offers consumers for remanufactured products relative to new ones; a larger ϕ implies a higher remanufactured-product buy-back price. In line with reality, unit buy-back prices never exceed unit selling prices, $r_n \leq p_r < p_n$. To guarantee a positive selling price for remanufactured products, we assume $0 < s_r < \min \left\{ s_n, \alpha \frac{1 + (1 - \beta)(1 - \phi)}{(1 - \beta)(1 - \phi)} \right\}$. Both new and remanufactured products last two periods;

within one period, each consumer buys at most one product. Consumers' willingness-to-pay for a new product is v , uniformly distributed on $[0, 1]$ ^[53-55]; their willingness-to-pay for a remanufactured product is αv , where $\alpha \in (0, 1)$ is the perceived-value discount factor representing the value gap consumers perceive. Empirical studies show that this gap stems mainly from consumers' loss-aversion toward remanufactured products.

Based on the above, we construct a two-period consumer-utility model. In period 1, each consumer chooses to buy either a new or a remanufactured product. Total period-1 demand is normalized to 1^[51, 56]; letting β denote the fraction of consumers who buy new, the fraction buying remanufactured is $1 - \beta$. In period 2, consumers who bought new in period 1 face three options: (i) trade in the period-1 new product for another new one (labelled S_n^n), (ii) trade it in for a remanufactured one (labelled S_n^r), or (iii) continue using it. Likewise, consumers who bought remanufactured in period 1 choose among: (i) trade in the period-1 remanufactured product for a new one (labelled S_r^n), (ii) trade it in for another remanufactured one (labelled S_r^r), or (iii) keep using it. In notation S_i^j , i stands for the period-1 purchase choice, j for the period-2 purchase choice, and $\{i, j\} \in \{n, r\}$. Consumers keep the used unit only if the utilities of both trade-in-for-new and trade-in-for-reman are negative.

Accordingly, period-1 demands for new and remanufactured products are $D_n = \beta$ and $D_r = 1 - \beta$, respectively. If a consumer bought new in period 1, the period-2 utility functions for buying new, buying remanufactured, and continuing to use are $v - p_n + r_n$, $\alpha v - p_r + r_n$ and 0. If the consumer bought remanufactured in period 1, the corresponding utilities are $v - p_n + \phi r_n$, $\alpha v - p_r + \phi r_n$ and 0. The period-2 demand function for new products under consumer behavior S_n^n is then derived as:

$$D_n^n = \beta \int_{\frac{p_n - p_r}{1 - \alpha}}^1 dv = \beta \left(1 - \frac{p_n - p_r}{1 - \alpha} \right) \quad (1)$$

The period-2 demand function for remanufactured products under consumer behavior S_n^r is:

$$D_n^r = \beta \int_{\frac{p_r - r_n}{\alpha}}^{\frac{p_n - p_r}{1 - \alpha}} dv = \beta \left(\frac{p_n - p_r}{1 - \alpha} - \frac{p_r - r_n}{\alpha} \right) \quad (2)$$

The period-2 demand function for new products under consumer behavior S_r^n is:

$$D_r^n = (1 - \beta) \int_{\frac{p_n - p_r}{1 - \alpha}}^1 dv = (1 - \beta) \left(1 - \frac{p_n - p_r}{1 - \alpha} \right) \quad (3)$$

The period-2 demand function for remanufactured products under consumer behavior S_r^r is:

$$D_r^r = (1 - \beta) \int_{\frac{p_r - \phi r_n}{\alpha}}^{\frac{p_n - p_r}{1 - \alpha}} dv = (1 - \beta) \left(\frac{p_n - p_r}{1 - \alpha} - \frac{p_r - \phi r_n}{\alpha} \right) \quad (4)$$

Based on consumers' complex purchasing behavior, this paper takes the unit selling price of new products, the unit selling price of remanufactured products, and the unit buy-back price of new products as decision variables, aims at maximizing the total profit over two periods, and investigates sales and collection pricing strategies for new and remanufactured products.

The sequence of the game is shown in Figure 1. Table 1 summarizes the main parameters and symbols.

Figure 1 Sequence of the Two-period Game

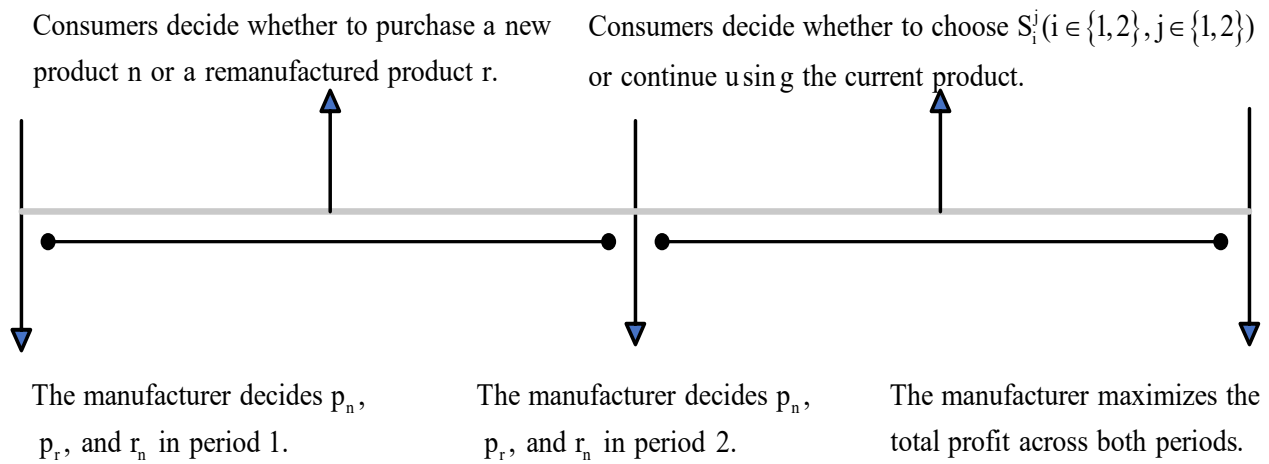


Table 1 Glossary of Symbols

Symbol	Definition
ϕ	Discount ratio of remanufactured product collection price
β	Proportion of consumers who purchased new products in period 1
s_n, s_r	Circular value of new/remanufactured products
p_n, p_r	Unit selling price of new/remanufactured products
c_n	Unit production cost of new products
α	Perceived value discount ratio of remanufactured products
r_n	Unit collection price of new products
D_i	Demand for product i in period 1, $i \in \{n, r\}$
S_i^j	Consumers holding product i from period 1 trade in for product j in period 2, $i \in \{n, r\}, j \in \{n, r\}$
D_i^j	Demand function for product j under consumer behavior S_i^j in period 2, $i \in \{n, r\}, j \in \{n, r\}$

4. Model Construction and Solution Analysis

This section formulates a two-period game-theoretic pricing model for the manufacturer under the trade-in-for-new / trade-in-for-reman policy. The manufacturer maximizes total profit over both periods, taking the unit selling prices and unit buy-back prices as decision variables. The optimal unit selling prices of new and remanufactured products and the optimal unit buy-back price of new products under various scenarios are derived by applying the Karush–Kuhn–Tucker (KKT) conditions.

The manufacturer's first-period profit function is expressed as:

$$\max_{\{p_n, p_r, r_n\}} \pi_1 = (p_n - c_n) D_n + p_r D_r \quad (5)$$

The manufacturer's second-period profit function can be expressed as:

$$\begin{aligned} \max_{\{p_n, p_r, r_n\}} \pi_2 = & (p_n - c_n - r_n + s_n) D_n^n + (p_r - r_n + s_n) D_n^r \\ & + (p_n - c_n - \phi r_n + s_r) D_r^n + (p_r - \phi r_n + s_r) D_r^r \end{aligned} \quad (6)$$

Therefore, the manufacturer's total profit over the two periods is:

$$\max_{\{p_n, p_r, r_n\}} \pi = (p_n - c_n)D_n + p_r D_r + (p_n - c_n - r_n + s_n)D_n^n + (p_r - r_n + s_n)D_n^r \quad (7)$$

$$+ (p_n - c_n - \phi r_n + s_r)D_r^n + (p_r - \phi r_n + s_r)D_r^r$$

$$s.t. 0 < r_n \leq p_r < p_n \quad (8)$$

In Equation (7), the first, second, third and fourth terms represent the profits that the manufacturer earns under consumer behaviors S_n^n , S_n^r , S_r^n and S_r^r , respectively. Constraint (8) ensures that the remanufactured product's selling price is lower than the new product's selling price and that the buy-back price does not exceed the selling price. Applying the Lagrangian multiplier method based on the KKT conditions yields Proposition 1.

Proposition 1 Under the trade-in-for-new/reman strategy, the manufacturer has two distinct optimal policy options: the high remanufactured-product pricing strategy A and the low remanufactured-product pricing strategy B , as shown in Table 2. The corresponding optimal sales and buy-back prices and the manufacturer's profits under strategies A and B are given in Table 3.

Table 2 Manufacturer's Optimal Strategy Choices under the Trade-in-for-New/Reman Policy

Range			Strategy
$0 < \beta \leq \beta_L$			low pricing strategy B
$\beta_L < \beta < 1$	$0 < \phi < \frac{1}{2}$	$s_r < s_n \leq \alpha(1 - \frac{\beta_L}{\beta})$	high pricing strategy A
		$\alpha(1 - \frac{\beta_L}{\beta}) < s_n < c_n$	low pricing strategy B
	$\frac{1}{2} \leq \phi < 1$		low pricing strategy B

Table 3 Manufacturer's Optimal Solutions under Different Strategies

Optimal solution	high pricing strategy	low pricing strategy
p_n	$G + \frac{(1+\beta)(\alpha + (1-\alpha)\beta) - \beta(s_n - c_n)}{2\beta}$	$M + \frac{1}{2}((1+\beta)(1-\alpha) + c_n)$
p_r	$G + \frac{\alpha(1+\beta) - \beta s_n}{2\beta}$	M
r_n	$G + \frac{\alpha}{2\beta(1-\phi)}$	M
D_n^n	$\frac{\beta((1-\beta)(1-\alpha) - c_n)}{2(1-\alpha)}$	$\frac{\beta((1-\beta)(1-\alpha) - c_n)}{2(1-\alpha)}$
D_n^r	$\frac{1}{2}\beta\left(\beta + \frac{c_n}{1-\alpha} + \frac{\phi}{\beta(1-\phi)} + \frac{s_n}{\alpha}\right)$	$\frac{1}{2}\beta\left(1 + \beta + \frac{c_n}{1-\alpha}\right)$
D_r^n	$\frac{1}{2}(1-\beta)\left(1 - \beta - \frac{c_n}{1-\alpha}\right)$	$\frac{1}{2}(1-\beta)\left(1 - \beta - \frac{c_n}{1-\alpha}\right)$
D_r^r	$\frac{1}{2}\left((1-\beta)\left(\beta + \frac{c_n}{1-\alpha} + \frac{s_r}{\alpha}\right) - \frac{1}{1-\phi}\right)$	$\frac{1}{2}\left((1-\beta)\left(\beta + \frac{c_n}{1-\alpha} + \frac{s_r}{\alpha}\right) - \frac{1}{1-\phi}\right)$
π	$\frac{1}{4}\left(N + \alpha\left(2 - \beta(2+\beta) + \frac{\beta + (1-\beta)\phi^2}{(1-\beta)\beta(1-\phi)^2}\right) + \frac{2\phi s_n}{1-\phi} + \frac{\beta s_n^2}{\alpha}\right)$	$\frac{1}{4}\left(N + \frac{\alpha(3 - 2(\beta(1-\phi) + \phi))}{(1-\beta)(1-\phi)^2} - \alpha\beta(3 + \beta) + 2\beta s_n\right)$

In Table 3, $N = (1 + \beta)(1 + \beta - 2c_n) + \frac{c_n^2}{1 - \alpha} + 2\beta s_n - \frac{2(\beta + \phi(1 - \beta))s_r}{1 - \phi} + \frac{(1 - \beta)s_r^2}{\alpha}$, $M = \frac{\alpha}{2(1 - \beta)(1 - \phi)^2} + \frac{\alpha - s_r}{2(1 - \phi)}$,

$$\beta_L = \frac{\phi}{1 - \phi}, \quad G = \frac{\alpha}{2(1 - \beta)\beta(1 - \phi)^2} - \frac{2\alpha - \beta(s_n - s_r)}{2\beta(1 - \phi)}.$$

The proof is provided in Appendix A.

High remanufactured-product pricing strategy A refers to the case where the remanufactured product's selling price is higher than the new-product buy-back price; low remanufactured-product pricing strategy B means the remanufactured product's selling price equals the new-product buy-back price and is higher than the remanufactured-product buy-back price. Notably, under the low pricing strategy every consumer who bought new in period 1 participates in trade-in-for-new/reman in period 2. Proposition 1 shows that the manufacturer's choice between the two strategies depends on the proportion of consumers who bought new products in period 1 β , the remanufactured-product buy-back price discount ϕ , and the circular value of new products r_n .

When the proportion of consumers who bought new products in period 1 is small, i.e., $0 < \beta \leq \beta_L$, the manufacturer adopts the low remanufactured-product pricing strategy B . At this time market acceptance of remanufactured products is relatively high. By pushing the remanufactured selling price down to the new-product buy-back price, the manufacturer on the one hand attracts more consumers to remanufactured products and enlarges period-2 demand ($(D_n^r + D_r^r)|_{p_r^B > r_n^B} < (D_n^r + D_r^r)|_{p_r^B = r_n^B}$), and on the other hand effectively converts the remanufactured option into a “free upgrade” that eliminates the possibility of keeping the original unit: the utility of continuing to use the period-1 new product is lower than the net surplus of trading it in for reman, so every unit is returned ($D_n^r + D_n^r = \beta$). This maximizes the collection rate and guarantees sales opportunities for remanufactured products in period 2, creating a profit model that compensates low margin with high volume.

When the proportion of consumers who bought new products in period 1 is large and the remanufactured buy-back discount is also large, i.e., $\beta_L < \beta < 1$ and $0 < \phi < \frac{1}{2}$, the optimal strategy hinges on the circular value of new products s_n . If the

circular value is low ($s_r < s_n \leq \alpha(1 - \frac{\beta_L}{\beta})$), the manufacturer chooses the high remanufactured-product pricing strategy

A ; if the circular value is high ($s_n > \alpha(1 - \frac{\beta_L}{\beta})$), the low pricing strategy B is preferred. When new products dominate

period-1 market share and the remanufactured buy-back price is far below the new buy-back price, the firm must balance the high margin of new products with the cost-saving potential of remanufacturing. A low circular value encourages the manufacturer to maintain a high remanufactured selling price to protect profit, while offering a high new-product buy-back price to stimulate trade-in-for-new. Conversely, a high circular value makes it attractive to lower the remanufactured price to induce trade-in-for-reman, exploit the low-cost remanufacturing opportunity, expand the remanufactured market, and ultimately increase profit.

When the proportion of consumers who bought new products in period 1 is large but the remanufactured buy-back discount is small, i.e., $\beta_L < \beta < 1$ and $\frac{1}{2} \leq \phi < 1$, the manufacturer again adopts the low remanufactured-product pricing strategy B .

With a sufficiently high share of new-product buyers, the manufacturer uses the low reman price to steer these consumers toward trade-in-for-reman instead of trade-in-for-new, preventing new products from cannibalizing the reman market and enlarging remanufactured demand. Simultaneously, a low discount (or high buy-back price) ensures that all period-1 new-product buyers return their units, forcing every used product into the collection system, securing ample remanufacturing cores, and lowering collection costs through economies of scale.

Thus, the manufacturer's pricing strategy always revolves around consumers' trade-in behavior and the circular value of used products: low-price strategies drive market penetration and collection, whereas high-price strategies balance cost and margin; the level of circular value and collection cost determines whether remanufactured products can achieve sustainable

profitability through scale effects.

5. Sensitivity Analysis under Different Pricing Strategies

This section examines how changes in key parameters affect the manufacturer's optimal pricing decisions and profit under the two remanufactured-product pricing strategies.

Proposition 2 reports the sensitivity of the optimal sales prices of new and remanufactured products and the optimal buy-back price of new products to parameter changes under the low and high remanufactured-product pricing strategies; the results are summarized in Table 4, where the symbols $+$, $-$, 0 and indicate an increase, a decrease, and no change, respectively, in the optimal prices.

Table 4 Sensitivity Analysis of Optimal Unit Sales Prices of New and Remanufactured Products under Different Strategies

Parameter	Strategy A			Strategy B	
	p_n^A	p_r^A	r_n^A	p_n^B	$p_r^B (r_n^B)$
ϕ	+	+	+	+	+
α	+	+	+	+	+
s_n	+	+	+	0	0
s_r	-	-	-	-	-
β	+	+	\pm^*	+	+
c_n	+	0	0	+	0

Note: \pm^* : If $\beta < \frac{\sqrt{\phi}}{1+\sqrt{\phi}}$, then $-$, else $+$.

Proof is provided in Appendix B.

Under the high remanufactured-product pricing strategy A, the selling prices p_n^A and buy-back price r_n^A of new products and the selling prices of remanufactured products p_r^A all increase with the remanufactured-product buy-back discount ratio ϕ , the remanufactured-product perceived-value discount ratio α , and the circular value of new products s_n , but decrease with the circular value of remanufactured products s_r . A higher remanufactured-product buy-back discount ratio and a higher perceived-value discount ratio imply higher collection costs and higher market acceptance of remanufactured products, which push up both the selling and buy-back prices of remanufactured products. A higher remanufactured-product buy-back price also raises the buy-back price of new products and, in turn, the selling price of new products. A higher circular value of new products increases the selling and buy-back prices of new products, which then lifts the buy-back price of remanufactured products and ultimately the selling price of remanufactured products. Notably, when the circular value of remanufactured products increases, the manufacturer earns more from remanufactured-product collection, but because consumers are loss-averse toward remanufactured products, the manufacturer lowers the unit selling price of remanufactured products to stimulate sales and simultaneously reduces the buy-back price to ease upfront cost pressure. This also lowers the buy-back price of new products, and to protect the market share of new products, the unit selling price of new products is reduced as well.

The selling price of new products p_n^A increases with the proportion of consumers c_n who bought new products in the first period β , indicating that stronger demand for new products encourages the manufacturer to charge a higher price, which also drives up the selling price of remanufactured products p_r^A . The buy-back price of new products r_n^A first decreases and then increases with the proportion of first-period new-product buyers. When this proportion is small (i.e., $\beta < \frac{\sqrt{\phi}}{1+\sqrt{\phi}}$), the incremental demand for new products gives the manufacturer more options in collection, so the buy-back price of new products falls. When the proportion is large (i.e., $\beta > \frac{\sqrt{\phi}}{1+\sqrt{\phi}}$), demand for remanufactured products is relatively low, so

the manufacturer raises the unit buy-back price of remanufactured products to incentivize consumers to choose remanufactured products, which in turn increases the buy-back price of new products. In addition, a higher unit production cost of new products c_n raises their selling price p_n^A , consistent with intuition. However, the unit selling price of remanufactured products p_r^A and the buy-back price of new products r_n^A are independent of the production cost of new products c_n , meaning that changes in this cost do not affect the manufacturer's pricing decisions for remanufactured-product selling or buy-back prices.

Under the low remanufactured-product pricing strategy B , the monotonicity of p_n^B and p_r^B with respect to ϕ , β , s_r , and α is the same as in strategy A . Because the unit selling price of remanufactured products p_r^B equals the unit buy-back price of new products r_n^B in this strategy, their sensitivity results are identical. Unlike the high-pricing strategy, the unit selling prices of both new and remanufactured products are independent of circular values s_n . This is because the buy-back price of new products has already reached its maximum; the manufacturer cannot earn additional trade-in surplus from consumers' a behavior, so changes in the circular value of new products have no impact on the unit selling prices of either new or remanufactured products.

Proposition 3 The sensitivity of the manufacturer's optimal profit to ϕ , β , s_n and c_n under the low and high remanufactured-product pricing strategies is reported in Table 5, where symbols $+$ and $-$ indicate an increase and a decrease in optimal profit, respectively.

Table 5 Sensitivity Analysis of Manufacturer's Total Profit under Different Strategies

Parameter	π^A	π^B
ϕ	+	+
β	\pm^{**}	\pm^{***}
s_n	+	+
c_n	\pm^{****}	\pm^{****}
\pm^{**} : If $c_n < c_{n1}$, then $+$, else $-$. \pm^{***} : If $c_n < c_{n2}$, then $+$, else $-$. \pm^{****} : If $c_n < c_{n3}$, then $-$, else $+$.		

In table 5, $c_{n1} = \frac{\alpha(2\beta-1)}{2(1-\beta)^2\beta^2(1-\phi)^2} + \frac{\alpha}{\beta^2(1-\phi)} - \frac{\alpha}{2\beta^2} + (1+\beta)(1-\alpha) + \frac{(s_n-s_r)(2\alpha+s_n+s_r)}{2\alpha}$, $c_{n3} = (1+\beta)(1-\alpha)$,

$$c_{n2} = \frac{\alpha}{2(1-\beta)^2(1-\phi)^2} + \frac{\alpha(2-3\alpha+2(1-\alpha)\beta+4s_n)-2\alpha s_r-s_r^2}{2\alpha}.$$

Proof is provided in Appendix C.

Proposition 3 shows that, in every scenario, an increase in the remanufactured-product buy-back discount ratio ϕ or in the circular value of new products s_n —by pushing up the selling and buy-back prices of both new and remanufactured products—improves the manufacturer's total profit. The unit production cost of new products c_n can also be viewed as an inverse indicator of the remanufacturing cost advantage. When this cost is low (i.e., the remanufacturing advantage is weak), profit is generated mainly from new products, so total profit rises with the proportion of consumers who bought new products in period 1 c_n ; conversely, when the cost is high (i.e., the remanufacturing advantage is strong), profit comes mainly from remanufactured products, and total profit falls as the proportion of period-1 new-product buyers β increases. The difference between strategy A and strategy B in the monotonicity of profit with respect to β lies only in the location of the critical threshold. Under either strategy, changes in the new-product production cost c_n affect only the unit selling price of new products, so total profit first decreases and then increases with this cost at the same threshold value. Because the monotonicity of profit with respect to the circular value of remanufactured products s_r and the perceived-value discount ratio α is too complex for analytical presentation, it is examined numerically in Section 5.

6. Numerical Verification and Analysis

This section uses extensive numerical examples to simulate the optimal sales-and-collection pricing outcomes and the sensitivity analyses under the two strategies. First, it supplements the sensitivity of the manufacturer's total profit with respect to the remanufactured-product circular value s_r and the consumer perceived-value discount ratio α . Second, it verifies the correctness of the sensitivity results stated in Propositions 2–4. Following related studies^[52, 57, 58], we set the unit production cost of new products $c_n = 0.3$, the remanufactured-product perceived-value discount ratio $\alpha = 0.6$, and the circular value of new products $s_n = 0.2$. The remaining parameters are fixed at $\beta = 0.8$ and $s_r = 0.1$. Because manufacturers must choose the optimal sales-and-collection pricing strategy according to different market conditions, we construct two scenarios that fit strategy and strategy : in the scenario for strategy A , ϕ is 0.3, whereas in the scenario for strategy B , ϕ is 0.6.

6.1 Impact of remanufactured-product circular value and perceived value discount ratio on total profit

Figures 2 and 3 show that, under either strategy A or strategy B , the manufacturer's total profit always decreases as the remanufactured-product circular value s_r rises and increases with the remanufactured-product perceived-value discount ratio α . Together with Proposition 4—total profit increases with the circular value of new products—this indicates that changes in the circular values of remanufactured and new products move total profit in opposite directions. A higher remanufactured-product circular value may erode the new-product market and reduce new-product sales, thereby lowering profit. In addition, greater consumer acceptance of remanufactured products is beneficial for profit growth, so manufacturers should actively promote the advantages of remanufactured products.

Figure 2 Impact of s_r on Manufacturer's Total Profit under Different Strategies

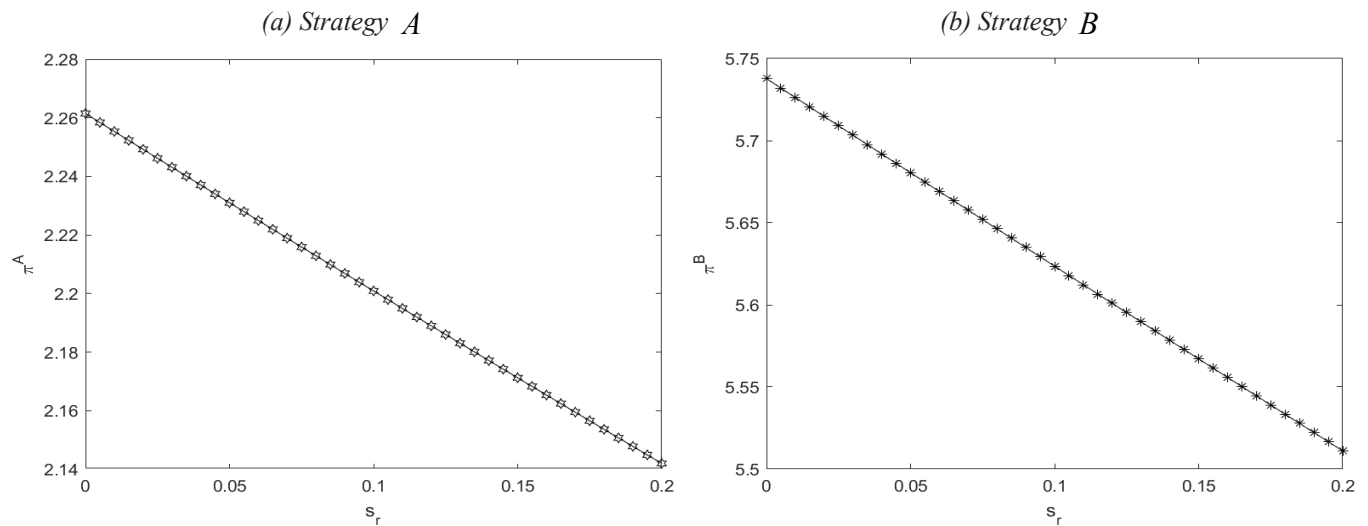
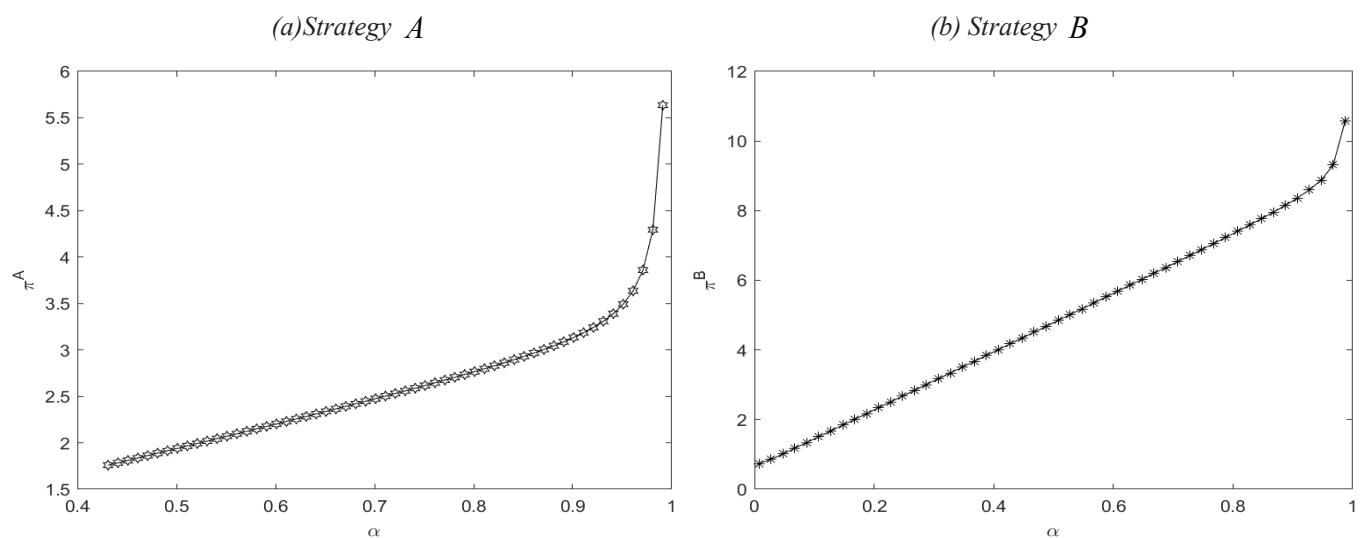


Figure 3 Impact of α on Manufacturer's Total Profit under Different Strategies



6.2 Numerical verification of the sensitivity results in each proposition

We first verify the sales- and collection-pricing sensitivities stated in Propositions 2 and 3. Figures 4–13 show that the simulation outcomes are consistent with the analytical results and always satisfy $0 < r_n \leq p_r \leq p_n$. To demonstrate the two theoretical cases, in Figure 5(a) we set $\phi = 0.009$, when $\beta < 0.087$, r_n^A decreases with β , whereas when $\beta > 0.087$, r_n^A increases with β . In Figure 11(a) we set $c_n = 6$, when $\beta < 0.661$, π^A decreases with β , whereas when $\beta > 0.661$, π^A increases with β . The same parameter is used in Figure 11(b), when $\beta < 0.413$, π^B decreases with β , whereas when $\beta > 0.413$, π^B increases with β . In Figure 13, when $c_n < 0.72$, both π^A and π^B decrease with c_n , and when $c_n > 0.72$, both π^A and π^B still decrease with c_n .

Figure 4 Impact of ϕ on Manufacturer's Sales and Collection Pricing under Different Strategies
(a) Strategy A (b) Strategy B

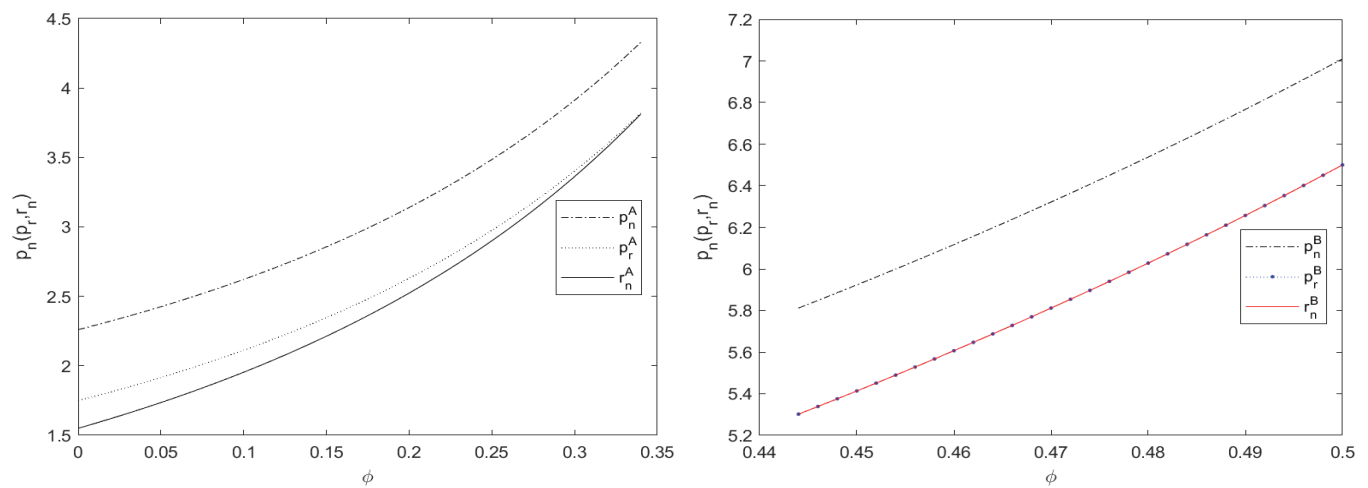


Figure 5 Impact of β on Manufacturer's Sales and Collection Pricing under Different Strategies
(a) Strategy A (b) Strategy B

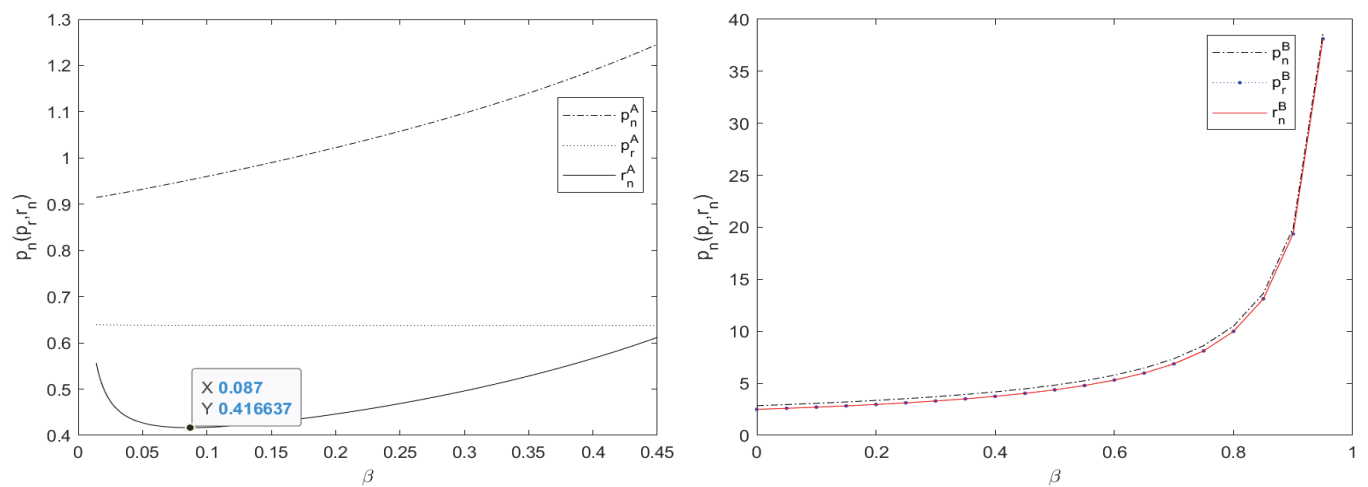


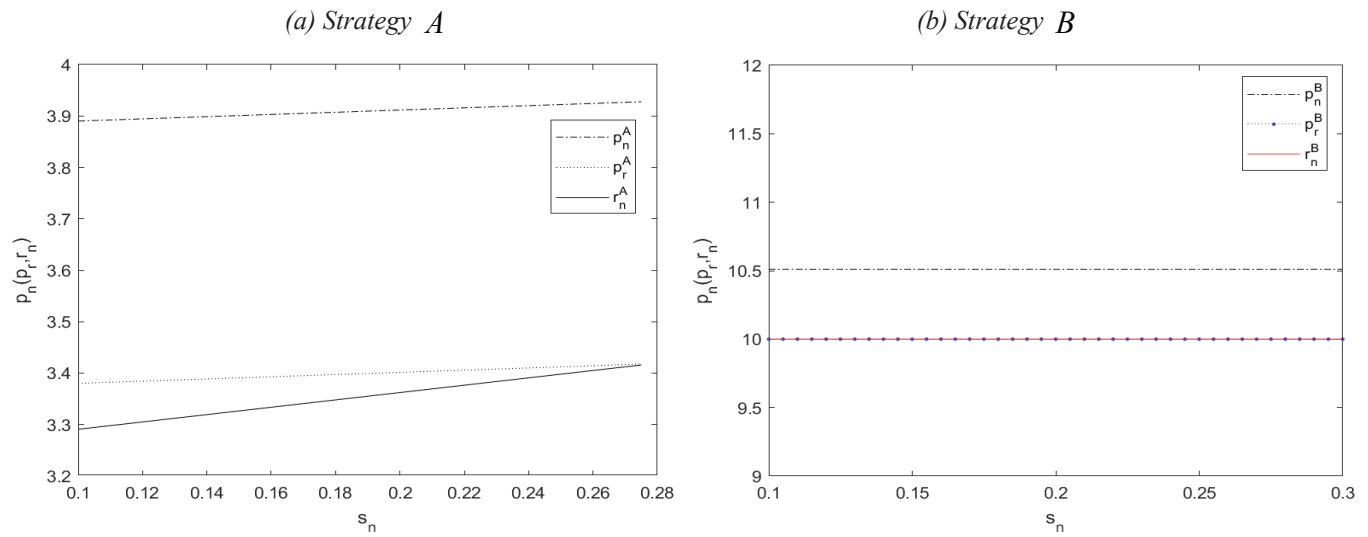
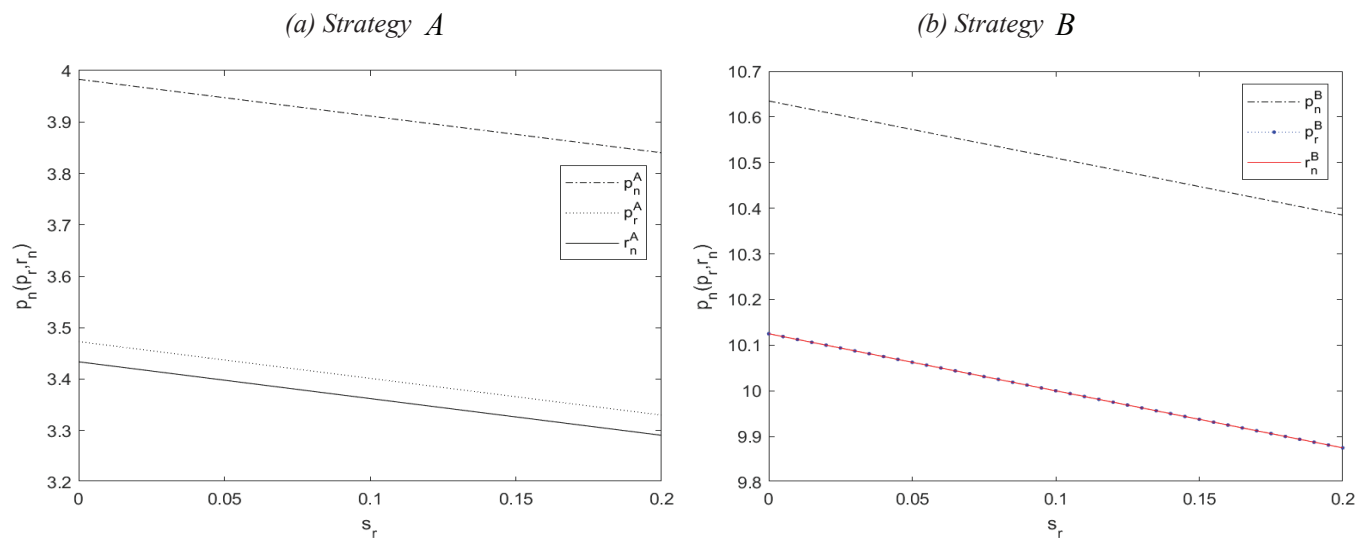
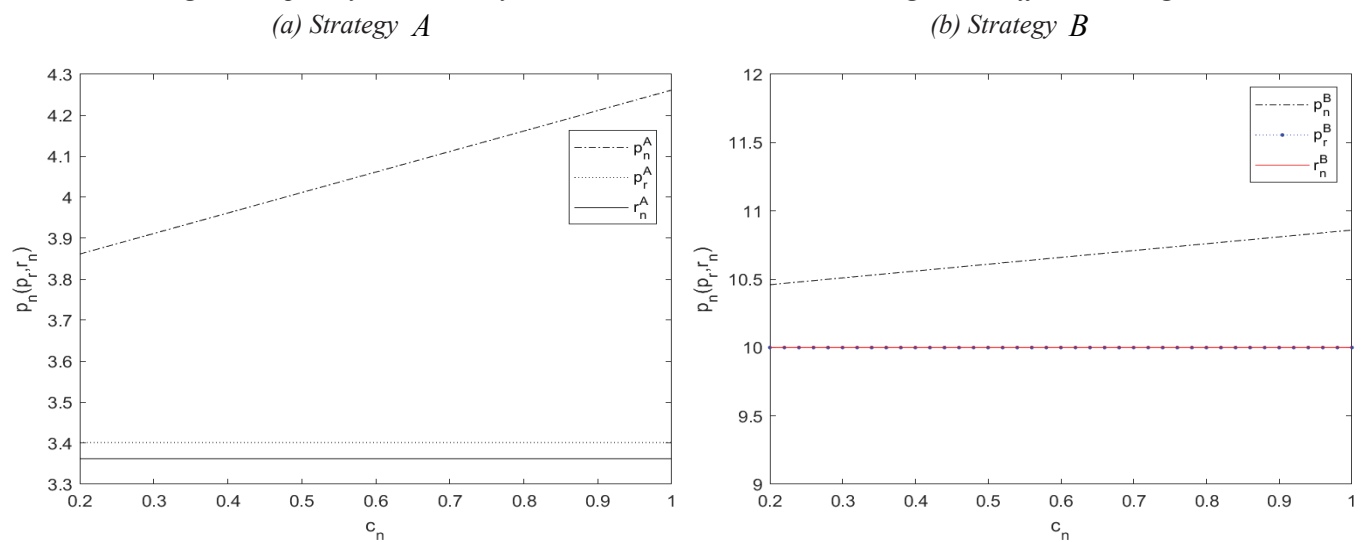
Figure 6 Impact of S_n on Manufacturer's Sales and Collection Pricing under Different StrategiesFigure 7 Impact of S_r on Manufacturer's Sales and Collection Pricing under Different StrategiesFigure 8 Impact of C_n on Manufacturer's Sales and Collection Pricing under Different Strategies

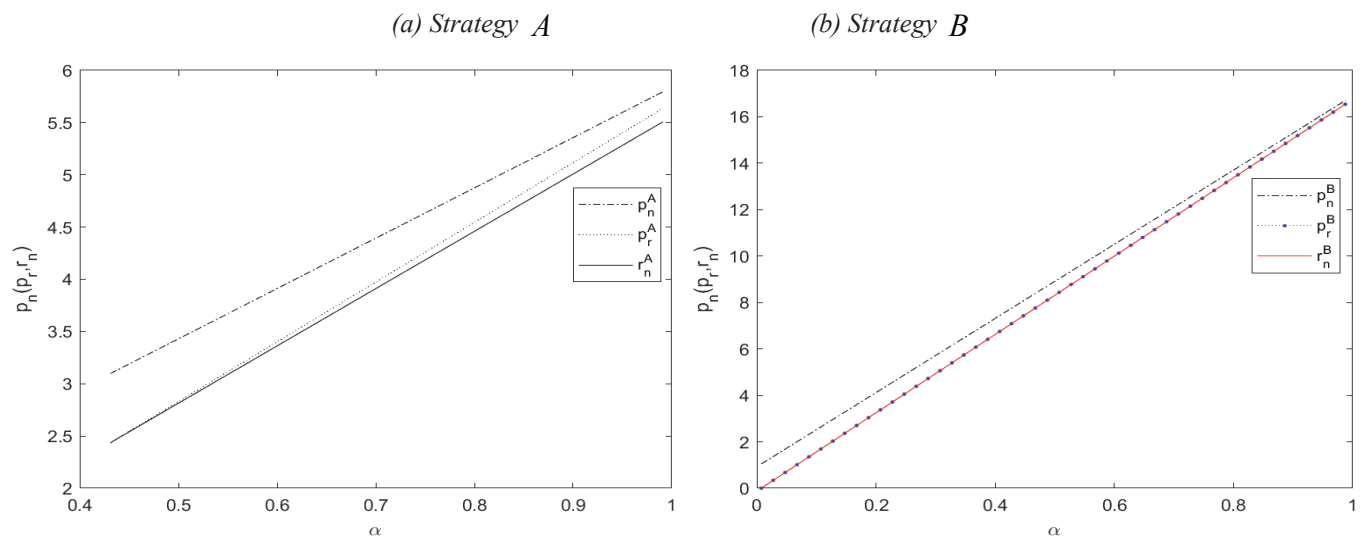
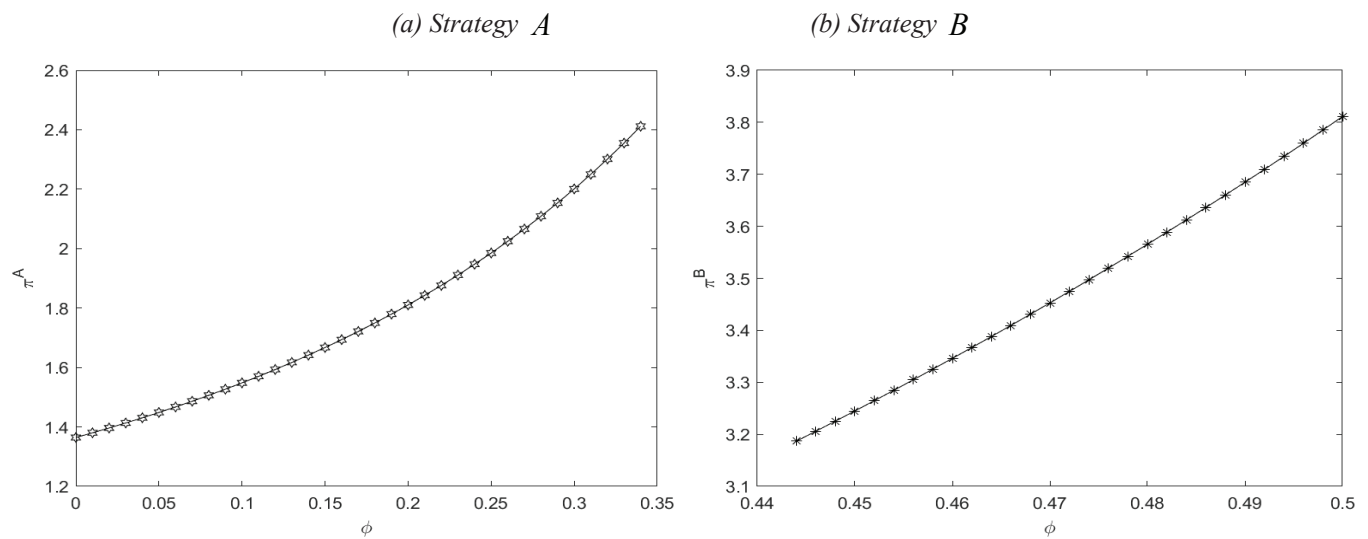
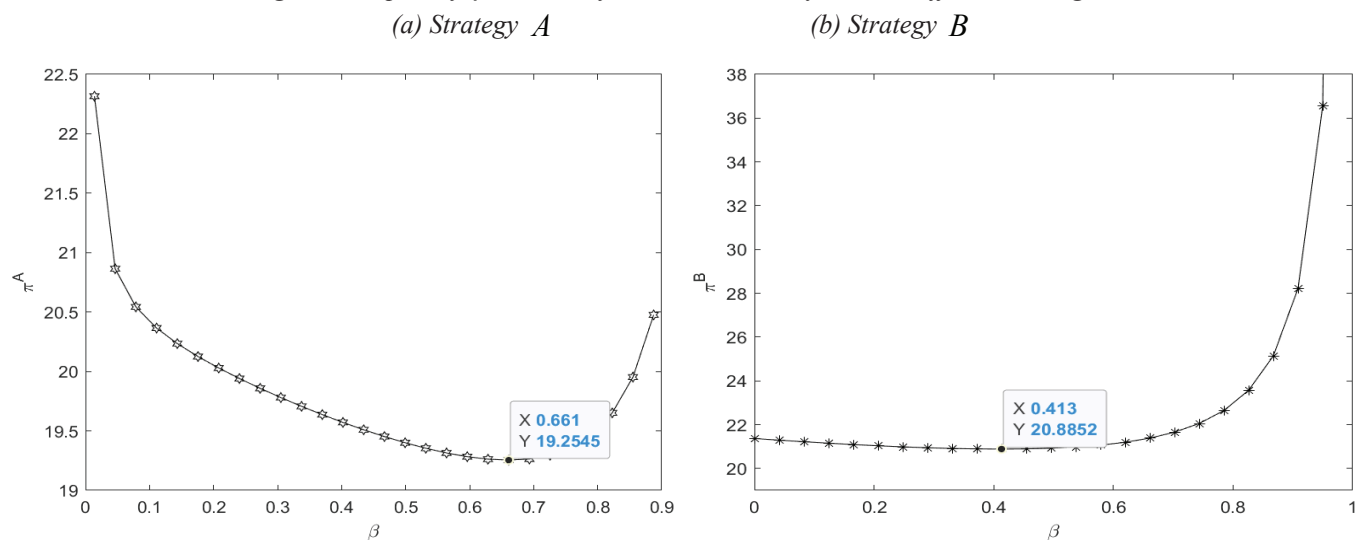
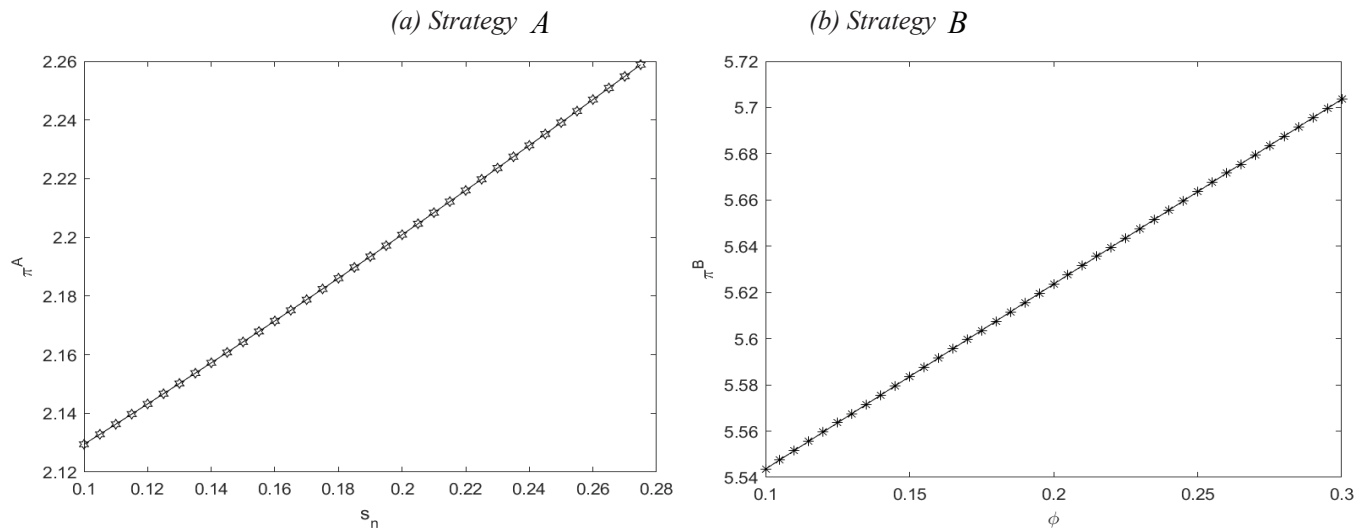
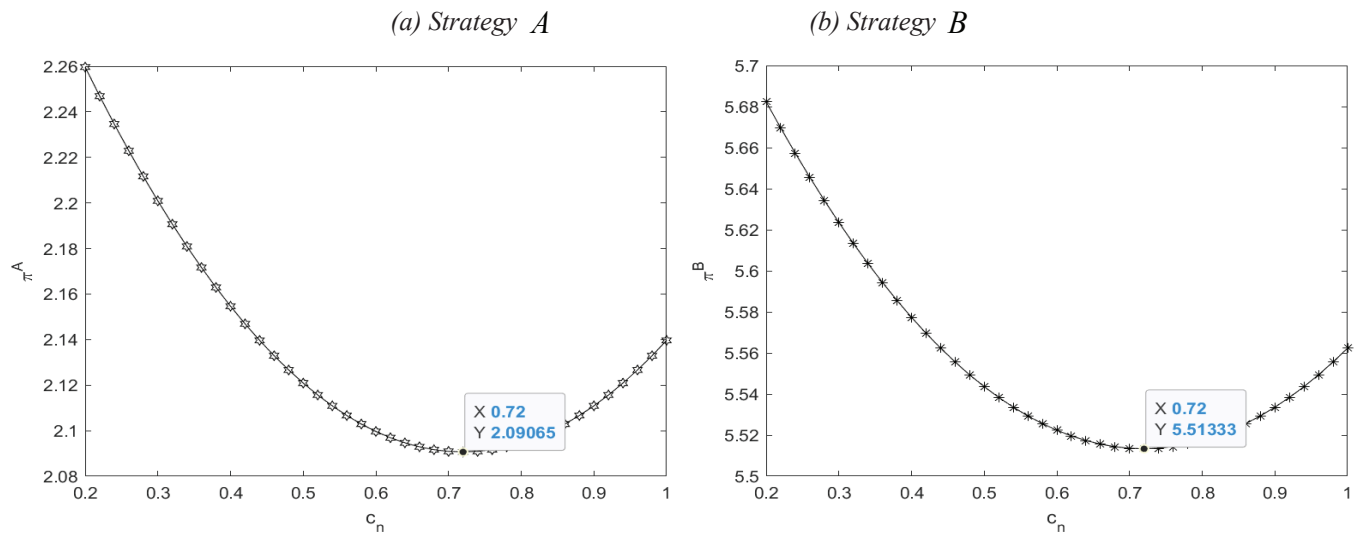
Figure 9 Impact of α on Manufacturer's Sales and Collection Pricing under Different StrategiesFigure 10 Impact of ϕ on Manufacturer's Sales and Collection Pricing under Different StrategiesFigure 11 Impact of β on Manufacturer's Total Profit under Different Strategies

Figure 12 Impact of S_n on Manufacturer's Total Profit under Different StrategiesFigure 13 Impact of C_n on Manufacturer's Total Profit under Different Strategies

6. Conclusions

This paper divides the market in the first period into new and remanufactured products, determines their demand shares, and then, in the second period, segments consumers holding different used units according to their trade-in choices. Utility-maximizing consumers yield demand functions for every scenario, and a two-period game-theoretic pricing model is built from the perspective of manufacturer profit maximization. The optimal sales prices for new and remanufactured products and the optimal buy-back price for new products are derived. The impacts of the proportion of consumers who bought new products in the first period, the remanufactured-product buy-back discount ratio, the unit production cost of new products, the remanufactured-product perceived-value discount ratio, and product circular values on sales and collection prices are examined, and the trends of total profit with respect to these key parameters are explored. The results show that: (1) When choosing the optimal pricing strategy, the manufacturer should jointly consider new-product demand, the remanufactured-product buy-back discount ratio, and the circular value of new products. In particular, when the proportion of consumers who bought new products in the first period is small ($0 < \beta \leq \beta_L$), or the circular value of new products is high ($(\alpha(1 - \frac{\beta_L}{\beta}) < s_n < c_n)$), or the remanufactured-product buy-back discount is large ($\frac{1}{2} \leq \phi < 1$), the manufacturer should set the unit buy-back price paid to consumers for returning used new products equal to the sales price of remanufactured products to maximize profit. (2) In every scenario, the unit sales prices of new and remanufactured products and the unit buy-back price of new products increase with the remanufactured-product buy-back discount ratio and the remanufactured-

product perceived-value discount ratio, but decrease with the circular value of remanufactured products. (3) An increase in the proportion of consumers who bought new products in the first period raises the sales prices of both new and remanufactured products; its effect on buy-back prices depends on the manufacturer's pricing strategy. Under the high-pricing strategy, the buy-back price first decreases and then increases with this proportion; otherwise, it increases continuously. (4) An increase in the production cost of new products only raises their sales price. The impact of the circular value of new products on sales and buy-back prices is market-dependent: if the proportion of consumers who bought new products in the first period is large, the remanufactured-product buy-back discount is small, and the circular value of new products is low, then an increase in this circular value raises all prices; otherwise, it has no effect. (5) Manufacturer profit increases with the remanufactured-product buy-back discount ratio, the circular value of new products, and the remanufactured-product perceived-value discount ratio, but decreases with the circular value of remanufactured products; profit first increases and then decreases with the production cost of new products. An increase in the proportion of consumers who bought new products in the first period raises profit, yet once the production cost of new products exceeds a critical threshold, total profit declines.

Based on these findings, managerial insights are offered. Manufacturers should flexibly adjust pricing strategies by integrating demand, cost, and circular-value considerations for both new and remanufactured products to maximize profit. They should also increase R&D investment in remanufacturing technology to improve remanufacturing efficiency and product quality, thereby enhancing consumer trust in remanufactured products. In addition, manufacturers can optimize collection channels and incentive mechanisms to encourage consumer participation in product returns and improve resource recycling rates. For governments, stronger policy support for the remanufacturing industry is needed, including tax incentives, fiscal subsidies, and R&D funding to lower remanufacturing costs and promote sustainable industrial development. Governments should also improve relevant regulations and standards, strengthen supervision of product quality and the collection market, and protect consumer rights. Meanwhile, public education campaigns can raise awareness and acceptance of remanufactured products, foster green consumption, and advance circular-economy development across the entire supply chain.

This study has limitations. It ignores the existence of a secondary market and assumes zero remanufacturing cost. Future research will incorporate the complex impact of remanufacturing costs and further investigate sales and collection pricing strategies for new and remanufactured products when a secondary market is present.

Funding

National Natural Science Foundation of China (72102112); Jiangsu Provincial Social Science Foundation (22GLC020); Qing-Lan Project of Jiangsu Higher Education Institutions; Young Science and Technology Talents Lifting Project of Jiangsu Province; Postgraduate Research & Practice Innovation Program of Jiangsu Province(KYCX24_2380).

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Jing, Y., & Du, P. (2021). Game analysis between manufacturers and remanufacturers under “trade-old-for-remanufactured” and “trade-old-for-new” strategies. *Journal of Systems Engineering*, 36(3), 339-352.
- [2] Zhu, R. J., Chen, X. J., & Dasgupta, S. (2008). Can trade-ins hurt you? Exploring the effect of a trade-in on consumers' willingness to pay for a new product. *Journal of Marketing Research*, 45(2), 159-170. <https://doi.org/10.1509/jmkr.45.2.159>
- [3] Wang, Y., Hazen, B. T., et al. (2016). Consumer product knowledge and intention to purchase remanufactured products. *International Journal of Production Economics*, 181, 460-469. <https://doi.org/10.1016/j.ijpe.2015.08.031>
- [4] Wang, S., Wang, J., Yang, F., et al. (2020). Determinants of consumers' remanufactured products purchase intentions: Evidence from China. *International Journal of Production Research*, 58(8), 2368-2383. <https://doi.org/10.1080/00207543.2019.1630767>
- [5] Wang, Y., Wiegerinck, V., Krikke, H. R., et al. (2013). Understanding the purchase intention towards remanufactured

- product in closed-loop supply chains: An empirical study in China. *International Journal of Physical Distribution & Logistics Management*, 43. <https://doi.org/10.1108/IJPDLM-01-2013-0011>
- [6] Singhal, D., Jena, S. K., Tripathy, S., et al. (2019). Factors influencing the purchase intention of consumers towards remanufactured products: A systematic review and meta-analysis. *International Journal of Production Research*, 57(23), 7289-7299. <https://doi.org/10.1080/00207543.2019.1598590>
- [7] Khor, K. S., Hazen, B. T., et al. (2017). Remanufactured products purchase intentions and behaviour: Evidence from Malaysia. *International Journal of Production Research*, 55(8), 2149-2162. <https://doi.org/10.1080/00207543.2016.1194534>
- [8] Lv, J., Liu, X., Cheng, S., et al. (2021). The impact of remanufactured products' similarity on purchase intention of new products. *Sustainability*, 13(4), 1825. <https://doi.org/10.3390/su13041825>
- [9] Alyahya, M., Agag, G., Aliedan, M., et al. (2023). A sustainable step forward: Understanding factors affecting customers' behaviour to purchase remanufactured products. *Journal of Retailing and Consumer Services*, 70, 103172. <https://doi.org/10.1016/j.jretconser.2022.103172>
- [10] Christensen, L. R., Manser, M. E., et al. (1977). Estimating U.S. consumer preferences for meat with a flexible utility function. *Journal of Econometrics*, 5(1), 37-53. [https://doi.org/10.1016/0304-4076\(77\)90033-1](https://doi.org/10.1016/0304-4076(77)90033-1)
- [11] Wang, Y., Xin, B., Wang, Z., et al. (2019). Managing supplier-manufacturer closed-loop supply chain considering product design and take-back legislation. *International Journal of Environmental Research and Public Health*, 16(4), E623. <https://doi.org/10.3390/ijerph16040623>
- [12] Esenduran, G., Kemahlioğlu-Ziya, E., Swaminathan, J. M., et al. (2016). Take-back legislation: Consequences for remanufacturing and environment. *Decision Sciences*, 47(2), 219-256. <https://doi.org/10.1111/deci.12174>
- [13] Dong, C., Lei, Y., Liu, Q., et al. (2023). (Un)conditional collection policies on used products with strategic customers. *Production and Operations Management*, 32(1), 82-97. <https://doi.org/10.1111/poms.13826>
- [14] Sun, X., Zhou, Y., Li, Y., et al. (2020). Differentiation competition between new and remanufactured products considering third-party remanufacturing. *Journal of the Operational Research Society*, 71(1), 161-180. <https://doi.org/10.1080/01605682.2018.1512843>
- [15] Guide, J. V. D. R., Li, J., et al. (2010). The potential for cannibalization of new products sales by remanufactured products. *Decision Sciences*, 41(3), 547-572. <https://doi.org/10.1111/j.1540-5915.2010.00280.x>
- [16] Abbey, J. D., Blackburn, J. D., Guide, V. D. R., et al. (2015). Optimal pricing for new and remanufactured products. *Journal of Operations Management*, 36, 130-146. <https://doi.org/10.1016/j.jom.2015.03.007>
- [17] Wang, B., Wang, J., et al. (2015). Price and service competition between new and remanufactured products. *Mathematical Problems in Engineering*, 2015, 1-18.
- [18] Wu, C., et al. (2012). Price and service competition between new and remanufactured products in a two-echelon supply chain. *International Journal of Production Economics*, 140(1), 496-507. <https://doi.org/10.1016/j.ijpe.2012.06.034>
- [19] Wu, C., et al. (2012). Product-design and pricing strategies with remanufacturing. *European Journal of Operational Research*, 222(2), 204-215. <https://doi.org/10.1016/j.ejor.2012.04.031>
- [20] Zheng, M., Shi, X., Xia, T., et al. (2021). Production and pricing decisions for new and remanufactured products with customer prejudice and accurate response. *Computers & Industrial Engineering*, 157, 107308. <https://doi.org/10.1016/j.cie.2021.107308>
- [21] Guide, D., Teunter, R., Van Wassenhove, L., et al. (2003). Matching demand and supply to maximize profits from remanufacturing. *Manufacturing & Service Operations Management*, 5, 303-316. <https://doi.org/10.1287/msom.5.4.303.24883>
- [22] Bhattacharya, R., Kaur, A., et al. (2015). Allocation of external returns of different quality grades to multiple stages of a closed loop supply chain. *Journal of Manufacturing Systems*, 37, 692-702. <https://doi.org/10.1016/j.jmsy.2015.01.004>
- [23] Raihanian Mashhadi, A., Behdad, S., et al. (2017). Optimal sorting policies in remanufacturing systems: Application of product life-cycle data in quality grading and end-of-use recovery. *Journal of Manufacturing Systems*, 43, 15-24. <https://doi.org/10.1016/j.jmsy.2017.02.006>

- [24] Fan, X., Guo, X., Wang, S., et al. (2022). Optimal collection delegation strategies in a retail-/dual-channel supply chain with trade-in programs. *European Journal of Operational Research*, 303(2), 633-649. <https://doi.org/10.1016/j.ejor.2022.02.053>
- [25] Li, Y., Wang, K., Xu, F., et al. (2022). Management of trade-in modes by recycling platforms based on consumer heterogeneity. *Transportation Research Part E: Logistics and Transportation Review*, 162, 102721. <https://doi.org/10.1016/j.tre.2022.102721>
- [26] Yin, J., Xie, J., Liu, J., et al. (2017). Research on decision-making mechanism of remanufacturing with graded recycling of old parts. *Shanghai Management Science*, 39(3), 22-29.
- [27] van Loon, P., Van Wassenhove, L. N., et al. (2018). Assessing the economic and environmental impact of remanufacturing: A decision support tool for OEM suppliers. *International Journal of Production Research*, 56, 1662-1674. <https://doi.org/10.1080/00207543.2017.1381820>
- [28] Zhang, Q., Xiao, T., et al. (2024). Incentive strategies of an e-tailer considering online reviews: Rebates or services. *Electronic Commerce Research and Applications*, 68, 101453. <https://doi.org/10.1016/j.elerap.2024.101453>
- [29] Sheldon, T. L., Dua, R., et al. (2024). The dynamic role of subsidies in promoting global electric vehicle sales. *Transportation Research Part A: Policy and Practice*, 187, 104173. <https://doi.org/10.1016/j.tra.2024.104173>
- [30] Du, Z., Fan, Z., Sun, F., et al. (2023). Live streaming sales: Streamer type choice and limited sales strategy for a manufacturer. *Electronic Commerce Research and Applications*, 61, 101300. <https://doi.org/10.1016/j.elerap.2023.101300>
- [31] Wan, Y., Yang, L., Zhang, J., et al. (2024). Optimal trade-in programs for quality differentiated recycled products. *Transportation Research Part E: Logistics and Transportation Review*, 188, 103617. <https://doi.org/10.1016/j.tre.2024.103617>
- [32] Xu, Y., Wang, J., Cao, K., et al. (2024). Dynamic joint strategy of channel encroachment and logistics choice considering trade-in service and strategic consumers. *Transportation Research Part E: Logistics and Transportation Review*, 185, 103528. <https://doi.org/10.1016/j.tre.2024.103528>
- [33] Liu, K., Li, Q., Zhang, H., et al. (2024). Trade-in strategies in closed-loop supply chain when considering manufacturer entrustment behavior and wholesale price contract. *Journal of the Operational Research Society*. <https://doi.org/10.1080/01605682.2024.2368018>
- [34] Shi, P., Shi, S., et al. (2022). Analysis of manufacturers' autonomous trade-in strategies in the presence of competition from informal recyclers. *Journal of Systems Engineering*, 37(1), 12-22.
- [35] Wang, W., Feng, L., Chen, X., et al. (2024). Impacts of selling models: Who should offer trade-in programs in e-commerce supply chains? *Transportation Research Part E: Logistics and Transportation Review*, 186, 103524. <https://doi.org/10.1016/j.tre.2024.103524>
- [36] Tang, F., Dai, Y., Ma, Z., et al. (2023). Trade-in operations under retail competition: Effects of brand loyalty. *European Journal of Operational Research*, 310(1), 397-414. <https://doi.org/10.1016/j.ejor.2023.03.020>
- [37] Yang, G., He, B., Ma, R., et al. (2023). Self-building or cooperating with a service platform: How should a dual-channel firm implement a trade-in program? *Electronic Commerce Research*. <https://doi.org/10.1007/s10660-023-09746-w>
- [38] Ma, P., Gong, Y., Mirchandani, P., et al. (2020). Trade-in for remanufactured products: Pricing with double reference effects. *International Journal of Production Economics*, 230, 107800. <https://doi.org/10.1016/j.ijpe.2020.107800>
- [39] Sun, X., Wu, Z., et al. (2020). Trade-old-for-remanufactured recycling models under different market leaders. *Industrial Engineering*, 23(5), 169-175.
- [40] Gao, P., Ding, X., et al. (2020). Manufacturer decision model based on "trade-old-for-remanufactured" and consumer segmentation. *Systems Engineering — Theory & Practice*, 40(4), 951-963.
- [41] Wan, F., Zou, W., et al. (2019). Impact of "trade-old-for-remanufactured" policy on closed-loop supply chain of end-of-life vehicle remanufacturing. *Ecological Economy*, 35(3), 79-86.
- [42] Han, X., Yang, Q., Shang, J., et al. (2017). Optimal strategies for trade-old-for-remanufactured programs: Receptivity, durability, and subsidy. *International Journal of Production Economics*, 193, 602-616. <https://doi.org/10.1016/j.ijpe.2017.07.025>

- [43] Liu, K., Li, Q., Liu, J., et al. (2024). Trade-In and Trade-Old-for-Remanufactured in Closed-Loop Supply Chain Under Different Power Structures and Government Subsidy. *SAGE Open*. <https://doi.org/10.1177/2158244024125721>
- [44] Li, D., Shen, B., et al. (2024). Closed-loop supply chain management under the interaction of “trade-old-for-new” and “trade-old-for-remanufactured”. *Systems Engineering*, 42(6), 72-83.
- [45] Xiong, Y., Zhou, Y., Li, G., et al. (2013). Don't forget your supplier when remanufacturing. *European Journal of Operational Research*, 230(1), 15-25. <https://doi.org/10.1016/j.ejor.2013.03.034>
- [46] Ke, C., Yan, B., et al. (2020). Trade-in value effects of used products in remanufacturing with considering consumer purchase behavior. *Journal of the Operational Research Society*, 73, 608-633. <https://doi.org/10.1080/01605682.2020.1783978>
- [47] Chen, J., Chang, C., et al. (2013). Dynamic pricing for new and remanufactured products in a closed-loop supply chain. *International Journal of Production Economics*, 146(1), 153-160. <https://doi.org/10.1016/j.ijpe.2013.06.017>
- [48] Wu, X., Zhou, Y., et al. (2015). Does the entry of third-party remanufacturers always hurt original equipment manufacturers? *Marketing Science eJournal*.
- [49] Nie, J., Liu, J., Yuan, H., et al. (2021). Economic and environmental impacts of competitive remanufacturing under government financial intervention. *Computers & Industrial Engineering*, 159, 107473. <https://doi.org/10.1016/j.cie.2021.107473>
- [50] Wang, Z., Wang, Y., Gong, Y., et al. (2024). Cooperate or not? Strategic analysis of formal and informal recyclers under different retired power battery recycling market structures. *Computers & Industrial Engineering*, 193, 110294. <https://doi.org/10.1016/j.cie.2024.110294>
- [51] Li, Y., Feng, L., Govindan, K., et al. (2019). Effects of a secondary market on original equipment manufacturers' pricing, trade-in remanufacturing, and entry decisions. *European Journal of Operational Research*, 279(3), 751-766. <https://doi.org/10.1016/j.ejor.2019.03.039>
- [52] Zhang, Z., Ren, D., Lan, Y., et al. (2022). Price competition and blockchain adoption in retailing markets. *European Journal of Operational Research*, 300(2), 647-660. <https://doi.org/10.1016/j.ejor.2021.08.027>
- [53] Wang, Q., Li, B., Chen, B., et al. (2021). Implication of take-back and carbon emission capacity regulations on remanufacturing in a competitive market. *Journal of Cleaner Production*, 325, 129231. <https://doi.org/10.1016/j.jclepro.2021.129231>
- [54] Wang, X., Xu, Y., Choi, T., et al. (2024). Who should pay for the return freight in e-commerce? Platforms, retailers or consumers. *International Journal of Production Economics*, 277, 109375. <https://doi.org/10.1016/j.ijpe.2024.109375>
- [55] Liang, Y., Liu, W., Li, K. W., et al. (2023). A co-opetitive game analysis of platform compatibility strategies under add-on services. *Production and Operations Management*, 32, 3541-3558. <https://doi.org/10.1111/poms.13991>
- [56] Ma, P., Zhou, X., et al. (2023). Financing strategies and government incentives in a competing supply chain with Trading-Old-for-Remanufactured programs. *CIRP Journal of Manufacturing Science and Technology*, 46, 242-263. <https://doi.org/10.1016/j.cirpj.2023.08.008>
- [57] Li, S., Zheng, B., Jia, D., et al. (2024). Optimal decisions for hybrid manufacturing and remanufacturing with trade-in program and carbon tax. *Omega*, 124, 103012. <https://doi.org/10.1016/j.omega.2023.103012>

Divergent Pathways of Artificial Intelligence Adoption in E-Commerce: A Multidimensional Comparative Analysis of China, the United States, and the European Union

Fengyu Zhao*

College of Economics and Management, Southwest Forestry University, Kunming, 650224, China

*Corresponding author: Fengyu Zhao, zhaofengyu@swfu.edu.cn

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: The transformative impact of Artificial Intelligence (AI) on global e-commerce is shaped by profound regional disparities, yet comparative analyses remain limited. This study introduces a novel Technology-Economics-Society-Regulation (TESR) framework to systematically compare AI adoption pathways in e-commerce across China, the United States, and the European Union. Through a systematic literature review following PRISMA guidelines, analyzing 142 peer-reviewed studies from 2018–2023, we identify distinct regional paradigms. China's platform-centric model leverages integrated ecosystems and vast data scale for operational efficiency and immersive engagement. The United States pursues a market-driven approach, emphasizing Software-as-a-Service solutions and personalization for competitive advantage. The European Union prioritizes a rights-based governance model, focusing on privacy, explainability, and ethical compliance. These divergent trajectories, driven by interdependent technological, economic, socio-cultural, and regulatory dynamics, challenge assumptions of global convergence in AI adoption. This research bridges a critical gap by providing a structured comparative framework, offering actionable insights for policymakers, practitioners, and researchers navigating the heterogeneous evolution of AI-powered e-commerce.

Keywords: Artificial Intelligence; E-Commerce; Comparative Analysis; TESS Framework; China; United States; European Union; Technology Adoption; Regulatory Policy

Published: Oct 12, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.653>

1.Introduction

The global e-commerce sector is undergoing a profound transformation, driven by algorithms and powered by Artificial Intelligence (AI). Technologies such as personalized recommendation systems, conversational chatbots, computer vision-enabled search, and predictive logistics are fundamentally reshaping how goods are discovered, purchased, and delivered ^[1,2]. This technological integration promises unprecedented efficiency, customer satisfaction, and economic growth, heralding a new era of intelligent commerce. By 2025, the global AI in e-commerce market is projected to exceed \$16 billion, with a compound annual growth rate surpassing 40% from 2023 to 2030 ^[3].

However, the notion of AI as a homogenizing global force is increasingly recognized as inadequate. Closer examination reveals significant variations in how AI is developed, deployed, and governed across different national and regional contexts. China, the United States, and the European Union represent three of the world's largest and most influential e-commerce

markets, each characterized by distinct digital ecosystems, economic philosophies, cultural norms, and regulatory landscapes^[4]. For instance, the pervasive, platform-driven AI integration in Chinese “super-apps” like Alibaba’s Taobao and JD.com, which command over 80% of the domestic market share^[5], contrasts with the decentralized, enterprise software-centric adoption pattern prevalent in the United States. This pattern, in turn, differs markedly from the cautiously innovative approach emerging in the European Union, influenced by stringent data protection laws such as the General Data Protection Regulation (GDPR), which has imposed fines exceeding €3 billion since its implementation^[6].

Despite extensive literature documenting AI applications within each market, a significant research gap persists: the absence of a systematic, multidimensional comparative analysis that transcends siloed case studies. Existing reviews often focus solely on technological capabilities, neglecting the intricate interplay of technology, economic models, social structures, and regulatory frameworks that shape AI empowerment trajectories^[7].

This study aims to address this gap by exploring the following primary research question: How do the pathways of AI empowerment in e-commerce differ among China, the United States, and the European Union, and what factors explain these divergences?

To answer this, we conducted a systematic literature review and proposed an original analytical framework based on four core dimensions: technological (comparing the focus and integration depth of AI applications), economic (analyzing differing business models and value creation paradigms), socio-cultural (examining varying consumer behaviors and trust levels), and regulatory (contrasting governmental policy approaches).

The contribution of this paper is threefold. First, it synthesizes disparate knowledge into a coherent comparative structure, addressing a critical literature gap. Second, it introduces and validates a novel Technology-Economics-Society-Regulation (TESR) framework for analyzing cross-contextual technology adoption, applicable beyond e-commerce. Third, it provides evidence-based insights into the future trajectory of global e-commerce, suggesting a trend toward divergent regional paradigms rather than a unified global model, with significant implications for strategy and policy.

The paper is structured as follows: Section 2 details the methodology of the systematic literature review. Section 3 presents the findings through the four-dimensional framework. Section 4 discusses the implications of these divergent pathways, and Section 5 concludes with limitations and directions for future research.

2. Methodology: A Systematic Review Approach

This study adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure a comprehensive, transparent, and reproducible literature search and selection process^[8].

2.1 Literature Search Strategy

A systematic search was conducted across four electronic databases: Web of Science Core Collection, Scopus, IEEE Xplore, and China National Knowledge Infrastructure (CNKI). The search strategy targeted literature published between January 2018 and December 2023. The search string combined keywords related to: (1) Artificial Intelligence (e.g., “AI,” “machine learning,” “deep learning,” “natural language processing,” “computer vision”), (2) e-commerce (e.g., “e-commerce,” “online retail,” “digital commerce”), and (3) specific regions (e.g., “China,” “United States,” “European Union”). Boolean and proximity operators were tailored to each database’s syntax.

2.2 Study Selection and Eligibility Criteria

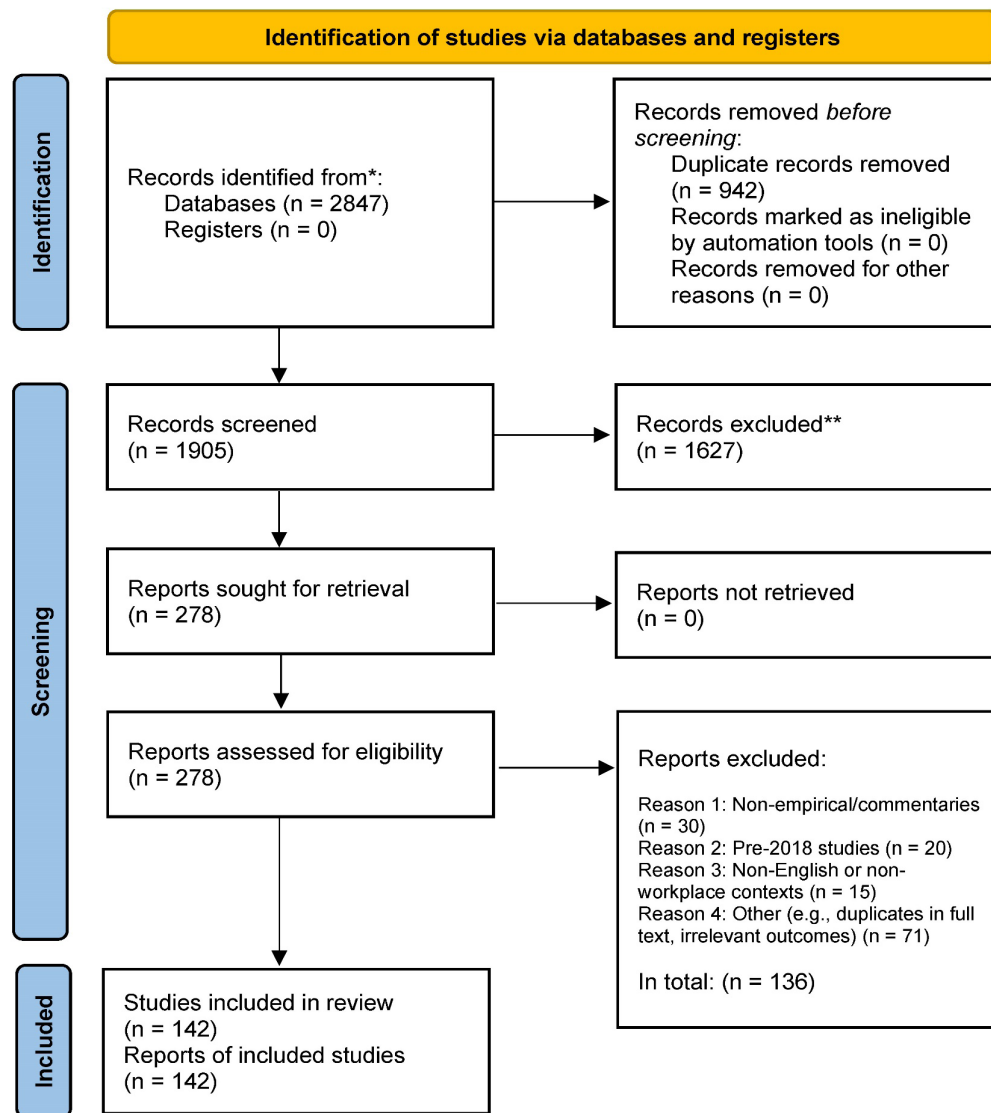
The initial search yielded 2,847 records. After removing duplicates, 1,905 titles and abstracts were screened against predefined eligibility criteria. Inclusion criteria encompassed:

- (a) empirical studies, conceptual papers, or review articles;
- (b) focus on AI applications in e-commerce;
- (c) explicit analysis of China, the United States, or the European Union;
- (d) publication in English or Chinese in peer-reviewed journals or conference proceedings.

Exclusion criteria included: (a) papers focused solely on AI technical development without e-commerce application; (b) papers lacking a clear regional focus; (c) editorials, prefaces, or short commentaries without original analysis; and (d) papers not accessible in full text.

Following initial screening, 278 full-text articles were assessed for eligibility, resulting in a final corpus of 142 studies for in-depth analysis. The selection process is summarized in Figure 1.

Figure 1. PRISMA Flow Diagram of Literature Selection Process



2.3 Data Extraction and Analytical Framework

Data from included studies were extracted into a standardized matrix, capturing author(s), publication year, region of focus, AI technology, e-commerce function, key findings, and challenges.

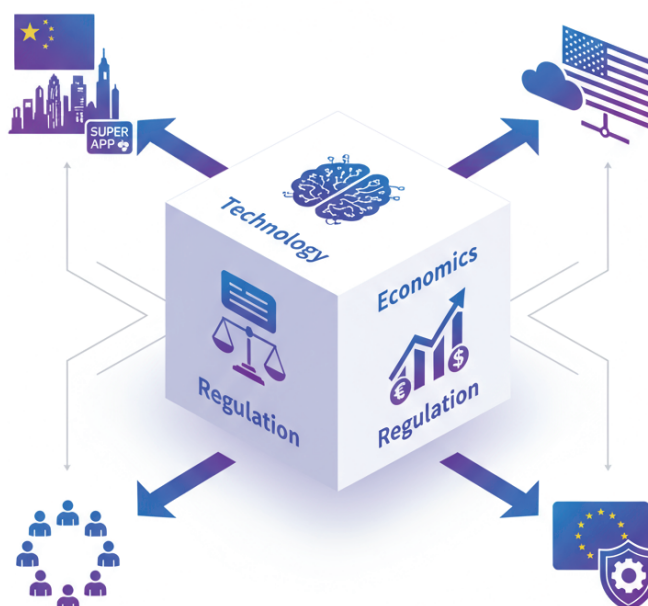
The data were analyzed using a multidimensional comparative framework, categorizing findings into four dimensions: technological (AI application types, e.g., recommendation systems, computer vision, NLP/chatbots, logistics, dynamic pricing); economic (business models, market concentration, investment patterns, key performance indicators like conversion rates); socio-cultural (consumer acceptance, trust, privacy concerns, societal impacts); and regulatory (data protection laws, AI ethics guidelines, platform governance). This framework enabled structured within-region and cross-region thematic analysis, identifying patterns, convergences, and divergences in AI empowerment pathways.

The analytical process was guided by a conceptual model expressing aggregate AI empowerment (AAE) for a region as a function of its scores across the four dimensions:

$$AAEr = f(Tech_r, Econ_r, Soc_r, Reg_r)$$

This qualitative model underscores the combined effect of dimensions on empowerment pathways. Figure 2 visually depicts how these dimensions interact to shape regional AI adoption.

Figure 2. The Technology-Economics-Society-Regulation (TESR) Analytical Framework



3. Findings

This systematic analysis reveals distinct divergences in AI empowerment in e-commerce across China, the United States, and the European Union, best understood through the Technology-Economics-Society-Regulation (TESR) framework. Each dimension's unique configuration forms self-reinforcing systems, culminating in fundamentally different pathways.

3.1 Technological Dimension: Divergent Integration Patterns

AI applications are advanced across all three regions, yet their architectural philosophies and primary focuses differ, reflecting contextual drivers.

In China, e-commerce is characterized by deeply embedded, platform-centric AI integration. Leveraging vast, multi-modal data streams—spanning social interactions, payment behaviors, and location data—within “super-app” ecosystems creates immersive user experiences. AI serves as the core operational engine for platforms like Alibaba’s Taobao and JD.com. For instance, recommendation algorithms integrated with live-streaming features enable seamless product discovery and purchase conversion, contributing to China’s live-streaming e-commerce market reaching \$480 billion in 2023, accounting for approximately 20% of online retail sales^[9]. Computer vision applications, such as augmented reality for virtual try-ons in cosmetics and apparel, reduce return rates by 25–40% and increase conversion rates by 15–30%^[10]. This end-to-end control optimizes the entire value chain, exemplified by AI-driven logistics networks that dynamically reroute packages based on real-time conditions.

The United States exhibits a specialized, disaggregated Software-as-a-Service (SaaS) model. While tech giants like Amazon develop proprietary AI systems, the defining feature is specialized B2B providers offering cloud-based solutions, creating a “best-of-breed” landscape where retailers assemble customized tech stacks. SaaS penetration in e-commerce grew from 35% in 2018 to 68% in 2023 among medium and large retailers^[11]. This ecosystem drives innovation in hyper-personalized recommendation engines using advanced neural networks for precise consumer preference prediction. The focus is on scalable solutions delivering measurable return on investment, particularly through enhanced customer acquisition and retention. Venture capital investment in AI-enabled retail technologies reached \$12.3 billion in 2022^[12].

The European Union’s technological trajectory prioritizes pragmatic, compliance-oriented approaches, emphasizing explainability, transparency, and privacy preservation. Significant efforts focus on Explainable AI (XAI) methodologies aligned with GDPR’s right to explanation, such as counterfactual explanations for automated decisions^[13]. Linguistic and cultural diversity drives innovation in multilingual AI solutions for cross-border complexities. Applications emphasize supply chain optimization and customer service automation, prioritizing reliability over immersive engagement. The Digital Europe Programme allocated over €2.1 billion for ethical and trustworthy AI development in 2022^[14].

Table 1: Technological Dimension Comparison

Feature	China	United States	European Union
Primary Driver	Ecosystem Integration & Data Scale	Innovation & Market Competition	Efficiency & Regulatory Compliance
Key Strength	Computer Vision, Integrated Recommenders	Foundational Models, SaaS Solutions	Supply Chain Logistics, XAI
Integration Model	Vertical, Platform-Centric	Horizontal, SaaS-Centric	Fragmented, Enterprise-Centric
Data Utilization	Holistic, Multi-modal	Targeted, Behavioral	Segmented, Privacy-conscious
Innovation Focus	Immersive Engagement	Personalization Accuracy	Explainability & Transparency

3.2 Economic Dimension: Contrasting Value Creation Models

Economic structures and incentives shape distinct value creation logics and business models across the regions.

China's model is dominated by vertically integrated platforms using AI as a competitive moat. These platforms create self-reinforcing ecosystem flywheels, where superior AI attracts users and merchants, generating diverse data to refine systems. The focus is on maximizing user engagement and Gross Merchandise Volume (GMV) within walled gardens, monetized through internal advertising, transaction fees, and cloud services. Alibaba invested \$6.8 billion in AI research in 2022^[15], driving market concentration with the top three platforms controlling over 78% of e-commerce market share^[5]. Small and medium enterprises (SMEs) participate as merchants within these platforms, aligning AI development with platform goals.

The United States features a hybrid model combining platform dominance with independent AI solutions. Specialized AI vendors offer subscription-based SaaS, enabling retailers to access sophisticated capabilities without large upfront costs, though creating third-party dependency. The economic focus is on measurable return on investment, emphasizing Customer Lifetime Value (CLV) and customer acquisition cost (CAC). Venture capital investment reached \$12.3 billion in AI retail technologies in 2022^[12]. This competitive landscape drives innovation but results in fragmentation, as retailers integrate multiple solutions.

The European Union's economic structure, marked by numerous SMEs and strong antitrust enforcement, emphasizes operational efficiency within the Digital Single Market. AI optimizes cross-border logistics, inventory management, and multilingual tools, enabling smaller retailers to compete. Venture funding for AI retail technologies was €3.2 billion in 2022, supplemented by €4.7 billion in public funds from the Digital Europe Programme for SME-focused AI^[14]. The Digital Markets Act discourages market concentration, promoting a distributed model where AI serves as an equalizing tool.

Table 2: Economic Dimension Comparison

Feature	China	United States	European Union
Dominant Model	Integrated Platform Economy	Hybrid (Platform + SaaS)	SME & Efficiency-Led
Investment Driver	Strategic Ecosystem Control	Venture Capital & ROI	Operational Efficiency & Grants
Key Metric	GMV, Engagement	CLV, CAC	Cost Savings, Cross-Border Efficiency
SME Role	Merchants within Platforms	Customers of SaaS Solutions	Primary Beneficiaries
Market Concentration	High (Top 3: 78%+)	Moderate (Top 3: 55%)	Low (Top 3: 42%)

3.3 Socio-Cultural Dimension: Varieties of Trust and Acceptance

Consumer attitudes and societal values create distinct cultural contexts, influencing AI deployment and forming feedback loops.

Chinese consumers exhibit utilitarian trust, prioritizing AI-powered convenience over privacy concerns. Research shows 68% are willing to share personal data for personalized experiences, compared to 42% in the United States and 28% in Germany

^[16]. Social commerce and group buying, facilitated by AI, are cultural differentiators, with live-stream shopping generating \$480 billion in 2023 ^[9]. AI-powered payment platforms like Alipay and WeChat Pay are used by 92% of mobile internet users ^[5]. Privacy concerns, though present, are secondary to hyper-convenience and engagement. American consumers show conditional, individualistic acceptance, expecting personalized experiences while remaining skeptical of data practices. Studies indicate 65% appreciate AI recommendations but express concerns about algorithmic bias and data misuse ^[11]. The Federal Trade Commission reported a 300% increase in algorithmic decision-making complaints from 2019 to 2023 ^[17]. This drives demand for transparency and ethical AI, with 45% of major retailers publishing AI ethics statements by 2023, up from 12% in 2018 ^[12]. European consumers adopt a rights-based cautious approach, viewing privacy and autonomy as fundamental. Research shows 72% are uncomfortable with AI-driven decisions without human oversight ^[14], and 64% seek information on data usage, compared to 38% in the United States and 29% in China ^[18]. Trust is earned through compliance and transparency, with 57% willing to switch platforms for better privacy protections ^[19].

Table 3: Socio-Cultural Dimension Comparison

Feature	China	United States	European Union
Consumer Priority	Convenience & Social Engagement	Personalization & Choice	Privacy & Rights
Attitude to Data	Generally Accepting	Ambivalent & Conditional	Cautious & Rights-Based
Key Catalyst	Social Commerce & Mobile Payments	Expectation of Customization	Value-Driven Digital Citizenship
Primary Concern	Service Quality	Bias & Manipulation	Surveillance & Autonomy
Trust Mechanism	Utilitarian Exchange	Conditional Value Delivery	Rights Protection

3.4 Regulatory Dimension: Governance Paradigms and Their Consequences

The regulatory environment significantly shapes AI empowerment pathways.

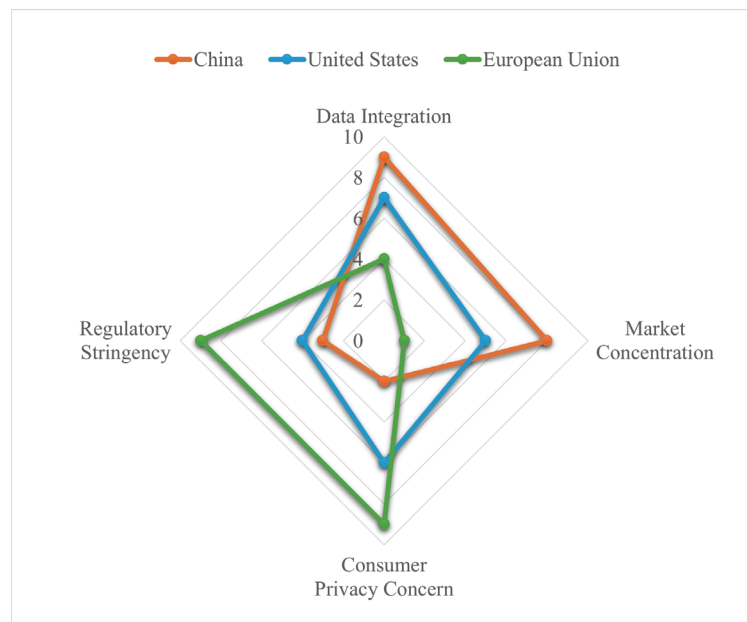
China's state-led strategic governance aligns AI with national economic objectives. The Personal Information Protection Law (PIPL) of 2021 balances data protection with technological sovereignty ^[20]. The "China Standards 2035" initiative aims to shape global AI standards ^[20]. This "guided innovation" allows rapid commercial AI scaling within strict data and content parameters. The United States employs a sectoral, pro-innovation approach with decentralized regulation. The absence of comprehensive federal AI legislation results in state-level and sector-specific rules. The Federal Trade Commission addressed AI-related harms with 23 enforcement actions from 2020 to 2023 ^[17]. By 2023, 12 states enacted consumer privacy laws and seven implemented AI regulations ^[21]. The European Union's precautionary, rights-based approach prioritizes fundamental rights. The GDPR (2018) and AI Act (2024) establish global benchmarks, with the latter introducing risk-based AI regulation ^[22]. This "Brussels Effect" influences global standards ^[6], driving focus on explainable, privacy-preserving AI.

Table 4: Regulatory Dimension Comparison

Feature	China	United States	European Union
Philosophy	State-Led Strategic Governance	Pro-Innovation, Sectoral Approach	Precautionary, Rights-Based
Key Legislation	Personal Information Protection Law (PIPL)	Sectoral Laws (FTC Act, State Laws)	GDPR, AI Act
Primary Goal	National Sovereignty, Social Stability	Market Competition, Innovation	Protection of Fundamental Rights
Enforcement Approach	Strategic, Adaptive	Reactive, Case-by-Case	Systematic, Risk-Based
Global Influence	Domestic Market Control	Corporate Power	Brussels Effect (Standard Setting)

In summary, systematic differences in AI empowerment pathways are evident. Figure 3 visualizes these through radar charts, highlighting distinct regional priorities.

Figure 3. Radar Chart Comparison of Key Metrics Across the TESR Dimensions



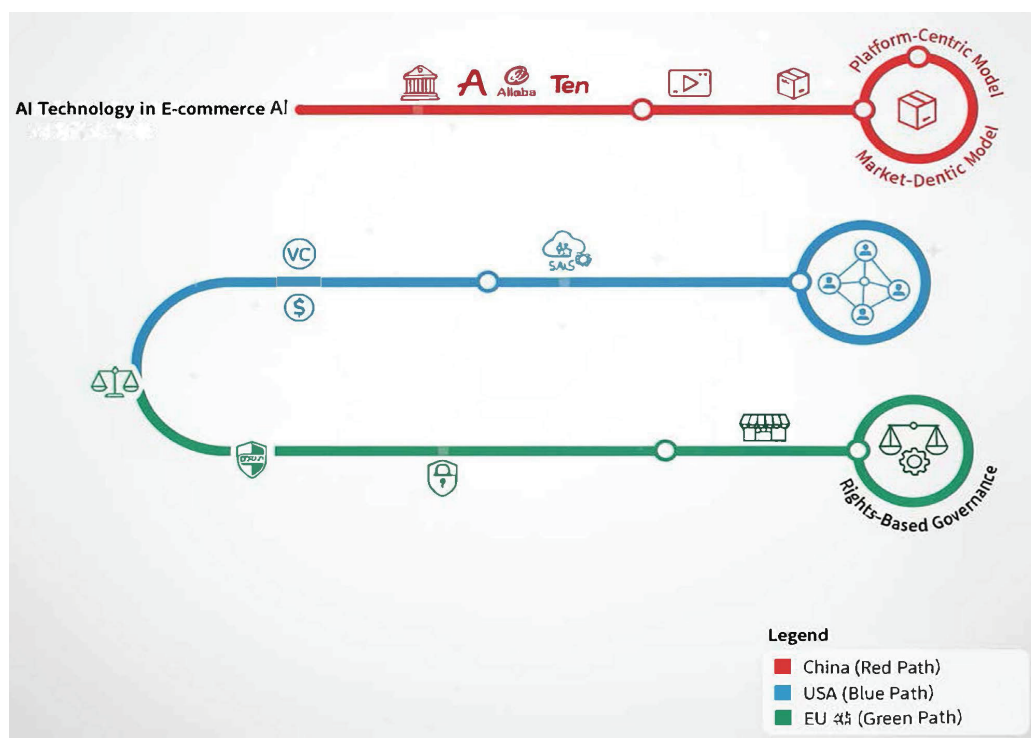
4. Discussion

The TESR framework reveals that AI empowerment in e-commerce follows divergent pathways shaped by the interplay of technological, economic, socio-cultural, and regulatory dimensions. These elements form self-reinforcing systems, creating distinct regional paradigms.

4.1 The Interdependent Nature of the Four Dimensions

The key insight is the interdependence of the TESR dimensions, resisting technological determinism and creating coherent regional patterns. As shown in the previous analysis, the four dimensions do not exist in isolation, but constitute a self-consistent complex feedback system, ultimately driving China, the United States, and Europe towards completely different development paths. Figure 4 reveals the mechanism of path differentiation caused by differences in initial institutional environments.

Figure 4. Schematic Diagram of Divergent AI Empowerment Pathways Driven by Institutional Context



In China, strategic regulation fosters large platforms, shaping economic structures around ecosystem control. These platforms leverage comprehensive data for integrated AI, delivering convenience valued by consumers, reinforcing social acceptance and creating a “platform-dominated AI integration” paradigm^[15,20].

In the United States, a pro-innovation regulatory approach enables platform growth and independent AI solutions, driving economic structures focused on personalization and efficiency. These meet consumer demands for customization while addressing privacy concerns, forming a “market-driven AI innovation” system^[11,17].

In the European Union, socio-cultural emphasis on rights shapes precautionary regulation, prioritizing explainable, transparent AI. This supports economic structures empowering SMEs, creating a “rights-based AI governance” paradigm^[14,22].

4.2 Theoretical and Practical Implications

The findings have significant implications for both theoretical understanding and practical application in AI and e-commerce.

Theoretically, the development and validation of the TESR framework offer a nuanced approach to understanding technology adoption, surpassing existing models like the Technology-Organization-Environment (TOE) framework. The TESR framework provides greater granularity by examining how economic, socio-cultural, and regulatory dimensions interact with technological capabilities, explaining why similar technologies yield different outcomes across contexts^[11,15]. This framework is adaptable for analyzing technology adoption in diverse institutional environments beyond e-commerce.

Practically, the analysis underscores the need for region-specific strategies for multinational enterprises. Success in China requires integration with platform ecosystems, while effectiveness in the United States demands participation in the SaaS market, and operations in the European Union necessitate compliance with rights-based regulations^[5,14,22]. For policymakers, the study highlights trade-offs in regulatory approaches, influencing innovation, market structures, and social outcomes^[17,20,22]. For researchers, it identifies avenues for further investigation, particularly the long-term impacts of divergent pathways on competition, innovation, and consumer welfare.

4.3 Limitations and Future Research Directions

This study provides a comprehensive analysis but has limitations. The rapid evolution of AI, particularly generative AI, may challenge identified patterns. The focus on three major economic blocs excludes emerging economies in Southeast Asia, Africa, and Latin America, which may exhibit unique AI adoption trajectories. Reliance on published literature introduces potential biases, as proprietary AI systems within private corporations are often undisclosed.

Future research should address these limitations. Investigating how generative AI and large language models reshape regional patterns could reveal whether they drive convergence or reinforce divergence. Longitudinal studies are needed to assess socioeconomic impacts on market competition, consumer welfare, labor markets, and technological sovereignty. Applying the TESR framework to regions like Southeast Asia, India, and Latin America could evaluate its generalizability. Sector-specific analyses in industries such as fashion, groceries, and digital services would clarify how these pathways manifest. Finally, policy effectiveness analyses could compare the EU’s comprehensive framework, the United States’ sectoral model, and China’s strategic governance to evaluate unintended consequences^[17,20,22].

5. Conclusion

This systematic review synthesizes 142 studies to demonstrate that AI adoption in e-commerce follows divergent pathways across China, the United States, and the European Union. These divergences reflect systemic variations in economic structures, societal values, and regulatory philosophies, necessitating a contextualized understanding beyond a purely technological lens.

The novel Technology-Economics-Society-Regulation (TESR) framework provides a comprehensive tool for analyzing these pathways, identifying three paradigms: China’s platform-centric model, emphasizing integration and ecosystem control; the United States’ market-driven model, focusing on innovation and personalization; and the European Union’s rights-based model, prioritizing ethical governance and fundamental rights^[5,11,14,15,22]. These paradigms form self-reinforcing systems where technological, economic, socio-cultural, and regulatory dimensions interact.

A key finding is the absence of convergence toward a universal AI adoption model. Instead, evidence suggests deepening divergence, with each region developing AI applications that reinforce institutional characteristics, challenging technological

determinist perspectives^[4,6]. This has significant implications for stakeholders. Multinational enterprises must adopt region-specific strategies, policymakers can learn from comparative regulatory impacts, and researchers gain a structured framework for further exploration.

Limitations include the rapid pace of AI development, particularly generative AI, which may alter patterns, and the focus on three regions, excluding emerging economies. Reliance on published literature may introduce biases regarding proprietary systems. Despite these, the TESR framework and empirical insights advance theoretical and practical understanding of AI's

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Toader, D.-C. M., Boca, G., Toader, R., Măcelaru, M., Toader, C., Ighian, D., & Rădulescu, A. T. (2021). Artificial intelligence in e-commerce: A bibliometric study and literature review. *Electronic Markets*, 31(2), 221–242. <https://doi.org/10.1007/s12525-020-00424-4>
- [2] Zhang, S., Yao, L., Sun, A., & Tay, Y. (2019). Deep learning based recommender system: A survey and new perspectives. *ACM Computing Surveys*, 52(1), Article 5. <https://doi.org/10.1145/3285029>
- [3] Gartner. (2023). What's new in artificial intelligence from the 2023 Gartner Hype Cycle for artificial intelligence. <https://www.gartner.com/en/articles/what-s-new-in-artificial-intelligence-from-the-2023-gartner-hype-cycle>
- [4] Lee, K.-F. (2018). AI superpowers: China, Silicon Valley, and the new world order. Houghton Mifflin Harcourt.
- [5] Statista. (2023). E-commerce worldwide. <https://www.statista.com/topics/871/online-shopping/>
- [6] Bradford, A. (2020). *The Brussels effect: How the European Union rules the world*. Oxford University Press.
- [7] Duan, Y., Edwards, J. S., & Dwivedi, Y. K. (2019). Artificial intelligence for decision making in the era of Big Data – evolution, challenges and research agenda. *International Journal of Information Management*, 48, 63–71. <https://doi.org/10.1016/j.ijinfomgt.2019.01.021>
- [8] Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, 372, Article n71. <https://doi.org/10.1136/bmj.n71>
- [9] Wei, Y., & Lu, S. (2022). How live-streaming e-commerce is transformed by AI: A case study of Taobao Live. *Journal of Consumer Behaviour*, 21(5), 987–1001. <https://doi.org/10.1002/cb.2056>
- [10] Poushneh, A., & Vasquez-Parraga, A. Z. (2017). Discernible impact of augmented reality on retail customer's experience, satisfaction and willingness to buy. *Journal of Retailing and Consumer Services*, 34, 229–234. <https://doi.org/10.1016/j.jretconser.2016.12.002>
- [11] Bharadwaj, A., El Sawy, O. A., Pavlou, P. A., & Venkatraman, N. (2013). Digital business strategy: Toward a next generation of insights. *MIS Quarterly*, 37(2), 471–482. <https://doi.org/10.25300/MISQ/2013/37.2.03>
- [12] McKinsey & Company. (2023). The state of AI in 2023: Generative AI's breakout year. <https://www.mckinsey.com/capabilities/quantumblack/our-insights/the-state-of-ai-in-2023-generative-ais-breakout-year>
- [13] Adadi, A., & Berrada, M. (2018). Peeking inside the black-box: A survey on explainable artificial intelligence (XAI). *IEEE Access*, 6, 52138–52160. <https://doi.org/10.1109/ACCESS.2018.2870052>
- [14] European Commission. (2022). Digital economy and society index (DESI) 2022. <https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2022>
- [15] Parker, G. G., Van Alstyne, M. W., & Choudary, S. P. (2016). *Platform revolution: How networked markets are transforming the economy—And how to make them work for you*. W. W. Norton & Company.
- [16] Mou, J., Shin, D.-H., & Cohen, J. (2020). Understanding trust and intention to use xAI-enabled services: The role of perceived risk. *International Journal of Human-Computer Interaction*, 36(14), 1329–1340. <https://doi.org/10.1080/10447>

318.2020.1765438

- [17] Federal Trade Commission. (2024, May 15). FTC releases fiscal year 2023 annual report [Press release]. <https://www.ftc.gov/news-events/news/press-releases/2024/05/ftc-releases-fiscal-year-2023-annual-report>
- [18] Eurostat. (2023). Digital economy and society statistics - households and individuals. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Digital_economy_and_society_statistics_-_households_and_individuals
- [19] Hoofnagle, C. J., van der Sloot, B., & Borgesius, F. Z. (2019). The European Union general data protection regulation: What it is and what it means. *Information & Communications Technology Law*, 28(1), 65–98. <https://doi.org/10.1080/13600834.2019.1573501>
- [20] State Council of the People's Republic of China. (2021). Outline of the 14th Five-Year Plan (2021-2025) for National Economic and Social Development and the 2035 Vision for a Modern Socialist Country. http://www.gov.cn/zhengce/2021-03/13/content_5592681.htm
- [21] National Conference of State Legislatures. (2023). Artificial intelligence 2023 legislation. <https://www.ncsl.org/technology-and-communication/artificial-intelligence-2023-legislation>
- [22] European Commission. (2024). Artificial Intelligence Act. <https://artificialintelligenceact.eu/>

Analysis of China's Local Government Debt Risk Causes and Resolution Pathways

Jingjing Cui¹, Dongping Xiao^{2*}

1.Shandong Provincial Student Financial Assistance Management Center, Jinan, 250002, China

2.Shandong Financial Investment Group Co., Ltd., Jinan, 250002, China

*Corresponding author: Dongping Xiao, 15916761@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In recent years, local government debt risk has emerged as a significant constraint on China's high-quality economic and social development. The continuously expanding scale of local debt, its complex structure, and notable regional disparities present substantial challenges, with county-level government debt risks being particularly prominent. Multiple factors—including real estate market adjustments, weakening land finance revenues, and tightening financing policies—have contributed to frequent debt defaults and credit risk events in certain regions, significantly intensifying debt sustainability pressures. To advance risk mitigation, authorities have implemented “three-debt integrated management,” exploring the unified administration of explicit government debt, implicit debt, and local government financing vehicle (LGFV) debt. Various measures have been employed to optimize debt structure and effectively contain new debt while resolving existing liabilities, including refinancing bond replacements, platform company restructuring, asset revitalization, and financial alliances. This paper analyzes the root causes of local government debt risks, systematically examines current challenges and governance effectiveness, and proposes targeted policy recommendations. These include further strengthening long-term risk prevention mechanisms, enhancing budget constraints and information disclosure, focusing on industrial upgrading and fiscal system reform, and promoting sustainable and refined local debt management. This research provides both practical reference and theoretical guidance for local government debt risk resolution.

Keywords: Local Government Debt; Risk Resolution

Published: Oct 19, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.763>

1.Introduction

In recent years, China's local government debt risk prevention and control have become a major issue affecting overall economic and social development. In May 2024, during his inspection tour of Shandong Province, General Secretary Xi Jinping specifically emphasized the need to “solidly advance risk prevention and resolution in key areas such as small and medium-sized financial institutions, local government debt, and real estate,” fully reflecting the central government's high-level attention to debt risk prevention and control.

In June 2010, the State Council issued the “Notice on Strengthening the Management of Local Government Financing Platform Companies” (State Council Document No. 19 of 2010), which focused on regulating financing platforms and their financing behaviors, as well as resolutely prohibiting local governments from providing irregular guarantees

and commitments. In September 2014, the “Opinions of the State Council on Strengthening Local Government Debt Management” (State Council Document No. 43 of 2014) proposed establishing a unified debt management mechanism for local governments that integrates “borrowing, using, and repaying,” aiming to reasonably control local government debt scale and effectively leverage the positive role of standardized local government borrowing.

Between 2015 and 2018, the central government coordinated the issuance of replacement bonds, replacing existing government debt totaling 12.2 trillion yuan. In August 2018, the “Opinions of the Central Committee of the Communist Party of China and the State Council on Preventing and Resolving Hidden Debt Risks of Local Governments” (Central Committee Document No. 27 of 2018) clearly prohibited new implicit debt and stipulated that the resolution period for existing implicit debt should not exceed 10 years.

Since July 2023, a series of important policies have been successively introduced, including the “Guiding Opinions on Financial Support for Resolving Financing Platform Debt Risks” (Document No. 35), the “Notice on Further Coordinating Local Debt Risk Prevention and Resolution” (Document No. 14), and Document No. 134, which aim to replace high-cost, short-term implicit debt with lower-interest, longer-term government bonds to reduce debt risk. On November 8, 2024, the 12th meeting of the Standing Committee of the 14th National People’s Congress approved an additional 6 trillion yuan in local government debt limits to replace existing implicit debt. The central government has also specified that 800 billion yuan will be allocated annually for five consecutive years from new local government special bonds specifically for debt resolution, potentially replacing 4 trillion yuan of implicit debt. Additionally, agreements have been made to repay 2 trillion yuan of implicit debt related to shantytown renovation projects maturing in 2029 and beyond according to contract terms.

As China’s economic and social transformation continues, local government debt risk prevention has received significant attention from academia, becoming a key research topic in fiscal and financial fields. Scholars have developed relatively systematic and diverse research frameworks around the causes of China’s local government debt, risk measurement, governance approaches, and its impact on the macro-economy.

Existing literature generally recognizes that local government debt issues reflect not just simple financial constraints but deeper systemic contradictions, including China’s fiscal decentralization system^[1], mismatches between administrative responsibilities and fiscal resources^[2], path dependence on land finance^[3] and local government incentive mechanisms^[4]. Some scholars point out that under the new economic normal, tensions between weak fiscal revenue growth and rigid expenditure obligations have become more pronounced^[5]. Coupled with local governments’ heavy reliance on land transfer revenues^[6] and financing platforms circumventing borrowing restrictions^[7], the scale of local government implicit debt continues to expand. Regional GDP competition among Chinese local governments, while supporting growth, has driven substantial local debt increases^[8].

Regarding debt prevention and resolution, some scholars propose “increasing revenue and reducing expenditure,” advocating for restoring and maintaining local government fiscal sustainability to mitigate debt risks^[9]. Others argue that fundamentally resolving local government debt issues requires completely eliminating soft budget constraints and establishing robust hard budget constraint mechanisms^[10].

In the process of promoting economic and social development, debt levels have gradually increased, with debt service pressures becoming increasingly prominent. Particularly under the dual influence of deep adjustments in the real estate sector and changes in the external environment, local land transfer revenues have declined, fiscal resources have tightened, and debt risk concerns have further intensified in some regions. When land sales revenue decreased, local governments increased debt as a substitute. This shift created higher short-term debt pressure and faster adjustments to interest rate structures, potentially generating new financial risks^[11]. To actively address these challenges, some regions have implemented “three-debt integrated management,” which emphasizes “strengthening the unified management of government debt, implicit debt, and LGFV debt, resolutely controlling new debt while reducing existing debt.” This approach aligns with the requirements set forth at the Central Financial Work Conference to “establish a government debt management mechanism compatible with high-quality development and long-term mechanisms for preventing and resolving local debt risks,” demonstrating determination and innovative thinking in debt risk prevention and control.

However, debt risk resolution is a systematic project involving multiple domains including economic development, fiscal management, and financial stability. Recent developments show that some regions have experienced defaults on non-standard debt and commercial bill delinquencies, increasing market concerns about debt issues. How to effectively prevent and resolve debt risks while ensuring stable economic operation and promoting sustainable fiscal development represents a significant challenge for governments. Particularly during this critical period of economic transformation and upgrading, finding a path that effectively resolves existing debt risks while supporting high-quality development is of great practical significance.

This paper analyzes the current debt risk situation and challenges, examines the root causes of debt risks, and proposes targeted policy recommendations to provide decision-making references for preventing and resolving local debt risks and promoting high-quality economic development.

2.Challenges in Managing Local Government Debt Risks

As of the end of 2023, the national government debt balance reached 70.77 trillion yuan, with local government debt accounting for 40.74 trillion yuan. From a debt service perspective, overall maturity and redemption pressures have eased somewhat in 2024, but certain regions still face significant rollover pressures. Notably, some platforms have chosen to issue high-cost, short-term financing products to supplement funds, further deteriorating their debt structures. Local debt risk resolution continues to face multiple challenges, including both short-term pressures to resolve existing debt and long-term institutional issues requiring solutions.

2.1 Pressure to Resolve Existing Debt

The current stock of debt is substantial, with issues including maturity mismatches and high costs affecting certain debts. Although the government has implemented measures such as “three-debt integrated management,” challenges remain regarding the sustainability and depth of debt resolution outcomes. Particularly against the backdrop of increasing economic downward pressure, balancing stable growth with risk prevention presents a significant challenge. Under strict debt supervision, implicit debt can no longer be extended or replaced through previous non-market-oriented methods (such as trust and non-standard financing), increasing the difficulty of resolving existing debt. While new implicit debt has been compressed, suitable market-oriented innovative pathways for addressing existing debt remain elusive. Debt pressure is widespread across the province, with insufficient coordination at the provincial fiscal level slowing the process of supporting debt adjustment in financially weaker cities and counties.

2.2 Impact of Changing Financing Environment

The financing environment has tightened due to macroeconomic conditions and changes in financial regulatory policies. To prevent risks associated with local government financing platforms in recent years, the State Council and relevant institutions have successively issued documents including “Guidance on Further Improving the Prevention and Resolution of Local Government Implicit Debt Risks by Banking and Insurance Institutions” (Banking and Insurance Regulatory Commission Document No. 15 of 2021), “Guiding Opinions of the General Office of the State Council on Financial Support for Resolving Financing Platform Debt Risks” (State Council Office Document No. 35 of 2023), “Notice of the General Office of the State Council on Printing and Distributing the ‘Measures for Classified Strengthening of Government Investment Project Management in Key Provinces (Trial)’” (State Council Office Document No. 47 of 2023), and “Notice of the General Office of the State Council on Further Coordinating Local Debt Risk Prevention and Resolution” (State Council Office Document No. 14 of 2024). These policies have restricted bank financing, inter-bank and exchange bond issuance for financing platform companies. For regions and platforms with weaker credit qualifications, financing difficulties have significantly increased, and costs have risen.

The financing environment has been notably affected by real estate market weakness, local fiscal pressures, and tightened policy supervision, showing overall differentiation. This situation benefits high-rated, quality LGFV companies, as policy clarification improves market confidence and enhances the financing environment. Meanwhile, lower-rated LGFV companies will gradually exit the financing market through restructuring and integration.

2.3 Concentrated and Widespread Debt Risks at District and County Levels

District and county-level governments have become the most concentrated tiers of debt risk. These risks frequently occur in

fiscally constrained county-level governments with extremely limited debt resolution capabilities, often entirely dependent on higher-level fiscal support. Field research indicates that some districts and counties have weak economic foundations and limited local fiscal revenues. To meet the needs of urbanization expansion and economic development, they often rely on LGFVs to undertake numerous public welfare and infrastructure projects, as well as investment attraction supporting construction tasks, resulting in comprehensive debt expansion and excessive debt burdens. Various degrees of debt risk are evident across district and county governments in both developed coastal regions and less developed central and western regions. In economically developed areas, despite stronger debt service capabilities, debt scales are often substantial during periods of rapid infrastructure expansion (such as industrial park construction and major transportation projects). In less developed areas, though debt scales may be slightly smaller, their significantly weaker repayment capabilities attract greater concern.

2.4 Difficulties in LGFV Transformation

In recent years, the central government has continuously strengthened restrictions on local government implicit debt. As primary vehicles for implicit debt, LGFVs face strict financing limitations, with funding channels cut off in areas such as non-standard financing and trust loans, significantly reducing their fundraising capabilities. Unlike the previous model of “debt-financed expansion and rapid construction,” current policies emphasize the profitability and capital utilization efficiency of infrastructure projects, posing higher requirements for traditional “infrastructure-driven” LGFVs, especially smaller ones lacking industrial projects capable of driving transformation.

In some inland cities (such as southwestern Shandong and resource-depleted cities), land finance accounts for a high proportion of revenue. The real estate market downturn has led to sharp declines in land and related asset prices, depriving local governments of their primary leverage for capitalizing LGFVs to support debt, urgently requiring these regions’ LGFVs to seek market-oriented profitability capabilities. However, their weak industrial foundations add difficulty to transformation efforts. LGFVs predominantly focus on local government projects, with highly concentrated business scopes including infrastructure construction, road and bridge development, and shantytown renovation, resulting in relatively singular profit models and heavy dependence on government fiscal support. Most LGFVs hold assets (such as land reserves and public facilities) that lack market-oriented development capabilities and face difficulties in asset revitalization and commercialization. Simultaneously, they lack truly commercial projects and operational experience, leading to a general sense of powerlessness when facing market-oriented transformation.

3. Analyzing the Causes of Debt Risk

The exposure of debt risk stems from the deterioration of balance sheets. When assets collapse while liabilities remain rigid or even expand, risks inevitably emerge. Factors triggering either asset collapse or liability rigidity and expansion can induce debt risks, which can be summarized as: difficulties in continuing the debt-financed urbanization model, internal and external pressures severing revenue streams, misalignment between fiscal responsibilities and resources breeding hidden dangers, and short-sighted performance evaluations stimulating borrowing.

First, the traditional development model relying on land finance and debt has become unsustainable. This model of operating cities through debt financing solved many operational issues during periods of economic prosperity but now faces sharp reductions in land fiscal revenues and sudden increases in debt service pressures during economic contraction.

Second, excessive borrowing by LGFVs has created substantial implicit debt. On one hand, there is ineffective supervision leading to uncontrolled debt scale; on the other hand, LGFVs have undertaken too many governments public welfare projects with low returns and long recovery periods. As important vehicles for debt financing, LGFVs suffer from insufficient profitability and persistently high debt-to-asset ratios, reduced financing channels, reliance on high-interest short-term financing, and operational difficulties.

Third, existing special bonds face significant principal and interest repayment pressures. Special bonds should be revenue bonds issued to raise funds for specific projects. However, in actual practice, some projects have been blindly initiated due to performance-oriented governance, insufficient feasibility studies, and other reasons. The actual returns on special bond projects have failed to meet expectations, with some even facing abandonment and non-performing asset issues, making

the originally designated repayment sources unable to service principal and interest. Declining land prices and falling fiscal revenues have subjected local governments to dual blows in revenue and financing.

The deeper causes include: first, the mismatch between fiscal resources and administrative responsibilities has led to grassroots governments assuming numerous public service responsibilities, exacerbating debt pressures; second, the current investment and financing system rewards state-owned platform companies for excessive reliance on government credit financing, allowing many low-return or no-return projects to receive financing support, with project returns often falling short of expectations and lacking scientific risk assessment; third, distorted evaluation and incentive mechanisms encourage local officials to promote short-term economic growth through borrowing while neglecting debt risks, with misalignment between official terms and project construction and revenue cycles increasing short-term performance pressure and accumulating debt risks, while rent-seeking issues in some projects further exacerbate debt problems; fourth, localities have failed to establish stable revenue sources, with major tax revenues declining sharply, widening funding gaps and heightening debt risks.

4. Systemic Risk Prevention Recommendations

For local debt resolution, the priority is to eliminate potential landmines accumulated in previous periods. A comprehensive approach using debt resolution policies, asset restructuring, LGFV transformation, and other measures should be employed to optimize local debt structure, broaden funding sources, and reduce liability scale. At a deeper level, institutional and mechanism innovations, fiscal system reforms, and changes in local government development models are needed to build a modern economic system.

4.1 Fully Utilize Debt Resolution Policies to Continuously Optimize Debt Structure

Debt maturity mismatches represent a significant cause of debt risk. Local governments should fully leverage and utilize special refinancing bonds, government special bonds designated for debt resolution, and implicit debt replacement bonds issued by the central government to replace high-cost LGFV debt with lower-interest government debt. Financial support policies should be effectively utilized to secure loans from state-owned commercial banks and policy banks for debt replacement, converting high-interest short-term debt into low-interest long-term debt, buying time to gradually resolve debt risks.

4.2 Improve Debt Management Systems and Resolutely Prevent New Implicit Debt

Provincial governments should take primary responsibility for local government debt management, with active cooperation from city and county levels. First, a comprehensive debt management platform should be established to achieve dynamic monitoring of government and LGFV debt across the province. The monitoring scope should be expanded to include all accounts payable, and provincial-level coordinated supervision mechanisms should be constructed to prevent new implicit debt. Second, debt risk management should be elevated, establishing a three-tier linkage mechanism, setting up provincial-level risk resolution funds, and allowing provincial takeover of risk areas when necessary. Finally, risk early warning and emergency response mechanisms should be introduced, establishing a tiered risk warning system and emergency fund pool to adopt corresponding measures for debts with different risk levels, particularly for high-risk cities and counties that should be included in key control lists, with provincial coordination mechanisms established to address emergencies.

4.3 Improve Debt Management Systems and Resolutely Prevent New Implicit Debt

Provincial governments should take primary responsibility for local government debt management, with active cooperation from city and county levels. First, a comprehensive debt management platform should be established to achieve dynamic monitoring of government and LGFV debt across the province. The monitoring scope should be expanded to include all accounts payable, and provincial-level coordinated supervision mechanisms should be constructed to prevent new implicit debt. Second, debt risk management should be elevated, establishing a three-tier linkage mechanism, setting up provincial-level risk resolution funds, and allowing provincial takeover of risk areas when necessary. Finally, risk early warning and emergency response mechanisms should be introduced, establishing a tiered risk warning system and emergency fund pool to adopt corresponding measures for debts with different risk levels, particularly for high-risk cities and counties that should be included in key control lists, with provincial coordination mechanisms established to address emergencies.

4.4 Innovate Debt Resolution Pathways and Mobilize All Available Resources

This debt crisis requires clear recognition that the current situation differs from previous ones, with multiple factors converging. Particularly against the backdrop of weak fiscal revenue growth and sharp declines in urban asset values, previous approaches relying on increasing land transfer revenues to resolve existing issues are no longer applicable. All levels of government must prepare for extended periods of austerity. Given limited local government resources, innovative debt resolution pathways must be created, funding sources broadened, and the operability of debt resolution enhanced.

4.4.1 Revitalize Existing Assets

Revitalizing existing assets represents an effective approach to addressing debt risks. Provincial governments can promote infrastructure asset securitization, such as the introduced REITs projects valued at approximately 15 billion yuan for subways and highways. Additionally, establishing asset management platforms to integrate government assets, including industrial park equipment, factories, and land resources, can realize revenue monetization. The “debt-to-equity + income linkage” model can also be explored to handle assets that are difficult to monetize, achieving balance between debt and assets through government industrial funds.

City and county-level governments should identify integrable assets, including idle administrative and state-owned enterprise assets and unutilized public resources. Through special bonds, renovation loans, franchise rights financing, and other policies, these assets can be sold or mortgaged to reduce debt ratios.

4.4.2 Promote LGFV Reform

Market-oriented reforms of LGFVs should separate public welfare and commercial projects, with financing for public welfare projects incorporated into government special bond management and commercial projects continuously enhancing profitability to ensure cash flows from operational assets can cover financing principal and interest. City and county governments should integrate LGFVs, clearing ineffective and loss-making enterprises to substantially reduce their number, clarifying boundaries between LGFVs and local governments, and preventing irregular new financing for governments.

4.4.3 Implement Market-Oriented Debt Restructuring Plans

Debt restructuring represents an important method for resolving existing debt. Different restructuring plans should be developed based on regional and debt type differences. Debt restructuring should proceed according to classification: economically strong cities can implement market-oriented restructuring, while financially weaker regions should adopt government-led approaches through special bond replacements, debt extensions, and other measures to reduce debt service pressure. Over 200 billion yuan of debt has already been restructured in 2024. Provincial-level coordination should be strengthened by establishing provincial debt resolution funds. Consideration should be given to issuing relief bonds and establishing a 50-billion-yuan debt investment fund to support debt restructuring in high-risk areas. The fund should adopt a government-guided, market-operated model to attract social capital participation.

4.5 Construct Long-Term Mechanisms for Preventing Local Debt Risks

4.5.1 Implement More Active Debt Resolution Policies at the Central Level

China’s liability ratio structure shows imbalances across different entities: local governments have high true liability ratios, and enterprise and resident leverage ratios are also elevated, but the central government maintains a low liability ratio with considerable room for additional debt. Current local government debt replacement primarily targets accounted implicit debt, aiming to repay financial institutions. The central government should consider issuing special national bonds and transferring them proportionally to local governments, primarily for paying accounts payable, effectively reducing local government and enterprise liability ratios and promoting economic development.

4.5.2 Deepen Fiscal System Reform

The key issue is resolving the mismatch between local government responsibilities and fiscal resources. The general reform direction should involve delegating fiscal authority, recentralizing administrative responsibilities, and clearly delineating government responsibilities at different levels to reduce overlaps. Government special bond reforms should implement “negative list” management for investment areas, strictly prohibiting the use of special bonds for non-revenue-generating projects. The scale of project-specific special bonds should be strictly limited, and new project-specific special bonds should be prohibited for local governments involved in new implicit debt or with poor previous records. Attention should

be paid to repayment risks associated with existing special bonds in some localities; for those genuinely lacking repayment sources, temporary deferrals of principal repayments should be allowed, with rolling issuance permitted at maturity and local governments allowed to arrange fiscal subsidy funds for interest payments to prevent special bond repayment risks. Local government tax structure transformation should be promoted to construct a local tax system suitable for the post-land finance era. Budget management reform should establish a standardized, transparent budget system with strengthened fiscal discipline. Expenditures must be drastically reduced to achieve local fiscal balance.

4.5.3 Improve Government Investment and Financing Mechanisms

Following the market-oriented reform of LGFVs, the financing system primarily based on “government credit” should be thoroughly transformed. Clear credit boundaries between local governments and LGFVs should be established, and for market-operated local state-owned enterprises, rigid redemption assumptions should be broken to shift market expectations away from unlimited government backing.

4.5.4 Establish Sustainable Development Models

Local governments must transform their economic development approaches, abandoning previous models of debt-financed investment, city operations, and major investment attraction in favor of constructing favorable business environments, cultivating entrepreneurial atmospheres, and guiding private development of new productive forces.

4.5.5 Improve Local Government Evaluation Systems

The weight of debt risk in evaluation systems should be increased, while GDP and other economic indicators should continue to be de-emphasized in favor of evaluation systems oriented toward resident satisfaction and business environment quality.

Development remains the most effective means of resolving issues, with reform serving as the sustainable driving force for development.

Conclusion

In summary, China’s local government debt risks stem from real estate market adjustments, declining land finances, tightening policies, and fiscal system imbalances, requiring a comprehensive approach for resolution. The “three-debt integrated management” framework offers a viable pathway that addresses explicit debt, implicit debt, and LGFV obligations simultaneously. Effective risk mitigation necessitates combining short-term measures—such as refinancing bonds and asset revitalization—with long-term institutional reforms of fiscal systems and evaluation mechanisms. Given regional disparities in debt profiles, a differentiated approach is essential, with market solutions for stronger economies and more direct interventions for weaker areas. Ultimately, debt resolution must balance financial stability with economic development, transitioning from debt-fueled growth toward an innovation-driven model that supports China’s high-quality development goals while building resilient local financial systems for the future.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Jia, J., Guo, Q., & Zhang, J. (2014). Fiscal Decentralization and Local Expenditure Policy in China. *China Economic Review*, 28, 107-122.
<https://doi.org/10.1016/j.chieco.2014.01.002>
- [2] Zhang, S., Li, Y., Xu, C., & Xiong, Z. (2024). Does Fiscal Decentralization Reduce Environmental Degradation Through Mitigating Resource Mismatch and Digital Transformation? Evidence from China’s Resource-based Cities. *Resources Policy*, 95, 105155.
<https://doi.org/10.1016/j.resourpol.2024.105155>
- [3] Zhan, C., de Jong, M., & de Bruijn, H. (2017). Path dependence in financing urban infrastructure development in China:

- 1949–2016. *Journal of Urban Technology*, 24(4), 73-93.
<https://doi.org/10.1080/10630732.2017.1334862>
- [4] Liu, Z., Jiang, C., Huang, J., Zhang, W., & Li, X. (2023). Fiscal Incentive, Political Incentive, and Strategic Interaction of Illegal Land Use by Local Governments. *Land Use Policy*, 129, 106647 .
<https://doi.org/10.1016/j.landusepol.2023.106647>
- [5] Corsetti, G., Meier, A., & Müller, G. J. (2012). What Determines Government Spending Multipliers?. *Economic Policy*, 27(72), 521-565.
<https://doi.org/10.1111/j.1468-0327.2012.00295.x>
- [6] Wang, Y., & Hui, E. C. M. (2017). Are Local Governments Maximizing Land Revenue? Evidence from China. *China Economic Review*, 43, 196-215.
<https://doi.org/10.1016/j.chieco.2017.02.005>
- [7] Lu, Y., & Sun, T. (2013). Local Government Financing Platforms in China: A fortune or misfortune?. *International Monetary Fund*.
- [8] Pan, F., Zhang, F., Zhu, S., & Wójcik, D. (2017). Develop by Borrowing? Inter-jurisdictional Competition, Land Finance and Local Debt Accumulation in China. *Urban Studies*, 54(4), 897-916.
<https://doi.org/10.1177/0042098015624838>
- [9] Li, T., & Du, T. (2021). Vertical Fiscal Imbalance, Transfer Payments, and Fiscal Sustainability of Local Governments in China. *International Review of Economics & Finance*, 74, 392-404. <https://doi.org/10.1016/j.iref.2021.03.019>
- [10] Ong, L. H. (2012). Fiscal Federalism and Soft Budget Constraints: The Case of China. *International Political Science Review*, 33(4), 455-474.
<https://doi.org/10.1177/0192512111414447>
- [11] Kashyap, A. K., & Stein, J. C. (2023). Monetary Policy When the Central Bank Shapes Financial-market Sentiment. *Journal of Economic Perspectives*, 37(1), 53-75.
<https://doi.org/10.1257/jep.37.1.53>

AI-Enhanced Traditional Crafts in Art Education: A Digital Approach to Revitalizing Chinese Tie-Dye in High School

Ruimin Li*

Kunming No.10 Middle School, Kunming, 650051, Yunnan, China

*Corresponding author: Ruimin Li, ruimin972@gmail.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This study examines the empowering role of artificial intelligence (AI) in high school art education, with a focus on teaching tie-dye, a nationally recognized intangible cultural heritage (ICH). Traditional art education often faces constraints in materials, time, and instructional resources. AI offers new opportunities to address these limitations and reframe heritage-based craft teaching. Based on an empirical project with 42 students, this study highlights four instructional models: virtual experimentation, AI-handcraft integration, immersive learning, and interdisciplinary innovation. The findings suggest that AI not only compensates for resource limitations but also strengthens cultural recognition, providing observable evidence for revitalizing traditional crafts in adolescent education. At the same time, challenges remain, including overreliance on digital tools, limited teacher expertise, and concerns over originality and equity. The study concludes that integrating AI into tie-dye education should follow the principle of “technology serving education and innovation grounded in culture.” Practical recommendations are proposed regarding teacher training, curriculum design, resource development, and policy support, aiming for a balanced integration of tradition and technology. By doing so, AI-enhanced art education can foster creativity, interdisciplinary literacy, and cultural transmission, contributing both to pedagogical innovation and the sustainable development of intangible cultural heritage.

Keywords: Artificial Intelligence; Art Education; Intangible Cultural Heritage; Tie-dye; Virtual Reality; Generative AI; Interdisciplinary Learning

Published: Oct 19, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.663>

1.Introduction

High school art education plays a critical role in developing students' aesthetic literacy, creativity, and cultural awareness. Tie-dye, an ancient Chinese textile craft recognized as national-level intangible cultural heritage, embodies cultural values and ethnic traditions. However, limited classroom resources, time, and technical guidance restrict opportunities for students to experience and master such complex crafts.

1.1 Theoretical Foundations of AI in Art Education

The integration of AI into art education is underpinned by established learning theories that explain how technology can enhance student engagement and cultural understanding. From the perspective of experiential learning theory^[1], AI provides opportunities for “learning by doing” through virtual dyeing experiments, interactive simulations, and iterative testing, enabling students to experience craft processes without the constraints of materials or time. In line with situated learning

theory^[2], AI-powered immersive environments and VR workshops allow learners to participate in culturally rich contexts, positioning them as active participants in authentic heritage practices rather than passive recipients of information. Consistent with constructivist theory^[3], AI facilitates learner-centered exploration, enabling students to generate, manipulate, and reinterpret visual patterns, thereby constructing new knowledge based on personal experience and collaboration^[4].

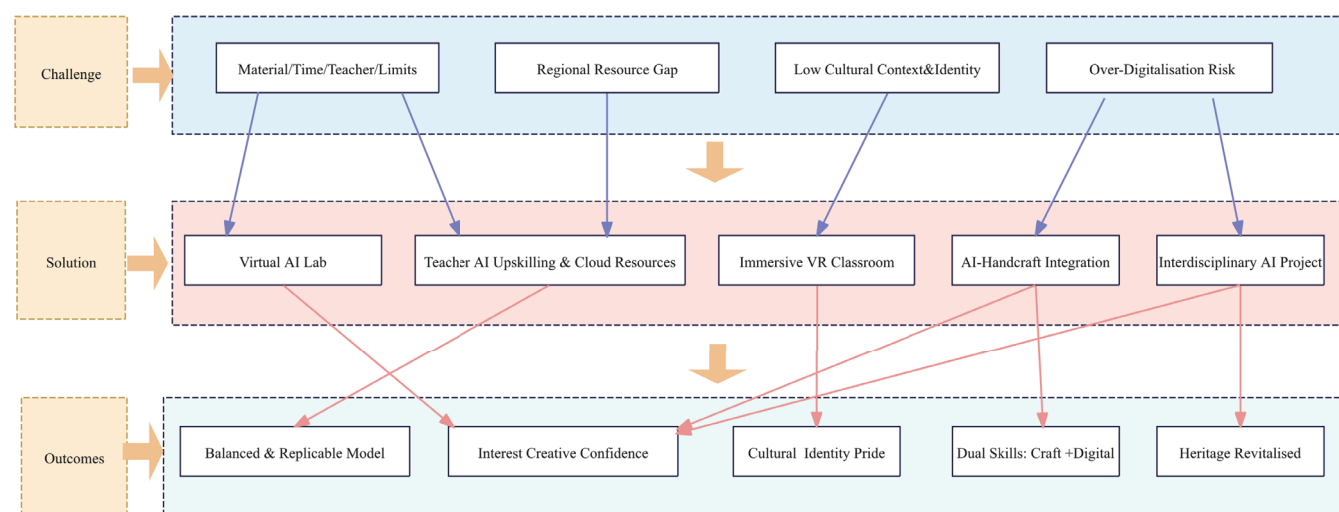
These theoretical perspectives highlight that the role of AI in art education goes beyond technical efficiency. It provides a pedagogical foundation for integrating traditional crafts with digital innovation, cultivating creativity, cultural identity, and deeper learning outcomes.

1.2 Research Purpose

This study investigates how AI can empower tie-dye instruction in high school classrooms, enhance cultural recognition, and promote innovative pedagogical practices. The objectives are fivefold: to explore how AI technologies can overcome resource and time constraints in traditional craft education; to examine the effects of AI-enhanced instructional models on students' learning interest, creativity, and cultural identity; to identify the challenges and limitations associated with AI-assisted art education; to provide practical recommendations for teachers, schools, and policymakers in integrating AI into intangible cultural heritage (ICH) instruction; and to develop a conceptual framework for AI-ICH integration that extends beyond tie-dye, offering insights for broader applications of technology in cultural heritage education.

To address these objectives, this study proposes a conceptual framework that illustrates how AI can be systematically integrated into intangible cultural heritage (ICH) education. The framework (Figure 1) connects the major challenges faced in traditional craft instruction with corresponding AI-based solutions and the anticipated educational and cultural outcomes. By positioning challenges such as material and teacher constraints, regional disparities, and risks of over-digitalization alongside targeted AI interventions, the framework highlights both the pedagogical logic and the cultural significance of the study. This visualization also reflects the study's broader goal of developing a transferable model for AI-ICH integration that extends beyond tie-dye education.

Figure 1. Conceptual framework of AI-ICH integration in tie-dye education.



1.3 Data Sources

The data for this study were collected from an empirical teaching project conducted by the author in March–April 2024 at Kunming No.10 Middle School, Kunming, Yunnan Province, China. The project involved a first-year high school elective art class with 42 students (aged 15–16, mixed gender). A total of 39 valid questionnaires were collected (response rate: 92.9%). The questionnaire employed a 5-point Likert scale with Cronbach's $\alpha = 0.85$ for reliability. Data were analyzed using Excel and SPSS 26.0 for descriptive statistics and one-sample t-tests ($p < 0.001$).

2. Artificial Intelligence and Art Education

2.1 Applications of AI in Education

As a significant outcome of contemporary information technology, AI is gradually transforming traditional education.

According to constructivist theory, learners are active constructors of meaning, and knowledge is formed through engagement and dialogue rather than simply transmitted by teachers^[1]. Emerging AI technologies—such as intelligent learning platforms, virtual teaching assistants, and adaptive learning systems—are shifting education from a teacher-centered to a learner-centered paradigm.

Learning platforms powered by big data analytics can track students' progress in real time, identify weak areas, and deliver personalized resources to enhance learning efficiency. AI applications, including speech recognition and natural language processing, are widely used in educational scenarios, such as automated grading systems and online Q&A assistants, significantly reducing repetitive teacher tasks and allowing educators to focus on classroom guidance and in-depth instruction. Consequently, AI integration promotes an intelligent, personalized, and interactive development in education^[2].

2.2 The Intersection of AI, Art Education, and ICH: Addressing the Gap

Prior research has attempted to address the challenges of teaching traditional crafts within formal education by incorporating modern technologies. For example, multimedia tools and digital archives have been used to provide visual resources and preserve intangible cultural heritage (ICH) materials, while online platforms have expanded accessibility to cultural content beyond local communities. Similarly, virtual reality (VR) and augmented reality (AR) applications have created immersive environments that allow students to experience traditional crafts without geographical or material constraints. These efforts have offered valuable resources for heritage education and improved cultural dissemination.

However, limitations remain. Many existing approaches emphasize heritage preservation rather than active learning, leaving students in passive roles as viewers or consumers of cultural content. Others lack strong pedagogical alignment with established learning theories, resulting in technological novelty without deep educational impact. Furthermore, such tools often fail to integrate digital experiences with hands-on practice, thereby reducing opportunities for learners to develop both cognitive and manual skills.

This study addresses these gaps by positioning artificial intelligence (AI) not only as a technical aid but also as a pedagogical enabler grounded in experiential, situated, and constructivist learning theories^[3]. By integrating AI tools with the teaching of tie-dye, the research demonstrates how technology can support resource efficiency, enhance creativity, and strengthen cultural identity while maintaining the craft's educational and cultural integrity. In doing so, the study contributes to a conceptual framework for AI-ICH integration that extends beyond tie-dye, providing insights for broader applications in cultural heritage education.

3. Educational Value of Tie-Dye in Intangible Cultural Heritage

Tie-dye, a traditional Chinese textile dyeing technique with over a thousand years of history, achieves localized resist-dyeing through folding, binding, and stitching, followed by repeated immersion in natural dyes to produce unique, inimitable patterns. Recognized as a national-level intangible cultural heritage, tie-dye embodies rich cultural memory and regional characteristics. For instance, the Bai ethnic tie-dye of Dali in Yunnan predominantly uses indigo and natural motifs, symbolizing auspiciousness and harmony. Its techniques not only reflect the Eastern philosophical concept of “harmony between humans and nature” but also encapsulate ethnic aesthetic sensibilities and practical wisdom.

From an educational perspective, cultural heritage instruction should not merely replicate traditional techniques. Instead, project- and context-based learning designs can guide students to understand cultural connotations and generate novel cultural expressions^[4]. Integrating tie-dye into high school art curricula fosters students' hands-on skills, concentration, and patience. The technique's inherent unpredictability stimulates creativity and encourages innovative experimentation. Moreover, the learning process enhances students' cultural identity and ethnic pride, allowing them to engage deeply with the cultural significance behind the craft.

Tie-dye also intersects with multiple disciplines—including textile science, chemistry, mathematics, and aesthetics—offering opportunities for interdisciplinary teaching and contributing to the development of students' comprehensive competencies and creative abilities^[5]. As such, tie-dye is more than an artistic skill; it represents a multifaceted educational resource with both cultural and pedagogical value. Incorporating intangible cultural heritage into school education not only promotes its creative transformation and innovative development but also helps cultivate the cultural foundations necessary for the

intergenerational transmission of Chinese modernity^[6].

4.Exploring AI-Enhanced High School Tie-Dye Education

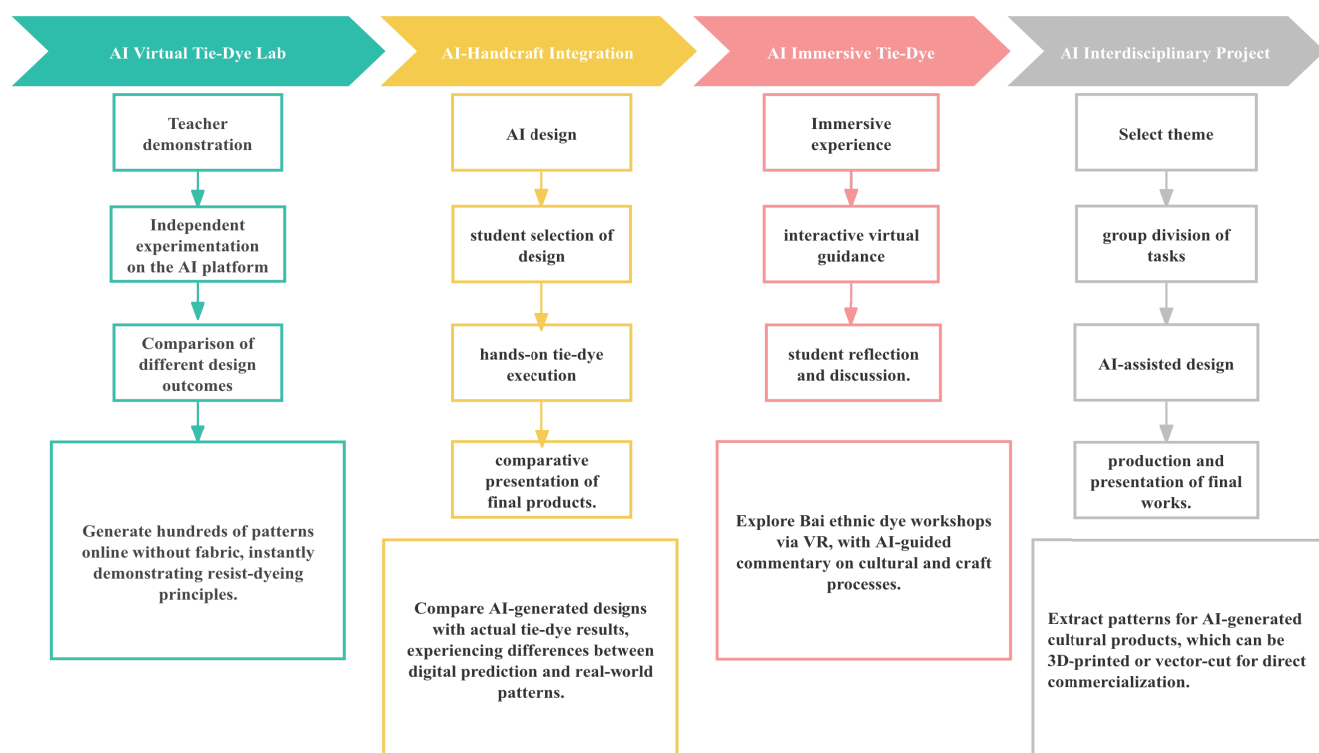
As discussed above, tie-dye holds significant educational value for high school art curricula. However, constraints in resources, time, and teacher expertise often hinder the implementation of systematic and in-depth instruction. The integration of artificial intelligence offers promising solutions to these challenges. Leveraging AI's capabilities in simulation, generation, and interaction, tie-dye instruction can transcend the limitations of traditional classrooms, enabling students to construct complementary learning experiences across virtual and physical environments.

More importantly, AI functions not merely as a tool but as a novel cognitive medium, capable of stimulating students' creative potential and guiding them to engage with intangible cultural heritage through more open and exploratory thinking. To fully realize its educational objectives and ensure instructional quality, high school art classrooms must operate as comprehensive and integrated systems, supporting students' holistic growth and development while fostering both technical skills and cultural understanding.

4.1 Types of AI-Enhanced Tie-Dye Teaching Models

Based on the characteristics of high school art education, AI-enhanced tie-dye instruction can be categorized into four representative models (Figure 2): virtual experimentation, hands-on integration, immersive experience, and interdisciplinary innovation. These models progress from basic to advanced levels, simultaneously addressing skill development and cultural heritage objectives, thereby providing a structured pathway for both technical mastery and creative exploration.

Figure 2. Comparison of AI-Enhanced High School Tie-Dye Teaching Models



4.1.1 AI Virtual Tie-Dye Laboratory

This model primarily leverages AI-based image generation and simulation tools to replicate the tie-dye process. On the virtual platform, students select folding techniques, pattern shapes, and color combinations to instantly generate diverse tie-dye effects. This “low-cost, high-feedback” approach allows repeated experimentation, enabling students to quickly grasp the fundamental principles of tie-dye. Compared with the one-time operations typical of traditional classrooms, AI virtual labs enable students to accumulate more experience in a shorter period, thereby enhancing creative confidence.

Teaching Objectives: Master the basic principles of tie-dye and deepen understanding of pattern formation rules. Instructional Process: Teacher demonstration → Independent experimentation on the AI platform → Comparison of different design

outcomes. AI Tools Applied: Image generation software, simulation platforms. Expected Outcomes: Reduce material consumption, stimulate student interest, and cultivate exploratory awareness.

4.1.2 AI-Handcraft Integration Course

Building on the virtual laboratory, students transform AI-generated tie-dye designs into tangible works^[7]. This “virtual-to-real” dual experience allows learners to enjoy the convenience of digital creation while engaging firsthand with the complexity and uniqueness of manual dyeing. The model effectively integrates “digital efficiency” with “craft depth,” enabling students to appreciate the aesthetic value of randomness and irreproducibility inherent in tie-dye through comparison between virtual and physical outcomes.

Teaching Objectives: Combine digital design with handcraft techniques to deepen students’ understanding of the essence of tie-dye. Instructional Process: AI design → student selection of design → hands-on tie-dye execution → comparative presentation of final products. AI Tools Applied: Style transfer algorithms, pattern generation platforms. Expected Outcomes: Foster the integration of virtual and real experiences, enhance practical skills, and cultivate aesthetic literacy.

4.1.3 AI Immersive Tie-Dye Classroom

Leveraging VR/AR technologies, teachers can create immersive learning environments that allow students to “enter” traditional dye workshops and experience the full tie-dye process—from weaving and folding to dyeing and drying^[8]. During this immersive experience, students not only learn the craft but also gain insights into the close connections between tie-dye and ethnic life, customs, and cultural practices. AI can further generate virtual mentors to guide students through interactive exploration, reinforcing cultural identification and emotional engagement^[9].

Teaching Objectives: Comprehend the cultural significance underlying tie-dye, and enhance ethnic pride and cultural identity. Instructional Process: Immersive experience → interactive virtual guidance → student reflection and discussion. AI Tools Applied: VR/AR headsets, AI-guided virtual tour systems. Expected Outcomes: Strengthen students’ cultural experiences and emotional resonance, fostering respect and appreciation for intangible cultural heritage.

4.1.4 AI Interdisciplinary Project Course

In interdisciplinary projects, students draw inspiration from tie-dye elements and leverage AI to carry out modern design and innovative applications. Within integrated design instruction, AI and parametric technologies serve as tools for addressing complex design challenges, enabling exploration of AI applications across production, social, knowledge, spatial, and everyday contexts^[10]. For example, students can use AI to create tie-dye-inspired fashion, digital product aesthetics, and cultural creative merchandise, which are subsequently transformed into exhibitable works through collaborative group efforts. This model transcends the traditional boundaries of tie-dye, positioning it as a central resource in contemporary design while fostering teamwork and interdisciplinary competencies^[11].

Teaching Objectives: Guide students to connect intangible cultural heritage with contemporary life, enhancing creativity and comprehensive competencies. Instructional Process: Select theme → group division of tasks → AI-assisted design → production and presentation of final works. AI Tools Applied: AI design software, product modeling tools. Expected Outcomes: Integrate art and design, strengthen students’ creative disposition, and cultivate cultural confidence.

4.2 Comparative Analysis and Educational Value of AI-Enhanced Models

The four AI-enhanced teaching models exhibit distinct instructional emphases: the virtual laboratory focuses on technical simulation and comprehension of fundamental principles; the handcraft integration course emphasizes craft experience and aesthetic awareness; the immersive classroom highlights cultural identity and emotional engagement; and the interdisciplinary project course extends tie-dye into contemporary life and design contexts. Together, these models form a progressive pathway—from skill cognition, craft experience, cultural understanding, to cross-disciplinary innovation—facilitating not only mastery of tie-dye techniques but also the integration of skill development, aesthetic education, and cultural heritage.

Crucially, these models illustrate the multifaceted roles of AI in education: as a “learning tool,” a “cultural communication bridge,” and an “innovation catalyst.” By enriching classroom formats and transforming instructional approaches, AI empowers high school tie-dye education to advance from single-dimensional craft training to broader objectives encompassing cultural identity and creative development. Leveraging virtual simulation, hybrid virtual-real experiences, immersive

learning, and interdisciplinary innovation, this framework offers practical, implementable strategies for art educators while providing new avenues for the preservation and dynamic evolution of intangible cultural heritage in contemporary contexts.

5. Advantages and Challenges of AI-Enhanced Tie-Dye Instruction

5.1 Advantages of AI-Enhanced Tie-Dye Instruction

AI-enhanced tie-dye instruction demonstrates clear advantages in high school art classrooms. It overcomes traditional limitations related to materials, procedures, and time. Utilizing virtual laboratory platforms, students can rapidly experience the full tie-dye process without consuming fabric or dye, reducing costs while extending exploration time. AI's generative and interactive capabilities enhance classroom engagement and interactivity, allowing students to experiment with multiple design options and receive immediate feedback, thus transforming the conventional “teacher demonstration, student imitation” model.

AI also enables personalized learning pathways tailored to students' abilities and interests, facilitating differentiated instruction and optimizing overall learning outcomes. Furthermore, it strengthens awareness of cultural heritage and innovation: students engage with the cultural significance of tie-dye through virtual scenarios and interdisciplinary projects, integrating traditional craft with contemporary design to stimulate creative potential. In this way, AI promotes a shift from skill training to creative production and from knowledge transmission to autonomous exploration, fostering core competencies, collaborative skills, and interdisciplinary literacy, and revitalizing intangible cultural heritage within art education.

To evaluate the practical impact of AI-enhanced tie-dye instruction, 39 high school elective art students completed anonymous questionnaires and participated in focus group interviews after course completion. As shown in Table 1, all five items on the Likert scale scored significantly above the midpoint of 3 ($p < 0.001$). “AI tools enhance learning interest” received the highest mean score ($M = 4.72$, $SD = 0.46$), indicating strong student acceptance of technological integration, followed by “AI + handcraft is superior to handcraft alone” ($M = 4.69$, $SD = 0.47$). Standard deviations below 0.6 suggest high consistency in student evaluations. Student A07 commented, “The AI-generated fireworks tie-dye patterns let me try a dozen styles in one go; I finally made a T-shirt to wear to school, and classmates kept asking for the link.” Student C04 noted during the interview, “In VR, the Bai grandmother led me through the dye workshop; I suddenly realized this wasn't just crafting—it was learning a nearly lost way of life.” Both quantitative and qualitative data indicate that AI not only enhances students' creative confidence but also strengthens emotional identification with and willingness to promote intangible cultural heritage, providing observable evidence for the revitalization of traditional crafts among adolescents.

Table 1. Student Feedback on AI-Enhanced Tie-Dye Instruction (Likert Scale)

Survey Item	Mean (M)	Standard Deviation (SD)
AI tools enhanced my interest in learning	4.72	0.46
I am willing to continue practicing tie-dye after class	4.65	0.51
I have developed a deeper appreciation for intangible cultural heritage	4.59	0.49
AI combined with handcraft is better than handcraft alone	4.69	0.47
I am willing to recommend tie-dye to friends or family	4.51	0.55

5.2 Challenges of AI-Enhanced Tie-Dye Instruction

Although AI-enhanced tie-dye instruction offers significant advantages in increasing engagement, enabling personalized learning experiences, and promoting cultural innovation, it also faces several challenges. Excessive reliance on AI may lead students to neglect hands-on practice, limiting the depth of intangible cultural heritage transmission. Teachers are required not only to master tie-dye techniques but also to acquire proficiency in operating AI tools; currently, most educators lack systematic training, which can result in a “technically capable but underutilized” scenario.

Differences in educational resources may exacerbate digital divides, potentially increasing regional disparities in instruction.

Additionally, AI-generated works raise concerns regarding copyright and originality, necessitating guidance for students to use these tools appropriately and maintain academic integrity. The interaction between traditional craftsmanship and innovative applications creates inherent tension; over-digitization risks diminishing both the technical depth and cultural richness of tie-dye. Therefore, AI should be applied judiciously in tie-dye education, following the principle of “technology serving education and innovation grounded in culture^[12].” This approach ensures that the advantages of AI are fully realized while preserving the essence of intangible cultural heritage, ultimately achieving both educational objectives and cultural transmission^[13].

Conclusion

This study explored the integration of artificial intelligence (AI) into high school art education through the teaching of tie-dye, a nationally recognized intangible cultural heritage. By examining four instructional models—virtual experimentation, AI–handcraft integration, immersive learning, and interdisciplinary innovation—the research demonstrated that AI can effectively overcome resource and time constraints, enhance student engagement, and foster cultural identity. Empirical evidence from student feedback confirmed that AI not only stimulates creative interest and confidence but also deepens appreciation for cultural heritage. At the same time, the findings highlight challenges, including risks of overreliance on digital tools, insufficient teacher training, and concerns regarding equity and originality. Addressing these issues requires coordinated efforts in professional development, curriculum design, resource sharing, and policy support. In conclusion, AI should be applied under the guiding principle of “technology serving education and culture guiding innovation.” When integrated appropriately, AI-enhanced tie-dye instruction can promote creativity, interdisciplinary learning, and cultural transmission, contributing to both pedagogical innovation and the sustainable revitalization of intangible cultural heritage.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice Hall.
- [2] Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press. <https://doi.org/10.1017/CBO9780511815355>
- [3] Piaget, J. (1976). *The grasp of consciousness: Action and concept in the young child*. Harvard University Press.
- [4] Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- [5] Li, S. (2024). Art, design, and new productive qualities: Exploring future education at the School of Design, Central Academy of Fine Arts (Part 3). *Industrial Design*, (05), 5–8.
- [6] di Meana, F. R. (2024). Enhancing artistic education with AI (ERIC Technical Paper No. ED665402). ERIC. <https://eric.ed.gov/?id=ED665402>
- [7] Wu, K., Jin, B., & Zhou, Q. (2024). Exploration of media innovation and teaching model transformation in art education in the era of artificial intelligence [In Chinese]. *Teacher Education Forum*, 37(11), 28–35.
- [8] Wu, X. (2023). A review of constructivist learning theory. *Frontiers in Social Sciences*, (11), 6645–6651. <https://doi.org/10.12677/ASS.2023.1211908>
- [9] Ma, W. (2024). Cultural dilemmas and optimization paths of integrating intangible cultural heritage into school education in ethnic regions: A case study of L County, Ningxia [In Chinese]. *Ethnic Education Research*, 35(2), 129–135. <https://doi.org/10.15946/j.cnki.1001-7178.20240509.001>
- [10] Bai, L., Wang, X., Dong, L., & Jiao, B. (2020). Curriculum design based on the STEAM education concept: A case study of the “Bionic Design” course [In Chinese]. *China Educational Informatization*, (16), 55–58.
- [11] Hutson, J., & Cotroneo, P. (2023). Generative AI tools in art education: Exploring prompt engineering and iterative

- processes for enhanced creativity. *Metaverse*, 4(1), 1–13. <https://doi.org/10.54517/m.v4i1.2164>
- [12] Wang, S. (2024). Enhancing art education through virtual reality: The impact of virtual art museums on junior high school students. *Research and Advances in Education*, 3(9), 52–58.
- [13] Liao, C.-W., Wang, C.-C., Wang, I.-C., Lin, E.-S., Chen, B.-S., Huang, W.-L., & Ho, W.-S. (2025). Integrating Virtual Reality into art education: Enhancing public art and environmental literacy among technical high school students. *Applied Sciences*, 15(6), 3094. <https://doi.org/10.3390/app15063094>
- [14] Jiangsu Normal University Research Group. (2023). Research on constructing STEAM teaching models for cultural heritage transmission (Report) [In Chinese]. Jiangsu Normal University.
- [15] Zheng, W., Wang, Z., Wang, S., Wang, J., & Gao, Y. (2024). Innovative tie-dye pattern design based on sound visualization technology. *Wool Textile Technology*, 52(5), 32–37. <https://doi.org/10.19333/j.mfkj.20230906606>
- [16] Marella, V. C. (2025). The impact of artificial intelligence on traditional art education. *arXiv*. <https://arxiv.org/pdf/2509.07029>
- [17] UNESCO. (2024, October 17–24). Exploring the impact of artificial intelligence and intangible cultural heritage (Policy Lab Materials). United Nations Educational, Scientific and Cultural Organization.

Research on the Decision-making of the Battery Swapping Supply Chain Considering Battery Standardization under the Battery Swapping Model

Chao Li*

School of Artificial Intelligence, Neijiang Normal University, Neijiang, 641100, China

*Corresponding author: Chao Li, chaolee77@163.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This paper examines the battery swapping supply chain comprising battery manufacturer, vehicle manufacturer, and battery swapping operator, focusing on scenarios where battery standardization is led either by the battery manufacturer or by the battery swapping operator. Optimal decisions are derived for both battery standard-setting modes, followed by a comparative analysis. The findings reveal that when the battery swapping operator leads the formulation of battery standards, it results in greater benefits for both the battery manufacturer and battery swapping operator, while also facilitating the adoption of battery-swapping vehicles. However, the optimal strategy for the vehicle manufacturer is influenced by the battery standardization cost coefficient. Although battery swapping operator-led battery standardization enhances the level of battery standardization, it also increases the cost of battery-swappable vehicle bodies. Furthermore, an increase in the battery standardization cost coefficient reduces firm profitability, whereas greater sensitivity to battery standardization positively impacts corporate profits.

Keywords: Battery Swapping Model; Battery Standardization; New Energy Vehicle (NEV); Battery Swapping Supply Chain

Published: Oct 22, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.774>

1.Introduction

The NEV industry plays a pivotal role in driving the new wave of scientific and technological innovation and industrial transformation. It serves as a critical foundation for building a strong manufacturing nation and remains a cornerstone of the national economy. According to data from the China Association of Automobile Manufacturers, China's NEV sales reached 12.8 million units in 2024, signaling that the NEV sector has entered a stage of steady growth. Nevertheless, despite this rapid expansion, the NEV market continues to face several significant challenges. These include high vehicle purchase costs, limited resale value due to battery depreciation risks, and persistent consumer concerns such as range anxiety, charging inconvenience, and low vehicle value retention. Together, these issues form key bottlenecks hindering the widespread adoption of NEVs^[1].

As an innovative solution to these challenges, the battery swapping model is emerging as a promising approach to enhance NEV market penetration. By enabling consumers to lease rather than purchase batteries, this model significantly lowers the upfront cost of vehicle ownership, thereby addressing affordability concerns^[2]. Moreover, battery swapping technology allows for rapid energy replenishment, reducing charging time, easing range anxiety, and improving the overall user experience.

Additionally, the centralized management and recycling of batteries under this model contribute to the green, low-carbon, and sustainable development of the NEV industry^[3].

However, the promotion of the battery swapping model faces a major obstacle: the lack of unified battery swapping standards. The lack of standardization has seriously restricted the interchange and sharing of batteries between different brands and models, and hindered the popularization and application of the battery swapping model. Therefore, the proposal of battery standardization has become an effective way to solve this problem. By formulating unified technical standards and specifications, and achieving standardization of batteries in terms of size, interface, communication protocol, etc., it will help improve the compatibility of battery swap equipment, improve battery swap efficiency, optimize user experience, and promote the coordinated development of the NEV industry chain.

The advancement of battery standardization under the battery swapping model will have a profound impact on the decision-making of the battery swapping supply chain. Faced with the new trend of deep integration of battery leasing services in the battery swapping model, companies in the battery swapping supply chain need to re-examine their pricing strategies and competitive situations, and explore how to achieve win-win results in all links of the supply chain while protecting the interests of consumers. For the supply chain composed of the battery manufacturer, battery swapping operator and vehicle company, research on the supply chain decision-making considering battery standardization under the battery swapping model have far-reaching strategic significance for promoting the healthy and sustainable development of the NEV industry.

2.Literature Review

Research related to this paper focuses on two aspects: battery swapping model and battery standardization.

Regarding the battery swapping model, Huang and Qian^[4] explored the psychological premises and influencing mechanisms of consumers' purchase of electric vehicles in different business models and found that consumers' demand for unique features of cars, such as car leasing models, increased their willingness to purchase NEVs in innovative business models. Considering the impact of consumer mileage anxiety and resale anxiety on the adoption of electric vehicles, Lim et al.^[5] developed a two-period model in the secondary market to compare the battery leasing model with the traditional battery purchasing model. Considering the quality of recycled batteries, Li et al.^[6] analyzed the decision-making of NEV power battery sellers under both battery leasing and direct sales models. Furthermore, in a supply chain comprising two automobile manufacturers and one battery swapping operator, Yang et al.^[7] investigated the strategic decision-making of vehicle manufacturers regarding whether to self-operate or authorize battery swap services. Shi and Hu^[8] took NIO BaaS model as an example, discussed the vehicle-battery separation model based on game theory, and explored the boundary conditions that are beneficial to manufacturers, customers and the environment by introducing flexible battery leasing in the BaaS model.

Research on battery standardization remains in its early exploratory stage, and relevant academic studies are still limited. Choi et al.^[9] proposed a set of battery standardization strategies designed to meet the diverse requirements of battery capacity and power across various NEV applications. Liu et al.^[10] explored potential scenarios for the development of battery swapping based on standardization and proposed a joint construction strategy for battery swapping stations and charging infrastructure. Brem et al.^[11] observed that the focus of electric vehicle standardization has gradually shifted—from engines to batteries, and more recently, to broader mobility solutions. They suggest that firms adopt different strategic postures—cooperation, competition, or compliance—depending on the stage of standardization. Fallah et al.^[12] assessed the economic viability of standardized battery recycling and cascade utilization. Tornheim et al.^[13] introduced two standardized testing protocols for battery materials, aimed at accelerating the evaluation of critical electrochemical properties.

The existing literature primarily addresses either battery leasing or battery swapping services individually within the battery swapping model, without considering the battery standardization. Furthermore, research on battery standardization has mainly concentrated on battery testing and cascade utilization, with little attention paid to its implications within the battery swapping model or its broader impact on the NEV industry chain. In response to these gaps, this study focuses on the battery swapping supply chain under the framework of battery leasing services, and conducts an analysis of the combined effects of battery leasing services and battery standardization on supply chain decision-making. The findings aim to offer both theoretical insights and practical guidance to support the sustainable development of the NEV industry.

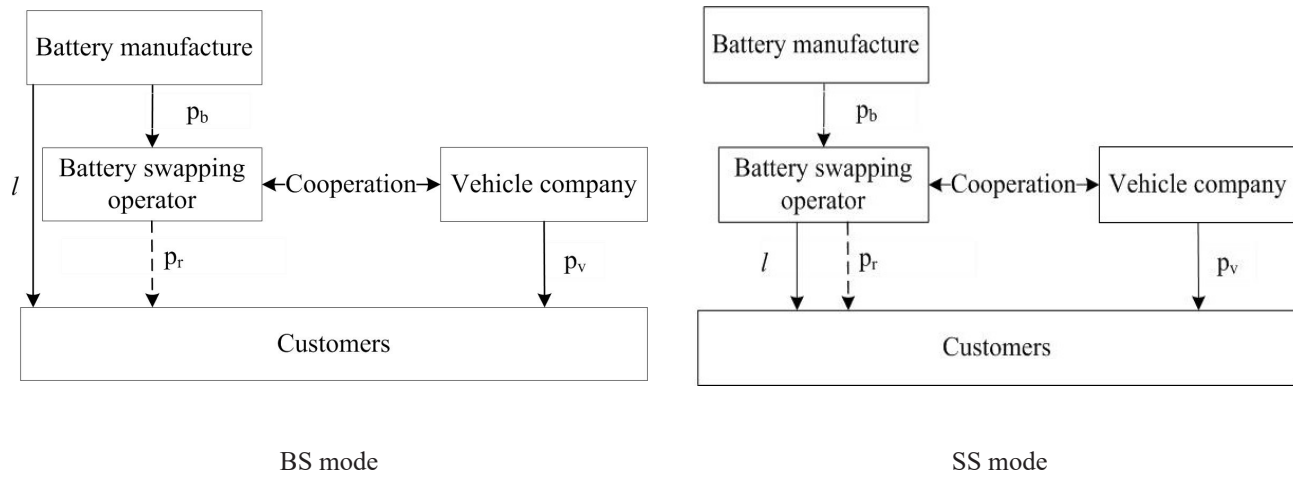
3. Problem Description and Model Assumptions

3.1 Problem Description

The battery swapping supply chain examined in this paper comprises a battery manufacturer, a vehicle manufacturer, and a battery swapping operator, as illustrated in Figure 1. In this supply chain, the battery manufacturer supplies batteries at the price of p_b to the battery swapping operator, who centrally manages the batteries and provide battery leasing services at the price of p_r (including the battery swapping fee) to consumers. The vehicle manufacturer is responsible for producing the bodies of battery-swappable vehicles at the price of p_v to consumers. However, due to technical limitations, the vehicle manufacturer lacks the capability to independently develop and produce standardized battery packs, and can only participate in the battery swapping sector through collaboration with the battery swapping operator.

For battery standardization, there are situations where either battery manufacturers or battery swapping operators are the dominant player. Specifically, battery manufacturers actively set battery standardization at the level l to facilitate battery sales (BS mode); and battery swapping operators pursue setting battery standardization at the level l to streamline operations and improve service efficiency (SS mode).

Figure 1: battery standardization dominant mode in battery swapping supply chain



3.2 Model Assumptions

In practice, the life cycle of a battery-swapping vehicle is significantly longer than that of a power battery. This implies that, over the vehicle's life cycle, more than one battery will be used. In this paper, the life cycle of the battery-swapping vehicle is taken as the reference period. The total duration of battery usage throughout this period is defined as the average battery leasing time (referred to as battery leasing time, the same below). For analytical simplicity, the number of batteries consumed over the vehicle's life cycle is normalized to one. Moreover, the demand for battery-swapping vehicles is affected by the price of the vehicle body, the price of battery leasing service and the battery standardization level. So the demand function for battery-swapping vehicles is: $D_v = a - t_s p_r - p_v + \beta l$. Among them, a ($a > 0$) is the battery swapping vehicle market size, t_s ($t_s > 0$) is the battery leasing time, p_r ($p_r > 0$) is the price of battery leasing services, p_v ($p_v > 0$) is the price of the vehicle body, β ($\beta > 0$) is the battery standardization level sensitivity coefficient, l ($l > 0$) is the battery standardization level.

The investment cost of the battery swapping station c_B primarily includes the battery swapping infrastructure cost and battery cost. According to Wang and Du^[14], assuming that the balanced battery ratio is δ and the battery price is p_b , so the battery cost is $\delta p_b D_v$. Moreover, let γ be the proportion of battery cost to battery swapping station investment cost, then $c_B = \frac{\delta p_b D_v}{\gamma}$. To simplify the model, let balanced battery cost ratio $\lambda = \frac{\delta}{\gamma}$, then $c_B = \lambda p_b D_v$. In addition, the battery standardized cost is $\frac{1}{2} k l^2$. Among them, k is battery standardization cost coefficient.

Table 1 Notations

Parameter	Meaning	Parameter	Meaning
α	Battery swapping vehicle market size	λ	Balanced battery cost ratio
t_s	Battery leasing time	D_v	Battery swapping vehicle demand
c_v	Battery swapping vehicle body production cost	π_b	Battery manufacturer profit
c_b	Standard battery pack production cost	π_v	vehicle company profit
k	Battery standardization cost coefficient	π_s	Battery swapping operator profit
c_s	Battery swapping operation cost	p_v	Vehicle Body price
l	Battery standardization level	p_b	Battery price
β	Battery standardization level sensitivity coefficient	p_r	Battery leasing price

4. Model Construction and Solution

4.1 Battery Manufacturers Determine the Battery Standardization (BS mode)

Under the BS mode, the battery manufacturer determines the battery standardization level l and provides batteries to battery swapping operator at a price of p_b ; the battery swapping operator centrally manages batteries and provides battery leasing services to consumers at a price of p_r ; the vehicle company provides battery swapping vehicle bodies to consumers at a price of p_v . The decision-making order is: first, the battery manufacturer decides the battery standardization level l and battery price p_b , then the battery swapping operator decides the battery leasing price p_r , and finally, the vehicle company decides the vehicle body price p_v . The objective functions of the battery manufacturer, the battery swapping operator and the vehicle company, are as follows:

$$\pi_b^{BS} = (p_b - c_b)D_v - \frac{1}{2}kl^2 \quad (1)$$

$$\pi_s^{BS} = (t_s p_r - c_s - p_b)D_v - \lambda p_b D_v \quad (2)$$

$$\pi_v^{BS} = (p_v - c_v)D_v \quad (3)$$

Proposition 1: The optimal price, demand and profit of the battery manufacturer, the battery swapping operator and the vehicle company under the BS model are:

$$p_v^{BS} = -\frac{ak\lambda - k\lambda^2 c_b - \beta^2 c_v - 2k\lambda c_b - k\lambda c_s + 7k\lambda c_v + ak - kc_b - kc_s + 7kc_v}{\beta^2 - 8k\lambda - 8k} \quad (4)$$

$$p_r^{BS} = -\frac{-\beta^2 \lambda c_b + 2k\lambda^2 c_b + 6ak\lambda - \beta^2 c_b - \beta^2 c_s + 4k\lambda c_b + 2k\lambda c_s - 6k\lambda c_v + 6ak + 2kc_b + 2kc_s - 6kc_v}{t_s(\beta^2 - 8k\lambda - 8k)} \quad (5)$$

$$p_b^{BS} = -\frac{4k\lambda c_b + 4ak + 4kc_b - \beta^2 c_b - 4kc_s - 4kc_v}{\beta^2 - 8k\lambda - 8k} \quad (6)$$

$$l^{BS} = -\frac{\beta(a - c_b\lambda - c_b - c_s - c_v)}{\beta^2 - 8k\lambda - 8k} \quad (7)$$

$$D_v^{BS} = -\frac{k(\lambda + 1)(a - c_b\lambda - c_b - c_s - c_v)}{\beta^2 - 8k\lambda - 8k} \quad (8)$$

$$\pi_b^{BS} = -\frac{k(a - c_b\lambda - c_b - c_s - c_v)^2}{2(\beta^2 - 8k\lambda - 8k)} \quad (9)$$

$$\pi_s^{BS} = \frac{2k^2(\lambda+1)^2(a-c_b\lambda-c_b-c_s-c_v)^2}{(\beta^2-8k\lambda-8k)^2} \quad (10)$$

$$\pi_v^{BS} = \frac{k^2(\lambda+1)^2(a-c_b\lambda-c_b-c_s-c_v)^2}{(\beta^2-8k\lambda-8k)^2} \quad (11)$$

4.2 Battery Swapping Operators Determine the Battery Standardization (SS mode)

Under the SS mode, the battery manufacturer provides batteries to battery swapping operators at a price of p_b ; the battery swapping operator determines the battery standardization level l and provides battery leasing services to consumers at a price of p_r ; and the vehicle company provides battery swapping vehicle bodies to consumers at a price of p_v . The decision-making order is: first, the battery manufacturer decides the battery price p_b , then the battery swapping operator decides the battery standardization level l and the battery leasing price p_r , and finally, the vehicle company decides the vehicle body price p_v . The objective functions of the battery manufacturer, the battery swapping operator and the vehicle company are as follows:

$$\pi_b^{SS} = (p_b - c_b)D_v \quad (12)$$

$$\pi_s^{SS} = (t_s p_r - c_s - p_b)D_v - \lambda p_b D_v - \frac{1}{2}kl^2 \quad (13)$$

$$\pi_v^{SS} = (p_v - c_v)D_v \quad (14)$$

Proposition 2: The optimal price, demand and profit of the battery manufacturer, the battery swapping operator and the vehicle company under the SS model are:

$$p_v^{SS} = -\frac{ak - 2\beta^2 c_v - k\lambda c_b - kc_b - kc_s + 7kc_v}{2(\beta^2 - 4k)} \quad (15)$$

$$p_r^{SS} = \frac{\beta^2 \lambda c_b + a\beta^2 + \beta^2 c_b + \beta^2 c_s - \beta^2 c_v - 2k\lambda c_b - 6ak - 2kc_b - 2kc_s + 6kc_v}{2t_s(\beta^2 - 4k)} \quad (16)$$

$$p_b^{SS} = \frac{\lambda c_b + a + c_b - c_s - c_v}{2(\lambda + 1)} \quad (17)$$

$$l^{SS} = -\frac{(a - \lambda c_b - c_b - c_s - c_v)\beta}{2(\beta^2 - 4k)} \quad (18)$$

$$D_v^{SS} = -\frac{k(a - \lambda c_b - c_b - c_s - c_v)}{2(\beta^2 - 4k)} \quad (19)$$

$$\pi_b^{SS} = -\frac{(a - \lambda c_b - c_b - c_s - c_v)^2 k}{4(\beta^2 - 4k)(\lambda + 1)} \quad (20)$$

$$\pi_s^{SS} = -\frac{(a - \lambda c_b - c_b - c_s - c_v)^2 k}{8(\beta^2 - 4k)} \quad (21)$$

$$\pi_v^{SS} = \frac{k^2(a - \lambda c_b - c_b - c_s - c_v)^2}{4(\beta^2 - 4k)^2} \quad (22)$$

5. Model Comparison and Analysis

5.1 Model Comparison

Corollary 1 Comparison of prices and battery standardization level in the battery swapping supply chain:

- (1) $p_v^{BS} < p_v^{SS}$;
- (2) When $0 < \lambda < \frac{1}{2}$, $p_r^{BS} > p_r^{SS}$; when $\frac{1}{2} \leq \lambda < 1$, $p_r^{BS} < p_r^{SS}$;
- (3) $I^{BS} < I^{SS}$.

According to Corollary 1(1), when battery standards are formulated by battery swapping operators, this indirectly leads to an increase in vehicle body prices. Corollary 1(2) suggests that the pricing strategy for battery leasing services is influenced by the balanced battery cost ratio. Specifically, only when this cost ratio is relatively low will battery standards set by battery manufacturers indirectly incentivize battery swapping operators to raise battery leasing prices. Otherwise, it can help offer more competitively priced battery leasing services. Corollary 1(3) indicates that battery standards established by battery swapping operators are more conducive to enhancing the overall level of battery standardization.

Corollary 2 Comparison of battery swapping vehicle demand: $D_v^{BS} < D_v^{SS}$

According to Corollary 2, the SS model—where battery swapping operators are responsible for setting battery standards—is more effective in promoting the adoption of battery-swapping vehicles. This is because, as supported by Corollary 1(3), battery standards formulated by battery swapping operators are more conducive to enhancing the overall level of battery standardization compared to those set by battery manufacturers. Higher levels of battery standardization reduce compatibility barriers and increase consumer confidence and willingness to adopt battery-swapping vehicles, thereby accelerating their market penetration. A practical example of this is Aulton New Energy, a leading battery-swapping operator in China. The company has actively taken the lead in formulating and reviewing numerous national and industry standards related to battery swapping, thereby playing a key role in advancing the widespread deployment of battery-swapping vehicles.

Corollary 3 Profit comparison of supply chain companies:

- (1) Profit comparison of vehicle companies: when $k^1 < k < k^2$, $\pi_v^{BS} > \pi_v^{SS}$; when $k \geq k^2$, $\pi_v^{BS} \leq \pi_v^{SS}$;
- (2) Profit comparison of battery swapping operators: $\pi_s^{BS} < \pi_s^{SS}$;
- (3) Profit comparison of battery manufacturers: $\pi_b^{BS} < \pi_b^{SS}$;
- (4) Profit comparison of supply chain systems: when $k^1 < k < k^3$, $\pi_T^{BS} > \pi_T^{SS}$; when $k \geq k^3$, $\pi_T^{BS} \leq \pi_T^{SS}$.

$$\text{Here, } k^1 = \frac{\beta^2}{8(\lambda+1)}, k^2 = \frac{\beta^2(2\lambda+3)}{16(\lambda+1)}, k^3 = \frac{\left(\sqrt{(36\lambda^4 + 228\lambda^3 + 445\lambda^2 + 310\lambda + 73)(1+2\lambda)^2} + 12\lambda^3 + 44\lambda^2 + 49\lambda + 13\right)\beta^2}{32(4\lambda^3 + 13\lambda^2 + 12\lambda + 3)}.$$

According to Corollary 3(1), the optimal strategy of vehicle manufacturers is influenced by the battery standardization cost coefficient. When the cost coefficient is low, although battery swapping operators formulating battery standards leads to higher demand for battery-swapping vehicles, it also raises the vehicle total production cost, thereby reducing vehicle manufacturers' profits. In contrast, when the cost coefficient is high, battery swapping operator' standard-setting results in higher profitability for vehicle manufacturers. Corollary 3(2) and 3(3) indicate that it is more advantageous for both battery manufacturers and battery swapping operators when battery standards are set by battery swapping operators. This is because battery swapping operators can enhance the level of battery standardization more effectively, thereby accelerating the adoption of battery-swapping vehicles. The improved market penetration of these vehicles creates a win-win outcome for both battery manufacturers and battery swapping operators. According to Corollary 3(4), the optimal standard-setting strategy for the battery swapping supply chain is also affected by the battery standardization cost coefficient. When the cost coefficient is low, having battery manufacturers lead standardization is more beneficial to the overall development of the supply chain. Conversely, when the cost coefficient is high, battery swapping operators taking the lead becomes more advantageous. This is because changes in vehicle manufacturers' profitability under different standardization schemes directly impact the total profit of the supply chain.

Taken together, Corollary 3 suggests that although battery manufacturers and battery swapping operators generally achieve higher profits under the SS model, the profitability of vehicle manufacturers—and thus the supply chain profit—varies depending on the battery standardization cost coefficient. Therefore, to promote the long-term and sustainable development of the battery swapping supply chain, all participating entities should closely care about shifts in the standardization cost coefficient and adopt corresponding battery standardization strategies accordingly.

5.2 Model Analysis

Corollary 4 The impact of battery standardization cost coefficient k

$$(1) \frac{\partial l^{BS}}{\partial k} < 0, \frac{\partial p_b^{BS}}{\partial k} < 0, \frac{\partial p_r^{BS}}{\partial k} < 0, \frac{\partial p_v^{BS}}{\partial k} < 0, \frac{\partial D_v^{BS}}{\partial k} < 0, \frac{\partial \pi_b^{BS}}{\partial k} < 0, \frac{\partial \pi_s^{BS}}{\partial k} < 0, \frac{\partial \pi_v^{BS}}{\partial k} < 0.$$

$$(2) \frac{\partial l^{SS}}{\partial k} < 0, \frac{\partial p_b^{SS}}{\partial k} = 0, \frac{\partial p_r^{SS}}{\partial k} < 0, \frac{\partial p_v^{SS}}{\partial k} < 0, \frac{\partial D_v^{SS}}{\partial k} < 0, \frac{\partial \pi_b^{SS}}{\partial k} < 0, \frac{\partial \pi_s^{SS}}{\partial k} < 0, \frac{\partial \pi_v^{SS}}{\partial k} < 0.$$

According to Corollary 4, as the battery standardization cost coefficient increases, the level of battery standardization declines, leading to reductions in battery leasing prices and vehicle body prices. However, this also results in a decrease in demand for battery-swapping vehicles, which in turn reduces the profitability of firms across the supply chain. The underlying reason is that a higher cost coefficient raises the overall cost of achieving battery standardization, thereby hindering the advancement of standardization efforts. This impedes the widespread adoption of battery-swapping vehicles and negatively impacts firm performance.

Currently, the growth of battery-swapping vehicles in China remains relatively slow. A key contributing factor is the low level of battery standardization—batteries are often restricted to circulation within a single enterprise or a limited group of allied companies, resulting in poor market liquidity. Therefore, identifying effective strategies to reduce the battery standardization cost coefficient, lower standardization costs, and promote the market-oriented development of battery standards is essential. These efforts are critical for enhancing the scalability, efficiency, and sustainability of the battery-swapping vehicle sector.

Corollary 5 The impact of battery standardization level sensitivity coefficient β

$$(1) \frac{\partial l^{BS}}{\partial \beta} > 0, \frac{\partial p_b^{BS}}{\partial \beta} > 0, \frac{\partial p_r^{BS}}{\partial \beta} > 0, \frac{\partial p_v^{BS}}{\partial \beta} > 0, \frac{\partial D_v^{BS}}{\partial \beta} > 0, \frac{\partial \pi_b^{BS}}{\partial \beta} > 0, \frac{\partial \pi_s^{BS}}{\partial \beta} > 0, \frac{\partial \pi_v^{BS}}{\partial \beta} > 0.$$

$$(2) \frac{\partial l^{SS}}{\partial \beta} > 0, \frac{\partial p_b^{SS}}{\partial \beta} = 0, \frac{\partial p_r^{SS}}{\partial \beta} > 0, \frac{\partial p_v^{SS}}{\partial \beta} > 0, \frac{\partial D_v^{SS}}{\partial \beta} > 0, \frac{\partial \pi_b^{SS}}{\partial \beta} > 0, \frac{\partial \pi_s^{SS}}{\partial \beta} > 0, \frac{\partial \pi_v^{SS}}{\partial \beta} > 0.$$

According to Corollary 5, as consumer sensitivity to battery standardization level increases, the level of battery standardization improves. This, in turn, leads to higher battery leasing prices, vehicle body prices and demand for battery-swapping vehicles, resulting in higher profits for firms within the supply chain. This is because greater consumer sensitivity to battery standardization incentivizes companies to enhance standardization levels. While improved battery standardization raises prices of vehicle body and battery leasing, it also boosts consumer confidence and willingness to adopt battery-swapping vehicles, thereby expanding market demand and enhancing profitability.

Therefore, in the current context of increasing consumer expectations for battery standardized, efforts by firms to improve battery standardization will not only promote the adoption of battery-swapping vehicles but also generate significant economic benefits. Enhancing battery standardization can thus serve as a strategic lever for both market expansion and profit growth.

6. Numerical Examples

To further explore the impact of the battery standardization cost coefficient and battery standardization sensitivity coefficient on battery standardization level and supply chain profitability, this paper employs numerical simulations. Based on the practical operation data of battery swapping model in Neijiang, Sichuan Province, China, and with reference to the research

of Hu et al.^[15], the parameters are assumed that $\alpha=100$, $t_s=8$, $\beta=0.8$, $k=100$, $c_v=4$, $c_b=3$, $c_s=6$, $\lambda=0.1$.

6.1 Impact of Battery Standardization Cost Coefficient k

Figure 2: The impact of k on battery standardization level l

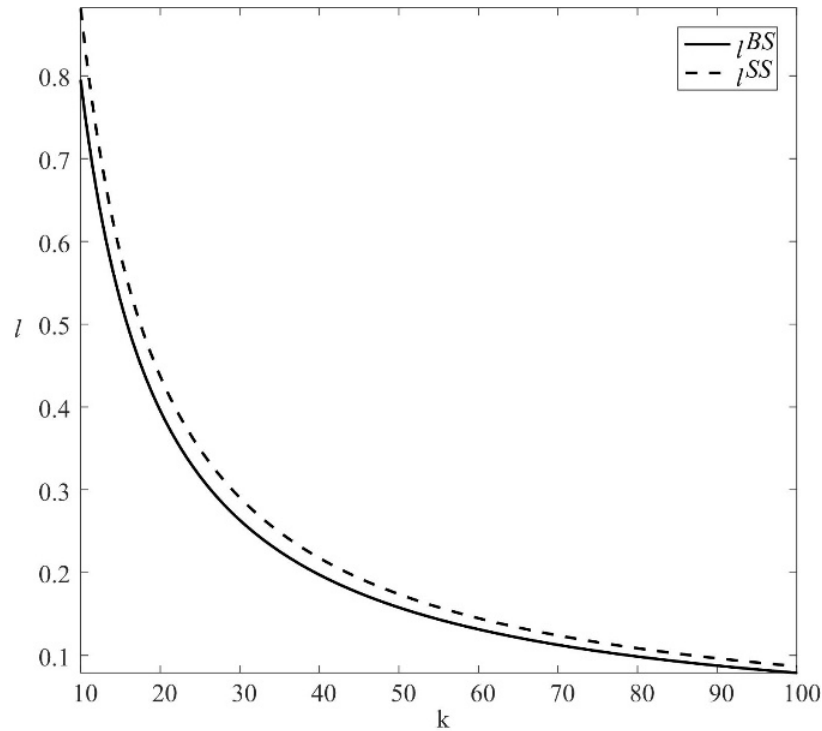
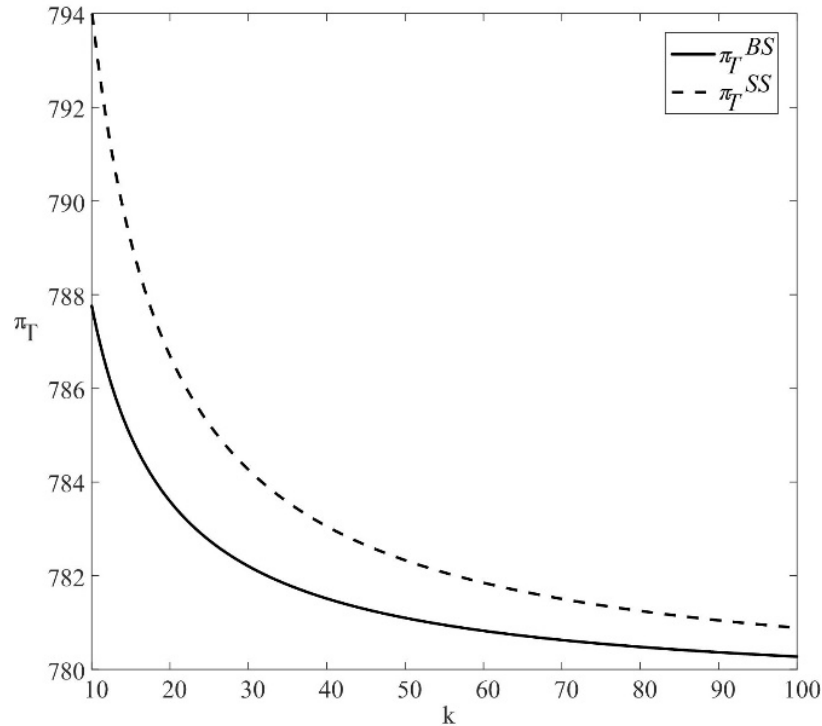


Figure 3: The impact of k on supply chain system profit π_T



According to Figures 2 and 3, as the battery standardization cost coefficient increases, the level of battery standardization decreases, resulting in a decline in supply chain profit. This indicates that higher battery standardization costs hinder efforts to improve battery standardization, which subsequently reduces overall profitability in the supply chain. The rising cost burden restricts standardization initiatives, ultimately impacting the performance of individual firms and the supply chain. These findings provide empirical support for Corollary 4.

6.2 Impact of Battery Standardization Level Sensitivity Coefficient β

Figure 4: The impact of β on battery standardization level l

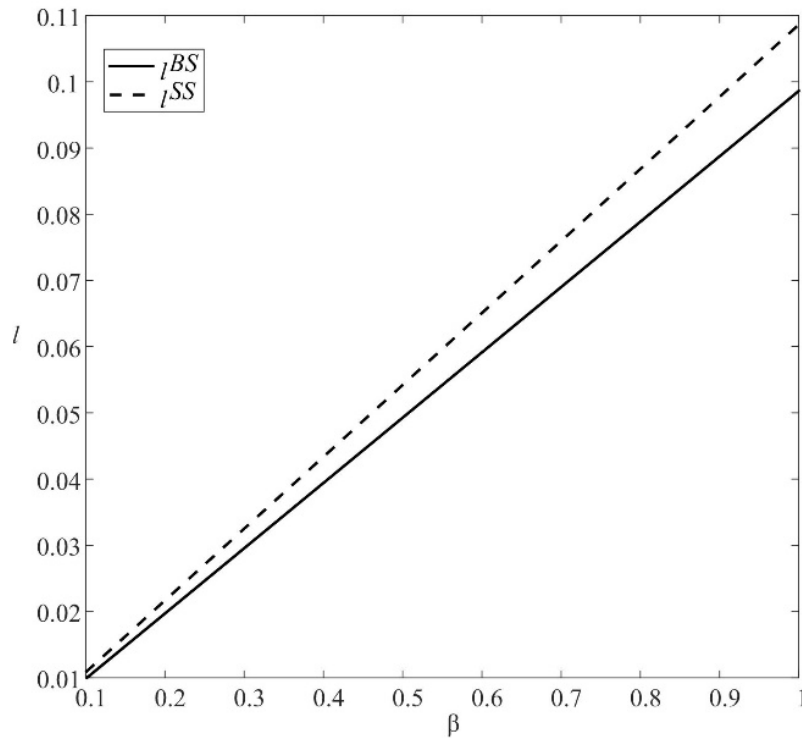
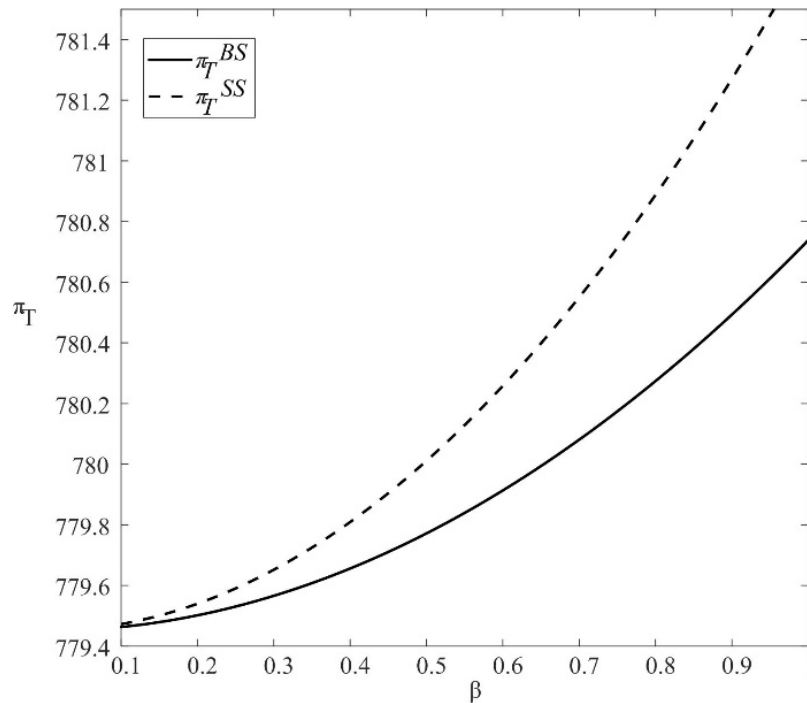


Figure 5: The impact of β on supply chain system profit π_T



According to Figures 4 and 5, as battery standardization sensitivity increases, the level of battery standardization improves, leading to a rise in supply chain profit. This demonstrates that a higher consumer sensitivity to battery standardization facilitates improvements in standardization levels, which in turn boosts demand for battery-swapping vehicles. The resulting increase in corporate profits contributes to enhanced overall supply chain profitability. These results provide support for the Corollary 5.

7. Conclusions

Battery standardization has emerged as a core issue influencing the promotion and scalability of the battery swapping model.

To explore the decision-making related to battery standardization, this paper constructs battery swapping supply chain composed of battery manufacturer, vehicle manufacturer, and battery swapping operator. Two modes are analyzed: one in which battery standards are set by battery manufacturers and another in which they are set by battery swapping operators. Game-theoretic models are developed for each scenario, and optimal decisions are derived using backward induction. A comparative analysis of the two modes is conducted, followed by numerical simulations for further validation and discussion. The study found that: (1) When battery standards are formulated by battery swapping operators, it is more beneficial for both battery manufacturers and battery swapping operators, and this mode also facilitates the wider adoption of battery-swapping vehicles. However, the optimal strategy of vehicle manufacturers is influenced by the battery standardization cost coefficient. (2) Battery swapping operators' involvement in setting battery standards enhances the level of battery standardization, but may indirectly lead to an increase in the vehicle body price of battery-swapping vehicles. (3) An increase in the battery standardization cost coefficient leads to a decline in firm-level and supply chain profits, whereas an increase in consumer sensitivity to battery standardization positively impacts corporate profitability.

Based on the above research conclusions, the following management insights can be obtained: (1) Battery swapping operators should take the lead in advancing battery standardization by building open, compatible, and widely accepted standard systems, thereby promoting the adoption of battery-swapping vehicles and creating mutual benefits across the supply chain. (2) While it is generally advantageous for battery swapping operators to determine battery standards, stakeholders should recognize that such a strategy may indirectly raise the vehicle body price, potentially affecting consumer adoption in price-sensitive markets. (3) Given that battery standardization in China is still in its early stages and the battery standardization cost coefficient remains high, firms should actively explore strategies to lower these costs. One feasible approach is the formation of battery swapping standard alliances to jointly develop and implement standardization documents. Additionally, companies should enhance consumers' perceived value of battery swapping services—for example, by emphasizing the convenience and speed of three-minute battery swaps.

This study focuses on a battery swapping supply chain consisting of a single battery manufacturer, a single vehicle manufacturer, and a single battery swapping operator. Future research could extend the model to incorporate competitive dynamics among multiple battery manufacturers, vehicle manufacturers, and battery swapping operators, thereby offering a more comprehensive understanding of strategic interactions and supply chain decision-making in a competitive market environment.

Funding

This research was funded by 2024 Basic Research and Applied Basic Research Projects in Neijiang City, grant number 2024NJCYJNJSY026.

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Adu-Gyamfi, G., Song, H., Obuobi, B., et al. (2022). Who will adopt? Investigating the adoption intention for battery swap technology for electric vehicles. *Renewable and Sustainable Energy Reviews*, 156, 111979.
- [2] Yang, S. X., Li, R. Y., & Li, J. L. (2020). "Separation of vehicle and battery" of private electric vehicles and customer delivered value: Based on the attempt of two Chinese EV companies. *Sustainability*, 12(5), 2042.
- [3] Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy*, 48, 717–729.
- [4] Huang, Y., & Qian, L. (2021). Consumer adoption of electric vehicles in alternative business models. *Energy Policy*, 155, 112338.
- [5] Lim, M. K., Mak, H.-Y., & Rong, Y. (2015). Toward mass adoption of electric vehicles: Impact of the range and resale anxieties. *Manufacturing & Service Operations Management*, 17(1), 101–119.
- [6] Li, K., Zhou, T., & Liu, B. (2021). The comparison between selling and leasing for new and remanufactured products

- with quality level in the electric vehicle industry. *Journal of Industrial and Management Optimization*, 17(3), 1505–1529.
- [7] Yang, Z. J., Lei, Q. L., Sun, J., et al. (2022). Strategizing battery swap service: Self-operation or authorization? *Transportation Research Part D: Transport and Environment*, 110, 103411.
- [8] Shi, L., & Hu, B. (2024). Frontiers in operations: Battery as a service—Flexible electric vehicle battery leasing. *Manufacturing & Service Operations Management*, 26(4), 1269–1285.
- [9] Choi, Y. H., Lim, H. K., Seo, J. H., et al. (2018). Development of standardized battery pack for next-generation PHEVs considering the effect of external pressure on lithium-ion pouch cells. *SAE International Journal of Alternative Powertrains*, 7(3), 195–206.
- [10] Liu, B., Gao, X., Wang, Y., et al. (2025). Co-construction strategy of battery swapping stations and charging piles in China. *Transport Policy*, 169, 56–73.
- [11] Brem, A., & Nylund, P. A. (2023). Incumbents' inertia in the automotive industry: Technological, market, and societal drivers of electric vehicle standardization. *IEEE Transactions on Engineering Management*, 71, 1683–1689.
- [12] Fallah, N., & Fitzpatrick, C. (2023). Is shifting from Li-ion NMC to LFP in EVs beneficial for second-life storages in electricity markets? *Journal of Energy Storage*, 68, 107740.
- [13] Tornheim, A., O'Hanlon, D. C., Vu, A., et al. (2023). Evaluation of cathode materials with lithium-metal anodes: Baseline performance and protocol standardization of coin cells. *Journal of the Electrochemical Society*, 170(1), 010507.
- [14] Wang, W., & Du, J. (2023). The impact of government subsidies on battery swapping mode: From the perspective of battery swapping supply chain. *International Journal of Industrial Engineering*, 30, 1578–1593.
- [15] Hu, X., Yang, Z., Sun, J., et al. (2023). Optimal pricing strategy for electric vehicle battery swapping: Pay-per-swap or subscription? *Transportation Research Part E: Logistics and Transportation Review*, 171, 103030.

Research on Tax Planning in Corporate Mergers and Acquisitions

Dongyang Huang*

School of Management, Xi'an Polytechnic University, Shaanxi, Xi'an, 710600, China

*Corresponding author: Dongyang Huang, 1047763613@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In an era marked by accelerating global economic integration, mergers and acquisitions have emerged as strategic in investigation examines the role of tax planning in M&A transactions through multidimensional analysis of theoretical foundations, policy frameworks, strategic approaches, and practical applications. The findings demonstrate that scientifically-designed tax planning mechanisms can substantially reduce transaction costs, realize synergistic tax benefits, and enhance post-merger organizational value. Incorporating contemporary developments in international instruments for resource optimization and organizational transformation within modern business ecosystems. This taxation policies, this study presents a structured approach to tax planning across various M&A phases and validates its efficacy through empirical case analysis, offering both theoretical guidance and practical reference points for enterprises engaging in merger activities.

Keywords: Corporate Mergers and Acquisitions; Tax Optimization; Special Tax Treatment; Tax Synergy; Restructuring Strategies

Published: Oct 25, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.799>

1.Introduction

The contemporary business landscape witnesses increasing global competition, making M&A activities crucial vehicles for corporate expansion and upgrading. Current data reveals a 71% year-on-year increase in A-share M&A transaction values during the first half of 2025, with industrial integration accounting for 77% of these transactions. Control rights transactions, asset injections, and bankruptcy reorganizations have emerged as predominant models in this evolving marketplace.

Taxation represents a significant cost consideration in M&A transactions, directly influencing both deal structure and payment mechanisms. Research indicates that M&A transactions typically involve multiple tax dimensions including corporate income tax, value-added tax, land appreciation tax, deed tax, and stamp duty, with cumulative tax obligations potentially reaching 30% or more of total transaction value. Consequently, strategic tax planning not only reduces transaction costs but also enables post-merger tax synergy through optimized transaction architectures, thereby enhancing overall corporate value.

Despite the recognized importance of tax planning in M&A processes, many organizations continue to underestimate its strategic value during restructuring initiatives, resulting in substantial tax liabilities. Numerous enterprises encounter significant tax-related challenges due to policy misinterpretations, inadequate tax planning, and insufficient compliance risk management. Thus, comprehensive research on tax planning in corporate M&A carries substantial theoretical and practical significance^[1].

This paper adopts graduate-level academic rigor while incorporating the latest tax policy developments through 2025 to systematically examine theoretical foundations, policy frameworks, and practical strategies for tax planning in corporate M&A. The research aims to provide enterprises with scientifically-grounded tax decision-making frameworks for merger activities, facilitating optimal resource allocation and achieving integrated financial and tax synergy in restructuring operations.

2.Theoretical Foundations of M&A Tax Planning

The theoretical underpinnings of M&A tax planning primarily encompass tax synergy theory, special tax treatment theory, and tax neutrality principles. These conceptual frameworks establish the fundamental structure guiding organizational approaches to tax planning during merger activities.

2.1 Tax Synergy Conceptual Framework

Tax synergy theory proposes that corporate M&A transactions can maximize tax efficiency through deliberate planning strategies. Tax synergy, functioning as a structural component within post-merger integration frameworks, occupies critical importance in strategic planning and transactional arrangements. Empirical investigations reveal that not all affiliated M&A activities generate stable tax synergy effects. Compared to financial statement integration mergers, resource integration mergers demonstrate more pronounced tax synergy benefits. The effective presence of an internal capital market substantially enhances tax synergy effects in related-party mergers.

Tax synergy manifestations primarily occur through three mechanisms: first, income tax reduction through loss offset mechanisms, where profitable entities utilize acquired companies' accumulated losses to reduce taxable income; second, enhanced depreciation deductions through asset revaluation; third, tax savings through optimized capital structures utilizing interest deduction strategies.

2.2 Special Tax Treatment Theory

Special tax treatment theory constitutes a cornerstone of M&A tax planning frameworks. China's Corporate Income Tax Law stipulates that enterprise restructuring may qualify for special tax treatment upon satisfying these conditions: demonstrates legitimate business purposes without primarily aiming to reduce, exempt, or defer tax obligations; meets prescribed thresholds for acquired assets or equity (generally exceeding 50%); maintains original substantive business operations for 12 consecutive months post-restructuring; contains equity payment components representing at least 85% of total transaction value; requires principal shareholders receiving equity compensation to retain shares for 12 consecutive months following restructuring.

The essence of special tax treatment involves providing tax-neutral treatment for M&A transactions, effectively deferring tax obligations until actual asset or equity transfers occur subsequently. This approach alleviates cash flow pressures during merger processes while promoting optimal resource allocation.

2.3 Tax Neutrality Doctrine

The tax neutrality principle advocates that taxation should not distort corporate economic decisions, including M&A choices. According to this doctrine, tax considerations should not primarily determine merger decisions but merely influence selection of implementation methods. An ideal tax system maintains neutrality regarding corporate growth through internal development versus external acquisition.

However, complete tax neutrality remains theoretically challenging in practice. Governments frequently utilize tax policies to guide M&A directions and promote industrial structure optimization. For instance, China's 2014 policy adjustment reduced qualifying thresholds for special corporate income tax treatment from 75% to 50%, expanding special treatment applicability and demonstrating policy support for corporate restructuring and industrial upgrading through tax incentives.

3.Policy Framework for M&A Tax Planning

The policy framework for M&A tax planning primarily includes special tax treatment provisions, cross-border M&A tax regulations, and multi-tax coordination mechanisms. Comprehensive understanding of this policy landscape constitutes essential preparation for effective organizational tax planning^[2].

3.1 Special Tax Treatment Provisions

Special tax treatment policies vary according to restructuring types, specifically addressing debt restructuring, equity acquisition, asset acquisition, mergers, and divisions.

Regarding debt restructuring, when recognized taxable income from enterprise debt restructuring exceeds 50% of annual taxable income, enterprises may apportion this income across five tax years. This provision reduces income tax burdens for debt-restructured enterprises, avoiding single-year taxation pressures on substantial restructuring gains.

Equity acquisition and asset acquisition share similar special treatment qualifications, requiring acquired equity or assets exceeding 50% ownership, with equity payments comprising at least 85% of total consideration. Qualifying transactions may temporarily defer gain or loss recognition, maintaining tax basis continuity.

Merger qualifications for special treatment remain relatively flexible, requiring either that shareholders receive equity consideration exceeding 85% of total payment, or that same-control mergers occur without payment consideration. Special treatment permits surviving entities to inherit tax attributes from merged enterprises, including loss carryforward qualifications.

Division qualifications for special treatment include: shareholders receiving division enterprise shares proportional to original holdings; both divided and surviving entities maintaining original substantive business operations; and equity payments comprising at least 85% of total consideration to shareholders of divided enterprises^[3].

3.2 Cross-Border M&A Tax Regulations

Cross-border M&A tax regulations form essential components of international tax planning. China's policies regarding transactions between Chinese residents and non-residents (including Hong Kong, Macao, and Taiwan regions) involve specific provisions.

These specialized policies primarily address four scenarios: non-resident enterprises transferring resident enterprise equity to wholly-owned non-resident enterprises without altering future withholding tax liabilities, with transferor committing to non-transfer for three years; non-resident enterprises transferring resident enterprise equity to wholly-owned resident enterprises; resident enterprises investing assets or equity into wholly-owned non-resident enterprises; and other circumstances approved by financial authorities.

These policies aim to facilitate cross-border investment while preventing abuse of tax benefits and protecting national revenue interests. Cross-border M&A planning requires comprehensive consideration of domestic and international tax policies, strategic utilization of bilateral tax agreements, and optimized transaction structures.

3.3 Multi-Tax Coordination Mechanisms

M&A transactions involve multiple tax dimensions beyond corporate income tax, including value-added tax, land appreciation tax, deed tax, and stamp duty. Effective tax planning requires coordinated consideration across all relevant taxes to achieve comprehensive tax minimization.

Regarding value-added tax, asset restructuring transactions involving complete transfer of physical assets with associated liabilities and labor to other entities through mergers, divisions, or similar mechanisms generally fall outside VAT scope. This provision offers VAT benefits for enterprise asset restructuring.

Concerning land appreciation tax, real estate transfers during qualifying restructurings may qualify for temporary land appreciation tax exemption. For example, technology companies transferring appliance business assets and liabilities to wholly-owned subsidiaries typically obtain land appreciation tax exemptions.

Related to deed tax, corporate mergers and divisions involving continuing ownership interests generally qualify for deed tax exemptions regarding transferred land and building rights.

Multi-tax coordination requires comprehensive tax knowledge and strategic application of various tax incentives to achieve overall tax optimization.

4.Strategic Approaches to M&A Tax Planning

Strategic tax planning in M&A transactions encompasses pre-transaction planning, execution-phase planning, and post-transaction planning stages. Each phase involves distinct planning priorities and strategic considerations.

4.1 Pre-Transaction Planning Strategies

Pre-transaction planning establishes foundation for overall tax optimization, including target selection, transaction design, and financing arrangements.

In target selection, enterprises should comprehensively evaluate tax attributes including loss carryforwards, tax incentive qualifications, and asset tax bases. Empirical research indicates that actual tax burdens significantly influence M&A decisions, with lower effective tax rates favoring restructuring initiatives. Enterprises with accumulated losses might consider “loss-making entities absorbing profitable enterprises” models to utilize loss carryforwards.

Regarding transaction design, organizations must compare tax implications of asset acquisitions, equity acquisitions, and statutory mergers. Asset acquisitions avoid inherited tax liabilities but may generate higher transaction taxes; equity acquisitions qualify for special treatment but assume target’s tax history. Enterprises should select optimal structures based on specific circumstances.

Concerning financing arrangements, companies should evaluate tax effects of equity versus debt financing. Debt financing provides interest deduction benefits, while equity financing offers lower financial risks despite reduced tax advantages. Organizations should optimize capital structures to maximize after-tax returns.

4.2 Execution-Phase Planning Strategies

Execution-phase planning represents critical tax optimization period, including consideration structuring, payment selection, and treatment determination.

In consideration structuring, enterprises must allocate acquisition costs to minimize tax burdens. Asset acquisitions require rational allocation among different assets considering varying tax bases and attributes. Equity acquisitions necessitate appropriate pricing to avoid tax authority adjustments.

Regarding payment selection, organizations balance cash versus equity components. China’s tax policies permit special treatment for transactions exceeding 85% equity payment, enabling tax deferral. Cash payments offer immediate liquidity benefits. Enterprises should select payment methods according to cash flow conditions and tax objectives.

Concerning treatment determination, companies evaluate general versus special treatment alternatives. Special treatment defers tax timing and alleviate cash flow pressures but requires strict qualification and compliance. Organizations should select optimal approaches based on comprehensive circumstances.

4.3 Post-Transaction Planning Strategies

Post-transaction planning extends tax optimization into integration phases, including tax integration, incentive succession, and subsequent restructuring.

Tax integration constitutes essential post-merger activity. Enterprises must consolidate tax management processes across combined entities, unify planning strategies, and achieve tax synergy benefits. Research indicates that effective internal capital markets significantly enhance tax synergy in related-party mergers. Organizations should establish efficient internal capital mechanisms to strengthen tax coordination.

Tax incentive succession requires particular attention during integration. Surviving entities in mergers maintaining qualifying conditions may continue predecessor tax incentives. Enterprises should ensure ongoing compliance to maximize tax benefits. Subsequent restructuring planning enables continuous tax optimization. Transactions occurring within 12 months before or after restructuring may require integrated treatment under substance-over-form principles. Organizations should adopt long-term perspectives when planning subsequent restructuring activities.

5. Case Studies in M&A Tax Planning

This chapter presents empirical analysis through two representative cases demonstrating practical application and effectiveness of M&A tax planning. The first case involves manufacturing group merger highlighting special treatment application; the second examines technology company division emphasizing multi-tax coordination.

5.1 Case 1: Manufacturing Group Acquisition

A manufacturing group proposed acquiring a peer enterprise possessing accumulated losses and substantial valuable assets. The transaction involved 100% equity acquisition valued at 1 billion RMB, comprising 850 million RMB equity

consideration and 150 million RMB cash payment.

Tax Planning Strategy: First, the transaction qualified for special treatment through exceeding 50% equity acquisition (100% actual) and achieving 85% equity payment ($850/1000=85\%$). Special treatment enabled target shareholders to defer gain recognition while establishing acquirer's tax basis using original target basis.

Second, the group arranged pre-acquisition asset restructuring to separate non-core assets and liabilities into specific subsidiaries, enhancing target asset quality and tax efficiency. This restructuring completed within 12 months preceding acquisition but qualified for integrated treatment under continuity principles.

Planning Outcomes: Special treatment deferred approximately 250 million RMB corporate income tax for target shareholders (calculated using 1 billion RMB net asset fair value-tax basis difference at 25% rate), alleviating cash flow pressures; acquirer obtained target's loss carryforwards and tax incentives, projecting 120 million RMB tax savings over five years; asset restructuring optimized target structure, improving post-acquisition management efficiency.

This case demonstrates how appropriate special treatment application reduces M&A tax costs and achieves tax synergy benefits.

5.2 Case 2: Technology Company Division

A technology company holding multiple patents and real estate assets sought to enhance business focus and unlock asset value through division into two entities: technology development and asset management specialists.

Tax Planning Strategy: First, the company designed a survival division structure with original entity continuing technology operations while new entity assumed real estate assets. The division qualified for special treatment through proportional shareholder allocation, 100% equity payment, and continued substantive operations by both entities.

Second, the company implemented coordinated multi-tax planning. Corporate income tax qualified for special treatment deferring gain recognition; value-added tax exemption applied to integrated asset-liability-labor transfers; land appreciation tax qualified for temporary exemption under restructuring provisions; deed tax exemption applied through continuing ownership interests.

Planning Outcomes: Comprehensive tax planning avoided immediate tax payments approximating 350 million RMB corporate income tax, 120 million RMB land appreciation tax, 30 million RMB deed tax, and 80 million RMB value-added tax, totaling 580 million RMB tax savings; post-division entities enhanced operational focus and efficiency; asset management company leveraged real estate assets more flexibly, unlocking hidden value.

This case illustrates how coordinated multi-tax planning achieves comprehensive tax optimization in restructuring transactions, creating substantial economic value.

6. Conclusions and Future Perspectives

Through comprehensive examination of theoretical foundations, policy frameworks, strategic methodologies, and practical case studies, this research yields following conclusions and recommendations:

First, M&A tax planning possesses significant theoretical and practical importance. Tax synergy theory, special treatment theory, and tax neutrality principles constitute fundamental theoretical frameworks. Research indicates that actual tax burdens significantly influence M&A decisions, with lower effective rates facilitating restructuring activities. Private enterprises demonstrate greater sensitivity to corporate income tax policies, showing more pronounced policy effects than state-owned enterprises.

Second, effective M&A tax planning requires comprehensive policy understanding and contemporary awareness. China has established relatively complete M&A tax policy systems covering multiple tax categories. The 2014 policy adjustment reducing special treatment thresholds from 75% to 50% significantly enhanced policy effectiveness for M&A restructuring. The 2025 draft Enterprise M&A Law amendments further relaxed tax regulations, permitting deferred securities transaction taxation upon actual share transfers.

Third, systematic strategic approaches are essential for M&A tax planning. Distinct planning strategies apply across pre-transaction, execution, and post-transaction phases. Pre-transaction planning focuses on target selection and structure design; execution planning emphasizes consideration allocation and payment selection; post-transaction planning addresses tax

integration and incentive maintenance. Systematic planning maximizes tax synergy and enhances transaction value.

Finally, M&A tax planning requires emphasis on risk management and compliance. Increasingly stringent regulatory environments necessitate heightened attention to planning compliance and rationality, avoiding aggressive approaches creating legal risks. Enterprises should strengthen communication with tax authorities and professional advisors while establishing comprehensive risk management systems covering target selection, valuation, and integration processes.

Looking forward, evolving economic globalization and digital transformation will increase M&A complexity, demanding enhanced tax planning capabilities. Future research should examine tax issues in digital economy M&A, international tax coordination in cross-border transactions, and policy impact mechanisms on corporate M&A behavior, providing deeper theoretical guidance and practical references for M&A tax planning.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Koivisto A. Tax planning and investment responses to dividend taxation. *International Tax and Public Finance*. 2024 Apr 16:1-40.
- [2] Kolay M, Schallheim J, Wells KS. The leverage puzzle-a new perspective. *Journal for International Business and Entrepreneurship Development*. 2024;16(3):313-32.
- [3] Zhang X, Zha X, Zhang H, Dan B. Information sharing in a cross-border e-commerce supply chain under tax uncertainty. *International Journal of Electronic Commerce*. 2022 Jan 2;26(1):123-46.

Research on Cost Management Issues of Small and Medium-Sized Enterprises - A Case Study of Company H

Wenjing Fan*

School of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710000, China

**Corresponding author: Wenjing Fan*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Small and medium-sized enterprises (SMEs) are an important part of China's national economy. Their development drives employment, taxation, innovation, the market economy, and many other fields. However, due to the influence of multiple factors, the current situation of cost management in many SMEs is worrying. Common problems in their production and operation include confused corporate functions, incomplete financial systems, and weak awareness of cost budget management. This article briefly introduces the current situation of SMEs in China, combines relevant theoretical knowledge of cost management, and uses research methods such as case analysis, literature review, and comparative analysis to elaborate on and analyze the cost management of SMEs in detail. The case selected in this article is a small and medium-sized retail enterprise mainly engaged in entrusted agency and distribution. It has been established for 24 years, with a relatively mature and complete overall operation model and management system. The operational problems it reflects are representative among retail SMEs. Firstly, the article expounds on the characteristics of SMEs and the content of cost management. On this basis, taking Company H as a case, it analyzes the problems existing in the company's cost management and puts forward corresponding suggestions. The main cost management problems of SMEs include weak awareness of cost budget, unreasonable organizational structure, lax control of indirect costs, long accounts receivable cycles, and difficulty in collecting payments. Secondly, it conducts a specific analysis of the problems existing in the enterprise and proposes suggestions. The specific improvement suggestions include strengthening the awareness of cost management, improving the organizational structure of cost control, enhancing the control of indirect costs, and strengthening the management policy of accounts receivable. Finally, considering that SMEs vary in industry fields and scales, in the actual cost management process, flexible application should be made according to industry characteristics and with reference to the management experience of successful enterprises in the same industry. This paper focuses on the main influencing factors of cost management in small and medium-sized retail enterprises and how to manage the cost issues in the production and operation of enterprises, hoping to provide references for the cost management of small and medium-sized retail enterprises.

Keywords: Small and Medium-Sized Enterprises; Cost Management; Enterprise Management

Published: Oct 25, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.800>

1.Introduction

Regarding the research on cost management issues of SMEs, Wang Shuwen (2021) proposed that under the background of integration of business and finance, enterprises should focus on building a financial management and control system.

On the premise of improving the quality of financial information, they should strengthen the performance evaluation of business departments and financial departments and enhance the professional quality of relevant personnel. Chen Guicai (2022) pointed out that SMEs play an important role in China's economic growth, but there are still problems of backward cost management methods in Chinese SMEs. Zhou Yunjun (2020) believed that when seeking ways to reduce enterprise costs, analyzing only a single aspect can no longer adapt to the market environment. Enterprises should analyze various ways to reduce costs, conduct comprehensive considerations, and form an optimized management plan. Liu Richeng (2020) proposed that enterprise cost management is not about squeezing departments and employees, but about fully mobilizing the enthusiasm of staff, giving play to their respective potentials, and achieving both internal and external improvements. Scholar Wang Zhe (2022) believed that cost management does not occur only in a single link, but integrates every link such as pre-production, in-production, and post-sales. Among them, the most representative work is "Refined Cost Management" by Zhang Cansong (published by Science Press in 2011). The main view of this work is to integrate cost control into every link from the initial material selection to product output, control costs from the source to achieve refined results, and provide feasible cost control plans for each link and detail, so as to improve product qualification rates, reduce production waste, and enhance work efficiency. Zhang Jide and Zhao Yanan (2020) proposed the application of strategic cost management in enterprise management, believing that enterprises should not blindly adhere to the cost leadership strategy, but should consider innovating products and providing distinctive products to the market, that is, indirectly obtaining cost advantages by adopting the differentiation leadership strategy. Song Qin (2024) proposed that enterprise management should establish a unified information platform. This platform can present information such as the research and development plans of different product projects of each business division, the progress of production and research and development, the real-time project revenue and expenditure status, and cost accumulation, truly realizing the effective combination of business data and financial data. Chen Yanjie and Ge Jun (2023) proposed that cost management should establish medium - level cost flexibility to promote the establishment of an industrial cluster digital ecological platform, so as to resist various economic risks and enhance the competitiveness and voice of China's industrial cluster organizations in the global industrial chain. Zhao Guoquan (2020) proposed that cost management needs to stand from the perspective of the value chain, especially in highly competitive industries. Reasonable internal value chain management and increasing the bargaining power of upstream and downstream can often maintain a cost - leading position in the competition. Liu Xiaojing (2018) proposed that for the implementation of cost management, the internal production consumption of enterprises should be gradually reduced, and the reproduction of enterprises should be ensured at all times. The income should be greater than the compensation for production consumption; otherwise, there will be a shortage of funds, and the reproduction will be affected.

Based on the above analysis of the current research situation of cost management, it can be concluded that scholars' research on SMEs mainly focuses on the characteristics and scale of SMEs, and there is little involvement in how SMEs should respond to the increasingly severe market economy. In addition, scholars have conducted a large number of in - depth studies on the construction of cost management systems, such as the establishment of financial control systems, the incentive of personnel, and the ways to reduce costs. However, there are still many deficiencies in the actual work of cost management, especially in the management of Chinese SMEs. The main problems are as follows: First, the lack of awareness of cost budgeting, including the insufficient awareness of financial managers and enterprise managers on enterprise cost budgeting; second, the widespread problems of confused organizational structure and unclear job responsibilities in SMEs; third, the insufficient control of enterprise period costs, which leads to high operating costs of enterprises and reduces enterprise profits; fourth, the slow collection speed of SMEs and low accounts receivable turnover rate, which seriously affects the cash flow of enterprises. Based on the above analysis, this article combines the current situation of cost management of the case company, focuses on analyzing the important aspects of cost management such as cost budgeting, organizational department management, and internal control of the enterprise, so as to find the deficiencies in the cost management of Company H and put forward optimization strategies.

1.1 Research Background and Significance

1.1.1 Research Background

Since the 1990s, many SMEs have developed rapidly like mushrooms after rain. Objectively speaking, SMEs are the ladder to promote the continuous development and progress of society. They not only drive the steady development of the economy, but also become a strong driving force for the continuous innovation of social science and technology. However, it is not easy to survive and develop steadily in the increasingly fierce market competition. Many reasons may lead to the weakness of SMEs, and even eventually lead to their tragic withdrawal from the market, such as the harsh external competitive environment, difficulty in financing, broken capital chains, and poor internal operation and management. In short, as the lifeblood of an enterprise, if there are management problems and operational hidden dangers in the enterprise, it will eventually bring a major impact on the survival and development of the enterprise.

1.1.2 Research Significance

All along, due to their large number, large proportion in the market scale, and wide range of involvement, SMEs have been the research objects of many scholars. However, due to the relatively concentrated management rights of SMEs, the development and management of enterprises are closely related to the ability and insight of enterprise leaders. Therefore, the management problems of SMEs are various. Through consulting materials, it is found that in recent years, after the economic contraction, few scholars have studied the cost management problems of SMEs. Especially in recent years, with the decline of the market economy, many small and micro - enterprises have poor business volume and are almost on the verge of bankruptcy. Therefore, the research on the cost management of SMEs is of certain necessity and urgency.

2. Overview of Theories Related to Cost Management of Small and Medium-Sized Enterprises

2.1 Characteristics of Small and Medium-Sized Enterprises

China's SMEs have the typical characteristics of "5, 6, 7, 8, 9", contributing more than 50% of tax revenue, more than 60% of GDP, more than 70% of technological innovation, more than 80% of urban employment, and more than 90% of the number of enterprises. They are small in scale, have a relatively high concentration of operating decision - making power, a small number of employees, a small scale of business premises, a low market share, a small amount of financing funds, few financing channels, weak external financing capacity, and a low level of capital profit margin. These disadvantages lead to a shortage of funds for SMEs. In addition, the slow speed of capital accumulation limits the appreciation of enterprise capital to a certain extent.

2.2 Content of Cost Management

Cost management mainly includes cost planning, cost accounting, cost control, cost analysis, and cost assessment. Cost planning refers to the pre - budgeting and planning of all items that can generate costs and expenses in the production and operation activities of an enterprise. Through cost planning, the difference between the planned cost and the actual cost incurred is analyzed, and then countermeasures for improvement are studied. Cost accounting is the collection and distribution of the consumption in the production and operation process of an enterprise according to a certain method to calculate its costs and expenses. Cost control is based on cost prediction, and in the links of material procurement, use, and consumption, preventive and control measures are taken in advance for various aspects that may affect the cost to ensure the achievement of cost control and the enterprise's strategic goals. Cost analysis is the analysis of various cost indicators using relevant data from cost accounting. Cost assessment refers to the regular comparative analysis of various indicators, and the comprehensive review and evaluation of the achievement of the target cost and the completion of the cost plan indicators.

3. Cost Management Problems of Small and Medium-Sized Enterprises - A Case Study of Company

3.1 Brief Introduction of Company H

Company H was established in July 1999. Its sales model mainly focuses on entrusted agency products. Its main business items include UPS power supplies, computer room air conditioners and purification equipment, power distribution equipment, security equipment, etc. It has first - level qualifications for housing construction and decoration, second - level qualifications for municipal public engineering, second - level qualifications for steel structure professional contracting, and third - level

qualifications for fire protection facilities engineering. The company has also passed the inspection of environment, quality, and safety. In recent years, the company has continuously adjusted its business model, changing from the previous model of both agency and self - operation to the current business model of only agency, forming a relatively complete sales system, financial system, and leadership system. It has undertaken the computer room equipment and computer room decoration projects of many colleges and universities, expanded its projects to many cities, and its suppliers are also distributed in various cities.

3.2 Analysis of Cost Management Problems of Company

3.2.1 Analysis of Organizational Structure

The internal organizational structure of Company H is divided into the Sales Department, Pre - sales Department, Technology Department, Finance Department, and Warehouse Department. The Sales Department is mainly responsible for product sales, sales services, customer maintenance, market development, and coordinating with technical personnel for product maintenance. The Pre - sales Department is mainly responsible for bid preparation, site inspection, formulating appropriate bidding documents according to the different sites of each project, and providing product consultation and maintenance. The personnel of the Technology Department are mainly responsible for the installation of products at the construction site and the maintenance of products during the product warranty period. The personnel of the Finance Department are responsible for the company's capital turnover, salary payment of employees, expense reimbursement, tax planning, cost control, the collection of payment from each sales project, and the progress of project follow - up. The Warehouse Department is mainly responsible for the regular inventory of warehouse products, product maintenance, the delivery and storage of products after the signing of contracts, the regular maintenance of the warehouse, and the timely conduct of safety inspections to eliminate potential safety hazards.

From the perspective of the company's departmental division, the overall division of functions is relatively complete. However, in the actual operation process of the company, there are many problems. Although the Purchasing Department is established, there are no real purchasing personnel considering the labor cost, and the business personnel of the company temporarily act as purchasing personnel. Therefore, when a contract is signed and a business occurs, there will be a situation where personnel shirk their responsibilities and the responsibilities cannot be specifically divided. In addition, since the company's main business is product agency and consignment sales, in the sales process, there is a situation where products are sent directly from the manufacturer to the construction site for installation and commissioning. The warehouse management personnel cannot directly manage the products. If the sales personnel do not communicate in a timely manner, it will lead to the situation where funds are spent to purchase products while the same type of products are overstocked in the warehouse, thereby increasing the operating cost of the enterprise. The work of the accounting department is too cumbersome and complex, with a large workload, resulting in low efficiency. The work of contract and financial cost accounting should be set up separately. In addition, all departments work independently, and there is no effective communication between departments and personnel.

3.2.2 Structure of Cost and Expense Expenditure

The cost items of Company H are specifically divided into product procurement, direct labor, other direct expenses, management expenses, sales expenses, financial expenses, and warehouse expenses. Among them, warehouse expenses and period expenses belong to indirect expenses.

The company does not have an accurate budget for material expenses, and the actual cost cannot be specifically controlled. The problem existing in material expenses is that the sales personnel directly purchase materials, and the warehouse personnel of the department are only responsible for the storage of goods and the delivery of products to customers. This leads to the situation where the sales personnel do not strictly control the quantity of purchases before purchasing, and do not compare the prices of multiple suppliers on the premise of ensuring quality, resulting in a high purchase price and high purchase cost. In addition, the period expenses of Company H are too large, especially the proportion of sales expenses is unreasonable. Due to the fact that the sales nature of Company H's entrusted consignment sales belongs to the industrial chain of small profits but quick turnover, the large proportion of sales expenses in the income leads to a reduction in the company's profits.

The labor cost is mainly reflected in the fact that the company's products are mainly non - daily products such as UPS power supplies and in - row air conditioners. The sales personnel face problems such as high early time cost and difficulty in signing orders. The low sales volume of sales personnel leads to a small workload of the personnel in the departments closely related to sales, resulting in a waste of human resources. Moreover, the company does not set up departments reasonably. Some positions have a small workload and simple work, but are staffed with too many personnel, leading to the idleness of staff. On the contrary, some positions have a large workload and insufficient personnel, leading to low work efficiency and high labor costs. At the same time, in order to save costs, the company has streamlined the positions to the minimum. When there are many projects, it is inevitable that there will be situations of shirking responsibilities and insufficient cooperation with each other.

4. Cost Management Problems of Small and Medium-Sized Enterprises

4.1 Weak Awareness of Cost Control and Inability to Specifically Measure the Company's Operating Status

Enterprise cost budgeting can help enterprises reduce costs and improve efficiency. Through the pre - calculation and arrangement of costs, enterprises can better control various costs in production and operation activities, reduce unnecessary waste, and improve the efficiency of resource utilization, thereby improving the operating efficiency of enterprises, which is crucial for enterprises. The cost control system of Company H is not sound. Each project of the enterprise only has a record of project costs, and there is no specific cost control plan at the beginning of the year. The cost control is reflected in the control of the material cost price when the project occurs, while ignoring the proportion of period expenses. In addition, employees do not have a strong awareness of full - staff participation in cost management. Especially, the financial personnel are responsible for recording costs, but the sales personnel who are actually responsible for purchasing products have insufficient awareness of cost control. They are prone to short - sighted behavior due to sales orders and lack a deep understanding of some potential risk factors that affect project costs. In addition, the company has not formed a sound incentive mechanism, which makes employees lack enthusiasm. As a result, cost management will be relaxed, and the binding force of cost control will be weakened.

4.2 Unreasonable Departmental Organizational Structure and Lack of Strict Management and Control

The research finds that the establishment of the organizational departments of Company H is unreasonable, and the project management functions are not sound. First of all, in order to save labor costs, the enterprise has streamlined the departmental positions repeatedly, leading to confused departmental functions and personnel holding multiple positions. The warehouse management is handled by business personnel. The sales personnel of the company need to be responsible for sales, quotation, procurement, and bidding business, which requires strong professionalism. As a result, the company's early talent training cost for sales personnel is high, and the benefit cycle is long.

At the same time, the work of the accounting department is too cumbersome and complex, with a large workload, resulting in low efficiency. The work of contract and financial cost accounting is not set up separately. The failure of timely communication between various departments affects the progress of the project.

4.3 Lax Control of Indirect Costs

For small and medium - sized retail enterprises, the amount of their income largely depends on the sales ability of sales personnel. Therefore, the sales expenses of enterprises will inevitably account for a high proportion of the enterprise's expense expenditure. The research finds that the main business of Company H is non - daily electronic products such as storage batteries. The sales cycle is long and the sales difficulty is high. For sales personnel, the proportion of sales expenses in sales income is too large, leading to a reduction in the company's profits. On the other hand, due to the particularity of the enterprise's products, high professional ability is required for sales personnel. For sales personnel, enterprises face the situation of paying salaries to sales personnel without sales income in the short term, which increases the proportion of management expenses. In addition, during the procurement process of goods in Company H, the purchasing personnel do not strictly control the quantity of purchases and do not compare prices, which will lead to high procurement costs.

4.4 Long Accounts Receivable Cycles and Difficulty in Collecting Payments

In the process of enterprise operation, the company does not pay attention to the changes in customer credit, leading to an increase in bad accounts receivable and difficulty in collecting payments in the later period. Some customers may have a weakening ability to repay or even be unable to repay due to some unexpected reasons during the process of the seller performing the sales obligation. However, in the sales management process of small and medium - sized enterprises, due to the lack of awareness of this situation, management is missing. The partners of Company H are all enterprises with long - term business contacts. For its downstream enterprises, there will be situations where the accounts receivable cycle is long and the payment cannot be collected in a timely manner. At the same time, the temporary capital turnover difficulty will affect the payment of goods to its upstream enterprises. Especially in recent years, with the depression of the market economy, most enterprises have a negative attitude towards paying goods. There are often situations where enterprises cannot collect the payment in a timely manner after issuing invoices, but have to pay taxes, which causes difficulties in the capital turnover of enterprises.

5. Countermeasures to Strengthen the Cost Management of Small and Medium-Sized Enterprises

5.1 Strengthen the Awareness of Cost Management

Cultivating the sense of responsibility of all employees and strengthening the awareness of cost management of all employees is the basis for strengthening cost management. For the awareness of cost management, the joint participation of the Sales Department, Purchasing Department, Finance Department, and enterprise managers is required. Each department should have its own division of responsibilities for cost control. First of all, financial personnel should do a good job in the statistics and management of cost and expense expenditures, and reasonably plan the proportion of project cost expenditures and the scope of early project expense expenditures according to the size of the project. Secondly, the Sales Department should reasonably arrange the expense budget according to the difficulty of the project to reduce unreasonable expense expenditures. Since the sales personnel are also responsible for the procurement of project goods, the sales personnel should be responsible for the control of procurement expenses and control the sales profit rate within a reasonable level. Finally, the enterprise operation managers play a crucial coordinating role. The enterprise leaders should delegate power. For the Sales Department, the salary assessment standard should no longer be based on sales income, but on sales profit rate, so as to avoid the problem that sales personnel ignore costs for the sake of sales volume. In addition, managers should adjust the control of cost management at any time according to the actual situation of the project, strictly implement the project budget plan made by the Finance Department, and timely provide incentives to personnel in various departments to stimulate the enthusiasm of employees to participate in cost management and internal control. The cost management and internal control system with the participation of all employees is the key to the real success of the enterprise.

5.2 Improve the Internal Organizational Structure of the Enterprise

In order to save costs, Company H has streamlined positions, making sales personnel not only responsible for sales, but also for procurement, product pricing, project after - sales service, and product registration. This requires high professionalism and heavy sales tasks. For the company, it reduces the economic expenditure of other positions in the short term, but in the long run, the company has high standards for sales personnel, resulting in high early training costs. It will also lead to a large turnover of enterprise personnel, which is not conducive to the enterprise's retention of talents. Enterprises should separate the responsibilities of various departments, establish a special Purchasing Department to strengthen the cooperation with sales business, so that the work focus of sales personnel is on product sales, and strengthen the performance assessment of sales personnel. For the Finance Department, enterprises should set up a special cost control position to be responsible for supervising and controlling the proportion of cost and expense expenditures of enterprise projects, adjust the control of project costs in a timely manner according to the difficulty and progress of the project, strengthen the verification of daily accounting, and ensure the authenticity, effectiveness, and legality of enterprise operations. In addition, it is necessary to standardize the corporate governance structure, include the process of enterprise managers exercising power in the monitoring scope of internal control, strengthen the internal control awareness of scientific management, and improve the efficiency of

internal management and control of enterprises.

5.3 Strengthen the Control of Indirect Costs

If enterprises want to strengthen the control of direct procurement expenses, purchasing personnel must strictly control the quantity of purchases, repeatedly compare prices, and reduce procurement costs. All departments should abide by the regulations. The Material and Supplies Department should also strictly control the quantity of materials received, not allow arbitrary receipt of materials, minimize the waste of materials, and achieve the purpose of taking materials on demand and making the best use of materials. In addition, it is necessary to strengthen the control of period expenses, formulate strict expense reimbursement procedures, ensure that the financial vouchers are consistent with the real economic business, and ensure the authenticity and accuracy of financial data. In addition, the company should reasonably set the performance quota according to the personal work ability of the sales personnel, the amount of work, and the difficulty of the work, so that the staff of all departments can complete their work, improve work efficiency, and save expense expenditures.

5.4 Strengthen the Management Policy of Accounts Receivable

The management level of accounts receivable directly affects the cash flow of a company and is related to whether the company can operate normally. Its core idea is to control the entire process of credit sales, so as to reduce the risk of accounts receivable to an acceptable range and comprehensively improve the enterprise value. The company should achieve pre - control, in - process control, and post - control. (1) Pre - control refers to the review of customer credit and the selection of credit granting methods before the formal transaction (before signing the contract or delivering the goods). For customers with poor credit, enterprises can adopt measures such as one - time payment upon delivery, payment before invoicing, and appropriate price increase to increase profits. (2) In - process control refers to the dynamic tracking and management of changes in customer conditions and accounts receivable from the signing of the contract or delivery of goods to the due date of payment. For the units in arrears, the payment reminder letter should be sent in a timely manner and the progress of payment collection should be followed up in a timely manner. (3) Post - control refers to the implementation of effective collection processing for overdue claims after the occurrence of arrears. For the arrears that have long passed the latest payment deadline, legal means should be taken in a timely manner, such as sending a lawyer's letter and applying for property preservation, to recover the payment.

6. Conclusion

To sum up, in view of the current situation of cost management and internal control systems of domestic SMEs, we cannot rigidly apply the existing management experience to various SMEs. We should proceed from reality as much as possible, combine the market environment in recent years and the needs and preferences of consumers, fully consider China's economic environment and the actual situation of enterprises, flexibly grasp the methods and means of management and control, and strive to explore a set of perfect and flexible cost management and internal control system models. This is not only a new requirement for domestic SMEs, but also an objective need for the faster development of China's economy. Through the research in this article, the following conclusions are obtained.

First of all, this study takes Company H as an example to study the cost management problems of SMEs, which are mainly reflected in the unclear division of positions, the employees' insufficient attention to cost control, the mutual shirking of responsibilities among various departments for cost management, the lax control of indirect costs, the long accounts receivable cycles, and the difficulty in collecting payments. Then, this article analyzes and puts forward relevant improvement policies, such as strengthening the awareness of cost management, improving the organizational structure of cost control, enhancing the control of direct procurement costs and indirect costs, and strengthening the management policy of accounts receivable. Finally, China's SMEs are large in number, wide in scale, and rich in industry types, and the cost management problems they reflect are also different. This article takes electronic product retail enterprises as a case to study and analyze the problems and drawbacks reflected in their cost management. At the same time, regarding the problem of unclear division of positions mentioned in the article, enterprise managers usually are unwilling to set up more positions due to cost considerations, and instead ask employees in other positions to handle the work of the unestablished positions. Therefore, there will be a contradiction between the employees' workload and unclear division of responsibilities and the enterprise's

management costs, which needs to be further solved.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Wang, S. W. (2021). Analysis of enterprise financial management and control and cost management under the background of integration of business and finance. *Accounting Learning*, (02), 111–112.
- [2] Chen, G. C. (2022). Problems and countermeasures of accounting cost management in small and medium-sized enterprises. *Cooperative Economy and Science*, (24), 141–143. <https://doi.org/10.13665/j.cnki.hzjjykj.2022.24.001>
- [3] Zhou, Y. J. (2020). Analysis on the ways to reduce enterprise costs. *Business News*, (36), 103–104.
- [4] Liu, R. C. (2020). Research on enterprise cost control. *China Collective Economy*, (35), 58–60.
- [5] Wang, Z. (2022). Research on cost management optimization of YDKJ company [Master's thesis or Doctoral dissertation]. Zhengzhou University.
- [6] Zhang, C. S. (2011). Refined cost management. Science Press.
- [7] Zhang, J. D., & Zhao, Y. N. (2020). Current situation, problems and countermeasures of the application of enterprise strategic cost management in China. *Friends of Accounting*, (26), 122–125.
- [8] Song, Q. (2024). Problems and optimization measures of cost management in a military research institute. *Finance and Accounting*, (03), 67–68.
- [9] Chen, Y. J., & Ge, J. (2023). Research on the cost management framework under the background of Chinese-style modernization. *Communication of Finance and Accounting*, (4), 9–15, 109.
- [10] Zhao, G. Q. (2020). Research on the strategic cost management model of intelligent home appliance enterprises—a case study of Haier and Xiaomi [Master's thesis or Doctoral dissertation]. University of International Business and Economics.
- [11] Li, X. J. (2018). Research on cost management of small and medium-sized enterprises. *Accounting Learning*, (24), 105–107.

Research on Accounting Recognition of Enterprise Data Assets—Taking A Group as an Example

Yifan Zhang*

School of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710600, China

*Corresponding author: Yifan Zhang

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In the digital economy era, data has emerged as a new production factor with significant economic value. However, current accounting standards lack systematic alignment in data asset recognition, making it difficult for enterprises to objectively reflect core data resources in financial statements and weakening the decision-usefulness of accounting information. Taking A Group, a leading domestic e-commerce platform, as a case study, this paper analyzes practical obstacles in accounting recognition of data assets through three dimensions: asset ownership definition, cost measurement, and assessment of future economic benefits. Drawing on its public financial reports, ESG reports, and data business practices, the study proposes solutions based on the “Interim Provisions on Accounting Treatment of Enterprise Data Resources” (Caihui [2023] No.11), providing practical references for corporate data asset accounting recognition and standard improvement.

Keywords: Data Assets; Accounting Recognition; Intangible Assets; Cost Measurement

Published: Oct 25, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.801>

1.Introduction

1.1 Research background: the contradiction between the release of data factor value and the adaptability of accounting system

Data, as a new factor of production explicitly defined in the “14th Five-Year Plan for Digital Economy Development”, has become the core engine driving economic growth. The “China Digital Economy Development Report (2024)” released by the China Academy of Information and Communications Technology shows that in 2024, China’s digital economy reached 53.9 trillion yuan, accounting for 42.8% of GDP, with data elements contributing over 15% to economic growth. This development trend aligns closely with the strategic positioning of the “Opinions on Building a Data Foundation System to Better Leverage the Role of Data Elements” (“Data Twenty Articles”), while also driving enterprises’ data asset value creation capabilities to gradually stand out: JD.com’s 2022 annual report disclosed that its supply chain data modeling improved inventory turnover rate by approximately 30%, directly reducing operational costs by 8%; Ant Group’s 2020 prospectus revealed that data technology service revenue accounted for 39% of total revenue, with risk control services based on user credit data contributing 62% of profits in this sector; IDC’s “Global Data Value White Paper (2023)” research indicates that among global listed companies, the value contribution of off-balance-sheet data assets exceeds 30% of market capitalization, reaching as high as 45% in the internet industry.

However, the non-exclusivity, scenario-dependent nature, and dynamic value characteristics of data assets present significant

conflicts with existing accounting frameworks. According to Accounting Standard for Business Enterprises No.6——Intangible Assets (issued in 2006), data asset recognition faces three core contradictions: First, the non-exclusive nature of data ownership conflicts with the accounting standard's "controlling" requirement; Second, data value depends on specific application scenarios, which clashes with the recognition criterion of "likely economic benefits flowing in"; Third, the initial cost of data assets often deviates from their ultimate value, contradicting traditional historical cost measurement principles. PwC's 2024 Shanghai-Shenzhen 300 Enterprise Data Asset Survey reveals that 90% of enterprises hold off-balance-sheet data assets, averaging 20% of their book value. This situation severely undermines the integrity of financial information.

The Interim Provisions on Accounting Treatment of Enterprise Data Resources (hereinafter referred to as the "Interim Provisions"), effective January 1, 2024, for the first time explicitly state that data resources may be accounted for under the intangible assets or inventory standards. However, enterprises still face operational challenges such as ambiguous ownership recognition criteria, lack of cost allocation methods, and incomplete valuation systems in practice. To address these issues, this paper selects Group A, a company with data operations spanning retail, cloud computing, and logistics sectors, as a case study. By analyzing its publicly disclosed financial data and data asset practices, the study systematically examines specific obstacles in accounting recognition, providing practical references for implementing the Interim Provisions.

1.2 Research significance: the dual value of theoretical complementation and practical guidance

Theoretically, this paper reconstructs the evolutionary trajectory of intangible asset accounting standards (from the 2006 edition to the 2023 Interim Provisions) while examining data assets' unique attributes. By establishing a three-dimensional analytical framework for data asset recognition, it addresses the adaptation gap between traditional accounting theories and the digital economy era. Furthermore, the study introduces a data asset lifecycle theory that divides data assets into five phases: collection, cleansing, storage, application, and iteration. Through analyzing the distinctive accounting recognition characteristics at each stage, the research provides a theoretical foundation for subsequent studies.

In practical terms, this study examines Group A as a case study to thoroughly analyze the specific obstacles in data asset recognition. By aligning with China's Interim Provisions on Data Asset Recognition, it proposes actionable solutions. For instance, addressing cost allocation challenges, the research developed a "Data Asset Cost Allocation Matrix" that clarifies cost allocation methods for externally purchased/internally generated and structured/unstructured data. To resolve ambiguous ownership issues, the study references legal requirements from China's Data Security Law and Personal Information Protection Law to propose a "Hierarchical Ownership Confirmation Model for Data". These findings provide direct guidance for enterprises to ensure compliant data asset accounting, while offering practical evidence for regulators to refine accounting standards.

2. Case Background: A Group's data business and financial status

2.1 Ecological layout of A Group's data business

As China's leading e-commerce enterprise, Group A operates across four core business segments: online retail (65% of total revenue in 2023), cloud computing (18%), digital media and entertainment (10%), and logistics services (7%). The company achieved 1.12 trillion yuan in revenue for 2023, with R&D investment accounting for 3.52% of total revenue. Notably, data-related R&D expenditures (including data collection, algorithm development, and data security) constituted 42.3% of this investment. According to its 2023 annual report and ESG report, the group has accumulated three categories of core data resources, establishing a self-reinforcing ecosystem where "data drives business operations while business data feeds back into data utilization."

2.1.1 User Data: The Group analyzes massive data from over 1 billion users across browsing, search, purchasing decisions, and transactions on its platform to build precise user profiles for personalized recommendations. Behavioral data covering over 800 million active users—including click-through rates, browsing patterns, and purchase preferences—along with transactional data such as order values and payment methods, collectively reveal users' interests in different product categories. This approach not only enhances shopping experiences and conversion rates but also provides insights into consumption habits and regional characteristics, thereby driving sustained business growth.

2.1.2 Merchant Data: The Group has accumulated comprehensive operational data for platform merchants, covering store

traffic, conversion rates, average order value (AOV), product sales volume, inventory levels, and merchant credit metrics based on fulfillment performance and after-sales service. This data not only helps merchants optimize their operations but also provides critical support for the platform to screen high-quality merchants, deliver differentiated services, and facilitate financial institutions' credit offerings (such as MYbank's unsecured loans). Additionally, the platform offers targeted operational guidance and training through data analysis, empowering merchants to enhance their capabilities and thereby boosting the platform's commercial vitality and competitiveness.

2.1.3 Logistics Data: As the logistics backbone of the group, Cainiao Network has accumulated extensive data in logistics and supply chain management. Real-time tracking of parcel trajectories enhances consumer experience; warehouse data optimizes inventory allocation and reduces costs; while supply chain collaboration data integrates operational information across merchants, logistics providers, and suppliers. Through analyzing these datasets, Cainiao achieves visualized and intelligent supply chain management. This includes predicting logistics peaks, reallocating resources to ensure stable promotions, and mitigating bullwhip effect through information sharing – all of which boost the entire supply chain's responsiveness and competitiveness^[1].

According to the financial statements, Group A's 2023 annual report shows intangible assets totaling 18.6 billion yuan, primarily comprising software copyrights and trademark rights, with no separate disclosure of "data assets". R&D expenses amounted to 38.5 billion yuan, where data-related expenditures such as data cleansing and algorithm development accounted for approximately 40% and were fully recognized in current period profits. In "other business income", data service revenue reached 6.2 billion yuan, representing 5.6% of total revenue, though the underlying data resources were not recognized as assets.

2.2 The current situation of financial accounting of A Group's data assets

According to the 2023 financial statements, the accounting of data assets of Group A has obvious off-balance sheet characteristics, which are as follows^[2]:

2.2.1 Asset side: Data assets are not separately recognized and presented

The balance of the "Intangible Assets" account stood at 18.62 billion yuan, primarily comprising software copyrights (8.53 billion yuan), trademark rights (6.21 billion yuan), and externally purchased technology licenses (3.88 billion yuan). Notably, the "Data Assets" item was not separately listed. In the "Fixed Assets" category, data storage-related servers and storage devices totaled 12.45 billion yuan. These assets were depreciated using the straight-line method over a five-year period, with full depreciation expenses recognized in current period income statements, without being linked to specific data asset projects^[3].

Cost side: All data-related expenses are expensed

In 2023, the total R&D expenditure reached 38.56 billion yuan, with data-related expenses (including 2.83 billion yuan for data collection, 3.21 billion yuan for manual data cleaning, 6.52 billion yuan for algorithm development, and 2.84 billion yuan for data security) totaling 15.4 billion yuan, accounting for 40% of the total R&D expenditure. All these expenditures were fully recognized in the current period's profit and loss in accordance with the "Research Stage Expenditure" requirements under Accounting Standard for Business Enterprises No.6 — Intangible Assets.

Revenue side: data service revenue does not match asset side recognition

In the "Other Business Revenue" segment, data service income reached 6.23 billion yuan, accounting for 5.6% of total revenue. This primarily included user profiling services provided to third-party merchants (3.21 billion yuan), merchant credit data services offered to financial institutions (2.12 billion yuan), and supply chain data services delivered to logistics companies (900 million yuan). However, the underlying data resources were not recognized as assets, rendering the "revenue-cost" matching principle ineffective — In 2023, the gross margin of the data service sector hit 68%, significantly higher than the group's overall 25% gross margin. This abnormal disparity essentially stems from cost underestimation caused by unrecorded data assets.

3. Case Analysis: Practical obstacles to accounting recognition of data assets in Group A

3.1 Ambiguous definition of asset attributes: the definition of "intangible assets" is not suitable

According to Accounting Standard for Business Enterprises No.6 — -Intangible Assets, an asset must meet four criteria: “identifiability,” “ownership or control,” “probable future economic benefits,” and “reliable cost measurement.” The data resources of Group A exhibit three layers of ambiguity in their attribute definition:

3.1.1 Legal level: Ownership stratification leads to difficulties in the identification of “control rights”

According to the Data Security Law and Personal Information Protection Law, data ownership can be divided into four tiers: “ownership, usage rights, income rights, and disposal rights.” In Group A’s data resources, externally purchased data has clear ownership with complete usage and income rights, which can be recognized as intangible assets acquired through external purchases^[4]. However, the ownership of internally generated data remains significantly contentious:

User Data: Under the User Service Agreement, Group obtains “limited usage rights” that must meet three conditions: desensitization processing (compliant with GB/T 35273-2020 “Information Security Technology-Personal Information Security Specification”), purpose limitations, and user revocability. For example, when users disable personalized recommendation permissions, companies can no longer access their historical behavioral data, resulting in a lack of “long-term control rights”.

Business Data: As data providers, merchants retain partial ownership of their operational data. Group A only holds “collaborative usage rights” — According to the Platform Service Agreement, merchants may request Group A to delete their historical sales data, with data service revenue to be proportionally shared between merchants and Group A. This conflicts with the core requirement of intangible assets that “enterprises have the right to control asset usage and exclusively enjoy economic benefits.”

3.1.2 Accounting level: “discernability” standard adaptation conflict

The Accounting Standards for Business Enterprises No.6 — -Intangible Assets stipulates that “discernability” must be satisfied by either “separability” or “originating from contractual rights.” A Group’s structured data can be independently separated and sold, meeting the discernability requirement. However, unstructured data (such as user clickstream data and logistics trajectory video data) cannot be isolated and requires algorithmic models to generate value —. For instance, user clickstream data must be processed through “recommendation algorithms” to transform into personalized recommendation services, as standalone click data lacks economic value. This strong binding relationship between “data and algorithms” makes it difficult for unstructured data to meet the “discernability” standard, thus failing to qualify as intangible assets.

3.1.3 Practical level: The blurred boundary between “asset-service” makes classification difficult

The Interim Provisions specify that data resources may be classified as either “intangible assets” or “inventory”. However, Group A’s data operations face ambiguity in defining the “asset-service” boundary. For instance, their “consumer profiling service” involves both user data and algorithmic analysis with report outputs— If recognized as intangible assets, separate accounting for data costs and value becomes necessary; if treated as service revenue, it risks overlooking the long-term value of data assets, leading to inconsistent accounting treatments for identical services.

3.2 Cost reliable measurement dilemma: operational difficulties in initial measurement

“Cost can be measured reliably” is the core condition of asset recognition. The cost composition of A Group’s data assets is complex, and there are three problems in practice: “difficult to collect, difficult to allocate and difficult to trace”.

3.2.1 Cost pooling: the boundary between direct cost and indirect cost is vague

The cost of data assets in Group A can be divided into direct costs and indirect costs, but the boundary between them is difficult to be clearly divided:

Direct cost: including data collection fee, data purchase fee, data cleaning and annotation labor cost, and amortization of special software. These costs can be directly attributed to specific data asset projects^[5];

Indirect costs: including server depreciation, cloud computing resource consumption, database R&D expenditure, data security investment, etc. These costs are shared by multiple data services — For example, the server simultaneously stores user data, merchant data and logistics data, which cannot be directly attributed to a single data asset project, resulting in incomplete cost collection.

3.2.2 Cost allocation: Shared cost allocation lacks standards

For the allocation of indirect costs, Group A currently adopts the “data storage ratio method”, which allocates shared costs such as server depreciation and cloud computing resource consumption according to the proportion of various data storage. However, this method has obvious defects:

The resource consumption does not match the storage capacity: the storage capacity of user data accounts for 60% of the total storage capacity, and 60% of the server depreciation is allocated according to this proportion. However, the average daily call times of user data are much higher than that of merchant data, and the actual resource consumption and storage capacity are significantly different, resulting in distorted cost allocation results;

Value and storage volume are not correlated: The value of 1TB user portrait data is far more than that of 10TB ordinary transaction data. Cost allocation based on storage volume will further amplify the deviation between cost and value, which does not conform to the principle of “cost and value ratio”.

3.2.3 Cost traceability: It is difficult to confirm the historical cost of endogenous data

The endogenous data of Group A is mostly accumulated through daily business, and its historical cost is difficult to trace:

Initial costs were not separately accounted for: User behavior data prior to 2021 was generated during the platform’s normal operations, with collection costs (such as server depreciation and labor expenses) not separately calculated. To recognize these data assets now, we need to retroactively trace costs since 2021. However, some original documents (e.g., server operation records) have been destroyed in accordance with regulations, making cost measurement unreliable.

Unclear capitalization standards for subsequent expenditures: Ongoing costs such as data cleansing and algorithm optimization continue to occur. For instance, in 2023, 1.23 billion yuan was invested in algorithmic iterations using user data from 2021. Current accounting standards fail to clarify whether such expenditures should be capitalized or expensed, leading to arbitrary practices in actual operations.

3.3 The problem of future economic benefit assessment: uncertainty and relevance are prominent

The value of data assets is heavily dependent on their application scenarios and timeliness. A Group’s user behavior data experiences rapid value decay, with its economic benefits being highly uncertain. For instance, a user preference model built for a promotional campaign may see its value plummet immediately after the event concludes. While precision marketing and similar operations can generate measurable cash flows, technically challenging to directly and reliably link these to the economic benefits flowing from specific underlying datasets. This high uncertainty in future economic returns makes it difficult for accountants to conclude during professional judgment that “economic benefits are likely to flow into the enterprise.”

4. Discussion and Implications

Through the case analysis of Group A, it can be found that the problem of accounting recognition of enterprise data assets is essentially a conflict between the current historical cost accounting model and the unique value creation model of data assets.

4.1 Implications for the development of the Standards: Refining guidance on the identification of “control rights” and cost allocation

The Ministry of Finance is advised to refine the criteria for determining “control rights” over data assets in conjunction with the Data Security Law. —For user data, merchant data, and other “limited-use” data that meets the conditions of “authorization period ≥ 1 year, clear purpose, and non-revocable,” it should be recognized as “having substantive control rights.” For instance, Group A’s “long-term authorization agreement” with users (authorization period 2 years) and desensitized data can be confirmed as intangible assets. Regarding cost allocation, following the logic of Accounting Standard for Business Enterprises No.17 —Borrowing Costs, it is recommended to adopt the “data storage ratio method” for shared indirect costs (e.g., server depreciation). If a data asset accounts for 20% of total storage volume, 20% of server depreciation should be allocated, enhancing the objectivity of cost measurement.

4.2 Implications for enterprises: building a whole-process management system of data assets

Group A may establish a data asset ledger in accordance with the Interim Provisions, categorizing and documenting data resources’ sources (external procurement/internal generation), ownership agreements, cost components, and application scenarios. For instance, regarding “credit data from external merchants,” it should separately record procurement costs, authorization periods, and usage scopes to provide a basis for cost aggregation;

For major data projects such as the “Smart Logistics Data Platform”, a project-based approach is adopted to aggregate costs. Costs are separately accounted for by project, with direct costs directly allocated and indirect costs proportionally allocated based on “project usage duration”. For example, in 2023, Group A’s “Smart Logistics Data Platform” utilized servers for 15% of total operating hours, resulting in a 15% allocation of server depreciation to meet cost objectification requirements.

4.3 Implications for regulation and evaluation: Promoting standardization of data value assessment

It is recommended that the China Appraisal Society for Assets issue the “Guidelines for Data Asset Valuation” to establish a framework for data asset valuation and clarify the application scenarios of the income approach and market approach. For example, Group A’s “user profile data” could adopt the income approach to assess value based on the present value of data service revenue over the next three years;

Referring to the “data asset on-balance sheet guidance mechanism” of Shenzhen Data Exchange, strengthen the coordination between data exchange and enterprises. Group A can list the compliant data products such as desensitized merchant credit data on the exchange, verify their value through market transaction prices, and provide reference for accounting recognition.

5. Conclusions

This study examines Group A as a case to reveal practical challenges in accounting recognition of data assets across three dimensions: asset ownership determination, cost measurement reliability, and future economic benefit valuation. These issues stem from the intangible nature and dynamic value characteristics of data assets, representing common challenges faced by traditional accounting frameworks when addressing new digital economy elements. The implementation of the Interim Provisions provides a policy foundation for data asset recognition, but practical application requires enterprises to establish comprehensive data asset management systems tailored to their business scenarios. Regulatory bodies need to refine operational guidelines on “control rights” identification and cost allocation, while evaluation agencies should develop standardized data valuation criteria. As the data market matures and accounting systems improve, data assets will progressively achieve “confirmable, measurable, and reportable” status, offering more precise financial support for enterprise valuation and digital economic development.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Lu Zheng, Zhou Ting, Wang Li, et al. Data Assets and Enterprise Development —— From Empirical Evidence of Listed Companies in China [J]. Industrial Economics Research, 2023, (04):128-142.
- [2] Zhang Junrui and Wei Yanlin. Data Asset Accounting: Current Status, Regulations, and Prospects [J]. Accounting Monthly, 2023,44(12):3-11.
- [3] Li Jian, Dong Xiaofan, Zhang Jinlin, et al. The Impact of Data Assets on Corporate Innovation Investment [J]. Foreign Economics and Management, 2023,45(12):18-33.
- [4] Huang Shizhong, Ye Fengying, Chen Chaolin. "Confirmation, Measurement and Reporting of Data Assets —— From a Business Model Perspective [J]. Accounting Monthly, 2023,44(08):3-7.
- [5] Zhu Xiaoqin and Wang Xuanton. Review and Prospects of Data Asset Valuation Research in the Digital Economy Environment [J]. Accounting Monthly, 2023,44(06):78-84.

Cost Control Analysis of Jingdong Logistics

Haotian Zhao*

College of Management, Xi'an Polytechnic University, Xi'an, Shaanxi 710000, China

*Corresponding author: Haotian Zhao

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: The 21st century will be a new era of rapid development of China's e-commerce, and with the acceleration of economic development, China's logistics shortage will become increasingly prominent. Therefore, how to effectively control excessive logistics costs has become an urgent problem for e-commerce companies. This paper selects JD to study the logistics cost control. At present, JD's cost control is faced with such problems as high human resource cost, insufficient warehousing cost control, and incomplete procurement cost control. The main reasons for the study are that the salary burden of personnel is too heavy, the cost control system is not highly integrated, and the procurement management system is not sound. Finally, according to the existing problems, suggestions are given, that is, JD should establish a sound and reasonable personnel management system, improve the logistics cost control system, and establish a sound procurement management system.

Keywords: JD; Logistics; Cost Control

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.802>

1.Introduction

1.1 research background

Since the beginning of the 21st century, in the development of the Internet for more than ten years, the main network purchase and sale models have entered our sight, and domestic Internet enterprises have also begun to seek a share from e-commerce websites. China Internet e-commerce companies have expanded their business space from the initial development strategy of constantly improving commodity diversification, service quality, breadth and depth of content, including cross-border e-commerce, agricultural e-commerce website construction, promotion of green and ecological Internet transactions, etc.^[1] At present, vertical e-commerce companies such as mother and infant, household appliances and so on of some enterprises in China constantly strengthen their deep cultivation in their own fields, providing more brand-new competition modes for China e-commerce field and producing more and more impact on traditional marketing modes. With the in-depth development of new retail, e-commerce logistics ushered in a very rare development opportunity, and the development space of e-commerce logistics in China is very considerable. Therefore, how to effectively control logistics costs has become a common problem faced by e-commerce enterprises.^[2]

Jingdong is currently ranked among the top ten Internet e-commerce enterprises in China. It is also the landmark platform of B2C online trade mode among all current e-commerce platforms in China. Different from traditional third-party logistics enterprises such as Tmall and Taobao, Jingdong places its products in its own online shopping mall and adopts the operation method of self-built warehousing and logistics distribution system. It creates a value chain of Internet products and services

from upstream to downstream for consumers.^[3] For network companies that do not need a lot of physical costs, Jingdong should pay most attention to its control and operation of the company's logistics costs, so this paper will carry out in-depth research on Jingdong's logistics cost control.

1.2 research significance

Taking Jingdong as an example, this paper analyzes Jingdong's unique self-supporting logistics mode and existing logistics cost control methods, analyzes Jingdong's unique self-supporting logistics distribution management mode and current logistics cost control methods, combines the logistics cost control situation of domestic companies in the same industry, deeply analyzes the problems and reasons Jingdong faces when managing logistics cost, and gives specific suggestions, so as to optimize the overall logistics efficiency and cost. For the same industry to control logistics costs to provide a certain practical reference significance.

1.3 purpose of research

The concept of logistics management has been introduced into China for more than 20 years, but it is still in the primary stage of management due to insufficient attention and simple cost accounting. How to apply these concepts to individual enterprises in China's unique economic development stage has become an urgent issue to be solved. Therefore, this study will choose Jingdong as a case, and according to the problems existing in the logistics cost control process of Jingdong, the corresponding treatment methods are given, hoping to bring effective help to the logistics cost control of China e-commerce companies.

2. Logistics cost and logistics cost control

Logistics costs usually cover core links such as warehousing, handling and transportation, and are an integrated process throughout the entire business operation, involving goods distribution, human resources and related investment expenditures. Specifically, it includes the cost of self-owned vehicles, land, sea and air transportation expenses, and other transportation and maintenance expenses. In the total logistics cost, the storage cost accounts for a large proportion, so enterprises often control the overall cost by optimizing the storage layout and distribution system. For example, Jingdong enhances the competitiveness of user cooperation by continuously improving the logistics network and warehouse planning.

Logistics cost control aims to maximize profits by optimizing operational processes, reducing redundant links and reasonably controlling expenses. Its core principles include antinomy and comprehensive management. "Antinomy" reflects the trade-off relationship between various activities in the logistics system. For example, the pursuit of optimal transportation plan may lead to the increase of storage cost, while the reduction of storage scale may affect the distribution efficiency. Enterprises usually take three main control measures: one is to build an economical and efficient information system, strengthen data verification and department coordination, and reduce information processing costs; the other is to strictly manage inventory, which has a direct impact on the total logistics cost, so it is necessary to deeply master each link to effectively control cost and increase efficiency; the third is to scientifically plan distribution routes to improve transportation efficiency, especially in the context of increasingly fierce market competition, optimizing vehicle scheduling and route selection is particularly important.

At present, some logistics enterprises in our country have not established professional and standardized business processes and equipment systems, so it is very important to measure and evaluate logistics costs reasonably. Strengthening the control and management of logistics costs will not only help enterprises maintain and expand customer relationships, but also maintain a leading position in competition and comprehensively enhance their competitiveness.

3. Specific practice of Jingdong logistics cost control

3.1 Composition and Distribution of Jingdong Logistics Cost

According to the classification of enterprise management characteristics, the logistics distribution of enterprises includes the logistics of manufacturing enterprises and the logistics of circulation enterprises, so the corresponding composition of logistics distribution costs can also be classified according to this.^[4] The logistics cost structure can be divided into manufacturing enterprises and commodity circulation enterprises. Jingdong is a self-supporting e-commerce company, so Jingdong's logistics cost structure should be consistent with that of commodity circulation enterprises. Its basic structure includes:

- (1) Logistics information costs, including logistics hardware, software procurement costs, and future maintenance costs.
- (2) Administrative expenses, including labor remuneration of employees of administrative organs, government service fees, fixed assets fees of enterprises, living service fees, travel expenses, taxes, etc.
- (3) Labor expenditure, including salary, treatment, reward, daily living allowance, social protection, housing accumulation fund, etc. for staff members.
- (4) Economic expenses, including loan interest expenses, exchange rate difference expenses, fund occupation fees, relevant handling expenses, etc

3.2 Jingdong logistics cost control methods used

3.2.1 POP Supplier Management

At present, Jingdong mainly has four pop modes:

- (1) After the consumer places an order, the third-party seller will deliver it by himself and issue an invoice to the consumer (SOP).
- (2) After the consumer places an order, the third-party seller is responsible for distributing the product logistics to Jingdong Sorting Service Center and providing invoices, and Jingdong Logistics is responsible for sending the products of the sorting service center to the consumer (Sopl).
- (3) After the consumer places an order, the third-party seller is responsible for delivering the product selected by the consumer to Jingdong Logistics Distribution Center, and Jingdong Company is responsible for providing invoices and completing logistics distribution. (LBP)
- (4) Jingdong assumes full responsibility for procurement, sales and distribution (FBP). Table 3-2 shows JD.com supplier management mode.

Jingdong Supplier Management Mode

online	storage	pattern	delivery speed	last mile
Open (self-operated + third-party)	Jingdong	self-operated、FBP	Same day, next day	
	seller	LBP/SOPL	within three days	Self-pick-up point, express cabinet
	seller	SOP	within three days	

Merchants cooperating with Jingdong can directly transport goods to Jingdong warehouse in various cities across the country, and Jingdong Company will carry out later inventory, logistics distribution, service and other links. With Jingdong's professional network platform, consumers can experience higher-quality after-sales service, stores do not have to spend huge costs to build their own logistics distribution system and service, with relatively small costs can also let consumers get more professional after-sales service.

3.2.2 Intelligent storage system

At present, Jingdong has established "Asia No.1" intelligent management platform in eight major markets such as Wuhan, Guangzhou and Shanghai, and has carried out intelligent management through comprehensive adoption of intelligent equipment and robot technology, and applied it to all aspects of business, thus greatly reducing logistics costs and improving the company's operation efficiency. At the same time, Jingdong Logistics has also made management norms for its problems in operation through intelligent management technology, so as to enhance its management ability to cope with difficulties. Among them, the "goods to people" management system can automatically store and move pallets, and can also complete the packaging of goods to people; efficient intelligent packaging management system, combined with fully automatic equipment, can minimize staff input, improve packaging quality, and reduce labor input.

3.2.3 smart supply chain

Jingdong analyzes user consumption behavior by using the whole big data analysis and the execution ability of AI execution and prediction. This strategy proposes a series of solutions from the four fields of artificial intelligence, data mining,

technological innovation and business process reshaping. In addition, the adoption of intelligent supply chain solutions is also more conducive to the development of Jingdong. The comprehensive use of intelligent supply chain system in Jingdong can improve the overall operation efficiency of Jingdong without spending huge manpower on some complicated work. In this way, Jingdong can better guarantee the explosion of goods on the network platform and reasonable stock.

3.3 Analysis on Cost Composition of Jingdong Logistics

Jingdong is the same as many other international self-built logistics distribution companies. Its cost accounting is roughly divided into raw material supply logistics cost, commodity distribution logistics cost, commodity inventory logistics cost and labor.

3.3.1 Current Situation of Labor Cost Control in Jingdong Logistics

Number of Jingdong Logistics Personnel

category	number of people	remark
support staff	about 5200	
Custodian, courier	about 60000	4 million square meters, 50 cities, 7 logistics centers
warehouse	256	
Self-pick-up and distribution station	6906	

Data source: Jingdong Annual Report 2021.

According to the information once published by Jingdong Company, due to the rapid expansion of Jingdong's business in recent years, the number of staff employed has also risen sharply. According to the monthly salary of 3500 yuan in 2021, about 60,000 personnel in Jingdong's distribution department means that the annual human resources cost will be at least 2.1 billion yuan. For a huge company with high labor cost in logistics such as Jingdong, how to realize scientific and reasonable distribution and the most effective use of human resources is the main task in the cost control of modern companies, and it is also a key area of cost control for modern company operation and enterprise development. Therefore, Jingdong still has problems in human resource cost control and effective use and control of logistics distribution talents.

3.3.2 Jingdong Logistics Cost Control Status

Cost Rate of Jingdong Logistics

	2021	2020	2019	2018	2017
Order processing costs	8.05%	7.68%	7.01%	5.93%	7.40%
marketing expenses	4.06%	4.27%	3.49%	2.29%	2.65%
Technology R & D expenses	2.07%	1.91%	1.60%	1.39%	1.54%
administration expense (cost)	1.79%	1.59%	4.57%	1.10%	1.50%
total	15.97%	15.4%	16.67%	10.71%	13.13%

Data source: Jingdong Annual Report 2017-2021.

Jingdong's order processing expense rate has remained below 7% since 2017, of which the order processing expense rate has dropped significantly in 2018. The main reason why this ratio will continue to increase in 2020 is the slowing pace of warehouse construction and the complex labor costs., machinery and equipment and other related cost factors, the proportion will continue to increase. The promotion expense rate of enterprises from 2019 to 2020 has also increased significantly, which is mainly due to Jingdong's increased investment in advertising. Through the relevant financial data released by Jingdong in the five-year report from 2017 to 2021, it can be found that Jingdong is not only strengthening the investment and purchase of fixed assets, but also continuously strengthening the construction of modern logistics system.

3.3.3 Current Situation of Jingdong Logistics Storage Cost Control

2017-2021 Jingdong Profit Statement (Part)

	2021	2020	2019	2018	2017
taking	260122	181287	115002	69340	41381
Administrative expenses Other	4663	2877	5260	760	639
Technology R & D expenses	58	3454	1836	964	636
Marketing expenses	10573	7736	4010	1590	1097
Order processing costs	20951	13921	8067	4109	3061
Less: Operating expenses	41568	27988	19173	7423	5433
gross margin	39423	24267	13371	6844	3482
Online revenue	237702	167721	108549	67018	40335
operating profit	6471	-64.59	-5802	-579	-1951

Data source: Jingdong Annual Report 2017-2021.

The storage cost in Jingdong's self-built logistics distribution system mainly involves the salary of warehouse personnel, investment in storage site and maintenance cost, as well as the maintenance cost required by the company in the whole logistics storage process. At present, although Jingdong's total gross profit of enterprise commodities continues to grow in recent years, its operating income is constantly losing money, and Jingdong's total enterprise management expenses are also continuously rising, which is mainly related to Jingdong's own large investment in self-built logistics. According to the enterprise annual report published by Jingdong, due to its large investment in logistics distribution over the years, the data profits in the report are negative, and under such a large amount of logistics investment, many problems such as low benefit and unreasonable resource allocation have arisen at the same time.

3.3.4 Current status of Jingdong logistics procurement cost control

Purchase Cost Table of Jingdong and Amazon from 2017 to 2021

		2021	2020	2019	2018	2017
Procurement costs as a percentage of revenue	Jingdong	84.84%	86.61%	88.37%	90.13%	91.59%
	Amazon	57.91%	68.29%	70.66%	73.51%	76.09%
gross profit rate	Jingdong	15.20%	13.39%	12.32%	10.21%	8.63%
	Amazon	34.98%	32.97%	30.02%	27.10%	9.23%

Source: Jingdong and Amazon Annual Report 2017-2021.

By selecting Amazon in the same industry for comparison and comparing the proportion of procurement cost to operating income, it can be found that Amazon's proportion is also gradually decreasing from 2017 to 2021, which indicates that under the condition of ensuring operating income, the enterprise is also carrying out a large number of measures to control production cost and improve logistics distribution quality. Moreover, Amazon's market share is still much smaller than Jingdong's, and the gap will remain at 18% in the five years from 2017 to 2021, indicating that Jingdong must make further efforts in its own logistics distribution system and cost control system construction to improve production efficiency and cost control. At the same time, we should improve our own customer data analysis cloud system, improve the data analysis effect, build our own storage system in the area with higher customer concentration, and reduce the production cost to the lowest level.

4. Jingdong logistics cost control problems and reasons

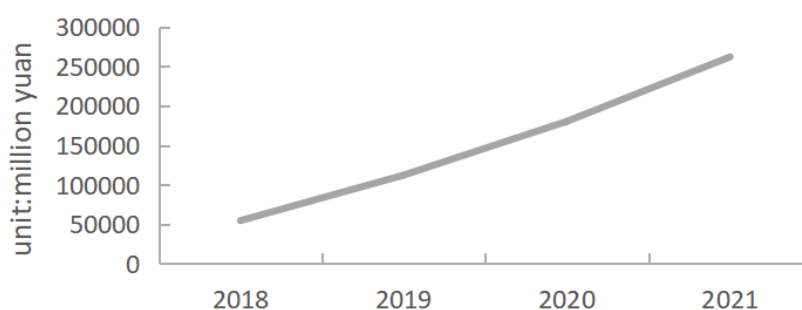
4.1 The main problems existing in Jingdong logistics cost control

4.1.1 High labor costs

It can be seen from the above that the labor cost of Jingdong Logistics is too high. For the company, the salary of logistics distribution personnel is originally a general human resource cost of the company. However, for Jingdong, the salary of logistics distribution personnel becomes an extra expense in the process of building its own logistics distribution system. The company must compensate for these human resource costs by increasing investment in its main business.^[5] Therefore, the human resource cost of Jingdong Mall is also relatively high. Jingdong's senior management turnover frequency is also relatively high. As the company is in the key period of expansion and transformation, although all departments and local governments of the company are constantly strengthening human resources management, it is still difficult to set up and manage talents of the company due to the great difficulty of talent management across regions, as well as the uneven quality of company culture and management personnel.

4.1.2 Insufficient storage cost control

Jingdong Logistics Cost Trend Chart



Jingdong has invested heavily every year since it started to build its own logistics center. The advantages of self-built logistics distribution mode are also gradually formed with the development of the system, which is mainly manifested in that the company can more conveniently supervise and control the logistics distribution process, the service level will be improved qualitatively than in the past, and the turnover times of loans will gradually decrease. Although the advantages of cost control of self-built logistics have become increasingly prominent in the business process during the company's development, with the further expansion of the company's scale, stronger capital chain guarantee is still needed, and the increase in the amount of investment in logistics distribution will also cause pressure on the company's capital flow.

4.1.3 Procurement cost control is not comprehensive

Jingdong has not set up departments related to procurement cost and accounting management, which is also the reason why the cost accounting management effect of the company in the process of commodity production is ordinary. The internal financial department of the company does not have the power to directly control the cost accounting management at the company level. The audit department of the company is only the middle department of the enterprise or the minister of the enterprise with a smaller level, while the chief financial officer and the accounting director are only the department managers of the company, not the management power of the deputy general manager level of the enterprise. The financial department is in charge of specific cost, planning and management, etc. The accounting organization does not make relatively complete design, calculation, supervision and correction of cost control from the overall perspective, or only relies on the current cost control regulations to complete general tasks. The imperfect management and unclear responsibility are also easy to cause the cost control results of the company's production process to be unsatisfactory.

4.2 Causes of Problems in Cost Control of Jingdong Logistics

4.2.1 Pay overload

As a large-scale e-commerce company, Jingdong has also reached the leading level in the industry. In terms of total personnel management and recruitment, Jingdong also exceeds other enterprises in the same industry due to its self-built logistics distribution system and demand for the number of distribution personnel. Therefore, this also shows that the main factor of

Jingdong's overall personnel cost is due to the large number of grass-roots personnel, plus the higher salary of the company's senior management. This is closely related to Jingdong's company strategy, because Jingdong enterprises always have to create their own characteristic high-end network platform in the field of self-built logistics applications, so the company will invest more in the management and treatment of personnel.

4.2.2 Imperfect cost control system

The logistics management control of Jingdong has not been managed by special personnel. The financial department only has the power to formulate the cost control system in the logistics cost control work, and has no power to control the logistics cost. The management is incomplete, and there is no overall planning and guidance. Jingdong did not establish a special logistics cost plan internally, but the financial department formulated the overall cost plan of the enterprise according to the business strategy, and then allocated the overall cost to the department first, and then allocated the overall cost of the department to the department group. However, this cost control was not fully implemented in the specific process of the whole work, but only formulated on a large scale. Enterprises do not effectively integrate logistics cost control and sales plan, and fail to make effective adjustment to logistics cost of internal management.

4.2.3 Lack of professionalism in procurement management

At present, Jingdong has insufficient professionalism in procurement management, but Jingdong has not issued specific management regulations and requirements for matters related to procurement management. The traditional management regulations are completely "castles in the air", and the compliance of staff responsible for procurement work on specific projects is not large.^[6] Because Jingdong adopts its own e-commerce operation mode, the relationship between Jingdong and suppliers is very close. With the continuous expansion of business scale, the procurement staff in charge of various fields will gradually form closer cooperation relationship with suppliers. In this process, there will also be some procurement staff who actually control power to abuse public power for personal gain, resulting in a profit supply chain. Throughout the workflow, these purchasers judge the enterprise at will, and their overall conceptual understanding of the real enterprise situation and capital situation is not obvious.

5. Suggestions for improving the cost control effect of Jingdong Logistics

5.1 Establishing Scientific and Rational Talent Management System

As for the control of human resources cost, it not only directly reduces the average value of human resources cost, but also improves the quality and cost performance of human resources cost. For college students who have just entered the company, they should rotate their posts from different positions, which can have a rough understanding of the overall operation of the enterprise and their respective job responsibilities. Therefore, from this concept point of view, for Jingdong, a large company with clear functional differentiation, it is necessary to improve and develop the ability of employees, especially the distribution personnel working in the front line, must grasp the strict degree of supervision, find appropriate methods to communicate with employees, and pay attention to appropriate rewards and punishments. For the enterprise operation level, Jingdong needs to constantly improve the standardized recruitment process. In addition, although the current UAV logistics technology is still difficult to achieve, but also can focus on the use of robots, intelligent equipment sorting goods and warehouse management, so as to introduce and improve production efficiency, reduce labor distribution rate, this is also effective control of labor costs Another way.

5.2 Strengthen the Control and Management of Logistics Cost

Jingdong's business scale continues to expand, and it is increasingly necessary to establish a certain supervision mechanism within the company. At present, since Jingdong's company structure mainly has functional departments, and most of its employees are distributed in business processing, more internal supervision organizations or administrative organizations are needed to restrict these parts, which is also very necessary for the company's internal logistics cost control. Therefore, Jingdong should refer to the management experience of other companies in the same industry and summarize and study in constructing its own cost plan system, and put forward appropriate cost plan or income expectation plan according to the reality that Jingdong is too focused on logistics service at present. In addition to independent management of one link and monitoring of one part, Jingdong should also set up supervision agencies to supervise the monitoring and assessment results

of each part, set up special personnel for management at each control point, and realize cross-monitoring and assessment of point-to-point and department-to-unit, such as in the purchase process of commodities, as well as in the picking and logistics process.

5.3 Building a sound procurement system

The procurement system needs to make specific behavior norms for the relationship between procurement personnel and procurement directors and procurement supervisors, and at the same time, specific and effective guidelines for the procedures and methods of enterprise procurement are also needed. As the most critical part of Jingdong, the enterprise procurement division also needs to pay attention to coordination with other departments of the enterprise, hold regular information sharing meetings with the enterprise marketing department, and propose targeted procurement methods for the customer intention information and relevant marketing planning proposed by the enterprise marketing department, which can reduce the procurement cost for the enterprise, thus improving the overall supplier work efficiency of the enterprise. At the same time, do not ignore the qualification review of suppliers, review the access qualifications of suppliers, establish a supplier filing registration standard suitable for Jingdong, and also evaluate the credit rating of suppliers to ensure the fairness and justice of the enterprise procurement process. At present, Jingdong's random inspection and review of purchased commodities is very small, so it is necessary to improve the degree of random inspection and review of purchased commodities, and it is also necessary to build a special price verification team.

6. Conclusions

Jingdong's development speed is relatively fast, and the company scale is also very large at present. Most of the research on Jingdong's self-built logistics cost in China focuses on theory, while the research results combining the actual situation of the company are relatively rare. According to the actual situation of Jingdong Company and its real operating situation in the market at present, this paper finds out the problems existing in its development process, and gives some measures to solve the problems after analyzing the reasons. It is expected that this paper can provide some enlightenment for B2C E-commerce Company in cost control, so as to promote the integration of logistics cost control theory and practice, further improve the corresponding management system, At the same time, targeted policies and measures are formulated for each link of the actual operation of the company, so as to achieve the purpose of effectively controlling logistics costs, thus enhancing the strength of the company.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Zhang, Y. J. (2021). Research on cost control of enterprise logistics. *Commercial News*, (24), 134–136.
- [2] Zhang, L. (2021). Research on logistics cost control of YJL supermarket [Master's thesis or Doctoral dissertation]. Northwest University of Agriculture and Forestry.
- [3] Li, W. (2019). Research on logistics cost control of B2C e-commerce enterprises—Taking Jingdong as an example. *China Township Enterprise Accounting*, (02), 131–132.
- [4] Lu, Z. L. (2019). Analysis of enterprise logistics cost control from the perspective of supply chain. *China Market*, (24), 174–175.
- [5] Zhang, C. X. (2019). JD logistics cost control research [Master's thesis or Doctoral dissertation]. Liaoning University of Petrochemical Technology.
- [6] Chen, L. H. (2019). Study on logistics cost control of Company B [Master's thesis or Doctoral dissertation]. Northwestern University.

Research on Financial Performance Evaluation of Company W Based on Factor Analysis Method

Haobin Li*

School of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710048, China

*Corresponding author: Haobin Li

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: As a core industry supporting global technological transformation, the semiconductor industry not only profoundly reshapes the technical pathways of traditional fields such as energy management, transportation, and medical diagnosis but also serves as a strategic cornerstone for ensuring the stable operation of the modern electronic information industry and driving innovation breakthroughs in artificial intelligence and the Internet of Things. Against the policy background of China vigorously promoting the autonomy of the semiconductor industry and encouraging breakthroughs in core technologies, domestic semiconductor enterprises are facing a critical period of opportunity for large-scale development. However, inherent characteristics of the industry, such as high R&D cost pressures, barriers posed by core technology patents, short product life cycles, and intensifying global market competition, also expose enterprises to operational risks like insufficient profit stability and pressure on capital chains. This paper takes Company W, a leader in the field of semiconductor image sensors, as the research object. Eight financial indicators are selected from four dimensions: profitability, solvency, operation, and growth. Factor analysis is conducted using SPSS to calculate performance scores and analyze its financial performance. Based on the analysis, optimization suggestions such as cost control and capital allocation are proposed, providing references for the sustainable development of Company W and other enterprises in the same industry.

Keywords: Financial Performance; Factor Analysis Method; Company W

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.803>

1.Introduction

The semiconductor industry is the core support of the information technology field, and its development is directly related to a nation's technological competitiveness. In recent years, China's semiconductor industry has steadily improved in both scale and structure, becoming an important force in scientific and technological development. The "14th Five-Year Plan" explicitly lists the integrated circuit industry as a strategic emerging industry, proposing the development goal of "breaking through key core technologies and enhancing the resilience and security level of the industrial and supply chains." Simultaneously, with the continuous advancement of the "New Infrastructure" strategy, the construction scale of 5G base stations, data centers, AI infrastructure, etc., continues to expand, further releasing the market demand for semiconductors. The characteristics of the semiconductor industry—high investment, high risk, and high technological barriers—are prominent. Coupled with the impact of global competition and technological controls, some enterprises face profit pressures, making scientific financial performance evaluation crucial for their stable development. This paper takes Company W as the research object, selects

indicators from four dimensions: profitability, solvency, operation, and growth, uses the factor analysis method to construct a financial performance evaluation system, analyzes its financial problems, and provides references for the high-quality development of Company W and other enterprises in the same industry.

2. Research Method

The research method employed in this paper is factor analysis. This method is an important tool in multivariate statistical analysis for dimensionality reduction and data simplification. It refines multiple highly correlated original variables into a few uncorrelated common factors, enabling simplified analysis of complex problems. Considering that the financial performance evaluation of Company W involves multiple financial indicators across four major dimensions—profitability, solvency, operational capability, and growth capability—where information overlap among indicators may exist, factor analysis can effectively eliminate redundant information and accurately identify the core drivers affecting financial performance. Meanwhile, by calculating factor scores and comprehensive performance scores, it provides a scientific basis for the quantitative evaluation of Company W's financial performance. This paper first selects 8 core financial indicators of Company W from the four dimensions based on the principles of scientificity, systematicness, and operability, collecting their annual financial data from the past 10 years to form an original data matrix. Then, the Z-score method is used to standardize the data to eliminate dimensional influences, and the KMO test and Bartlett's test of sphericity are used to verify data suitability. Subsequently, principal component analysis is used to extract common factors, and the Varimax orthogonal rotation method is applied to clarify the financial meaning of each common factor. Finally, based on the factor score coefficient matrix, the annual scores of the common factors are calculated, and the variance contribution rates of the common factors are used as weights to calculate the comprehensive financial performance score through a formula, in order to judge the level and change trend of Company W's financial performance.

3. Literature Review

In recent years, the application of factor analysis in the field of corporate financial performance evaluation has become increasingly widespread. Many scholars have conducted in-depth empirical research on various industries such as pharmaceuticals, manufacturing, new energy vehicles, semiconductors, and logistics using this method, systematically revealing the financial performance characteristics and core issues of different industries. Liu Jingxuan (2025) further used factor analysis to evaluate the financial performance of Kang'enbei and 66 other A-share listed traditional Chinese medicine companies. The research showed that driven by policy support, growing market demand, and technological progress, the traditional Chinese medicine industry maintained an average annual growth rate of 7%-9%, with certain progress made in modernization, standardization, and internationalization. However, it still faced deep-seated challenges such as lagging basic theoretical research, insufficient innovation in production processes, relatively limited R&D investment, and the gradual dilution of local traditional technological advantages by foreign companies^[1]. Fu Honglei (2025) conducted a longitudinal study on the financial performance of Company L from 2014 to 2023 using factor analysis. It was found that although the comprehensive financial performance of the enterprise showed a steady upward trend, and its operational capability significantly enhanced since 2019, with solvency generally improving, it still faced prominent problems such as net profit turning from profit to loss, a sharp decline in total operating revenue, and a sharp reduction in net cash inflow from operating activities. In 2022, its profitability factor value even fell to a low point, mainly affected by multiple factors including intensified industry competition, increased uncertainty in the international trade environment, fluctuations in raw material costs, and continuous increase in technological innovation investment^[2]. An Hongxia (2025) conducted a comprehensive evaluation of the financial performance of Shanxi Fenjiu and 20 other liquor companies in the same industry based on factor analysis. It was found that in the 2024 industry evaluation, Shanxi Fenjiu ranked first, demonstrating its comprehensive advantages in profitability, operational efficiency, and development potential. However, its solvency ranked sixth among the sample companies, becoming a key constraint for further improvement of its financial performance^[3]. Hu Furui (2024) conducted a financial performance evaluation study on China Resources Vanguard based on factor analysis. The study found that the overall financial performance of the enterprise ranked high among retail peers, and the performance of various

capability factors was relatively balanced. However, the solvency factor ranking was relatively low, reflecting room for optimization in the control of the asset-liability ratio and the use of financial leverage. If liabilities continue to rise, it may trigger financial risks^[4]. Chen Kun (2025) focused on the semiconductor IDM company Silan Microelectronics, using factor analysis to deeply investigate the evolution of its financial performance from 2003 to 2022. The research pointed out that China's semiconductor industry has achieved rapid development driven by both industrial policy and downstream application demand. Silan Microelectronics achieved good performance in 2021 benefiting from market and policy dividends. However, the inherent characteristics of the industry, such as high risk, high investment, long R&D cycles, and high technological barriers, led to significant overall fluctuations in the company's financial performance. Affected by factors such as global economic slowdown, industry growth rate decline, and its own declining solvency in 2022, its performance significantly declined compared to 2021^[5].

In summary, factor analysis can effectively extract multi-dimensional financial information, systematically reveal the key factors driving performance and potential risks within different industries and enterprises, providing a powerful analytical tool for academic research and corporate decision-making.

4. Sample Selection and Indicator Selection

4.1 Sample Selection

This paper evaluates the financial performance of Company W using factor analysis. The data comes from the annual reports of Company W, selecting financial data disclosed in the annual statements from 2015 to 2024 as samples, and uses IBM SPSS Statistics 27.0 software for analysis.

4.2 Establishment of the Financial Performance Evaluation Indicator System for Company W

The construction follows four principles: scientificity, systematicness, operability, and pertinence. Indicators must conform to financial theory and the requirements of factor analysis, cover core dimensions, and data must be obtainable from financial reports. Eight indicators are selected from four dimensions: solvency, profitability, operation, and growth, as follows: Profitability dimension: Return on Equity (X1), Net Profit Margin on Total Assets (X2), reflecting the level and quality of profitability. Solvency dimension: Current Ratio (X3), Equity Multiplier (X4). Operational capability dimension: Total Asset Turnover (X5), Fixed Asset Turnover (X6). Growth capability dimension: Operating Revenue Growth Rate (X7), Net Asset Growth Rate (X8), verifying growth sustainability.

4.3 Factor Analysis of Financial Performance Indicators of Company W

4.3.1 Model Suitability Test

Factor analysis requires first eliminating the dimensional differences of indicators before conducting suitability tests. Dimensional differences in financial indicators can affect the analysis results. Z-score standardization is first performed using SPSS 27. Then, the KMO test and Bartlett's test of sphericity are used to judge the suitability of the initially selected 8 financial indicators, to verify whether these variable indicators are suitable for factor analysis. The test results are shown in Table 1.

Table1 KMO and Bartlett's Test

KMO Measure of Sampling Adequacy.		0.627
Bartlett's Test of Sphericity	Approx. Chi-Square	63.026
	df	28
	Sig.	0.000

From the test results, the KMO value is 0.627, indicating a certain degree of information overlap among the 8 financial indicators, and the correlation level between variables meets the basic requirements of factor analysis for data. Meanwhile, the significance probability (Sig.) of Bartlett's test of sphericity is 0.000, which is less than the significance level of 0.05, indicating significant linear correlations among the 8 indicators, and no situation of information independence exists.

Combining the results of the two tests, it shows that the selected data of the 8 financial indicators of Company W have good suitability and can be used for factor analysis of Company W's financial performance.

4.3.2 Common Factor Extraction

The total variance of the extracted factors is analyzed using Principal Component Analysis in SPSS to extract common factors. As can be seen from Table 2, among the eigenvalues of the 8 indicators, the eigenvalues of the first 3 common factors are 3.777, 2.421, and 1.256 respectively, all greater than the critical value of 1; the eigenvalues of the fourth and subsequent factors are all less than 1, indicating that the first 3 factors can sufficiently summarize the core information of the original indicators. Therefore, it is determined to extract 3 common factors, denoted as F1, F2, F3. From the variance contribution rate and cumulative variance contribution rate in the Total Variance Explained table, the variance contribution rate of the first common factor F1 is 47.206%, the second common factor F2 is 30.262%, and the third common factor F3 is 15.700%; the cumulative variance contribution rate of the three reaches 93.168%, far exceeding the standard threshold of 70%. This indicates that the extracted 3 common factors can explain 93.168% of the information of the 8 financial indicators of Company W, with a high degree of information retention, and can effectively replace the original indicators for financial performance evaluation without needing to add additional common factors.

Table 2 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.777	47.206	47.206	3.777	47.206	47.206	3.609	45.112	45.112
2	2.421	30.262	77.468	2.421	30.262	77.468	2.238	27.970	73.081
3	1.256	15.700	93.168	1.256	15.700	93.168	1.607	20.087	93.168
4	.316	3.949	97.118						
5	.123	1.541	98.659						
6	.069	.864	99.523						
7	.024	.298	99.821						
8	.014	.179	100.000						

Extraction Method: Principal Component Analysis.

4.3.3 Factor Rotation and Naming

By rotating the factor loading matrix, the variables can be interpreted more intuitively. Based on the magnitude of the absolute value of the loading weights, each common factor is named. From the Rotated Component Matrix in Table 3, it can be seen that the Current Ratio and Equity Multiplier from the solvency dimension, and the Total Asset Turnover and Fixed Asset Turnover from the operational capability dimension have large loading coefficients on F1. This indicates that F1 mainly reflects Company W's solvency and operational capability, hence it is named the Solvency and Operational Capability Factor. The Return on Equity and Net Profit Margin on Total Assets from the profitability dimension have large loading coefficients on F2. This indicates that F2 mainly reflects Company W's profitability, hence it is named the Profitability Factor. The Operating Revenue Growth Rate and Net Asset Growth Rate from the growth capability dimension have large loading coefficients on F3. This indicates that F3 mainly reflects Company W's growth capability, hence it is named the Growth Capability Factor.

Table 3 Rotated Component Matrix

	Component		
	1	2	3
X1 Return on Equity		0.968	
X2 Net Profit Margin on Total Assets		0.975	
X3 Current Ratio	-0.925	0.300	
X4 Equity Multiplier	0.851		0.353
X5 Total Asset Turnover	0.876	0.357	
X6 Fixed Asset Turnover	0.967		
X7 Operating Revenue Growth Rate	0.556		0.694
X8 Net Asset Growth Rate			0.959
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 5 iterations.			

4.3.4 Factor Score Model

Table 4 Component Score Coefficient Matrix

	Component		
	1	2	3
X1 Return on Equity	0.025	0.440	-0.036
X2 Net Profit Margin on Total Assets	-0.022	0.440	-0.023
X3 Current Ratio	-0.261	0.125	0.035
X4 Equity Multiplier	0.205	-0.140	0.183
X5 Total Asset Turnover	0.288	0.215	-0.269
X6 Fixed Asset Turnover	0.279	0.053	-0.064
X7 Operating Revenue Growth Rate	0.090	0.016	0.395
X8 Net Asset Growth Rate	-0.127	-0.058	0.659
Extraction Method: Principal Component Analysis.			

Based on the component score coefficient matrix, the following equations can be derived:

$$F1 = 0.025 \times X1 - 0.022 \times X2 - 0.261 \times X3 + 0.205 \times X4 + 0.288 \times X5 + 0.279 \times X6 + 0.090 \times X7 - 0.127 \times X8$$

$$F2 = 0.440 \times X1 + 0.440 \times X2 + 0.125 \times X3 - 0.140 \times X4 + 0.215 \times X5 + 0.053 \times X6 + 0.016 \times X7 - 0.058 \times X8$$

$$F3 = -0.036 \times X1 - 0.023 \times X2 + 0.035 \times X3 + 0.183 \times X4 - 0.269 \times X5 - 0.064 \times X6 + 0.395 \times X7 + 0.659 \times X8$$

After calculating the three common factors, the comprehensive factor F score is obtained by weighted summation using the weights of each common factor's variance contribution rate (after rotation) relative to the cumulative contribution rate, as obtained earlier:

$$F = (45.11\% \times F1 + 27.97\% \times F2 + 20.08\% \times F3)$$

The scores and rankings of each common factor and the comprehensive factor are calculated according to the above formulas, and the results are shown in Table 5.

Table 5 Scores and Rankings of Each Common Factor and the Comprehensive Factor

Year	F1	F2	F3	F	F Score
2024	-1.417	0.199	0.121	-0.600	8
2023	-1.187	-1.281	0.099	-0.938	10
2022	-0.749	-1.085	-1.006	-0.905	9
2021	-0.605	1.648	0.559	0.322	4
2020	-0.380	1.147	0.909	0.356	3
2019	0.630	-0.308	-0.061	0.200	5
2018	1.374	-1.073	1.475	0.661	2
2017	0.294	-0.418	0.028	0.023	7
2016	0.842	0.646	-2.155	0.137	6
2015	1.197	0.525	0.030	0.744	1

4.3.5 Comprehensive Analysis

(1) F1 Solvency and Operational Capability Factor

As the core factor reflecting solvency and operational capability, the F1 score decreased from 1.197 in 2015 to -1.417 in 2024, showing an overall trend of first stabilizing and then declining. The F1 scores from 2015 to 2018 were all positive, indicating that during this stage, Company W had sufficient fund liquidity, indicators such as the current ratio and equity multiplier were adapted to the needs of the semiconductor industry, and the total asset turnover and fixed asset turnover were efficient, indicating a good level of asset operation efficiency. However, after 2019, the F1 score turned volatile and declined, dropping to -0.605 in 2021 and further falling to -1.417 in 2023-2024, reflecting the weakening of the company's solvency and operational capability in recent years. From the perspective of actual business operations, this change is closely related to the business expansion of Company W. Although the company is not directly engaged in wafer manufacturing, after 2020, it increased its packaging and testing capacity reserves to capture the automotive sensor market, leading to increased fixed asset investment. However, capacity utilization did not match this increase in a timely manner, dragging down the fixed asset turnover. Meanwhile, global supply chain fluctuations led to extended payment cycles from downstream consumer electronics customers, reducing the current ratio. Although the asset-liability ratio remained at 37.89% in 2024, short-term debt pressure still increased significantly.

(2) F2 Profitability Factor

The F2 score shows cyclical fluctuations without forming a sustained growth trend. The F2 scores in 2015-2016 were 0.525 and 0.646 respectively, indicating stable profitability. It dropped to negative values in 2017-2018, affected by smartphone market saturation and intensified competition in semiconductor image sensors, leading to declining product prices and subsequent decreases in return on equity and net profit margin on total assets. After a brief rebound in 2019, it peaked in 2020-2021, benefiting from the mobile phone replacement cycle and the explosion in demand for smart car sensors, which simultaneously increased product sales and gross profit margins. However, it fell again to -1.281 in 2023, and although it slightly recovered to 0.199 in 2024, it remained at a relatively low level. This trend is highly related to the business structure of Company W. The company's traditional business mainly focuses on consumer electronics sensors. The weakness in consumer electronics demand in 2022 directly impacted profitability, while the automotive business had not yet formed sufficient scale to provide support, leading to insufficient stability in profits.

(3) F3 Growth Capability Factor

The F3 score shows the largest fluctuation amplitude, dropping to -2.155 in 2016, soaring to 1.475 in 2018, falling again to -1.006 in 2022, and slightly recovering to 0.121 in 2023-2024. The high score in 2018 stemmed from the company's

launch of a 48-megapixel high-definition image sensor, which met the demand for smartphone camera upgrades, driving rapid growth in operating revenue and net assets. The low scores in 2016 and 2022 were due to lagging technology iteration, leading to stagnant revenue growth. The lack of a long-term upward trend in the F3 score reflects that Company W's growth capability relies on short-term product cycles. Furthermore, in the context of global semiconductor market growth in 2024 being mainly driven by the memory storage and logic chip sectors, the company faces technological pressure from leading enterprises like Sony and Samsung. The shortcomings in the market competitiveness of its core products have become more prominent, posing severe challenges to the company's long-term sustainable growth momentum.

(4) Comprehensive F Score Analysis

The comprehensive performance score ranked first in 2015. Although it fluctuated between 2019 and 2021, it remained in the positive range. However, from 2022 to 2024, it turned negative for three consecutive years, showing an overall trend of initial stability, mid-term volatility, and recent decline. In terms of driving factors, the decline in comprehensive performance after 2022 mainly stems from two core issues: first, the continuous deterioration of solvency and operational capability, which is the primary factor dragging down the comprehensive score; second, profitability falling into a trough again, coupled with weak recovery of growth capability. These three factors jointly put pressure on the company's overall financial performance. This result also confirms the high-risk and strong cyclical characteristics of the semiconductor industry, further highlighting the operational vulnerability brought by Company W's dual dependence on external supply chains and downstream demand.

5. Suggestions and Countermeasures

5.1 Persist in High-Intensity R&D Investment to Break Through High-End Technological Barriers

Company W must continue to make high-intensity and forward-looking R&D investments to break through high-end technological barriers and build long-term core competitiveness. Meanwhile, it should actively conduct global patent layout, building an intellectual property moat around core technologies and processes to resist competition pressure from international giants and explore potential technology licensing businesses. While consolidating its advantages in CMOS image sensors, it should also pay appropriate attention to emerging technological paths such as 3D stacking and event-driven vision to address future technological change risks and cultivate diversified growth points, thereby reducing reliance on single product cycles.

5.2 Optimize Financial Strategy to Enhance Financial Robustness and Anti-Cyclical Capability

In response to emerging solvency pressures and significant profit fluctuations, Company W needs to focus on optimizing its financial strategy to enhance robustness. The company should prudently control the scale of interest-bearing debt, optimize its capital structure, avoid over-reliance on debt financing during expansion periods, and explore diversified channels such as equity financing to reduce financial risks. Simultaneously, it must strengthen cash flow management, establish strict budgeting and monitoring mechanisms, focus on strengthening accounts receivable collection to shorten the payment cycle, and maintain sufficient cash reserves to cope with industry fluctuations. During periods of high investment demand or profit volatility, consider implementing more flexible dividend policies, retaining more profits within the company for reinvestment or enhancing risk resistance, thereby improving overall financial flexibility.

5.3 Implement Operational Management to Comprehensively Improve Asset Operation Efficiency

To reverse the decline in operational efficiency, Company W's primary task is to improve the utilization efficiency of existing assets, especially by conducting benefit evaluations of the newly invested automotive sensor packaging and testing capacity. Enhance capacity utilization and fixed asset turnover through production and process optimization and intelligent transformation. Secondly, strengthen supply chain collaboration and inventory management, establish closer collaborative relationships with upstream and downstream partners, and implement precise inventory strategies to reduce capital occupancy and accelerate inventory turnover. Company W also needs to implement refined cost control, strictly control R&D, sales, and administrative expenses through comprehensive budget management, ensuring that various expenses efficiently support strategic objectives, and fundamentally improve operational capability.

5.4 Establish a Dynamic Monitoring System for Timely Strategic Adjustment

Facing the rapid changes in the semiconductor industry, Company W should establish an integrated dynamic monitoring

and strategic adjustment system. The core of this system is to build a dynamic early warning mechanism based on key financial indicators, regularly evaluate performance, and respond promptly to unfavorable trends. Meanwhile, it is necessary to strengthen market and competitive intelligence analysis, continuously track technology trends, competitor movements, and changes in downstream demand, and combine external insights with internal assessments. On this basis, the company should cultivate strategic agility within the organization, establish regular review mechanisms, and be able to adjust business priorities and resource allocation appropriately based on internal and external monitoring results, thereby maintaining strategic initiative and adaptability in a complex and changing market environment.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Liu, J. X., & Lin, Y. X. (2025). Financial performance evaluation of Kang Enbei Company. *Cooperative Economy and Science*, (17), 147-150.
- [2] Fu, H. L., & Zhu, X. (2025). Financial performance evaluation of L Enterprise based on factor analysis. *Market Modernization*, (15), 174-176.
- [3] An, H. X. (2025). Study on financial performance evaluation of Shanxi Fenjiu based on factor analysis. *Shanghai Enterprise*, (03), 39-41.
- [4] Hu, F. R. (2024). Enterprise financial performance evaluation based on factor analysis: A case study of China Resources Vanguard. *Modern Business*, (08), 168-171.
- [5] Chen, K., & Zheng, X. Y. (2024). Financial performance evaluation of semiconductor companies based on factor analysis: A case study of Silan Microelectronics Co., Ltd. *Industrial Innovation Research*, (24), 154-156.

The Theoretical basis and literature Review of esg and Enterprise Performance

Dong Fan*

School of Management, Xi'an Polytechnic University, Xi'an , Shaanxi , 710048, China

**Corresponding author: Dong Fan*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This paper focuses on the relationship between ESG (Environment, Social Responsibility, and Corporate Governance) and corporate performance, with a specific emphasis on new energy enterprises. It first defines core concepts—clarifying ESG as an investment and operational philosophy guiding enterprises to balance financial and non-financial goals, and corporate performance as a measure of operational quality covering both financial and non-financial dimensions—then elaborates on two key theoretical foundations: Stakeholder Theory, which views enterprises as contractual networks of multiple stakeholders and argues fulfilling ESG responsibilities is key to balancing stakeholder demands and securing long-term resources, and Signaling Theory, which explains ESG practices reduce information asymmetry as credible signals to help enterprises gain trust, acquire resources, and boost performance. The literature review analyzes three areas: corporate performance evaluation methods (DuPont Analysis, BSC, EVA) with their advantages and limitations, new energy enterprise performance evaluation (noting positive impacts of R&D investment and government subsidies but over-reliance on traditional financial indicators), and ESG (tracing its origin, pointing out the lack of a unified global definition, and comparing international evaluation systems like MSCI and FTSE Russell with China's fledgling localized systems that draw on international experience). Overall, the paper lays a theoretical and empirical groundwork for exploring the ESG-performance relationship (especially for China's new energy enterprises) and identifies research gaps, such as the need for localized ESG systems and improved new energy enterprise performance evaluation frameworks.

Keywords: ESG (Environment, Social Responsibility, Corporate Governance); Corporate Performance; New Energy Enterprises; Stakeholder Theory; Signaling Theory; Performance Evaluation System; Literature Review

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.804>

1.Section One: Definition of Core Concepts

1.1 ESG

ESG, an acronym for “Environment, Social Responsibility, and Corporate Governance,” represents an investment and corporate operating philosophy that has gained widespread global recognition and is highly congruent with the sustainable development policies of various countries. The ESG concept encourages enterprises to adopt a long - term sustainable development perspective. During their operations, enterprises should eschew the “short - term growth achieved at the expense of the environment” model. Instead, they must not only focus on enhancing traditional financial performance metrics (such as revenue and profit), but also comprehensively assess the level of their green development and the effectiveness of fulfilling social responsibilities from non - financial perspectives.

Specifically, this involves evaluating the impact of a company's production and operations on the ecological environment (such as carbon emissions and resource consumption), its contributions to society (including safeguarding employees' rights and interests, investing in public welfare, and assuming supply chain responsibilities), and the soundness of its internal governance (such as the equity structure, decision - making mechanisms, and information disclosure practices).

Fundamentally, ESG serves as a crucial reference criterion for market stakeholders (such as investors, consumers, and regulatory authorities) when making decisions. For instance, investors incorporate ESG performance into their investment evaluation frameworks to mitigate long - term risks. Moreover, ESG is a tangible manifestation of the sustainable development concept at the micro - enterprise level, compelling enterprises to translate macro - level development goals into their day - to - day business operations.

Since the United Nations Global Compact first officially introduced the ESG concept in the 2004 report "Who Cares Wins," academic and practical research on ESG around the world has continued to deepen. Compared to mature international markets, ESG development in China is still in its nascent stage. In areas such as concept definition, evaluation criteria, and practical models, China mainly draws on international experience (for example, referring to the ESG rating systems of international institutions like MSCI and FTSE Russell), and has yet to establish a localized system that fully aligns with China's national circumstances and the characteristics of domestic enterprises.

Specifically, the core essence of ESG development in China currently mainly converges on the following aspects: strengthening environmental - dimension practices guided by the "dual - carbon" goals (such as energy conservation, carbon emissions reduction, and green production); deepening the fulfillment of social responsibilities with the aim of achieving common prosperity (such as respecting and protecting employees' rights and interests, and ensuring employee welfare); and improving corporate governance in accordance with the requirements of high - quality development (such as enhancing information disclosure transparency and optimizing internal control mechanisms).

1.2 Enterprise performance

Enterprise performance, in essence, is the comprehensive external manifestation of an enterprise's operational management level, resource allocation efficiency and final economic achievements within a specific business cycle. It serves as the core yardstick for measuring the quality of an enterprise's operation and its development capacity. Due to the differences in research objectives and analytical perspectives, there are multiple standards for the dimension division of enterprise performance in the academic circle. In combination with the research topic and analytical requirements of this paper, the focus will be placed on the two core dimensions of enterprise performance: financial performance and non-financial performance, to construct a comprehensive performance evaluation framework.

2. Section Two: Theoretical basis

2.1 Stakeholder Theory

In the research field of ESG (Environmental, Social, and Governance), stakeholder theory has always occupied a fundamental and core position, providing a key theoretical framework for analyzing the logical starting point, behavioral motives, and value orientation of corporate ESG practices. This theory breaks through the traditional perception that "enterprises serve only the interests of shareholders" and proposes that an enterprise is essentially a "contractual network" jointly constructed by diverse stakeholders (including shareholders, employees, customers, suppliers, governments, communities, the environment, etc.), rather than a mere economic entity.

From the perspective of corporate sustainable development logic, for an enterprise to achieve long-term stable growth, it needs the support of two types of core capital: on the one hand, the enterprise's own capital (such as fixed assets, own funds, etc.), which serves as the foundation for its business operations; on the other hand, the capital support provided by external stakeholders is equally indispensable and exerts a decisive impact on the enterprise's long-term development.

In the process of corporate operations, various stakeholders inject key resources into the enterprise through direct or indirect means:

Shareholders provide financial support through equity or debt investments, ensuring the enterprise's capital liquidity;

Employees directly participate in the value creation process by contributing labor, skills, and creativity, serving as an

important carrier of the enterprise's core competitiveness;

Governments and society provide the enterprise with infrastructure (e.g., transportation, energy), policy guarantees (e.g., industrial support, compliance supervision), and market environment, establishing a necessary framework for the enterprise's business activities;

Communities and the environment are even the external cornerstones for the enterprise's survival and development, providing the natural resources and social space required for production.

As the core link connecting various stakeholders, an enterprise not only bears the responsibility of growing its own interests but also needs to play a coordinating role to balance and meet the value demands of different stakeholders (Che Mi et al., 2022). This "balance of responsibilities" is precisely the core logic of ESG practices. For instance, in the environmental dimension, enterprises respond to the ecological protection needs of communities and society; in the social dimension, they safeguard employees' rights and interests and fulfill commitments to customers regarding product quality; in the governance dimension, they protect shareholders' rights to information and decision-making.

Therefore, proactively fulfilling responsibilities to all stakeholders is not only an inherent requirement of stakeholder theory but also a key path for enterprises to gain multi-party trust, obtain continuous resource support, and thereby achieve long-term sustainable development through ESG practices.

2.2 Signaling Theory

In economic transaction scenarios, information asymmetry is a prevalent market dilemma, which can easily give rise to problems of adverse selection and moral hazard. Among these, "effective information transmission" is regarded as the core approach to resolving the issue of adverse selection. The prototype of signaling theory was proposed by Michael Spence. In 1973, in his work *Market Signaling: Informational Transfer in Hiring and Related Processes*, he introduced the concept of "signaling" into labor market research for the first time. The book points out that in the employment relationship between employers and employees, information asymmetry manifests itself in employers' difficulty in accurately assessing the actual productivity level of employees. To help employers recognize their own advantages, employees use "educational attainment" as a key signal to convey information about their capabilities that distinguishes them from low-quality job seekers. This research laid the core logic of signaling theory: in situations of information asymmetry, the party with information advantages will transmit information about their advantageous characteristics to the outside through specific "signals"; meanwhile, the party at an information disadvantage, due to limited ability to screen information, needs to rely on these signals to adjust their decisions. Ultimately, the rationality of transaction behaviors directly depends on the authenticity, relevance, and timeliness of the signals** (note: the original text mentions "quality of the signals" followed by specific attributes, which is integrated here for logical consistency).

With the expansion of the theory's application, Spence further extended signaling theory to the field of corporate finance. He pointed out that information asymmetry also exists in corporate financial information, and corporate managers, as the party with information advantages, can proactively disclose information (such as financial reports and non-financial information) to send signals to the information-disadvantaged party (such as investors and creditors), conveying positive messages about the company's stable operations and sound value. This process helps information users more accurately evaluate the company's value and operational risks, effectively reducing the negative impact of information asymmetry on corporate performance.

From the perspective of the research theme of this paper, signaling theory provides a key analytical framework for explaining the inherent connection between [the two subjects, e.g., ESG practices and corporate performance—consistent with the context]. Its core logic can be specifically decomposed into a transmission chain of "***signal sending → perception adjustment → resource acquisition":

ESG Practices as a "Signal Carrier" As the market's attention to corporate non-financial performance increases, ESG practices—including environmental governance, fulfillment of social responsibilities, and optimization of corporate governance—have become important dimensions for stakeholders such as investors and the public to evaluate enterprises. When a company publishes ESG reports and discloses the results of its ESG practices, it is essentially sending positive signals to the outside world, such as "the company values sustainable development and has a long-term sense of responsibility."

Unlike traditional financial information, these signals are more capable of reflecting a company's long-term value and risk management capabilities.

The Role of ESG Signal Transmission The transmission of ESG signals can effectively reduce the information gap between enterprises and stakeholders, especially investors. For example, transparent ESG performance can alleviate investors' concerns about potential environmental risks (such as fines for environmental non-compliance) and social risks (such as employee disputes) of the enterprise. This not only reduces the risk of stock price crashes caused by information opacity but also enhances investor confidence and eases corporate financing constraints (e.g., obtaining credit support at a lower cost). After external stakeholders form a positive perception of the enterprise based on ESG signals, they will translate this perception into actual supportive behaviors: consumers will be more inclined to choose the enterprise's products, and the government or local communities may provide policy preferences or resource support. These supportive behaviors ultimately become important drivers for the improvement of corporate performance, forming a closed loop of "ESG signal transmission → stakeholder trust → corporate resource acquisition → performance growth"

In summary, signaling theory clearly explains the "value conversion path" of corporate ESG practices: ESG is not merely an act of fulfilling responsibilities, but also an important carrier for enterprises to transmit advantageous signals to the outside world. Only through effective signal transmission can ESG practices be widely recognized by society, thereby helping enterprises gain stakeholder support, acquire key resources, and ultimately achieve a positive correlation with corporate performance.

3. Section Three : Literature Review

3.1 Research on Corporate Performance Evaluation

The concept of corporate performance evaluation originated overseas, and by the 1980s, a corporate performance evaluation system integrating both financial and non-financial indicators had taken shape. Currently, the commonly used corporate performance evaluation methods include DuPont Analysis, Economic Value Added (EVA), and the Balanced Scorecard (BSC).

(1) DuPont Analysis

With a long history dating back to 1919, DuPont Analysis was first proposed by Pierre S. du Pont, then president of the DuPont Company in the United States. The method decomposes Return on Equity (ROE) into the product of multiple financial indicators and analyzes the inherent relationships between these indicators to assess a company's profitability. DuPont Analysis allows for both individual indicator comparison and comprehensive evaluation of corporate operating performance, featuring advantages such as "reasonable organizational structure" and "clear structural analysis." It has now been adopted by an increasing number of enterprises (Fan Jinjuan et al., 2021)^[1]

However, DuPont Analysis has limitations: it overly simplifies the complexity of business operations, ignores the impact of non-financial factors on corporate performance, and its data reliability is constrained by the information in financial statements. Therefore, scholars at home and abroad have continuously improved and refined the DuPont system. On the basis of traditional DuPont Analysis, incorporating dividend-paying capacity indicators and cash flow indicators can help reduce hidden financial risks masked by the averaging effect of DuPont Analysis. Additionally, these indicators can present a three-dimensional and objective view of a company's actual situation, which is of great significance for reflecting the company's development status and operating results (Gao Tianqi et al., 2023)^[2]

(2) Balanced Scorecard (BSC)

The Balanced Scorecard performance evaluation system was established in 1992. It comprehensively assesses a company's business strategy from four dimensions: Financial, Customer, Internal Process, and Learning & Growth (Kaplan R.S. & Norton D.P., 1992)^[3] As an information-based and multi-dimensional corporate performance evaluation system, the BSC systematically considers the driving factors of corporate performance.

Furthermore, the BSC integrates key elements such as corporate strategy, employees, customers, processes, and execution, thereby improving the efficiency of corporate operation and management (Wu Chongxing, 2021)^[4]. From a long-term perspective, it takes into account corporate development, balances short-term and long-term goals, and provides strong support for corporate performance management (Yao Chao, 2020)^[5]. In addition, the BSC links corporate strategy with daily

operations, helping to ensure the achievement of strategic objectives. By defining specific performance indicators, companies can better monitor and adjust the process of strategy implementation (Paranjape, 2019)^[6].

Nevertheless, the BSC also has limitations. Due to the interlocking nature of its four dimensions, the first visible outcome during implementation is an increase in costs, leading to a certain lag in profit growth (Dong Hao et al., 2019)^[7]. Moreover, the four dimensions involve a large number of indicators, and it is difficult to assign weights to these indicators; some non-financial indicators are even hard to quantify (Hou Hui, 2021)^[8]. At the same time, the BSC's evaluation process is overly subjective, failing to conduct assessments from an objective perspective and lacking transparency (Zhou Hailong, 2022)^[9].

(3) Economic Value Added (EVA)

In 1991, Stewart proposed the Economic Value Added (EVA) indicator for evaluating financial performance, which has since exerted a significant impact on corporate performance evaluation. Studies on using EVA to assess corporate performance have shown that EVA helps improve corporate business decisions and enhance profitability (Eddie C.M. Hui et al., 2015)^[10].

The essence of EVA theory lies in examining the “economic profit” generated by corporate operations. It argues that shareholders' capital is also a key component of costs, so the cost of equity must be taken into account when measuring a company's performance. Using EVA as an indicator for corporate performance evaluation can truly reflect corporate value and maximize shareholder wealth (Xu Guanghua et al., 2019)^[11].

However, EVA has shortcomings: its calculation is complex, and as a financial indicator, it exhibits lag. Therefore, corporate performance should be evaluated comprehensively from multiple dimensions—non-financial indicators should be introduced and combined with other evaluation methods to improve the effectiveness of the evaluation (Jiang Shuangfeng, 2020)^[12].

3.2 Research on Performance Evaluation of New Energy Enterprises

Research on the performance evaluation of new energy enterprises mainly focuses on three aspects: influencing factors and their impact extent, and the construction and application of evaluation systems.

An empirical study on 36 listed new energy companies found that R&D investment is positively correlated with corporate performance. Additionally, corporate scale and executive shareholding play a positive moderating role in the relationship between R&D fund investment and corporate performance, while exerting a negative moderating effect on the relationship between R&D personnel input and corporate performance (Li Huajing et al., 2017)^[13].

Another study, which took 62 listed new energy companies in China as research objects to explore the impact of government subsidies and R&D investment on their performance, pointed out that government subsidies and R&D investment are conducive to improving the performance of new energy enterprises. Furthermore, for enterprises with higher total asset turnover, higher ownership concentration, and higher operating income growth rate, the promotional effect of government subsidies is more significant (Xiu Miaomiao et al., 2020)^[14].

A study based on the behavioral utility function revealed that policies such as fiscal subsidies and government/public procurement have exerted a significant positive impact on the promotion of new energy enterprises in China (Li Xiaomin et al., 2022)^[15].

Regarding the construction of performance evaluation systems for new energy enterprises, typical practices include:

- Combining Data Envelopment Analysis (DEA) with the Malmquist index method to construct a DEA-Malmquist index model for evaluating the performance of power supply companies (Yong Hao et al., 2019)^[16];
- Introducing innovation and organizational learning as mediating variables to explore the influence path of market orientation on the performance of forest biomass energy enterprises (Peng Xi et al., 2019)^[17].

Currently, most performance evaluations of new energy enterprises in China still rely on traditional financial indicators. Therefore, developing a more scientific and reasonable performance evaluation system for new energy enterprises and ensuring its effective application has become an urgent issue to be addressed.

3.3 Research on ESG

The concept of ESG was first proposed by the United Nations Environment Programme Finance Initiative (UNEP FI) in 1992. Subsequently, the notion that enterprises should assume certain social responsibilities while pursuing profits promoted the rise of ESG investment (Sharma et al., 2021)^[18].

As a form of disclosure covering non-financial information such as environmental protection, fulfillment of social responsibilities, and corporate governance status, ESG information disclosure aligns with the trend of corporate sustainable development and the concept of high-quality economic development, thus attracting widespread attention from both academia and industry (Li Jinglin et al., 2021)^[19]. However, a unified definition of ESG has not yet been formed. Most authoritative organizations emphasize that enterprises should attach greater importance to the environmental, social, and corporate governance dimensions; the differences in ESG definitions among different institutions mainly lie in the classification of various fields and specific indicators (Qiu Muyuan et al., 2019)^[20].

3.3.1 International ESG Evaluation Systems

Internationally, ESG evaluation systems mainly come from three types of entities: international organizations and stock exchanges, rating agencies, and major international investment institutions. Five global rating companies, such as MSCI and Dow Jones, have established indicator evaluation systems covering the three ESG dimensions and different fields. For example, Thomson Reuters' performance evaluation system involves 10 fields with a total of 178 indicators, while the UK's FTSE Index covers 12 fields with 300 indicators.

A study that decomposed ESG indicators into individual components found that during the epidemic, companies with higher ESG scores achieved higher abnormal returns and lower stock volatility (Nils et al., 2021)^[21].

3.3.2 China's ESG Evaluation Systems

China is still in the exploration stage regarding ESG evaluation systems. In 2003, a corporate governance-focused evaluation system was first established, which set more than 80 indicators to assess corporate governance from six dimensions, including the board of directors, information disclosure, and minority shareholders (Li Weian, 2003)^[22].

Later, in 2017, the Green Finance Research Group of Industrial and Commercial Bank of China (ICBC) integrated China's national conditions with corporate credit conditions and constructed China's first ESG green rating system. This evaluation system designed secondary indicators under each of the three ESG dimensions and identified key performance indicators (KPIs) affecting various factors through three rounds of screening.

Some scholars further subdivided four primary indicators—finance, environment, society, and governance—into several secondary indicators. They calculated the weight of each factor at each level using the Analytic Hierarchy Process (AHP) by constructing a judgment matrix, and evaluated the consistency of the judgment matrix through consistency tests to analyze the performance of logistics enterprises (Zhang Wang et al., 2024)^[23].

In addition, another study constructed a multi-dimensional value evaluation system for listed enterprises from three dimensions: benefit, market value, and ESG. It selected 20 specific indicators using the expert survey method and built a multi-dimensional value evaluation indicator system covering 8 secondary dimensions—profit return, risk prevention and control, asset operation, sustainable development, value recognition, value realization, value creation, and ESG performance—to evaluate the performance of oil-listed companies (Du Min et al., 2024)^[24].

However, China's ESG system construction is still in its initial stage, with an incomplete data foundation and limited social awareness of the ESG concept. These factors have restricted the in-depth development of the ESG concept to a certain extent. A review of 14 well-known domestic and foreign ESG rating agencies found that China's ESG rating faces many core issues, such as poor quality of information disclosure, opaque evaluation processes, unobjective evaluation methods, inconsistent evaluation results, and an incomplete ESG ecosystem. To address these issues, efforts should be made to accelerate the popularization of ESG, formulate unified and reasonable ESG information disclosure standards, and thus build an ESG evaluation system with Chinese characteristics (Wang Kai et al., 2022)^[25].

Therefore, some scholars have proposed that a semi-mandatory ESG information disclosure system should be implemented. ESG evaluation standards and procedures need to be further established, and the responsibilities of all parties in ESG disclosure also need to be clarified (Bai Murong et al., 2022)^[26].

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Fan, J. J., & Guo, H. (2021). A study on corporate financial performance evaluation methods. **Manager**, (01), 94-95.
- [2] Gao, T. Q., & Zhao, Q. Y. (2023). Research on the limitations and improvement of DuPont Analysis. **Management and Technology of SME**, (04), 164-166.
- [3] Kaplan, R. S., & Norton, D. P. (1992). The balanced scorecard: measures that drive performance. **Harvard Business Review**, 70(1), 71-79.
- [4] Wu, C. X. (2021). Application of the balanced scorecard in corporate performance appraisal. **Money China**, (02), 189-190.
- [5] Yao, C. (2020). A study on the application of the balanced scorecard in corporate performance management. **China Management Informationization**, 23(01), 117-118.
- [6] Paranjape, B., Stojanovic, J., & Dave, B. (2019). Balanced Scorecard: A review and future directions. **International Journal of Productivity and Performance Management**, 68(6), 1243-1264.
- [7] Dong, H., & Wang, X. L. (2019). Analysis of performance management issues based on the balanced scorecard. **Modern Marketing (Business Edition)**, (02), 137.
- [8] Hou, H. (2021). Research on a comprehensive performance evaluation system combining EVA and the balanced scorecard. **Marketing Industry**, (09), 88-89.
- [9] Zhou, H. L., Chen, M. Y., & Cao, M. H. (2021). Research on performance management based on the balanced scorecard. **China Circulation Economy**, (30), 76-78.
- [10] Hui, E. C. M., Gao, Y. O., & Chan, K. K. K. (2015). Does EVA truly reflect the performance of property companies in China? **International Journal of Strategic Property Management**, 19(3), 260-270.
- [11] Xu, G. H., & Gu, T. Y. (2019). A study on EVA performance evaluation of "China State Shipbuilding Corporation Heavy Industry". **Communication of Finance and Accounting**, (26), 53-55.
- [12] Jiang, S. F. (2020). A brief discussion on the role of Economic Value Added (EVA) in corporate performance management. **China Business & Trade**, (22), 146-147.
- [13] Li, H. J., Sun, Y., & Ren, L. (2017). Research on green technology innovation performance of listed new energy companies. **Science and Technology Management Research**, 37(21), 240-246.
- [14] Xiu, M. M., & Dai, Y. C. (2020). Government subsidies, R&D investment and corporate economic performance: A case study of listed new energy companies. **Journal of Qingdao University (Natural Science Edition)**, 33(03), 102-109.
- [15] Li, X. M., Zhang, C., & Li, D. K. (2024). The impact of the digital economy on technological innovation in the new energy vehicle industry. **Journal of Xinyang Normal University (Philosophy and Social Sciences Edition)**, 44(01), 44-50.
- [16] Yong, H., He, Y., Li, Y., & An, P. Y. (2019). Research on market competition strategies of power supply enterprises under the background of new power system reform. **Hubei Electric Power**, 43(02), 36-41+49.
- [17] Peng, X., Guo, Y. R., Wang, C. Z., Wen, Y., & Chen, K. (2019). The impact path of market orientation on the performance of forest biomass energy enterprises. **Forestry Economy**, 41(11), 10-17+33.
- [18] Sharma, V., & Kumar, A. (2021). The rise of moral capitalism: Assessing the impact on business practices. **Journal of Business Ethics**, 175(3), 425-440.
- [19] Li, J. L., Yang, Z., & Chen, J. (2024). How does ESG performance empower corporate green technological innovation? Micro-evidence from Chinese listed companies. **Journal of Industrial Engineering and Engineering Management**, 38(05), 1-17.
- [20] Qiu, M. Y., & Yin, H. (2019). Corporate ESG performance and financing costs under the background of ecological civilization construction. **Journal of Quantitative & Technical Economics**, 36(03), 108-123.

- [21] Engelhardt, N., Ekkenga, J., & Posch, P. (2021). ESG Ratings and Stock Performance during the COVID-19 Crisis. **Sustainability**, 13(13), 7133.
- [22] Li, W. A. (2003). Research on the internal constraint mechanism of corporate credit based on corporate governance. **Tianjin: Nankai University**, 2003-06-05. (Unpublished)
- [23] Zhang, W., & Zhou, Z. D. (2024). Research on the construction of ESG performance evaluation system for logistics enterprises under the background of "dual carbon". **Logistics Sci-Tech**, 47(18), 27-31.
- [24] Du, M., Yang, H. M., Xu, D., Fang, J. H., Liu, Y., & Zhao, N. (2024). Exploration on the construction of a multi-dimensional value evaluation system for listed enterprises: A case study of oil engineering technology service and oil & petrochemical companies. **International Petroleum Economics**, 32(08), 80-88.
- [25] Wang, K., Li, K. X., & Qu, R. (2022). Thoughts on the construction of China's ESG ecosystem. **Finance and Accounting**, (10), 80.
- [26] Bai, M. R., & Zhang, J. X. (2022). Exploration on the construction path of ESG information disclosure system for listed companies. **Finance and Accounting Monthly**, (07), 90-99.

Construction of an AI-supported Business Administration Course System in the Context of Digital Transformation

Man Liu*

School of Economics and Management, Chongqing Normal University, Chongqing, 401331, PR China

*Corresponding author: Man Liu, liuman651@163.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: With the rapid development of digital education, this paper focuses on business administration education and studies how to apply artificial intelligence (AI) to curriculum system construction. The current business administration course system has problems such as slow updating of course content, traditional teaching modes, scattered practical teaching, and a single evaluation mechanism, which affect the cultivation of students' digital and practical abilities. Therefore, this paper proposes a four-layer course structure consisting of core courses, professional electives, practical teaching, and AI-supported systems. In terms of curriculum content, intelligent recommendation technology is used to optimize teaching content; in the teaching process, learning behavior data of students is analyzed to grasp the learning situation; in the practical stage, virtual simulation technology is utilized to enhance students' hands-on ability; in the evaluation system, an intelligent assessment model is adopted to improve the scientificity and practicality of the curriculum system. During the specific implementation process, measures such as modular design of courses, cultivating teachers' digital literacy, building a practical teaching platform, and optimizing the multi-dimensional evaluation system are adopted to transform the theoretical design into actual teaching. This achievement provides a new method for cultivating comprehensive management talents and offers a feasible solution for the reform of business administration courses.

Keywords: Digital Transformation; Artificial Intelligence; Business Administration; Curriculum System

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.805>

1.Introduction

The pace of digital transformation in the global economy and society is accelerating, and information technologies such as artificial intelligence (AI) are increasingly being applied in various industries, which has had an impact on the education system. The business administration major shoulders the responsibility of cultivating modern enterprise management talents, and its curriculum system construction is facing new challenges and opportunities. The traditional curriculum system has shortcomings in knowledge updating, practical ability cultivation, and innovative teaching modes, which cannot meet the diverse needs of enterprises for management talents in the digital economy era. Therefore, exploring the use of AI technology to construct a business administration course system has become an important issue that urgently needs to be addressed in the education field.

The transformation of the digital age has led to a systematic reconstruction of organizational management paradigms and educational models. The curriculum system of business administration education needs to be transformed accordingly,

and market demand should be guided to cultivate students' abilities in data analysis, digital management, innovation and entrepreneurship, and interdisciplinary integration. AI technology provides support for curriculum system innovation. Teachers use intelligent data analysis to optimize course content and teaching strategies, virtual simulation and intelligent experimental platforms to enhance practical teaching effectiveness, and AI personalized recommendation systems to ensure the scientific architecture of the curriculum system and enhance students' learning initiative and pertinence. These technological applications can expand teaching methods and provide a new theoretical basis for curriculum system design.

At present, research on the curriculum system of business administration mainly focuses on content updates, teaching mode reforms, and practical teaching design, while there is relatively little research on the overall optimization of digital transformation and AI technology. The traditional curriculum system often focuses on imparting theoretical knowledge and lacks systematic integration of digital skills and intelligent tools. The application of AI in education mostly remains in the areas of learning analysis and teaching assistance, lacking mature theoretical frameworks and practical guidance in curriculum structure design, module settings, and practical optimization. Therefore, it is necessary to start from the strategic height of digital transformation, build an AI empowered curriculum system, and achieve the unity of scientific curriculum structure, intelligent teaching mode, and modernization of talent cultivation goals.

This paper focuses on the business administration course system under the background of digital transformation, researching how to use AI to build and optimize courses, and exploring specific application methods and implementation strategies. Firstly, this paper analyzes the current status of the curriculum system, identifies the problems and improvement directions in digital transformation, and then builds an AI-driven curriculum framework to form a scientific, feasible, and adaptable curriculum plan for future development.

This paper has both theoretical and practical value. In theory, promoting the deep integration of AI technology and curriculum system construction, and expanding the research mode of digital and intelligent education. In practice, providing reference models and methods for the reform of business administration courses in universities, and helping to cultivate composite management talents that meet the needs of digital economy development.

With the continuous deepening of digital transformation, the application of AI in the education field is becoming more and more mature, and the construction of the business administration course system is facing new opportunities. This paper provides theoretical and practical guidance for the construction of an intelligent, scientific, and modern business administration course system through systematic analysis, construction of theoretical frameworks, and exploration of practical paths, and explores effective ways for universities to reform talent cultivation in the digital age.

2.Literature Review

The rapid development of global digitization has brought about significant changes in both enterprises and the education industry. The continuous advancement of new technologies such as big data, cloud computing, and the Internet of Things has brought new development opportunities and challenges to traditional business management education. Research shows that digitalization of education is not just about moving teaching resources online or building management platforms, but more importantly, creating intelligent learning environments and planning personalized learning paths for students ^[1]. AI technology plays a significant role in the digitalization of education, not only improving teaching efficiency but also driving educational decision-making towards data-driven approaches ^[2]. Therefore, researching how to use AI technology to build a business administration course system suitable for digital transformation has become a key focus of educational research and practice.

In the education field, the research on the application of AI has yielded some achievements. Scholars have proposed that AI technology can help teachers accurately understand the individual learning status of students through adaptive learning systems, intelligent assessment tools, and learning behavior data analysis ^[3]. Butler et al. have focused on the role of AI in optimizing the learning process, including using learning data to predict students' grades and relying on intelligent recommendation systems to push appropriate learning materials ^[4]. These research results provide a theoretical basis for the digital transformation of business administration courses.

From the perspective of digital transformation, universities need to enhance their organizational capabilities and innovate

their systems in order to adapt to technological changes. Previous studies have shown that digital transformation is not just about applying technology, but also a comprehensive reshaping of cognitive styles, management structures, and cultural concepts ^[5]. In terms of curriculum construction, AI should not be treated as just an ordinary teaching tool, but should be comprehensively planned in terms of course goal determination, teaching content arrangement, teaching method design, and evaluation system construction ^[6], which provides specific methods for rebuilding the business administration course system. The business administration major has interdisciplinary and practical characteristics, and the curriculum design should not only include the basic theories of management, but also integrate the application of AI in fields such as strategy, marketing, finance, and human resources ^[7]. When constructing a curriculum system, actual data from enterprises and real projects can be introduced, and AI can be used to analyze data and assist decision-making, making teaching more in line with industry needs ^{[8][9]}. Course evaluation should also abandon the single examination mode and establish a multidimensional feedback mechanism through data analysis to continuously optimize teaching ^[10].

Overall, digital transformation has changed the direction of development for business management education. The application of AI technology has not only changed course content and teaching methods but also changed the entire education ecosystem and talent cultivation model. Building a new curriculum system requires finding a balance between technological application and the educational essence, while pursuing cutting-edge technology and ensuring operability. Although current research has provided many inspirations, the complete system design and dynamic update mechanism still need to be further improved in order to construct a scientific and reasonable business administration course system supported by AI, and promote the high-quality development of management education.

3.Problems in Business Administration Courses

With the acceleration of digital development and the popularization of AI technology, business administration education in universities is facing both opportunities and challenges. Although the existing curriculum system can impart traditional management theory knowledge, it is difficult to keep up with the development of the industry and the pace of digital transformation. Therefore, sorting out the current curriculum system is the key to building a new system using AI in the future. This paper conducts research from four aspects: Curriculum design, teaching content and methods, practical teaching, and evaluation mechanism.

In terms of curriculum design, most business administration majors in universities currently focus on basic theoretical courses such as management principles, marketing, and financial management. These theoretical systems can help students build a management knowledge framework. However, with the advancement of digitalization, traditional courses expose problems such as insufficient technological integration, a lack of cultivation of students' data processing and innovation abilities, and a shortage of cutting-edge courses such as big data analysis and AI applications, with slow content updates, which makes it difficult to meet the needs of cultivating composite digital management talents.

In terms of teaching content and methods, traditional teaching adopts a classroom teaching and case discussion mode, emphasizing theory over practice, and there is little interaction between teachers and students. Although some universities attempt to introduce methods such as case analysis and simulated management, their application scope is limited, there is a lack of systematic planning, and a complete practical teaching system is difficult to establish. At the same time, the teaching content lacks a comprehensive explanation of the application of digital technology in management, especially the systematic teaching of AI in management decision-making and data analysis, which makes it difficult for students to combine theory with modern information technology to solve practical management problems.

Practical teaching is a weak link in the existing curriculum system. The practical business administration courses include enterprise internships, project research, and classroom simulations, but there are problems, such as a short cycle and scattered design. Some practical activities lack intelligent technology support, and the application of online data analysis platforms and intelligent decision simulation systems is insufficient. Students find it difficult to deeply experience digital management and AI-supported decision-making operations, which affects the cultivation of professional practical abilities.

The course evaluation mechanism relies on final exams and classroom assignments, with a single approach that makes it difficult to comprehensively assess students' knowledge mastery, skill application, and innovation development. Although

the development of AI and big data technologies creates conditions for dynamic evaluation, the application of evaluation mechanisms based on learning data is not widespread, and the scientific and personalized aspects of curriculum evaluation need to be improved.

Overall, there are four problems with the current business administration course system: Firstly, slow updating of course content, which is difficult to keep up with the development of digital transformation and AI applications; Secondly, the teaching mode is traditional, with insufficient practical interaction and intelligent tool assistance; Thirdly, scattered practical teaching is not conducive to cultivating students' digital management abilities; Fourthly, the evaluation system is single and lacks a data-driven dynamic evaluation mechanism. These issues hinder the deep integration of business management education and enterprise management practice, and require comprehensive and systematic reforms to achieve intelligent upgrading of the curriculum system.

4. Construction of an AI-supported curriculum system in the context of digital transformation

The above analysis indicates that the current business administration course system has some problems in integrating digital technology, using AI, building practical teaching frameworks, and designing evaluation mechanisms. Therefore, creating an AI-supported curriculum system in the context of digital transformation is to meet the urgent demand of enterprises for composite digital management talents. This paper intends to discuss four aspects: Design principles, system architecture, AI application strategies, and implementation paths.

The design of the curriculum system should follow four important principles: Firstly, it should be systematicity. The curriculum should cover core theories, professional knowledge, and digital skills of business management, and ensure logical coherence between each module to gradually enhance students' abilities; The second is foresight, and the course content should keep up with the pace of industry development, combining the latest digital management tools and AI application cases to equip students with the technical abilities needed to cope with future management positions; The third aspect is practicality, which requires providing a variety of operational and simulation scenarios to enhance students' ability to solve practical problems through virtual experiments, case studies, and enterprise practices; The fourth is flexibility, which supports students to choose course modules according to their own interests, abilities, and career plans, while also being able to adapt to the continuous updates of digital platforms and intelligent teaching tools.

The curriculum system is divided into four major modules. The core theoretical module retains basic courses such as management principles and strategic management, and adds technical content such as data analysis to achieve the integration of theory and technology; the professional expansion module offers advanced elective courses such as digital marketing and the application of AI in business to enhance students' professional capabilities; the practical empowerment module builds a practical system including enterprise training and case simulation, helping students apply theory to practice; the AI assisted module uses intelligent systems, analysis platforms and simulation environments to complete intelligent course selection, customized learning paths and precise assessment of learning outcomes, providing technical support for teaching.

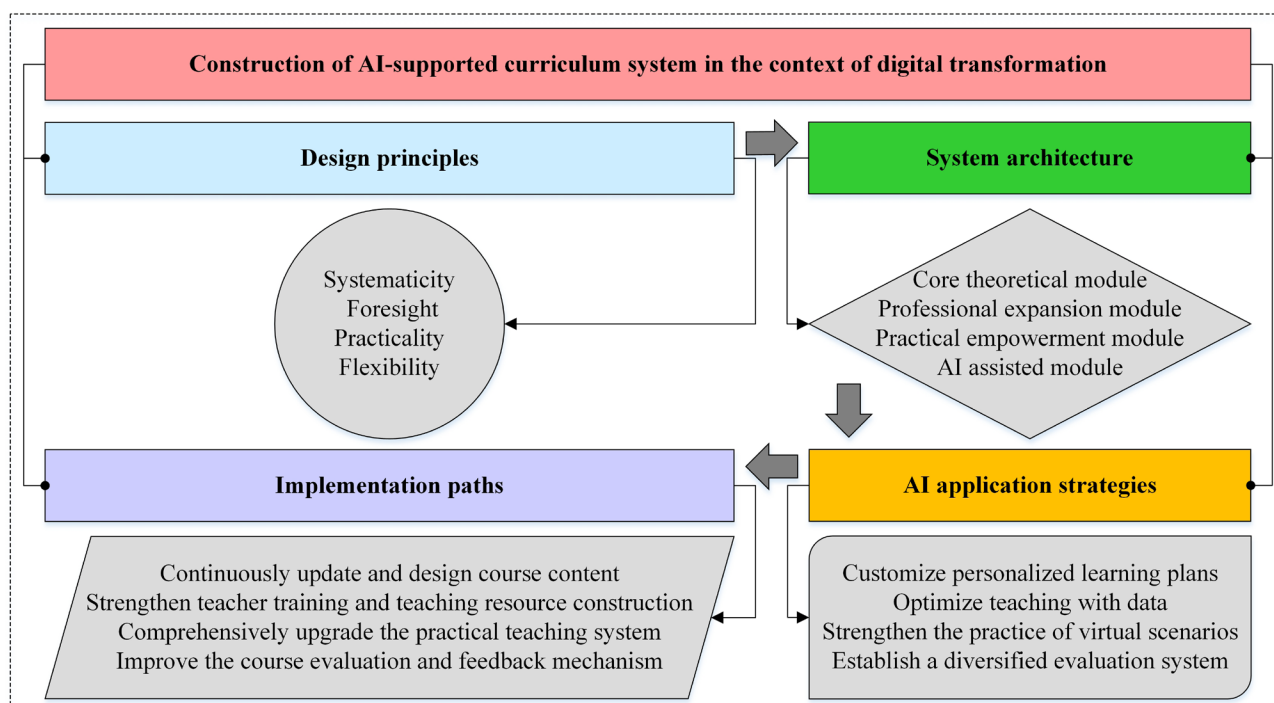
The integration of AI technology into business administration courses can be implemented through four strategies. The first is to customize personalized learning plans, dynamically arrange courses, and push learning materials based on students' interests, abilities, and career planning, to meet the unique needs of each student. The second is to optimize teaching with data, by analyzing students' learning behavior, real-time understanding of knowledge mastery and ability gaps, providing a data basis for teachers to adjust courses and students to improve learning methods. The third is to strengthen the practice of virtual scenarios, using virtual simulation technology to restore enterprise operation scenarios, allowing students to make management decisions, data analysis, and project operations in simulated environments, and enhance their practical operational abilities. The fourth is to establish a diversified evaluation system, change the single examination mode, integrate learning data analysis, ability assessment, and other methods, and establish a flexible and personalized course evaluation mechanism.

The implementation of a new business administration course system can be approached from four aspects. Firstly, the course content should be continuously updated and designed in a modular manner, closely monitoring digital development and

industry demand changes, and timely incorporating new technological knowledge, practical cases, and teaching content. Through modularization, the course system can be flexibly adjusted to adapt to new situations. Secondly, this paper believes that it is necessary to strengthen teacher training and teaching resource construction, provide training for teachers on the application of AI technology and digital management course design, establish a unified and standardized teaching resource library and digital teaching platform, and provide basic guarantees for integrating technology into teaching. Thirdly, this paper comprehensively upgrades the practical teaching system, deepens the cooperative education model between schools and enterprises, vigorously promotes virtual simulation teaching and project-based learning, and forms a complete practical teaching chain of “classroom theoretical explanation, virtual scene practice, enterprise real project practice”. Fourth, this paper can improve the course evaluation and feedback mechanism, use technological means to monitor the learning process throughout, deeply analyze learning data, and provide timely feedback, establish a circular management model of “designing courses, conducting teaching, evaluating effectiveness, optimizing and improving”, and promote the continuous improvement of the course system.

The business administration course system built with the help of AI in the digital transformation environment is designed according to the principles of systematicity, foresight, practicality, and flexibility. By laying a solid theoretical foundation through core courses, expanding the curriculum to cultivate innovative thinking, enhancing practical abilities through practical courses, empowering teaching with AI technology, combining theoretical teaching with practical training, achieving equal emphasis on knowledge transmission and skill development, and integrating technical application and humanistic literacy. This curriculum system relies on technology to provide students with precise learning assistance, optimizes the teaching process through data analysis, focuses on cultivating students’ practical abilities and comprehensive literacy, and provides feasible solutions for cultivating compound management talents in the digital age. The logical relationship among the above contents can be intuitively presented by Figure 4-1. According to the above implementation methods, it can effectively promote the transformation of business management education towards intelligence, and promote the deep integration and development of theoretical teaching and industrial practice needs.

Figure 4-1 Construction of an AI-supported curriculum system in the context of digital transformation



5. Conclusions

This paper has focused on the construction of an AI-supported business administration course system under digital transformation, and key achievements have been obtained by analyzing existing problems and designing practical systems. After research, it has been found that the current curriculum system has problems such as slow updating of course content,

traditional teaching modes, scattered practical teaching, and a single evaluation mechanism, which hinder the cultivation of students' digital literacy and practical abilities, resulting in a mismatch between educational achievements and industry employment needs. In response to these issues, this paper has determined the reform direction of increasing digital courses, innovating teaching methods, improving practical systems, and creating dynamic evaluation mechanisms, laying a practical foundation for subsequent system design.

In the construction of the curriculum system, a four-layer architecture consisting of core courses, professional electives, practical teaching, and AI-supported systems has been proposed. The course content has incorporated an intelligent recommendation mechanism, the teaching process has adopted learning behavior analysis, practical activities have utilized virtual simulation, and the evaluation system has integrated an intelligent assessment model, all of which aim to enhance the scientificity, practicality, and intelligence level of the course system. In terms of implementation methods, strategies have been formulated from four aspects: Modular curriculum design, enhancing teachers' digital literacy, improving practical teaching platforms, and optimizing diversified evaluation systems to promote the transformation of theoretical design into practical teaching and ensure the implementation of the curriculum system.

However, the research findings also have limitations. On the one hand, with the rapid development of AI technology, the industry's demand for digital talents' abilities is constantly changing, and the existing system needs to be continuously optimized according to technological development and industry needs; On the other hand, the positioning, resource conditions, and student foundation of each university are different, and the promotion of the curriculum system needs to be adjusted according to the actual situation of different universities.

Based on these shortcomings, further research can be conducted in three directions: First, exploring methods for the deep integration of AI technology with blended learning, virtual simulation experiments, project-based learning, and other modes to create teaching frameworks that are more tailored to individual needs and have stronger adaptability; The second is to develop an intelligent course management platform and dynamic update mechanism, establish a sustainable and updated course resource library, and enable the system to adapt to the talent cultivation requirements under digital transformation in the long term; The third is to promote cross university and interdisciplinary curriculum cooperation and innovation, promote digital management of educational resources sharing, achieve complementary advantages, and improve the education quality and resource utilization efficiency.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Yu, Y.D., & Yao, Y.G. Empowerment of precise ideological and political education in higher education with educational digitalization. *Journal of Contemporary Educational Research*, 2024, 8(4), 23-28.
- [2] Zhang, Y., Zhang, M.L., Wu, L.M., & Li, J. Digital transition framework for higher education in ai-assisted engineering teaching. *Science & Education*, 2025, 34(2), 933-954.
- [3] Rani, S., Kaur, G., & Dutta, S. Educational AI tools: A new revolution in outcome-based education. *Information Systems Engineering and Management*, 2024, 19, 43-60.
- [4] Butler, R.C., Blair, C.D., Newman, R.E., & Batchelor, L.L. Using a computer-aided personalized system of instruction to enhance the mastery of statistics in online learning. *Teaching Statistics*, 2023, 45(3), 148-157.
- [5] Surjawan, D.J., Langi, A.Z.R., & Imbar, R.V. Digital transformation for institution operations in higher education: A literature review. *IEEE Access*, 2025, 13, 61457-61468.
- [6] Tang, H.J., Wang, M., Guo, L., Liu, J.Q., Zhang, J.Y., & Wu, F. Shouguang city empowers the high-quality development of education with the digital transformation of education. *Lecture Notes in Educational Technology*, 2025, 653-659.
- [7] Jesus, F.S.D., & Co, A.G.E. The assessment on the use of artificial intelligence writing tools as a confidant of business

- administration student-researchers using technology acceptance model. *International Journal of Innovative Research and Scientific Studies*, 2025, 8(1), 1450-1461.
- [8] Huang, H.Z., & Chen, M.H. Research on the construction of practice teaching system of business administration specialty based on artificial intelligence. *Journal of Physics: Conference Series*, 2020, 1648(4), 042055.
- [9] Wu, C.L., & Li, Y. Research on the application and strategy of big data technology in business administration under the background of digital economy. *International Conference on Computational Finance and Business Analytics*, 2024, 536-546.
- [10] Yang, X.X. Optimization and implementation of management technology integrated with data analysis for college students' course evaluation and academic early warning. *Systems and Soft Computing*, 2025, 7, 200255.

Theoretical Research on AIGC-Assisted Teaching in the Course of Introduction to Digital Media Art

Wenju Gao*

Xianda College of Economics and Humanities, Shanghai International Studies University, Hongkou District, Shanghai, 200080, China

*Corresponding author: Wenju Gao, 1773953820@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: With the rapid development of Artificial Intelligence Generated Content (AIGC) technology, digital media art education is facing unprecedented transformations. This paper takes the course “Introduction to Digital Media Art” as the research object and explores the enabling paths and challenges of AIGC technology at the theoretical level of teaching. By analyzing the applications of AIGC in reconstructing the context of art history, integrating interdisciplinary theories, and transforming technological practices, it proposes a three-dimensional teaching model of “theory foundation, technology empowerment, and ethics safeguarding.” Additionally, the effectiveness of this model is verified through case studies of school-enterprise cooperation, providing theoretical references for educational innovation in the age of artificial intelligence.

Keywords: AIGC; Digital Media Art; Teaching Theory; School-Enterprise Cooperation; Ethics Education

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.806>

1.Introduction

As an emerging field deeply integrating technology and art, digital media art has long faced the dilemma of “theories lagging behind technological iterations” in its teaching system. Traditional teaching models rely heavily on teacher-led lectures, with students passively receiving knowledge of art history and lacking practical exploration of technological tools, resulting in insufficient knowledge transferability. By 2025, AIGC technology has achieved a leap forward from image generation to multimodal interaction, and its powerful content generation capabilities offer new breakthroughs for art education. Taking the course “Introduction to Digital Media Art” as a starting point, this paper systematically explores how AIGC can reconstruct the theoretical framework of teaching and proposes corresponding strategies.

2.Enabling Paths of AIGC in Teaching Theory

2.1 Dynamic Reconstruction of the Context of Art History

Traditional art history teaching follows a linear timeline, making it difficult for students to understand the interconnections between different art movements. AIGC can reconstruct art history by generating comparative visual materials, enabling a “space-time folding” effect. For example, when explaining “Dadaism and Postmodern Collage,” teachers can use Midjourney to generate a fused image of the “Mona Lisa” and “Balloon Girl,” guiding students to analyze the deconstructive logic in Banksy’s works^[1]. Xi’an Maya Visual Effects Company utilizes the ControlNet plugin to control generation effects, combining the brushstroke characteristics of “A Thousand Li of Rivers and Mountains” with the light and shadow contrasts

of Baroque art, allowing students to intuitively feel the differences between Eastern and Western aesthetics. This dynamic reconstruction shifts art history teaching from “memory-based” to “analytical,” with a 40% increase in the academic depth of students’ creative interpretation reports^[2].

2.2 Scenario-Based Integration of Interdisciplinary Theories

The core competitiveness of digital media art lies in its interdisciplinary integration capabilities. AIGC can construct virtual experimental scenarios, transforming theories from cognitive psychology, human-computer engineering, and other fields into interactive teaching modules. For example, in the “Human-Computer Interface Design” unit, teachers can build a virtual studio using the Unity engine, where students use AIGC to generate interactive interfaces for different user personas and optimize designs based on eye-tracking data. Central Saint Martins College utilizes AIGC to generate a large number of artistic materials. When analyzing the golden ratio in Leonardo da Vinci’s “Vitruvian Man,” students can instantly compare it with AI-generated variant versions, deepening their understanding of formal aesthetic principles. This scenario-based teaching increases the recognition rate of interconnectedness among interdisciplinary knowledge to 75%^[3].

2.3 Gradient Design of Technological Practices

The complexity of AIGC technology toolchains requires a gradient design for teaching implementation. The course can be divided into three stages: Foundation Level: Students conduct style transfer training using Stable Diffusion, transforming classical oil paintings into cyberpunk styles and mastering the logic of prompt engineering. Intermediate Level: Students use Runway ML to achieve dynamic video generation. Based on the original footage of “L’Arrivée d’un Train en Gare de la Ciotat,” they add AI-generated special effects to simulate early film experiments. Advanced Level: Students combine TouchDesigner for interactive installation design, using AIGC to generate dynamic visual elements and triggering audience behavior through Kinect sensors. In the “Hongru Cup” AIGC Creation Competition, 63% of the award-winning works adopted this gradient design model. Among them, the project “Digital Dunhuang: The Rebirth of Flying Apsaras” restored mural fragments using AI and combined motion capture technology to realize virtual character performances, which was adopted by the Dunhuang Academy as a digital exhibition solution^[4].

3. Core Challenges in the Application of AIGC in Teaching

3.1 The Contradiction Between Technological Dependence and Creativity Suppression

The “one-click generation” feature of AIGC may lead students into a “technological comfort zone.” Surveys show that 32% of students directly use AI-generated complete compositions in their creations, while only 18% engage in secondary creation. Xi’an Peihua University addresses this issue through a “dual-track evaluation” system: technical implementation accounts for 40%, and theoretical explanation accounts for 60%. Students are required to attach a creative explanation to each AI work, analyzing the match between algorithm selection and artistic goals.

3.2 The Ambiguity of Ethical Risks and Copyright Ownership

The originality controversy surrounding AIGC-generated content continues to escalate. In 2024, Dow Jones & Company sued OpenAI for unauthorized use of content from “The Wall Street Journal” to train models, exposing systemic risks of training data infringement. Teaching needs to establish a three-tier review mechanism: Material Traceability: Use the Wanfang AIGC Detection System to check for plagiarism and ensure the legality of training data. Process Recording: Store student creation processes on the blockchain to distinguish between AI-assisted and AI-dominated parts. Ethics Training: Offer a course on “Legal Practices in AI Art” to interpret regulations such as the “Interim Measures for the Administration of Generative Artificial Intelligence Services.”

3.3 The Structural Gap in Teachers’ Digital Literacy

The teaching community faces dual challenges of “technological anxiety” and “teaching inertia.” A survey by the Communication University of China revealed that only 28% of art teachers can proficiently use the ControlNet plugin, and 15% rely entirely on AI-generated lesson plans. Solutions include: Establishing a “dual-instructor” team: Enterprise mentors provide technical training, while university teachers lead the theoretical framework. Developing a micro-credential system: Divide AIGC skills into 20 micro-modules, with teachers obtaining qualifications by passing Adobe international certification exams. Building a dynamic knowledge base: Use Notion to create a shared platform for real-time updates on AI tool tutorials and case studies.

4. Construction and Practice of the Three-Dimensional Teaching Model

4.1 Theory Foundation: In-Depth Deconstruction of Classic Cases

The course selects 20 cross-temporal art cases and constructs a three-dimensional analysis model of “technology-aesthetics-society.” For example, when analyzing Cai Guoqiang’s “Sky Ladder,” students are required to complete three tasks: Technology Level: Analyze the collaborative mechanism between drone photography and 3D modeling. Aesthetic Level: Compare the Eastern philosophical concept of “harmony between humanity and nature” with the Western concept of “conquering nature.” Social Level: Explore the impact of short-video dissemination on the publicity of art.

4.2 Technology Empowerment: Immersive Learning Through Project-Based Learning

Collaborate with companies such as ByteDance and Tencent to establish “AI Art Workshops,” where students must complete real-world projects within six weeks. In the spring semester of 2025, one team designed AI dynamic posters for “Black Myth: Wukong” through the following process:

Data Collection: Scan architectural components of the Xuankong Temple in Shanxi to generate a 3D model library.

Style Training: Use LoRA to fine-tune Stable Diffusion, blending the styles of meticulous brushwork and cyberpunk.

Interactive Development: Use TouchDesigner to realize scene transformations triggered by user gestures.

4.3 Ethics Safeguarding: Systematic Cultivation of Critical Thinking

Offer a compulsory course on “Philosophy of AI Art,” focusing on three major propositions for debate: Algorithmic Bias: Do AI-generated images of “beautiful women” reinforce gender stereotypes? Creative Sovereignty: How should ownership be defined when AI prompts contribute more than 50% to a work? Cultural Security: Does AIGC lead to the alienation of indigenous artistic symbols? Through the Socratic method of questioning, students are required to submit 3,000-word ethical analysis reports, with outstanding works published in the “Journal of Digital Humanities Research.”

5. Conclusion and Outlook

AIGC technology is reshaping the ecosystem of digital media art education. The three-dimensional model of “theory foundation, technology empowerment, and ethics safeguarding” proposed in this paper effectively addresses core issues such as technological dependence, copyright ambiguity, and literacy gaps through school-enterprise cooperation, project-driven learning, and ethical infiltration. Future research should further explore: The impact of the integration of quantum computing and AIGC on artistic creation paradigms. The artistic perception revolution triggered by brain-computer interface technology. The construction of discourse power for Global South countries in AI art governance. Educational innovation in the age of artificial intelligence is essentially the symbiotic evolution of human creativity and machine intelligence. Only by adhering to the value orientation of “technology as a tool and humanities as the foundation” can we cultivate artistic creators who truly master AIGC rather than being dominated by it.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Modern information technology teaching into college English classroom teaching mode-Comment on “College English teaching theory and practice research from the perspective of media integration”. Sun Li. Foreign language audio-visual teaching, 2021(04)
- [2] Research on the strategy of improving digital literacy of art teachers in secondary vocational schools under the digital background. Xu Wei; Li Siqu. New Legend, 2025(01)
- [3] Research on the Influence of Digital Literacy of Art Teachers in Colleges and Universities on Professional Development. Zhang Zhiyuan. Huazhang, 2025(02)
- [4] Research on the Ecological Path of Professional Growth of Art Teachers in Off-campus Education under the Background of “Double Reduction” Policy. Guo Shuang. Art Education, 2025(09)

Taking Agricultural Products as the Core Lever: An Analysis of the Mechanism by Which Northeast China's Digital Economy Catalyzes New Quality Productive Forces in Agriculture

Xinci Zhang*, Xiwen Zhang, Chuhan Wang, Qingshuo Yang

School of Economics, Shenyang University of Technology, Shenyang, Liaoning, 110870, China

*Corresponding author: Xinci Zhang, 3073372944@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Driven by rural revitalization and smart agriculture policies, Digital economy has become a key force driving agricultural modernization and cultivating new-quality productive forces. This article takes Anshan Nanguo pear as an example, based on the current situation of agriculture and digital economy development in Northeast, PEST analysis and two-way fixed effect model are used to empirically test the impact of digital inclusive finance on agricultural output value. Research shows that For every 1 unit of digital inclusive finance, the average output value per mu has increased significantly by 8 yuan. The mechanism lies in the digital economy through such paths: production empowerment, circulation efficiency and brand value-added, to comprehensively empower new-quality productive forces in agriculture. Finally, countermeasures and suggestions are put forward for the shortcomings of digital infrastructure and scientific and technological resources to provide reference for the revitalization of agriculture in Northeast China.

Keywords: Northeast Region; Digital Economy; New Quality Productivity in Agriculture; Anshan Nanguo Pear

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.807>

1. The current situation of China's pear industry and the development of digital economy in Northeast China

1.1 The overall development situation of China's pear industry

From 2012 to 2024, due to reasons such as structural adjustment, the planting area of pear trees in China fluctuates year by year. However, overall, it showed a slight downward trend year by year, from 14.5458 million mu in 2012 to 13.5234 million mu in 2024. Especially since 2020, the downward trend of the planting area has been more obvious year by year. However, thanks to the development of science and technology, the optimization of varieties and the improvement of management levels, the annual output of pears in China has generally maintained a steady growth trend. It rose from 15.5044 million tons to 20.2045 million tons, with an average annual growth rate of 4.7 percent.

1.2 The development trend of the digital economy in Northeast China

The development of the digital economy in Northeast China is currently at a critical stage driven by policies and industrial transformation. Between 2012 and 2023, the digital inclusive finance index in Northeast China rose from below 100 points to

201.187 points. In Liaoning Province, the index performed particularly outstandingly, reaching 206.260 points. Meanwhile, Heilongjiang Province achieved the highest score in terms of digitalization, with an index of 243.426 points. However, the digital economy in Northeast China also faces problems such as lagging digital infrastructure and a lack of technological resource allocation.

2. Current Status of Integration Between Anshan Nanguo Pear Industry and Digital Economy

Nan Guo Pear is a geographically distinctive specialty agricultural product from Anshan City, Liaoning Province. In 2024, the planting area of Nan Guo pears reached 410,000 mu (approximately 27,333 hectares), with 84,600 mu (approximately 5,644 hectares) designated as priority production zones. Annual output amounted to 410,000 tons, generating a total output value of 1.74 billion yuan and a comprehensive output value of 2.35 billion yuan. The city operates 1,256 temperature-controlled storage facilities capable of holding 50,000 tons of Nan Guo pears. It hosts one year-round trading market and three seasonal markets, and has been recognized as a “Second Batch of China’s Specialty Agricultural Product Priority Zones.”

Today, Anshan Nanguo pears have achieved deep integration with the digital economy. Leveraging meteorological data and AI models in production, they enable precision cultivation and climate-quality traceability across 410,000 mu of digital demonstration bases^[1]. Rural e-commerce and live-streaming sales thrive at the distribution end, with typical villages processing over 4,000 daily orders and annual sales exceeding one million jin^[2]. The brand leverages a digital ecosystem to establish the new “Aipin zhi” brand, implementing a membership system to enhance premium pricing and repeat purchases. However, the industry still faces challenges such as inconsistent standards across the entire supply chain, low levels of industry organization, and inadequate brand protection, which to some extent constrain the full realization of digital technology’s potential.

3. Industry Development Environment (PEST Analysis)

3.1 Policy Environment

The national rural revitalization strategy and the Ministry of Agriculture and Rural Affairs’ Guiding Opinions on Vigorously Developing Smart Agriculture provide policy support for digital agriculture development^[3]. Anshan City has incorporated “digital economy + Nanguo Pear” into its rural revitalization priorities, implementing a strategy of “building industrial parks and strengthening leading enterprises” to support industrial chain extension.

3.2 Economic Environment

In 2024, Anshan City’s per capital disposable income reached 38,980 yuan, with a growth rate of 4.0%. Urban residents’ per capital disposable income reached 45,036 yuan, increasing by 3.6%. Digital empowerment yielded remarkable results: fruit farmers in Qianshan District achieved an average selling price of 24 yuan per kilogram through live-streaming sales, while financial institutions’ digital approval processes accelerated industrial capital turnover.

3.3 Social Environment

The people of Anshan hold high regard for the Nanguo Pear industry, with a deep-rooted tradition of cultivation. The region actively promotes the integration of agriculture, culture, and tourism by hosting events like the Pear Blossom Festival and Harvest Festival, attracting large numbers of tourists and enhancing the industry’s influence. Meanwhile, returning college students are contributing their efforts by leveraging new media platforms for live-streaming sales, expanding distribution channels. For instance, Tangjiafang Town achieved online sales of southern pears exceeding 750,000kg^[4].

3.4 Technical Environment

The 2025 No. 1 Central Document explicitly states that science and technology should be leveraged to drive the aggregation of advanced production factors, developing new-quality productive forces in agriculture based on actual conditions^[5]. The Anshan Municipal Government has consistently provided technological support for digital and smart agricultural initiatives. By successfully integrating 5G technology with the BeiDou Navigation System, it has achieved precision management through a “one tree, one code” approach, enhancing both agricultural management efficiency and production output.

4. Empirical Analysis

4.1 Research Design

This study employs a two-way fixed effects model for empirical testing based on panel data from 2018 to 2022 across three core Nanguo pear production areas in Anshan City (Haicheng City, Xiuyan County, and Qianshan District). The dependent variable is output value per mu, with the core explanatory variable being the Peking University Digital Inclusive Finance Index. Mechanical power input is controlled to mitigate omitted variable bias. The study employs a fixed-effects model to account for unobservable factors that do not vary over time or across individuals, and utilizes robust standard errors to address heteroskedasticity. All data are sourced from the Anshan Statistical Yearbook and the Digital Finance Research Center at Peking University. The final sample comprises 15 observations, forming a balanced panel data structure.

4.2 Empirical Findings

Table 1 reports the regression results of the digital economy on the per-mu output value of Nan Guo pears. Column (1) presents the fixed-effects model incorporating the digital inclusive finance index and the mechanization variable. Although the coefficients of the core explanatory variables are positive, their statistical significance falls short of conventional levels due to the limited sample size of county-level observations.

To address the issue of insufficient degrees of freedom, the simplified model results in Column (2) indicate that the coefficient for the Digital Inclusive Finance Index is significantly positive at the 10% level ($\beta=0.0008$, $p<0.1$). This finding suggests that a one-unit increase in the index leads to an average significant increase of 8 yuan in the output value per mu of southern pear cultivation. The mixed OLS regression results in Column (3), serving as a comparative reference, exhibit consistent sign for the core variable coefficient with the fixed effects model, further enhancing the robustness of the aforementioned conclusion. Although statistical significance is limited, all model coefficients consistently exhibit positive signs, and Figure 1 clearly demonstrates a positive trend between the two variables, indicating that the digital economy exerts a positive influence on output value enhancement. This finding aligns with theoretical expectations, and its insufficient statistical power may stem from factors such as sample size limitations, lagged effects, and the inadequate capture of complex mechanisms by quantitative indicators.

Figure 1: Positive Relationship Between Digital Inclusive Finance Index and Output Value per Mu

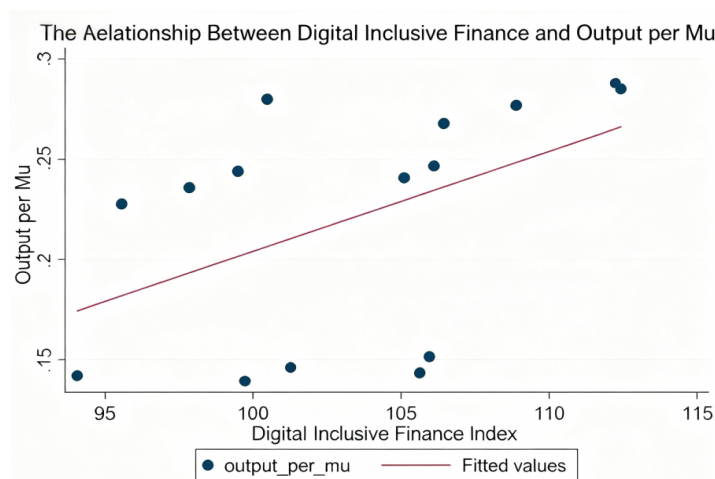


Table 1: Regression Results on the Impact of the Digital Economy on the Average Output Value per Mu of Southern Pear

Variable	(1) Fixed effects	(2) Fixed effects	(3) Mixed OLS
Digital Inclusive Finance Index	0.0001	0.0008*	0.0032
	(0.0003)	(0.0002)	(0.0030)
Mechanical Power (10,000 kW)	0.0046		0.0008
	(0.00200)		(0.0009)
Constant term	0.539	0.1332**	-0.1424
	(0.0571)	(0.0217)	(0.2865)
observed values	15	15	15
Within R-squared	0.321	0.311	
Adjust R-squared			0.138

Note:

1. “***, **, **” indicate significance at the 1%, 5%, and 10% levels, respectively.
2. Values in parentheses represent robust standard errors.
3. Columns (1) and (2) report the within-group R-squared (Within R-squared) for the fixed-effects model.

4.3 Analysis of Impact Mechanisms

From the perspective of factor allocation, taking the Anshan Nanguo pear industry as an example, the digital economy leverages intelligent technologies such as AI models and drone remote sensing to propel agricultural production from experience-driven to data-driven approaches. By precisely regulating factors like light, heat, water, and fertilizers, it enhances total factor productivity, laying a solid efficiency foundation for new-quality productive forces.

At the distribution level, e-commerce platforms and digital payment systems are reshaping the agricultural product market. Leveraging these platforms, the southern pear industry has reduced intermediary links and lowered transaction costs. By harnessing the demand-side aggregation effect, it has broken geographical constraints, achieved efficient production-to-sales matching, and increased farmers' income.

On the brand side, the digital traceability system establishes quality trust for Nanguo pears. New media marketing unlocks their cultural significance, while membership programs and other models target specific consumer groups. These strategies help Nanguo pears break free from homogeneous competition, achieve differentiated and premium brand value, and complete a leap in value.

In short, the digital economy synergistically drives production, distribution, and branding, fostering new productive forces in agriculture and propelling the development of Northeast China's agricultural sector.

5. The current problems existing in the market

5.1 The synergy between northeast agriculture and digital finance is weak

The lagging digital infrastructure in Northeast China has led to a relatively low level of development in digital inclusive finance, which has restricted the sales market of Nanguo pear. Due to insufficient network coverage and digital tools, it is impossible to break down information barriers through live-streaming sales and online promotion, which has prevented Nanguo pear from penetrating the southern market.

5.2 The shortage of scientific and technological resources restricts the development of both fields

The investment in scientific and technological resources and the number of patent authorizations in Northeast China lag significantly behind those in developed regions, Liaoning's R&D expenditure of 67.64 billion yuan is far lower than that of Guangdong's 480.2 billion yuan. This not only makes it difficult to enhance the technological level of agricultural products but also hinders digital financial innovation, greatly limiting the application value and industrial upgrading of the Nanguo pear.

6. Development suggestions

6.1 Strengthen technological innovation and investment in research.

At the heart of the digital economy is information technology. The government and enterprises should increase investment in technological innovation and research and development and promote the transformation of scientific and technological achievements into productivity. Establish an integration platform between digital technology and traditional industries and promote industrial upgrading and efficiency improvement. We should also pay attention to the construction of digital infrastructure and provide efficient and low-cost technical support.

6.2 Promote the sharing and circulation of data resources

Data is a “new factor of production” in the digital economy. In order to improve the level of new quality productivity, we should promote cross-industry and cross-field data sharing by optimizing the data circulation mechanism. Strengthen data privacy protection and security management to ensure the legality and security of data. The government can introduce relevant policies to encourage enterprises to open data platforms and promote the circulation of data between primary, secondary and tertiary industries.

7. Research Conclusion

The digital economy has injected new-quality productive forces into Anshan's Nanguo Pear industry through production empowerment, circulation efficiency gains, and brand value enhancement. Moving forward, Anshan should leverage technological advantages like 5G and BeiDou to enhance the Nanguo Pear "digital ID" system, enabling full-chain traceability and quality control from cultivation to consumption. By deeply integrating data elements, Anshan Nanguo Pear have the potential to become a model for digital agriculture development in Northeast China, Provide reproducible pathways to success for agricultural modernization.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Liaoning Provincial Meteorological Bureau. (2025, July 21). Meteorological data empowers full-chain industrial upgrade of southern pear production.
- [2] Anshan Municipal People's Government. (2020, July 22). Insights from the development of the southern pear industry for rural revitalization in Anshan.
- [3] Ministry of Agriculture and Rural Affairs. (2024, October 23). Notice of the Ministry of Agriculture and Rural Affairs on issuing the National Smart Agriculture Action Plan (2024–2028) (Nong Shi Fa [2024] No. 4) [EB/OL]. Retrieved September 19, 2025.
- [4] Qianshan District People's Government of Anshan City. (2025, June 9). Tangjiafang Town: Pioneering innovative e-commerce models to expand new pathways for rural development [EB/OL].
- [5] Wang, Y., Yan, H., & Dong, F. (2025). Research on diverse pathways for cultivating new quality productivity in agriculture driven by digitalization: A configurational analysis based on dynamic QCA. *Research on Agricultural Modernization*, 46(4), 623–636.

Analysis of Enterprise Audit Failure Issues: A Case Study of Guangdong Rongtai's Audit

Shiyuan Li*

School of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710048, China

*Corresponding author: Shiyuan Li

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In recent years, cases of audit failures have occurred frequently, causing significant losses to auditing firms, investors, and enterprises, and damaging the credibility of the auditing industry. This paper takes the audit failure event of Guangdong Rongtai Company as a case study. By analyzing this case, it points out that the audit failure was due to the insufficient professional competence of the certified public accountants (CPAs), their failure to maintain due professional skepticism, unreasonable audit procedures, and fraud by the management of the audited entity. Accordingly, suggestions for preventing audit failures are proposed, including that CPAs should strengthen their professional skills, adhere to professional skepticism, enhance the supervision of audit procedures, and enterprises should strengthen internal management to reduce the occurrence of audit failure cases.

Keywords: Audit Failure; Professional Competence; Audit Procedures; Professional Skepticism

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.808>

1.Introduction

Since the reform and opening up, China's social economy has developed rapidly, the number of enterprises has continuously increased like bamboo shoots after a spring rain, and the demand for auditing enterprise businesses has also risen^[1]. Auditing is an extremely important economic service, which involves auditors conducting detailed supervision and inspection of the financial status of the audited entity to ensure the authenticity and reliability of its financial information.

Certified Public Accountant (CPA) audits are independent third-party audits conducted by CPAs on the audited entity in accordance with relevant laws, regulations, and audit permissions. This requires CPAs to maintain due professional skepticism and possess corresponding professional competence during the audit. However, in recent years, audit failures have begun to occur frequently, causing huge losses to auditing firms, investors, and enterprises, which is shocking. Therefore, research on audit failure issues has profound significance, both theoretically and practically^[2].

2.Overview of Audit Failure

2.1 Meaning of Audit Failure

Audit failure specifically refers to the situation where auditors, during the audit process, do not truly evaluate the financial status of the audited entity accurately and meticulously in accordance with the institutional norms of the auditing industry. The occurrence of audit failure can cause huge losses to enterprises, investors, and society. For a company, audit failure indicates problems with its financial status and errors in its financial reports, which may seriously damage the company's

economic benefits and reputation. For auditors, audit failure indicates that they failed to strictly follow rules and regulations or performed incorrect actions in their work, which may lead to legal accountability and reputational damage. The consequences caused by audit failure are multifaceted^[3].

2.2 Causes of Audit Failure

The cause of audit failure is the situation where the audit results do not match the actual circumstances during the auditors' conduct of the audit on the audited entity. There can be many reasons for audit failure: insufficient professional competence of auditors, unreasonable application of audit methods, lack of cooperation within the audited entity, fraud, etc.

Generally speaking, the main reasons for audit failure are, on one hand, the improper application of audit methods by auditors. Audit methods refer to the series of norms and corresponding steps used by auditors to carry out audit work. On the other hand, it is the improper execution of audit procedures. Audit procedures mainly include investigating and understanding the basic situation of the audited entity, signing an engagement letter with the audited entity, preliminarily evaluating the internal control of the audited entity, determining materiality levels, analyzing audit risk, collecting audit evidence obtained during the execution of the audit, reviewing audit working papers, forming an audit opinion, and preparing the audit report. Any of these can lead to audit failure^[4]. In audit practice, if auditors themselves lack professional competence and are unfamiliar with audit procedures and methods, it is possible to arrive at audit results that are inconsistent with the actual situation. For example, during the audit process, auditors might misjudge the financial status and business operations of the audited entity, consequently failing to fully understand its business characteristics and not adopting sufficiently adaptive audit procedures, leading to problems in the audit.

The enterprise itself might also create barriers with auditors due to poor communication and mutual misunderstanding, which is also detrimental to the conduct of the audit business. An important factor affecting the accuracy of the audit conclusion is whether the audited entity provides complete and accurate financial information during the audit process and actively cooperates with the auditors in their work.

In today's continuously developing economy, to reduce the frequent occurrence of audit failure cases, CPA audits should strengthen their in-depth learning of audit procedures and methods, and continuously improve their operational skills. Additionally, enterprises should actively cooperate with the work of CPA audits, providing complete, detailed, and accurate financial information to auditors on a monthly or quarterly basis.

3. Case Analysis of Guangdong Rongtai Company

3.1 Introduction to Guangdong Rongtai Company

The Guangdong Rongtai Company case is an important case for studying audit failure issues. Analyzing the causes and reflecting on the audit failure of this company is conducive to an in-depth analysis of the causes and impacts of audit failure later, thereby summarizing the causes and impacts of audit failure from both the internal perspective of the audited entity and the perspective of the CPAs.

Guangdong Rongtai Company was established as a joint stock limited company with Guangdong Rongtai Advanced Ceramics Co., Ltd. and Jieyang Xingsheng Chemical Raw Materials Co., Ltd. as the main promoters, jointly with three other companies. In its early days, Guangdong Rongtai vigorously developed the scientific research industry, increased investment in emerging technology industries, and, to ensure the company had a continuous source of innovation capability, also took scientific research and innovation as its fundamental driving force. Internally, it emphasized the cultivation and importance of talent, establishing an effective performance management method. Thus, Guangdong Rongtai Company managed to stand out in the fierce market competition. As a well-known company, it once enjoyed a good reputation in the industry. However, during the audit process in 2018, auditors discovered a series of problems, which severely damaged the company's image and caused huge economic losses to the enterprise and investors. This also became the trigger for subsequent problems^[5].

3.2 Details of the Audit Failure Incident

Since Guangdong Rongtai Company announced its listing in 2001, Zhengzhong Zhujiang Accounting Firm had been providing audit services to the company. Over the years, Zhengzhong Zhujiang Accounting Firm issued unqualified audit opinions to the public. In 2019, Guangdong Rongtai Company suddenly changed its accounting firm during the audit, switching to

Dahua Certified Public Accountants for the audit. In that year's audit report, Dahua Certified Public Accountants issued a qualified opinion on the financial statements of Guangdong Rongtai Company, leading to a divergence of opinions between the audited entity and the audit firm. Under these circumstances, Guangdong Rongtai Company also failed to disclose its financial reports in a timely manner, which triggered an investigation by the China Securities Regulatory Commission (CSRC). After a detailed investigation, the CSRC found that Guangdong Rongtai Company had committed significant fraud in the financial audits for 2018 and 2019, which Zhengzhong Zhujiang Accounting Firm had failed to discover at the time. This fully indicates that the CPAs of Zhengzhong Zhujiang Accounting Firm did not strictly follow audit rules when auditing the company and issued an incorrect audit report, resulting in audit failure. In 2021, Guangdong Rongtai Company received a penalty notice from the CSRC.

4. Analysis of the Causes of Audit Failure in Guangdong Rongtai Company

4.1 Insufficient Professional Competence of Certified Public Accountants

The CPAs of Zhengzhong Zhujiang Accounting Firm lacked professional competence in handling the audit business of Guangdong Rongtai Company. Due to the lack of professional skills of the appointed CPAs, they were unable to conduct a comprehensive and detailed audit of the company's various businesses, thus issuing unreasonable audit opinions on Guangdong Rongtai Company's audit. In practical work, if auditors lack relevant business knowledge and audit experience, it may lead to difficulties in carrying out audit work, making it hard to identify potential problems and hidden risks^[6].

Zhengzhong Zhujiang Accounting Firm was established in 2000. At the beginning of its operation, it was diligent and meticulous in handling audit business, gaining a good reputation. However, as its business scale continuously expanded, Zhengzhong Zhujiang Accounting Firm absorbed many CPAs with varying abilities, and the firm lacked corresponding on-the-job training. This led to insufficient professional ability and lack of practical experience among its auditors. In the case of Guangdong Rongtai's audit failure, there was a phenomenon of the Guangdong Rongtai management itself deceiving superiors and subordinates and acting intentionally, which increased the difficulty of the audit work. To accurately identify and expose the company's fraud, CPAs with strong professional competence and extensive experience are needed. In the Guangdong Rongtai audit failure case, the CPAs failed to accurately identify the full picture of the internal fraud events at Guangdong Rongtai Company. They handled audit issues by taking things out of context and applying dogma, which is a manifestation of the insufficient professional competence of the CPAs.

4.2 CPAs' Failure to Maintain Due Professional Skepticism

The CPAs of Zhengzhong Zhujiang Accounting Firm failed to adhere to an attitude of professional skepticism in the audit of Guangdong Rongtai. The firm's accountants learned during their review of the company that three clients, including Jieyang Jin Hua Trading Co., Ltd., had transferred receivables from already deregistered customers to Jieyang Fenghua Chemical Additives Co., Ltd. and Jieyang Jiegao Footwear Co., Ltd., with the payment made by these two companies on behalf [of the deregistered clients]. During visits to the two proxy companies, the accountants failed to maintain due professional skepticism regarding the act of paying receivables on behalf under abnormal circumstances, suspecting that the audit evidence for this action was inconsistent with the situation where the proxy companies and the represented company were part of the same family, or the two were friend companies^[7]. The firm failed to obtain sufficient and appropriate audit evidence in a timely and accurate manner. The firm needed to increase necessary audit procedures in various aspects such as the real relationship between the agent and the payer, the reason for payment, and the time when the payment obligation was established.

Furthermore, the amount of cash flow between Guangdong Rongtai Company and its suppliers was much higher than expected, which was also an abnormal situation. In 2018, the funds paid by Guangdong Rongtai to three suppliers—Hetong Plastic, Zhongyue Agricultural Materials, and Yongjia Agricultural Materials—were more than five times the procurement amount recorded in their official documents. Moreover, in the absence of business operations, the amount received by Guangdong Rongtai Company from these three suppliers in 2018 was also several times that of normal activities. The CPAs noticed anomalies during the audit of this matter but still failed to maintain professional skepticism and did not further obtain sufficient appropriate audit evidence.

5. Unreasonable Audit Procedures by CPAs

In the Guangdong Rongtai Company case, the execution of audit procedures by the CPAs was unreasonable. Audit procedures are the core of audit work. If the audit program design is unreasonable, it is difficult to discover potential problems and risks within the company. In the audit work of Guangdong Rongtai Company, the execution of audit procedures had a certain degree of blindness and arbitrariness. Such defects affected the accuracy and effectiveness of the confirmation process work performed by the accountants. During the audit, the auditors requested confirmation letters for already deregistered customers Jieyang Haiwei Plastic Industry Co., Ltd. and Jieyang Wanliheng Plastic Products Co., Ltd. During the CPA's investigation period, this correspondence was handed over to its paying company, Taizhou Jiegao Footwear Co., Ltd., and then the reply letter was obtained directly from the financial director of Guangdong Rongtai.

The CPAs visited the three suppliers—Yongjia Agricultural Materials, Zhongyue Agricultural Materials, and Hetong Plastic—and received reply letters from each, but the CPAs did not obtain the reply letters directly from the confirming units. The sender of the reply letters was the Financial Director of Guangdong Rongtai, and the mailing address was the office address of Guangdong Rongtai. Zhengzhong Zhujiang Accounting Firm failed to follow up on this anomaly and also did not discover that the express tracking numbers for these three suppliers showed significant discrepancies.

In Guangdong Rongtai's procurement business, internal control activities such as "implementing an advance payment guarantee system and proportional payment management, establishing an advance payment ledger management system, regularly tracking and verifying large or long-term advance payments, and analyzing the reasonableness of fund occupation" were not actually performed. This is also an important manifestation of unreasonable audit procedures.

The CPAs' erroneous execution of the confirmation procedure was also one of the reasons leading to the audit failure. The purpose of the confirmation procedure is to obtain details about the audited entity and obtain corresponding evidence through third-party statements about relevant information and existing conditions. Confirmation is an important audit procedure for CPAs to obtain audit evidence when performing verification and capital verification services. Evidence obtained through confirmation is highly recognized by society, so confirmation is popular and frequently used. For letters related to the same audit object, if the auditor sends the summary table of confirmation results as comprehensive audit evidence and audit working papers to multiple respondents, their evaluation of the confirmation results should be recorded after receiving the replies. In the case of Guangdong Rongtai's audit failure, the CPAs failed to obtain replies directly from the confirming units as required by the standards during the confirmation process, indicating inadequate execution of their confirmation procedures.

After accepting the audit engagement from the audited entity, CPAs need to comprehensively and meticulously understand the situation of the audited entity. Auditors must not only understand the specific situation of Guangdong Rongtai Company in detail but also analyze practical problems realistically. They should also avoid audit engagements with high risks and where the auditors themselves are uncertain. The audit firm must ensure it has a clear understanding of its own audit engagements, which can also serve as the practical basis for subsequent audit work. In the initial stages of conducting the audit, due to the lack of in-depth understanding of the audited entity, the information collected about the audited entity can easily become somewhat one-sided due to time pressure. However, as the audit work on Guangdong Rongtai Company's business deepened, the auditors became more familiar with its internal situation. This could lead some CPAs, aiming to save audit costs, to directly apply past audit experience when collecting information about Guangdong Rongtai Company. In the case of Guangdong Rongtai's audit failure, this paper identified some unusual behaviors in Guangdong Rongtai Company, but the CPAs of the audit firm did not conduct investigations or research into these, nor did they strictly perform other duties expected of CPAs. Zhengzhong Zhujiang Accounting Firm was overly optimistic in its estimates of significant changes occurring during the audit process of Guangdong Rongtai Company and failed to strictly follow audit procedures in conducting the audit work.

Furthermore, during the 2018 and 2019 audit work, there was poor communication between the CPAs of Zhengzhong Zhujiang Accounting Firm and the audited entity, which also created obstacles to the smooth progress of the audit work. Poor communication between CPAs and the company's internal staff during the audit can lead to asymmetric and incomplete

information collected by the CPAs, which is also a manifestation of unreasonable audit procedures by the CPAs. The difficulty for CPAs in obtaining accurate and detailed internal financial information from Guangdong Rongtai Company limited the in-depth development of the audit work. Simultaneously, communication problems can also cause friction and conflict between the CPAs and the company's internal staff, further affecting the smooth progress of the audit work.

6. Fraud by the Management of the Audited Entity

Guangdong Rongtai Company failed to disclose related party relationships as required and deliberately concealed them. The Chairman of Guangdong Rongtai had his close associates actually control several companies from June 2008 to April 2019, including Guangdong Guohua Mechanical & Electrical Equipment Installation Co., Ltd., Jieyang Hetong Plastic Co., Ltd., Jieyang Zhongyue Agricultural Materials Co., Ltd., and Jieyang Yongjia Agricultural Materials Co., Ltd. It was also discovered that several employees of Guangdong Rongtai held nominal leadership positions in these companies, their main behavior being to control important functions and interfere with actual work in these companies^[9]. From this, it is not difficult to see that the boss of Guangdong Rongtai Company was also the actual boss of these four companies. Therefore, the aforementioned four companies all had related party relationships with Guangdong Rongtai. However, in its 2018 and 2019 annual reports, Guangdong Rongtai did not disclose this relationship as required by relevant regulations. Secondly, Guangdong Rongtai Company artificially increased profits through related parties to benefit from it. Guangdong Rongtai discovered that three customers with whom it had business dealings had been dissolved and were unreachable in March 2019, with total accounts receivable of 12.246 million yuan. To avoid making a full provision for bad debts on these receivables, Guangdong Rongtai Company used its own funds to make circular payments to related parties and third-party institutions such as Zhongyue Agricultural Materials and Hetong Plastic, and forged payment agreements. Guangdong Rongtai Company falsely claimed to have collected 12.246 million yuan from the three customers, thereby reducing the accounts receivable balance for these three customers to zero, thus avoiding recognizing a 12.246 million yuan bad debt for these three customers. This resulted in an overstatement of profits by 12.246 million yuan in the 2018 annual report, accounting for 6.87% of the total profit of 178.3345 million yuan disclosed in the 2018 annual report^[10].

Guangdong Rongtai Company employed methods of falsely reporting sales returns to artificially increase profits and benefit from it. In November 2019, the accounts receivable balance for 10 customers of Guangdong Rongtai Company was 31.2423 million yuan. However, when Guangdong Rongtai reviewed its accounts receivable at year-end, it found that, except for Jieyang Baishijia Footwear Co., Ltd., the other 9 customers had lost contact, and Baishijia Footwear was also unable to repay its outstanding debt. Guangdong Rongtai used its own funds and third-party institutions for circular payments to avoid making a provision for bad debts on accounts receivable in 2019, thereby avoiding a negative impact on the company's profits. Subsequently, the company created false third-party payment agreements, falsely claiming to have received 31.2423 million yuan, reducing the accounts receivable balance for these related customers to zero, thus avoiding a 31.2423 million yuan bad debt provision on these accounts. This resulted in an artificial increase in the company's 2019 profits by 31.2423 million yuan.

7. Suggestions for Preventing Audit Failure

7.1 CPAs Should Strengthen Their Professional Skills

Many CPAs, when they first obtain their CPA qualification and initially undertake audit work, can still firmly implement qualities such as independence, focus on professional foundations and learning ability, and handle practical problems cautiously, as if treading on thin ice. However, after dealing with daily work, especially large amounts of cyclical work, they begin to stop progressing, neglecting the continuous learning of professional knowledge and self-improvement. When encountering unexpected situations in practical work, they may panic and act rashly, causing economic losses to enterprises and investors, and damaging the reputation of the auditing industry. Therefore, as a CPA, one must pay attention to the continuous learning of professional knowledge, focus on the training of professional business levels, continuously accumulate experience, consolidate professional foundations, and enhance one's own professional quality.

In practical audit work, to obtain reasonable audit evidence, CPAs should always maintain a professional attitude during

the audit process, adhere to their stance, and be diligent and responsible. CPAs should promptly discover problems in the enterprise's financial data. Furthermore, CPAs need to continuously strengthen their professional skills, establish correct values, and adhere to principles. In their future work, they should be fully aware of the adjustments in accounting standards and keep pace with the development and changes in the industry. During the implementation of audit work, CPAs should continuously uphold their professional stance, distinguish right from wrong in their work, and fully exert the responsibilities of a CPA auditor.

7.2 Adhere to the CPA's Professional Skepticism

If CPAs cannot maintain an attitude of professional skepticism at all times in their work, they are likely to overlook various detailed issues in practical business operations, leading to the eventual occurrence of audit failure^[11]. The professional skepticism of CPAs requires that no CPA should consider identified frauds in an audit as isolated incidents. If audit evidence obtained from different sources is inconsistent, it may indicate that some or several pieces of audit evidence are unreliable. Similarly, if a management representation contradicts other audit evidence, the CPA should investigate this situation. If unusual circumstances are identified during the audit process, the CPA should conduct further investigation^[12]. In practical audit work, as a CPA, professional skepticism can allow auditors to "find doubts" in a traceable and targeted manner, rather than working mechanically and blindly, leading to audit failure. In the Guangdong Rongtai audit failure case, the CPAs failed to maintain the necessary professional skepticism, thus failing to promptly discover the close relationship between the audited entity and other related enterprises^[13].

7.3 Strengthen Supervision of CPA Audit Procedures

Currently, China's audit procedures are still not perfect compared to foreign countries, and there is a need to further strengthen the supervision of CPA audit procedures, strictly implement the responsibility system, and enforce the concept that whoever makes the error bears the responsibility. Strengthening the supervision of audit procedures can start from the following two aspects: First, increase the supervision of the audited entity and increase the penalties for financial fraud to raise the cost of deception for the audited entity. This will fundamentally curb the financial fraud behavior of audited companies. Second, strengthen the supervision of CPAs. The new "Securities Law" increases the responsibility of CPAs for false reporting by the audited entity, requiring accounting firms to bear joint liability for false reporting by the audited entity. This significantly increases the cost of violations for accounting firms, which has a certain deterrent effect on CPAs who make errors of varying degrees in their audit work. As a result, the phenomenon of CPAs colluding privately with audited entities will decrease. To avoid inefficient communication with the audited entity, repetitive supervision procedures, and clandestine cooperation between CPAs and the audited entity, various regulatory departments need to optimize communication channels, optimize the regulatory framework, clarify responsibilities, avoid misunderstandings and mutual buck-passing, and penalize enterprises and accounting firms that violate the law^[14]. Of course, punishment is not the ultimate goal. Regulatory agencies need to guide enterprises and CPAs to assume their respective responsibilities, strictly comply with relevant laws and regulations, and avoid illegal incidents.

8. Enterprises Should Strengthen Internal Management

If there are flaws within an enterprise, the probability of financial fraud increases significantly. Guangdong Rongtai used various methods for financial fraud, but the company's board of supervisors and other board members did not stop its behavior. Among them, the company's independent directors did not question its practices but adopted a permissive and indifferent attitude. Such behavior allowed major shareholders to manipulate the financial statements, which to some extent reflects the defects in Guangdong Rongtai's internal control system.

Although Guangdong Rongtai established an internal governance structure in accordance with the regulations for listed companies, its governance structure still had serious defects. The company's governance layer did not perform its duties diligently, and such chaos ultimately led to the serious consequences of financial fraud. To effectively prevent audit failure incidents, from the enterprise's internal perspective, perfecting the enterprise's internal control system, establishing a strict supervision system, improving the effectiveness of corporate governance, continuously leveraging the supervisory duties of independent directors, and strengthening internal enterprise management are urgent tasks for improving the enterprise's

internal control system^[15]. Whether it is the audited object or the auditing object, all aspects rely on improving the audit system, comprehensively applying various means and measures such as training and education, supervision and management, and professional ethics. Only in this way can the quality and efficiency of audit work be effectively improved, and the effectiveness of audit work in serving economic construction and social development be better guaranteed.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Xiang, Y. (2024). Case study on audit failure of J accounting firm. *Hebei Enterprise*, (04), 102–105.
- [2] Qiu, Y. (2024). Case analysis of audit failure in accounting firms. *Cooperative Economy & Science*, (13), 163–165.
- [3] Xiamierdan, N., Ren, S., & Zhao, T. (2024). Empirical research on environmental accounting information disclosure of energy listed companies. *Cooperative Economy & Science*, (11), 140–143.
- [4] Han, C., & Wang, Y. (2024). Research on environmental accounting information disclosure in pharmaceutical enterprises. *Market Modernization*, (08), 171–173.
- [5] Wang, P. (2023). Case study on audit failure of Company A. *Financial Forum*, (10), 72–74.
- [6] Yang, Q. (2005). The framework of China's social responsibility accounting information disclosure model. *Contemporary Finance & Economics*, (06), 121–124.
- [7] Ran, C. (2024). Research on the social responsibility and regulatory mechanism of accounting information disclosure. *International Business Accounting*, (04), 29–32.
- [8] Chen, R. (2024). Research on enterprise social responsibility accounting information disclosure. *Business Observation*, 10(03), 37–40.
- [9] Chen, D. (2019). Social responsibility, profitability and environmental accounting information disclosure. *Communication of Finance and Accounting*, (21), 25–29.
- [10] Song, H., & Yang, Y. (2022). Analysis of the connotation and development path of modernization of China's industrial chain and supply chain. *Journal of Renmin University of China*, 36(01), 120–134.
- [11] Ji, M. (2023). Audit failure case from the perspective of risk-oriented auditing: Taking Xinlv Co., Ltd. as an example. *Fortune Times*, (12), 57–59.
- [12] Ye, S., Xie, T., & Zhou, Y. (2023). Exploration of the impact of the “filing suspension” mechanism on accounting firms: Based on the Ruihua audit failure case. *Chinese Collective Economy*, (35), 104–107.
- [13] Zhang, X., Liu, Y., & Zhang, C. (2022). Exploration of the application of activity-based costing in express logistics enterprises. *Logistics Engineering and Management*, 44(12), 1–4.
- [14] Yang, S. (2023). Exploration of issues in enterprise financial cost control and management. *Investment and Entrepreneurship*, 34(21), 72–74.
- [15] Tian, Y. (2023). Exploration of problems and solutions in cost control of manufacturing enterprises. *Commerce 2.0*, (32), 68–70.

A Study on Corporate Income Tax Planning Strategies: The Case of Alibaba Group

Ping Wang*

School of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710000, China

**Corresponding author: Ping Wang*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In the globalized digital economy, multinational corporations (MNCs) face complex tax environments, making effective corporate income tax (CIT) planning a critical component of strategic financial management. This paper conducts an in-depth case study of Alibaba Group Holding Limited, a leading global e-commerce and technology giant from China. The research aims to dissect the sophisticated tax planning strategies employed by Alibaba, analyzing their theoretical underpinnings, practical implementation, and overall effectiveness. By integrating established tax planning theories—such as the theory of tax shield, leverage effect, and the birth and development theory of tax planning—with a detailed examination of Alibaba's corporate structure, intangible asset management, and related-party transactions, this study provides a holistic view of its tax optimization approach. The findings reveal that Alibaba utilizes a multi-faceted strategy, prominently featuring the use of a Variable Interest Entity (VIE) structure to navigate regulatory constraints, the strategic location of holding companies and intangible property in low-tax jurisdictions, and the extensive use of preferential tax policies for High-tech and New Technology Enterprises (HTEs) in China. While these strategies have successfully minimized the group's effective tax rate and enhanced shareholder value, they also attract significant regulatory scrutiny and raise concerns regarding tax base erosion. This paper concludes by discussing the ethical implications, the evolving global tax landscape (including the OECD's BEPS 2.0 initiative), and the future challenges and strategic adjustments Alibaba and similar MNCs may encounter. The study contributes to the understanding of modern tax planning in the digital era and offers valuable insights for corporations, policymakers, and academic researchers.

Keywords: Corporate Income Tax Planning; Tax Strategy; Alibaba; Multinational Corporation (MNC); Base Erosion and Profit Shifting (BEPS); Variable Interest Entity (VIE)

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.809>

1.Introduction

Corporate Income Tax (CIT) represents a significant cash outflow for corporations, directly impacting their profitability and shareholder returns. Consequently, tax planning—the lawful and strategic organization of affairs to minimize tax liability—has become an integral part of corporate strategy, especially for multinational corporations (MNCs) operating across diverse tax jurisdictions. The rise of the digital economy, characterized by intangible assets, network effects, and the ability to operate remotely, has further complicated the international tax landscape, creating both opportunities and challenges for tax optimization^[1].

Alibaba Group Holding Limited, founded in 1999, has grown from a Chinese e-commerce startup into a global technology behemoth with businesses spanning core commerce, cloud computing, digital media, and innovation initiatives. Its rapid international expansion and complex business model make it a quintessential case for studying modern CIT planning strategies^[2]. Unlike traditional manufacturing firms, Alibaba's value is heavily derived from intangible assets such as its platform technology, brand, and user data, which are highly mobile and can be strategically located for tax purposes.

This paper seeks to answer the following research questions: (1) What are the primary CIT planning strategies employed by Alibaba Group? (2) What theoretical principles underpin these strategies? (3) How effective have these strategies been in reducing Alibaba's tax burden? (4) What are the associated risks and future prospects in light of global tax reforms?

Through a detailed case study methodology, this research will analyze Alibaba's public financial reports, annual filings (20-F forms), and existing literature on its corporate structure. The findings will provide a nuanced understanding of sophisticated tax planning in practice, offering valuable lessons for other global firms and contributing to the ongoing policy debate on international tax fairness^[3].

2.Theoretical Framework for Corporate Tax Planning

Effective tax planning is not merely about exploiting loopholes; it is a strategic exercise grounded in financial and economic theory. The following theories provide the foundation for understanding Alibaba's approach:

Tax Shield Theory: This theory posits that certain expenses, such as interest payments on debt, are tax-deductible. This "shield" reduces taxable income, thereby lowering the tax liability. Corporations can strategically use debt financing to create an interest tax shield, enhancing firm value. While highly relevant, its application in Alibaba's context is less pronounced than other strategies, given the company's historically strong cash position^[4].

Leverage Effect of Tax Planning: This concept refers to the magnified impact that successful tax planning has on a company's key financial metrics. A reduction in the effective tax rate (ETR) directly boosts net income and earnings per share (EPS), which in turn can positively influence the company's stock price and market valuation. For a high-profile company like Alibaba, even a slight reduction in ETR can translate into billions of RMB in additional profit.

Birth and Development Theory of Tax Planning: This theory suggests that tax planning evolves in response to the tax environment. It is "born" from the existence of tax laws and differentials and "develops" as corporations innovate new strategies to leverage these differences, while governments simultaneously amend laws to close perceived gaps. Alibaba's use of the VIE structure is a prime example of a strategy born from a specific regulatory constraint (foreign ownership restrictions in China).

Principle of Tax Benefit-Cost Analysis: Any tax planning strategy entails costs, including professional advisory fees, compliance costs, and potential reputational damage. Rational tax planning requires that the expected tax savings outweigh these associated costs. For Alibaba, the complexity of its structure implies high implementation costs, which are justified by the substantial tax benefits achieved.

3.Alibaba's Corporate Income Tax Planning Strategies: A Multi-pronged Approach

Alibaba's tax strategy is a sophisticated blend of structures designed to navigate Chinese regulations and optimize its global tax position.

3.1 The Foundational Structure: The Variable Interest Entity (VIE)

Strategy: To attract foreign investment while complying with Chinese restrictions on foreign ownership in key sectors like internet content provision (ICP), Alibaba, like many Chinese tech firms, adopted the VIE structure. While primarily an investment and control mechanism, it has profound tax implications.

Mechanism: Alibaba's listed entity, Alibaba Group Holding Limited, is a Cayman Islands-incorporated company. It does not directly own the Chinese operating companies that hold the valuable ICP licenses. Instead, it establishes a series of contractual arrangements (rather than equity ownership) with these Chinese VIEs and their Chinese owners. This allows

profits to be transferred from the VIE to the wholly foreign-owned enterprise (WFOE) in China through service fees, royalty payments, or other contractual means.

Tax Implication: This structure creates a conduit for shifting profits from the protected domestic entity (VIE) to an entity (the WFOE) that is part of the global corporate group, making those profits available for global tax planning strategies. It is the critical first step in Alibaba's international tax chain.

3.2 Leveraging Regional Tax Incentives within China

Strategy: Proactively qualifying for and utilizing official tax incentives offered by the Chinese government.

Mechanism: High-tech and New Technology Enterprise (HTE) Status: A significant portion of Alibaba's core technology subsidiaries, such as those involved in cloud computing (Alibaba Cloud) and R&D, have obtained HTE status. This status grants a preferential CIT rate of 15%, compared to the standard 25%.

Software Product VAT Refund: As a software developer, Alibaba benefits from VAT refund policies for software products, which improves cash flow and indirectly supports profitability.

Headquarters Economy Incentives: Locating regional headquarters in specific Chinese cities or zones that offer tax rebates or subsidies for headquarters functions.

3.3 International Profit Allocation and Holding Company Structure

Strategy: Utilizing a network of subsidiaries in low-tax jurisdictions to hold intangible assets and facilitate intra-group transactions, thereby allocating profits to locations with favorable tax treatments^[5].

Mechanism: Holding Companies: Alibaba's top holding company is in the Cayman Islands (a tax-neutral territory for non-resident companies). For its international expansion, it has used subsidiaries in jurisdictions like Hong Kong and Singapore, which have territorial tax systems and favorable tax treaties.

Intangible Property (IP) Migration: The group's valuable non-Chinese IP, such as the "Alibaba.com" brand for international business-to-business (B2B) commerce, is often held by subsidiaries in low-tax jurisdictions. Operating companies in high-tax countries then pay royalties or service fees to these IP-holding entities, effectively shifting profits out of high-tax areas. This is a classic application of the OECD-identified Base Erosion and Profit Shifting (BEPS) concern^[6].

Related-Party Transactions: The group engages in extensive intra-group services, technology licensing, and cost-sharing arrangements. By setting the transfer prices for these transactions, Alibaba can manage where profits are recorded for tax purposes.

4. Analysis of Effectiveness and Outcomes

The effectiveness of Alibaba's tax strategies is evident from its financial statements.

4.1 Financial Performance and Effective Tax Rate (ETR) Analysis

A review of Alibaba's annual reports over the past decade shows a consistent pattern of its ETR being significantly below the Chinese statutory rate of 25%. For instance, in fiscal years following the widespread certification of its subsidiaries as HTEs, the group's ETR often hovered around the 18-22% range. This persistent gap is a direct result of the blended rate achieved through the HTE incentives and the profits allocated to lower-taxed international subsidiaries.

Calculation Example (Hypothetical for Illustration):

Assume Alibaba China has 70% of its profits taxed at the HTE rate of 15% and 30% at the standard 25%.

Blended China ETR = $(0.7 * 15\%) + (0.3 * 25\%) = 10.5\% + 7.5\% = 18\%$

If a portion of the global profit is allocated to a Singapore subsidiary taxed at 17%, the overall group ETR can be further reduced.

This lower ETR directly translates to higher net income and enhanced shareholder value, demonstrating the powerful "leverage effect" of its tax planning.

4.2 Risk Assessment

Despite its effectiveness, Alibaba's strategy is not without significant risks:

Regulatory and Political Scrutiny: The VIE structure exists in a legal gray area and has never been formally endorsed by the Chinese government. Any future policy shift could jeopardize the entire control and profit-transfer mechanism. Internationally, Alibaba faces scrutiny under the OECD's BEPS project, particularly from tax authorities in countries where it has significant sales but reports minimal taxable profits.

Reputational Risk: Aggressive tax planning, especially involving tax havens, can attract negative media attention and public backlash, potentially damaging the brand's image.

Complexity and Compliance Cost: The intricate web of entities and transactions requires a large, expert tax team and incurs substantial annual compliance costs.

5. The Future Landscape: Challenges and Strategic Adaptation

The global tax environment is undergoing a seismic shift, which will inevitably impact Alibaba's future tax strategy.

The OECD BEPS 2.0 Pillar Two: The implementation of the global minimum tax of 15% is a direct challenge to Alibaba's current strategies. If the group's ETR in certain jurisdictions falls below this threshold, it could face "top-up" taxes in other countries, potentially neutralizing the benefits of profit shifting to low-tax jurisdictions.

Increasing Scrutiny in China: The Chinese government is becoming more sophisticated in its tax administration and is actively participating in global tax cooperation. Transfer pricing regulations are being tightened, and the focus on "substance over form" may challenge the rationale behind some intra-group arrangements.

Strategic Adaptation: To adapt, Alibaba will likely need to:

1. **Re-evaluate its Holding Structure:** The tax efficiency of certain jurisdictions may diminish under Pillar Two, prompting a restructuring of its international holdings.
2. **Emphasize Substance:** Ensuring that its IP-holding companies have adequate personnel, decision-making capability, and economic substance in their host jurisdictions will be critical to defending their tax status.
3. **Focus on Sustainable Incentives:** Rather than aggressive profit shifting, the future of its tax strategy may rely more heavily on leveraging legitimate, government-sponsored incentives for R&D and green technology, which are less contentious and more sustainable.

6. Conclusion

Alibaba Group serves as a paradigmatic case of sophisticated corporate income tax planning in the 21st century. Its strategies are a masterful, albeit high-risk, application of theoretical principles, tailored to the specific constraints of the Chinese regulatory system and the opportunities of the global tax landscape. The multi-pronged approach—centered on the VIE structure, domestic HTE incentives, and international profit allocation—has been highly effective in minimizing its global tax burden and maximizing shareholder value.

However, the era of unfettered tax optimization is closing. The dual pressures of global tax reform (BEPS 2.0) and heightened domestic scrutiny are creating a new paradigm where substance, transparency, and alignment with real economic activity will be paramount. For Alibaba and its peers, the future of tax strategy will lie not in navigating the gaps between different tax systems, but in strategically managing their global footprint and operations within a more harmonized and rigorous international tax framework. This case study underscores that in the new global tax order, the most sustainable tax strategy is one that is integrated with, and supportive of, the company's long-term business strategy and social license to operate.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Alibaba Group Holding Limited. (2023). Annual Report on Form 20-F for the fiscal year ended March 31, 2023. U.S. Securities and Exchange Commission.
- [2] OECD. (2015). Base Erosion and Profit Shifting (BEPS) Project Final Reports. OECD Publishing, Paris.
- [3] OECD. (2021). Tax Challenges Arising from the Digitalisation of the Economy – Global Anti-Base Erosion Model Rules (Pillar Two). OECD Publishing, Paris.
- [4] Modigliani, F., & Miller, M. H. (1963). Corporate income taxes and the cost of capital: a correction. *The American Economic Review*, 53(3), 433-443.
- [5] Hanlon, M., & Heitzman, S. (2010). A review of tax research. *Journal of Accounting and Economics*, 50(2-3), 127-178.
- [6] Liu, L., & Cao, Y. (2019). The Variable Interest Entity structure in China: A systematic review and future research agenda. *Pacific-Basin Finance Journal*, 57, 101-114.

The Empowering Effect of Digital Transformation on Corporate ESG Performance: A Case Study of the New Energy Industry

Wenyi Sun*

School of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710048, China

**Corresponding author: Wenyi Sun*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In the context of the global pursuit of sustainable development, the New Energy industry stands at the forefront of the green transition. Simultaneously, digital transformation (DT) has become a pivotal force reshaping corporate operations. This study investigates the synergistic interplay between these two megatrends, specifically exploring the empowering effect of corporate digital transformation on Environmental, Social, and Governance (ESG) performance within the new energy sector. Grounded in dynamic capability theory and stakeholder theory, this paper constructs a conceptual framework analyzing how DT acts as a technological enabler across the E, S, and G dimensions. Through a qualitative analysis of leading global new energy companies, including contemporary giants, the research identifies three primary pathways of empowerment: 1) Environmental Enhancement through smart energy management, predictive maintenance, and circular economy optimization; 2) Social Empowerment via bolstered occupational health and safety, supply chain transparency, and community engagement; and 3) Governance Improvement by enabling data-driven decision-making, enhancing risk management, and boosting information transparency. The findings reveal that DT is not merely a supportive tool but a transformative force that amplifies the intrinsic sustainability potential of new energy firms. However, the implementation is fraught with challenges, including high upfront costs, data security risks, and the digital skills gap. This paper concludes that a strategic, integrated approach to DT is crucial for new energy companies to fully unlock their ESG potential, thereby securing long-term competitiveness and investor confidence in an increasingly sustainability-oriented market.

Keywords: Digital Transformation; ESG Performance; Corporate Sustainability; New Energy Industry; Dynamic Capabilities; Green Technology

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.810>

1.Introduction

The twin imperatives of the Fourth Industrial Revolution and the global climate crisis are compelling corporations to redefine their strategies. On one hand, the transition to a low-carbon economy has propelled the New Energy industry—encompassing solar, wind, energy storage, and hydrogen—into a strategic pillar for national economies and a focal point for global investment. On the other hand, Digital Transformation (DT), characterized by the integration of technologies like the Internet of Things (IoT), Big Data, Artificial Intelligence (AI), and blockchain, is fundamentally altering business models and operational processes across all sectors.

The convergence of these two trends presents a critical research opportunity. While the new energy industry is inherently “green” in its output, its internal operations and broader value chain are not automatically sustainable or exemplary in their ESG (Environmental, Social, and Governance) performance. ESG has evolved from a niche concern to a mainstream framework for evaluating corporate sustainability and long-term risk, significantly influencing investment decisions, regulatory policies, and consumer preferences^[1].

This paper posits that digital transformation serves as a powerful enabler, or “empowerer,” that can significantly augment the ESG performance of new energy companies. It moves beyond the siloed view of technology and sustainability to argue that DT provides the tools and data necessary to translate sustainability ambitions into measurable outcomes. The central research question is: Through what mechanisms does digital transformation empower the ESG performance of firms in the new energy industry?

By employing a theory-based conceptual framework and analyzing practices from leading companies, this study aims to delineate the specific pathways of this empowerment effect. The insights will be valuable for managers in the new energy sector seeking to leverage technology for competitive advantage, for investors assessing corporate sustainability, and for policymakers designing supportive regulatory frameworks.

2.Theoretical Foundation and Literature Review

2.1 Dynamic Capability Theory and Stakeholder Theory

The empowering effect of DT on ESG can be effectively understood through the lens of two complementary theories^[2]:

Dynamic Capability Theory: This theory refers to a firm’s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments (Teece et al., 1997). Digital transformation is a manifestation of dynamic capabilities. It equips firms with the ability to sense emerging ESG-related risks and opportunities (e.g., through AI-powered regulatory scanning), seize them by developing new sustainable products or processes, and transform their organizational structure to maintain alignment. For a new energy firm, DT enhances its capacity to dynamically manage its environmental footprint, social impact, and governance structures in real-time^[3].

Stakeholder Theory: Proposed by Freeman (1984), this theory argues that corporations must create value for all stakeholders, including employees, customers, suppliers, communities, and the environment, not just shareholders. ESG is the operationalization of stakeholder theory. Digital transformation provides the mechanisms to better identify, engage, and respond to diverse stakeholder concerns. For instance, blockchain can ensure supply chain transparency for ethically conscious consumers, while digital platforms can facilitate more effective communication with local communities.

2.2 The Intersection of Digital Transformation and ESG

Existing literature has begun to explore the DT-ESG nexus, though industry-specific deep dives remain limited. Prior research has generally found a positive correlation between corporate digitalization and ESG ratings at a macro level. Studies suggest that DT can improve resource efficiency, optimize corporate governance, and enhance information disclosure. However, the “how” and “why”—the specific causal mechanisms and their application in a mission-critical industry like new energy—require further elaboration. This paper seeks to fill this gap by moving from correlation to causation, detailing the operational pathways through which empowerment occurs^[4].

3.Digital Transformation as an Enabler for ESG in the New Energy Industry

The following sections dissect the empowering effect across the three pillars of ESG.

3.1 Empowering Environmental (E) Performance

The core environmental mission of new energy companies is amplified by DT, moving beyond clean energy production to sustainable operations.

Smart Resource Management and Efficiency: IoT sensors and AI algorithms are deployed across wind farms and solar parks to optimize energy production. For example, AI-powered predictive analytics can forecast weather patterns to adjust the angle of solar panels or the pitch of wind turbine blades in real-time, maximizing energy capture and reducing inefficiency. This directly lowers the energy intensity of operations^[5].

Predictive Maintenance and Lifespan Extension: Instead of scheduled or reactive maintenance, DT enables condition-based monitoring. Vibration sensors and thermal imaging on turbines and other equipment can predict failures before they occur. This minimizes downtime, reduces resource waste from major repairs, and extends the operational lifespan of assets, contributing to a circular economy model.

Circular Economy and Waste Management: In battery manufacturing and recycling, digital platforms can track materials throughout their lifecycle. AI can optimize the disassembly and sorting processes for end-of-life batteries, improving the recovery rates of valuable materials like lithium and cobalt, thereby reducing environmental degradation from mining.

3.2 Empowering Social (S) Performance

DT strengthens the social license to operate for new energy firms.

Occupational Health and Safety (OHS): This is critical in an industry involving high-voltage equipment and construction. Digital twins can simulate hazardous scenarios for training. Wearable IoT devices can monitor workers' vital signs and location in real-time, automatically triggering alerts in case of accidents or exposure to hazardous conditions. Computer vision can enforce the use of personal protective equipment (PPE)^[6].

Supply Chain Due Diligence and Transparency: The complex supply chains for minerals like cobalt and silicon are under intense scrutiny for human rights practices. Blockchain technology can create an immutable ledger tracing raw materials from the source to the finished product, ensuring conflict-free and ethically sourced materials and protecting workers' rights upstream.

Community Engagement and Just Transition: DT facilitates better stakeholder dialogue. GIS (Geographic Information Systems) and data analytics can help in selecting project sites that minimize social and environmental impact. Digital platforms can be used to inform and engage local communities about projects, address grievances, and ensure that the benefits of the energy transition are shared equitably.

3.3 Empowering Governance (G) Performance

Strong governance is the bedrock for effective E and S performance, and DT provides the tools for its enhancement.

Data-Driven Board Oversight and Decision-Making: Instead of relying on lagging indicators, boards can access integrated dashboards that provide real-time ESG data—from carbon emissions and safety incidents to supply chain compliance. This enables more proactive and strategic oversight of ESG risks and opportunities.

Enhanced Risk Management and Internal Controls: AI and machine learning can continuously monitor vast datasets for emerging risks, be it regulatory non-compliance, cybersecurity threats, or operational failures. This allows for pre-emptive mitigation actions, strengthening the overall control environment.

Transparency and Anti-Corruption: Automated reporting systems reduce human error and the potential for manipulation in ESG disclosures. Blockchain-based systems for procurement and contracts can significantly reduce opportunities for corruption and fraud, building trust with investors and regulators.

4. Case in Point: A Glimpse into Contemporary Practices

While a single case cannot represent the entire industry, examining the practices of a leading wind turbine manufacturer, Vestas, illustrates these pathways effectively.

Environmental: Vestas uses its “VestasPerformance+” platform, which employs big data from over 40,000 turbines globally. AI and machine learning analyze this data to optimize the performance of entire wind farms, increasing energy output and reducing the Levelized Cost of Energy (LCOE), a key environmental and economic metric.

Social: The company utilizes digital tools for remote monitoring and troubleshooting, which reduces the need for physical visits and lowers safety risks for technicians. Furthermore, their global supply chain is managed through digital systems that enforce a strict code of conduct for suppliers.

Governance: Vestas has integrated ESG data into its corporate reporting and risk management systems. The board receives regular updates on sustainability KPIs, and the company's commitment to transparency is evidenced by its detailed annual sustainability report, the data for which is largely collected and processed through digital means.

5.Challenges and the Path Forward

Despite the clear benefits, the integration of DT for ESG purposes is not without obstacles:

High Initial Investment: The capital expenditure for IoT sensors, AI software, and digital infrastructure can be prohibitive, especially for smaller players.

Data Security and Privacy: The increased data collection raises significant cybersecurity and data privacy concerns that must be robustly managed.

Skills Gap and Organizational Resistance: A shortage of talent skilled in both data science and sustainability, coupled with cultural resistance to change, can hinder successful implementation.

To overcome these challenges, new energy companies must:

1. Develop a Coherent DT-ESG Strategy: DT initiatives must be aligned with and driven by ESG objectives, not pursued in isolation.
- 2.Foster Cross-Functional Collaboration: Break down silos between IT, sustainability, operations, and finance departments.
- 3.Adopt a Phased Approach: Start with pilot projects to demonstrate value before scaling up.
4. Prioritize Data Governance: Implement strong cybersecurity measures and ethical data usage policies from the outset.

6.Conclusion

This study demonstrates that digital transformation is a critical lever for unlocking superior ESG performance in the new energy industry. It acts as a multifaceted enforcer, enhancing environmental efficiency through data-driven optimization, strengthening social equity via transparency and safety, and solidifying governance with robust, data-informed oversight. The empowerment effect is realized through the enhancement of a firm's dynamic capabilities, allowing it to better serve its broad stakeholders.

For the new energy sector, which is intrinsically linked to the global sustainability agenda, embracing digital transformation is no longer an optional competitive advantage but a strategic necessity. The companies that successfully integrate digital and sustainability strategies will be best positioned to lead the energy transition, attract conscious capital, and build resilient, future-proof enterprises. Future research should quantitatively measure the strength of these relationships and conduct longitudinal studies to track the long-term impact of DT on the financial and ESG performance of new energy firms.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7), 509-533.
- [2] Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Pitman.
- [3] WEF. (2021). *Digital Transformation for a Sustainable Energy Future*. World Economic Forum.
- [4] George, G., Merrill, R. K., & Schillebeeckx, S. J. (2021). Digital transformation and sustainability: A review and research agenda. *Journal of Management Studies*, 58(1), 1-32.
- [5] Bock, S., & Wiener, M. (2021). Towards a taxonomy of digital transformation pathways. *Journal of Information Technology Theory and Application*, 22(1), 4.
- [6] Vestas. (2023). *Annual and Sustainability Report 2022*. Retrieved from Vestas website.

Performance Analysis of Green Transformation in High Energy-Consuming Enterprises: A Case Study of Huaneng Power International, Inc.

Xiaoyu Li*

College of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710000, China

*Corresponding author: Xiaoyu Li

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: The global transition to a low-carbon economy presents a formidable challenge and a strategic imperative for high energy-consuming enterprises, particularly in the power generation sector. As a dominant player in China's thermal power industry and a significant global carbon emitter, Huaneng Power International, Inc. (HPI) serves as a critical case for examining the viability and outcomes of green transformation within a traditionally carbon-intensive framework. This paper conducts a comprehensive performance analysis of HPI's multi-faceted green transformation journey from 2010 to the present. By integrating strategic management theories like the Resource-Based View (RBV) with a multi-dimensional performance framework, this study assesses the environmental, financial, and operational consequences of HPI's initiatives. These initiatives include the aggressive expansion of its renewable energy portfolio (notably wind and solar), the deployment of ultra-supercritical coal-fired technologies, and active participation in the national carbon emissions trading scheme (ETS). The analysis reveals a complex and nuanced outcome: while HPI has made significant strides in reducing its carbon and pollutant emission intensity and enhancing its operational efficiency, the transformation has imposed substantial financial burdens, including elevated debt levels and short-term profitability pressures. The findings indicate that the green transformation of a high energy-consuming giant is not a linear path to immediate prosperity but a strategic, long-term recalibration. Success hinges on a delicate balance between regulatory compliance, technological investment, and financial viability. This study contributes to the broader understanding of sustainability transitions in hard-to-abate sectors and offers valuable insights for corporate managers, investors, and policymakers navigating the complexities of the energy transition.

Keywords: Green Transformation; High Energy-Consuming Enterprise; Huaneng Power International; Environmental Performance; Financial Performance; Renewable Energy; Carbon Emissions; Sustainability Transition

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.811>

1.Introduction

The existential threat of climate change has catalyzed a global shift towards sustainable development, placing immense pressure on high energy-consuming and high-emission industries. The electric power sector, responsible for a substantial portion of global CO₂ emissions, sits at the epicenter of this transition. In China, the world's largest energy consumer and carbon emitter, the power sector's transformation is crucial to achieving the nation's "Dual Carbon" goals (carbon peaking by 2030 and carbon neutrality by 2060). This transition necessitates a fundamental overhaul of business models, particularly for

state-owned giants historically reliant on coal-fired power generation.

Huaneng Power International, Inc. (HPI), one of China's largest listed power producers, embodies this challenge and opportunity. As a flagship subsidiary of the China Huaneng Group, HPI's asset portfolio was overwhelmingly dominated by coal-fired plants for decades. Its strategic pivot towards a greener energy mix represents a microcosm of the broader struggle within China's industrial landscape. Analyzing HPI's journey provides critical insights into the tangible costs, benefits, and trade-offs of corporate green transformation.

This paper aims to dissect the performance outcomes of HPI's green transformation strategy. It moves beyond a mere description of its green initiatives to a systematic analysis of their impact on three core performance dimensions: environmental, financial, and operational. The central research questions are: (1) What key strategies has HPI employed in its green transformation? (2) How have these strategies impacted its environmental footprint, financial health, and operational metrics? (3) What are the key lessons and future challenges for HPI and similar enterprises?

By employing a longitudinal case study approach and analyzing data from annual reports, sustainability reports, and industry databases, this study offers an evidence-based evaluation of a high-stakes corporate metamorphosis. The findings are pertinent for corporate leaders in energy-intensive industries, investors assessing transition risks and opportunities, and policymakers crafting effective regulatory frameworks to enable a just and efficient energy transition^[1].

2.Theoretical Framework: The Resource-Based View and Green Transformation

The Green Transformation of a firm can be effectively analyzed through the lens of the Resource-Based View (RBV). RBV posits that firms gain sustainable competitive advantage by developing and deploying valuable, rare, inimitable, and non-substitutable (VRIN) resources and capabilities (Barney, 1991)^[2].

In the context of HPI's transformation:

Traditional Resources: Its historical competitive advantage was built on tangible resources like large-scale coal-fired power plants and intangible capabilities in coal procurement and thermal operations. In a carbon-constrained world, these very resources risk becoming "stranded assets" and sources of competitive disadvantage.

New Strategic Resources: Green transformation requires HPI to reconfigure its resource base. This involves acquiring and developing new VRIN resources, such as:

Physical Resources: Wind farms, solar parks, and high-efficiency, low-emission (HELE) coal technologies.

Intangible Resources: Carbon asset management capabilities, green technology R&D, a "green" corporate brand, and the managerial expertise to navigate a complex regulatory environment.

Financial Resources: Access to capital for massive investments in renewable projects, often facilitated by green bonds and ESG-focused financing.

The performance analysis, therefore, assesses how successfully HPI is shedding its dependency on carbon-intensive resources and building a new, sustainable resource portfolio that aligns with the future low-carbon economy.

3.HPI's Green Transformation Strategy: A Multi-Pronged Approach

HPI's transformation is not a single project but a sustained strategic shift, characterized by three interconnected pillars:

3.1 Structural Shift: Aggressive Expansion of Renewable Energy Capacity

HPI has systematically diversified its generation mix by channeling a significant portion of its capital expenditure (CAPEX) into non-fossil fuel sources. This involves the large-scale development and acquisition of wind, solar, and hydropower projects across China. The strategic goal is to incrementally reduce the proportion of coal-fired power in its total installed capacity and energy output. This is the most direct and impactful component of its decarbonization strategy.

3.2 Technological Optimization: Greening the Existing Coal Fleet

Recognizing the continued role of coal in ensuring grid stability in the medium term, HPI has invested heavily in upgrading its existing coal-fired assets. Key initiatives include:

Retrofitting with Ultra-Supercritical (USC) Technology: Replacing or upgrading subcritical units with more efficient USC units, which have higher steam parameters and thus lower coal consumption and emissions per unit of electricity generated.

Co-firing with Biomass: Piloting and implementing projects that mix biomass with coal to reduce the net carbon footprint of power generation.

Pollution Control Technologies: Installing and upgrading flue-gas desulfurization (FGD), denitrification, and dust removal systems to meet increasingly stringent air pollutant emission standards.

3.3 Strategic Adaptation: Engaging with Carbon and Green Certificate Markets

HPI has proactively engaged with emerging environmental markets as both a compliance obligation and a new business frontier.

Carbon Emissions Trading Scheme (ETS): HPI has developed in-house capabilities to manage its carbon assets, optimize its ETS compliance costs, and explore revenue opportunities through carbon trading^[3].

Green Power Certificates: By generating renewable energy, HPI creates Green Certificates that can be sold, providing an additional revenue stream and improving the economics of its green projects^[4].

4. Performance Analysis of the Green Transformation

The impact of these strategies is evaluated across three performance dimensions.

4.1 Environmental Performance

This is the most direct and positive outcome of HPI's transformation.

Reduction in Emission Intensity: Data from HPI's sustainability reports shows a consistent downward trend in its carbon dioxide (CO₂) emission intensity (g CO₂/kWh) and pollutant emission intensity (e.g., SO₂, NO_x). This is a direct result of the increased share of zero-emission renewables and the improved efficiency of its coal fleet.

Improvement in Energy Efficiency: The average coal consumption rate (gce/kWh) for its coal-fired power plants has decreased significantly, demonstrating enhanced operational efficiency and resource utilization driven by technological upgrades.

Growth in Renewable Capacity: The proportion of non-fossil fuel installed capacity in HPI's total portfolio has seen a marked increase, reflecting a fundamental structural change in its asset base.

4.2 Financial Performance

The financial impact is complex and reveals the significant cost of transition.

CAPEX and Financial Leverage: The massive investments in renewable energy infrastructure have led to sustained high capital expenditures. This, in turn, has often been financed through debt, resulting in an increased asset-liability ratio and higher interest expenses, pressuring the company's financial structure in the short to medium term.

Profitability Pressures: While renewable energy has low marginal costs, its high fixed costs and the phasing out of feed-in tariffs (FITs) can squeeze profit margins. Meanwhile, the profitability of its legacy coal-fired business is highly volatile, susceptible to fluctuations in coal prices and the fixed on-grid tariff, sometimes leading to significant losses in its thermal power segment.

Emerging Opportunities: On the positive side, HPI has begun to access green financing (e.g., green bonds), which often comes with lower interest rates. Furthermore, its improved ESG rating helps attract long-term sustainability-focused investors, potentially lowering its cost of capital over time.

4.3 Operational and Market Performance

The transformation has reshaped HPI's operational dynamics and market perception.

Operational Efficiency: The integration of digital technologies for "smart power plant" management and the use of AI for predictive maintenance have improved the availability and reliability of both its renewable and thermal assets^[5].

Market Perception and ESG Ratings: HPI's active transition strategy has been recognized by rating agencies, leading to a gradual improvement in its ESG scores. This enhances its corporate reputation and mitigates regulatory and reputational risks associated with being a carbon-intensive entity^[6].

Navigating Regulatory Risks: By proactively aligning with national climate policies, HPI has positioned itself to better manage regulatory risks, such as carbon pricing and stricter emission standards, compared to less-prepared peers.

5.Challenges and Strategic Implications

HPI's journey underscores several persistent challenges:

High Debt Burden: The capital-intensive nature of the transformation continues to strain its balance sheet.

Integration of Intermittent Renewables: Managing the grid stability challenges posed by the variable nature of wind and solar power requires further investment in energy storage and smart grid technologies.

Just Transition for the Thermal Workforce: The gradual phase-down of coal assets necessitates managing the social impact and retraining or redeploying employees from the thermal power sector.

For HPI and similar enterprises, the strategic implications are clear:

1.**Diversified and Phased Investment:** A balanced investment strategy that manages the pace of renewable expansion to maintain financial health is crucial.

2.**Technological Innovation:** Continued R&D in carbon capture, utilization, and storage (CCUS), advanced energy storage, and green hydrogen is essential for deep decarbonization.

3.**Mastery of Carbon Asset Management:** Excelling in carbon trading and green certificate markets will transform compliance from a cost center into a potential profit center.

6.Conclusion

The case of Huaneng Power International demonstrates that the green transformation of a high energy-consuming enterprise is a complex, multi-dimensional, and long-term endeavor fraught with tensions, particularly between environmental goals and financial performance in the short term. HPI has successfully initiated a critical structural shift, evidenced by its improved environmental metrics and growing renewable portfolio. However, this transition has come at a significant financial cost, highlighting the substantial economic challenges inherent in decarbonizing heavy industry.

The journey is not about an immediate trade-off but a strategic reallocation of resources from a sunset model to a sunrise one. HPI's experience suggests that success depends on a firm's ability to dynamically manage this reallocation—navigating policy landscapes, leveraging new technologies, and securing patient capital. For policymakers, this case underscores the need for stable, long-term policies that de-risk such investments and support a just transition. For the global community, HPI's transformation offers a critical real-world example of how an industrial giant can begin to pivot its core business towards a sustainable future, providing both a cautionary tale and a source of strategic insight for the many other enterprises that must follow a similar path.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management**, 17(1), 99-120.
- [2] Huaneng Power International, Inc. (2015-2022). Annual Reports, Shanghai Stock Exchange.
- [3] Huaneng Power International, Inc. (2018-2022). Social Responsibility/Environmental, Social and Governance (ESG) Reports.
- [4] Zhang, S., & Zhang, M. (2021). The impact of carbon ETS on the corporate financial performance of China's power industry: A case study of Huaneng Power. *Energy Policy*, 158, 112557.
- [5] Yuan, J., & Li, P. (2020). The green transformation of China's power sector: Policies and corporate strategies. *The Energy Journal*, 41(4), 1-22.
- [6] International Energy Agency (IEA). (2021). *An Energy Sector Roadmap to Carbon Neutrality in China*. OECD Publishing.

Accounts Receivable Risk Control in Small and Medium-Sized Enterprises: A Case Study of Manufacturing Industry

Min Yang*

College of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710000, China

**Corresponding author: Min Yang*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: With intensifying market competition and growing supply chain complexity, accounts receivable risks have become a critical factor affecting the survival and development of small and medium-sized manufacturing enterprises (SMEs). This paper analyzes the causes, types, and impacts of accounts receivable risks in manufacturing SMEs based on their management characteristics and regulatory frameworks such as the newly revised “Regulations on Ensuring Payment to Small and Medium-sized Enterprises”. A comprehensive risk control system covering pre-emptive prevention, real-time monitoring, and post-event resolution is established. Practical implementation strategies are proposed through case studies, offering actionable guidance for SMEs to optimize accounts receivable management, reduce bad debt risks, and enhance capital turnover efficiency.

Keywords: Manufacturing Industry; SMEs; Accounts Receivable; Risk Management; Cash Flow

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.812>

1.Introduction

As the backbone of the national economy, the healthy development of manufacturing is crucial for economic stability and industrial security. Small and medium-sized enterprises (SMEs) constitute a significant portion of this sector, forming vital components of industrial and supply chains. However, in recent years, compounded by complex domestic and international economic conditions, accounts receivable defaults have become increasingly prevalent, making accounts receivable risks a major challenge for SMEs. According to data from the National Bureau of Statistics, as of April 2025, accounts receivable at large-scale industrial enterprises reached 25.86 trillion yuan, marking a 9.7% year-on-year increase. The average collection period for these receivables rose by 4.0 days to 70.3 days. For resource-constrained SMEs in manufacturing, this “chronic hemorrhage” poses critical risks—— with escalating financial chain ruptures. Cases of forced production cuts, wage arrears, and even bankruptcy have become all too common^[1].

The continuous expansion of accounts receivable and extended payment cycles not only intensify corporate cash flow pressures but also create a vicious cycle of “chain defaults” through multi-tiered industrial chain transmission, severely undermining market credit systems and transactional order. Particularly in manufacturing sectors where transactions involve large sums, prolonged terms, and complex processes, effective accounts receivable risk management becomes paramount. A prime example from the construction machinery industry demonstrates that over-reliance on credit sales can lead to massive receivables, adversely affecting corporate liquidity and potentially triggering critical operational risks. Therefore,

strengthening accounts receivable risk control for SMEs in manufacturing is vital—not just for individual enterprise survival, but for maintaining stable operations across entire industrial chains.

The continuous expansion of accounts receivable and extended payment cycles not only intensify corporate cash flow pressures but also create a vicious cycle of “chain defaults” through multi-tiered industrial chain transmission, severely undermining market credit systems and transactional order. Particularly in manufacturing sectors where transactions involve large sums, prolonged terms, and complex processes, effective accounts receivable risk management becomes paramount. A prime example from the construction machinery industry demonstrates that over-reliance on credit sales can lead to massive receivables, adversely affecting corporate liquidity and potentially triggering critical operational risks. Therefore, strengthening accounts receivable risk control for SMEs in manufacturing is vital—not just for individual enterprise survival, but for maintaining stable operations across entire industrial chains^[2].

Table 1: Main risk types and impacts of accounts receivable in manufacturing industry

Risk type	Key performance	Impact on business
default risk	The customer is overdue on payment	Slow capital return, tight working capital
The bad debt risk	Accounts receivable cannot be collected	Direct loss of assets, decline in profitability
Cash flow risk	Working capital is being occupied in large quantities	Insufficient capacity to pay and increased financing costs
Risk of implicit default	Change the payment term indefinitely	Difficulties in safeguarding rights and increased management costs

2. Analysis of Causes for Accounts Receivable Risks in Manufacturing

1.) The formation of accounts receivable risks in manufacturing involves both external environmental factors and internal management issues. Externally, intensified market competition compels small and medium-sized enterprises (SMEs) to accept more lenient credit terms to secure orders. Economic downturn pressures strain supply chain participants, reducing their payment capacity. Meanwhile, an imperfect legal framework minimizes the cost of default penalties for delayed payments. Internally, SMEs in manufacturing face common challenges: 1). The primary risk source stems from inadequate customer credit evaluation. Many companies prioritize business expansion over systematic assessment of partners' financial health and reputation, leading to partnerships with high-risk clients. Driven by order-driven operations, manufacturers often focus excessively on production delivery while neglecting customer credit screening processes^[3].

2.) The legal risks stemming from contractual loopholes are equally significant. Issues such as ambiguous payment cycle stipulations and unclear definitions of breach liabilities often leave companies in a passive position during disputes. Recently, a trading company faced malicious payment delays by its client for 18 months due to the contract's failure to specify penalty clauses for delayed payments.

3.) The imperfect debt collection mechanism exacerbates financial pressure. The absence of standardized accounts tracking systems and information disconnect between finance departments and business teams result in delayed collection opportunities. Traditional reliance on Excel ledgers and manual statistics creates disconnections between accounts receivable/payable information and business contracts, project progress, and frequent issues like unclear project alignment for collections and confusion between old and new accounts receivable/payable.

4.) Furthermore, the widespread misuse of non-cash payment methods has become a key factor in artificially prolonging payment cycles. Large corporations frequently pressure small and medium-sized enterprises (SMEs) to adopt non-cash instruments like commercial drafts under the guise of “streamlining settlement processes.” This practice not only subjects businesses to high discount costs but also creates a vicious cycle where companies hold bills in their hands while struggling to secure financing.

3. Policy and regulatory environment analysis

In recent years, the Chinese government has prioritized addressing accounts receivable defaults for SMEs, intensifying

regulatory efforts through a series of policy measures. These initiatives have provided robust support for risk management in SMEs' accounts receivable. The revised "Regulations on Ensuring Payment of Accounts to Small and Medium-sized Enterprises" (hereinafter referred to as the "Regulations"), officially promulgated in March 2025, will take effect on June 1, 2025. The updated regulations introduce new provisions to standardize payment practices and strengthen accountability mechanisms, effectively safeguarding SMEs' financial stability.

3.1 Core content of Regulations on Guaranteeing Payment of Small and Medium Enterprises

The newly revised Regulations establish a dedicated chapter titled "Payment Clauses", introducing amendments in three key areas: 1. Payment Deadlines Clarification: Defines payment deadlines for government agencies, public institutions, and large enterprises, requiring major corporations to settle payments within 60 days after delivery of goods, construction projects, or services. Where contractual terms conflict, the latest industry standards or established practices shall prevail, but payment deadlines must be clearly defined and enforced. 2. Non-cash Payment Mechanisms: Prohibits forcing SMEs to accept commercial drafts or electronic accounts receivable certificates as payment methods, while preventing such instruments from being used to artificially extend payment cycles. 3. Disputed Payment Obligations: Requires timely settlement of undisputed payments in transactions between government entities, public institutions, large enterprises, and SMEs, provided that disputed portions do not affect other obligations. The Regulations also enhance oversight through mandatory reporting systems, interview mechanisms, and detailed restrictive measures. Addressing critical SME concerns—including difficulties in claim verification, rights confirmation, debt recovery, appeals, and penalties—the provisions demonstrate targeted regulatory solutions.

3.2 Supply chain finance policy support

In addition to the Regulation, in June 2025, six departments including the People's Bank of China jointly issued the "Notice on Regulating Supply Chain Finance Business and Guiding Supply Chain Information Service Institutions to Better Serve SME Financing," effective from June 15, 2025. This notice aims to standardize supply chain finance operations, enhance the quality and efficiency of financial services for the real economy, and reduce capital occupation and payment arrears for SMEs. The notice requires core enterprises in supply chains to promptly pay SMEs, reasonably share supply chain financing costs, refrain from exploiting their dominant position to delay payments or improperly increase SME accounts receivable, avoid imposing unreasonable payment terms, and prevent the misuse of non-cash payment methods to extend payment periods. Additionally, it specifies that the payment period for electronic accounts receivable certificates should generally be within six months, with a maximum duration of one year. Furthermore, the "Promotion Law of Private Economy of the People's Republic of China," implemented on May 20, clearly stipulates legal obligations for state organs, public institutions, and state-owned enterprises to timely pay private economic organizations, as well as large enterprises to promptly settle payments to small and medium-sized private economic entities. These provisions establish legal constraints and curb corporate payment arrears through statutory enforcement^[4].

Table2 : The impact of major policies and regulations on accounts receivable management

policies and regulations, laws and regulations	When it was implemented	Core provisions	The significance of enterprise management
Regulations on the Payment of Small and Medium Enterprises (Revised)	1 June 2025	Make it clear that payment is made within 60 days and non-cash payments are prohibited	Strengthen the collection rights of small and medium-sized enterprises, shorten the account period
Notice on Regulating Supply Chain Finance Business	15 June 2025	Standardize the business of electronic certificate of accounts receivable	Prevent disguised extension of payment terms and promote financing
Law of the People's Republic of China on Promotion of Private Economy	20 May 2025	Clear payment liability and consequences of violation	Enhance the legal binding force and increase the cost of default

These policies and regulations have formed a multi-level, comprehensive safeguard system, providing legal weapons and policy tools for the accounts receivable risk management of small and medium-sized manufacturing enterprises. Chinese enterprises, especially those in the manufacturing sector, should fully utilize these policies to enhance their own risk resistance capabilities.

4. Risk management and control strategy of manufacturing accounts receivable

In view of the characteristics and causes of accounts receivable risks in the manufacturing industry, combined with the latest policy environment, small and medium-sized enterprises in the manufacturing industry should build a whole-process and systematic risk control system, covering three links of pre-emptive prevention, in-process control and post-handling, so as to effectively reduce bad debt risks and improve the efficiency of capital use.

4.1 Proactive Prevention Mechanisms

Proactive prevention serves as the first line of defense in accounts receivable risk management, aiming to reduce the probability of risks at their source. Small and medium-sized manufacturing enterprises should establish the following preventive mechanisms: Establish a customer credit evaluation system: Companies should maintain comprehensive customer credit profiles and conduct credit ratings based on financial status, historical payment records, and industry reputation. For instance, an electronic component supplier implemented an automated credit rating system through a risk control platform, reducing the average payment cycle from 90 days to 45 days. For customers with lower credit ratings, measures such as advance payments, shortened payment terms, or transaction rejection may be adopted. Improve contract management systems: Before signing contracts, carefully review terms to ensure clear and unambiguous provisions regarding payment conditions, payment cycles, and liability for breach. Special attention should be paid to avoiding hidden risk clauses like “back-to-back clauses” that require third-party payments as payment conditions. Contracts must explicitly specify penalty interest rates for overdue payments. According to the Regulations, overdue interest rates must not be lower than the one-year Loan Prime Rate (LPR) at the time of contract execution. If no agreement exists, a daily interest rate of 0.05% (approximately 18.25% annual) shall apply. Develop reasonable credit policies: Formulate differentiated credit policies based on customer credit ratings and transaction history. Provide moderately lenient credit terms for high-quality clients while requiring advance payments or guarantees for riskier customers. An electronic components enterprise successfully reduced the DSO (days of receivables turnover) from 75 days to 43 days by setting the account period and advance payment ratio according to the annual purchase amount of customers through dynamic account period strategy.

4.2 In-process control mechanisms

The system monitors the entire accounts receivable lifecycle to promptly identify and address anomalies, preventing risk escalation. Key measures include: 1) Age analysis and early warning: Establishing an aging analysis framework for accounts receivable, conducting regular classification and risk assessments. Hubei Liantou's proprietary accounts receivable management system automatically identifies overdue payments through predefined rules, calculates delinquency days, generates risk lists and aging reports, achieving 95% real-time alert accuracy. This intelligent system enables proactive risk detection and timely collection actions. 2) Enhanced tracking: Implementing standardized processes with automatic reminders before payment deadlines and scheduled follow-ups post-overdue. A fast-moving consumer goods company achieved a 40% improvement in overdue payment recovery rates through this system. Manufacturing enterprises can implement tiered tracking mechanisms: sales personnel handle overdue amounts within 7 days, finance departments intervene after 15 days, and legal teams manage cases exceeding 30 days. 3) Strengthened collaboration and performance metrics: Linking accounts receivable management to departmental performance incentives encourages staff to prioritize client creditworthiness and repayment prospects during order processing. Improved communication between finance and sales departments ensures seamless information flow. After integrating the system, a logistics company successfully alerted five partners about potential cash flow crises, preventing losses exceeding 10 million yuan.

4.3 Post-incident handling mechanism

When the accounts receivable are overdue or face the risk of bad debts, active and effective disposal measures should be taken to minimize losses :

Implement a tiered collection process: Tailor measures to overdue duration and amount. Initial steps may include friendly reminders via phone or email; formal collection letters for mid-term cases; and professional agency involvement or legal action for advanced stages. Throughout the process, maintain proper documentation of evidence to prepare for potential litigation.

Leverage financial instruments flexibly: Actively explore accounts receivable financing channels such as factoring services and accounts receivable pledge financing to convert receivables into cash flow. According to the “Notice on Regulating Supply Chain Finance Business”, commercial banks should enhance the quality and efficiency of accounts receivable financing services, supporting supply chain enterprises—especially SMEs—to obtain credit loans and pledge financing based on orders, inventory, warehouse receipts, and other movable assets and rights. Additionally, credit insurance can be utilized to transfer bad debt risks. When buyers go bankrupt or default for extended periods, insurance companies will compensate for accounts receivable losses according to agreed ratios.

Legal Rights Protection: Enterprises may fully exercise their rights under regulations such as the “Regulations” to report serious payment defaults to relevant authorities or even initiate legal proceedings. The Regulations stipulate that when policies for safeguarding SMEs’ payment rights are inadequately implemented, progress is insufficient, or severe defaults occur, authorities may take measures including written inquiries, interviews, and official notifications. In cases involving severe default scenarios or significant negative social impacts, necessary restrictive measures may also be imposed on defaulting parties.

4.4 Empowerment through digital transformation

The application of digital tools can significantly enhance accounts receivable management efficiency, serving as a crucial direction for modern enterprises’ risk control. Manufacturing SMEs should consider implementing accounts receivable management systems to achieve digital and intelligent process optimization: Automated reconciliation and reminders: The system automatically generates statements to reduce manual errors while setting up automatic alerts to notify clients in advance. After implementing the digital system, a logistics company saw a 62% decrease in overdue payments and an 80% reduction in reconciliation time. Data integration and analysis: By consolidating customer data, transaction records, and payment information through the system, comprehensive data analysis is achieved to support management decisions. Hubei Liantou’s accounts receivable management system has established a “meridian network” for payment information, enabling real-time synchronization between ledger management and financial processing. Risk prediction and visualization: AI and big data technologies predict customer default probabilities, with visual dashboards displaying account receivable status in real time. An electronic component supplier introduced a risk control platform, where automated alerts reduced overdue payments by 28%.

Table 3: Manufacturing accounts receivable whole process control strategy

Management stage	Core measures	Expected accomplishments
Preventive measures	Customer credit evaluation, contract review, credit policy formulation	Reduce bad debt risk and overdue ratio from the source
in-process control	Accountage analysis, early warning mechanism, departmental cooperation assessment	Detect and handle anomalies in time to prevent risks from expanding
Post-incident disposal	Graded collection, application of financial instruments, legal rights protection	Accelerate the recovery of funds and reduce bad debt losses
Digital transformation	Digital transformation	Improve management efficiency and strengthen risk early warning capacity

5. Case application

Risk control practice of a manufacturing enterprise In order to more specifically illustrate the implementation path and effect of accounts receivable risk control in small and medium-sized manufacturing enterprises, this part analyzes the successful experience of accounts receivable management based on the actual case of a manufacturing enterprise.

5.1 Case background

A specialized equipment manufacturer (hereinafter referred to as “Company A”) specializes in industrial automation systems, serving clients across automotive, electronics, and home appliance industries. With rapid business expansion, the company has experienced continuous growth in accounts receivable, with an average payment collection period exceeding 90 days and a DSO (Days on Account) of 75 days – significantly higher than industry averages. Over 20% of receivables are overdue, exacerbating bad debt risks and intensifying cash flow pressures. Through comprehensive analysis, Company A identified critical weaknesses in its accounts receivable management: (1) Inadequate customer credit evaluation, resulting in neglect of qualification reviews for order acquisition; (2) Non-standard contract management with ambiguous payment terms and insufficient default clauses.

The collection mechanism is not perfect, the responsibilities of departments are unclear, and the collection is not timely; (4) the information is not transparent, the manual accounting is relied on, and the data lags behind seriously.

5.2 Risk control implementation plan

To address these challenges, Company A implemented a comprehensive accounts receivable risk management reform by leveraging industry best practices: 1. Credit Management System: The company introduced a digital risk control platform with customer credit profiles and rating systems. Customers are classified into three tiers (A, B, C) based on financial data, payment history, and industry evaluations, each receiving tailored credit policies. Tier A premium clients enjoy 60-day payment terms with credit limits, Tier B standard clients receive 30-day terms requiring partial upfront payments, while Tier C high-risk clients must provide full prepayments or guarantees. After six months, the proportion of transactions with high-risk clients decreased by 15%, with average payment cycles shortened to 60 days. 2. Contract & Process Optimization: Company A revised standard contract templates to specify critical clauses including payment terms, billing cycles, and default penalties. A key clause explicitly states: “Payment obligations under this contract remain independent of any third-party agreements and are not contingent upon receiving prior payments,” effectively eliminating risks associated with “back-to-back clauses.” An AI-powered contract management system automatically extracts key terms and triggers reminders to ensure compliance. 3. Multi-Stage Collection Mechanism: The company established a three-phase collection process: 1) Automated payment reminders issued 3 days before due dates; 2) Phone follow-ups by sales representatives within 7 days of default; 3) Formal collection letters from finance departments for defaults exceeding 15 days, with escalation to legal teams for cases over 30 days overdue. Meanwhile, linking payment collection rates to sales team performance incentivizes business personnel to prioritize accounts receivable recovery. Fourth, implementing digital transformation. Company A has adopted an intelligent accounts receivable management system that achieves full-process digitalization from order placement to payment collection. The system automatically generates statements, aging analysis reports, and risk alerts, significantly enhancing operational efficiency. Through real-time dashboard visualization, management can monitor accounts receivable status and make timely decisions. Additionally, the system integrates with third-party databases to help monitor client operational anomalies and identify potential risks proactively.

5.3 Impact assessment of implementation

Through implementing comprehensive accounts receivable risk management measures, Company A has achieved significant improvements in its accounts receivable status: Improved capital efficiency: The accounts receivable turnover days decreased from 75 to 43 days, a reduction of 42.7% and approaching industry-leading levels. Reduced bad debt risk: The overdue accounts ratio dropped from over 20% to below 5%, with bad debt losses decreasing by 70%. Enhanced management efficiency: Accounts receivable reconciliation time was shortened by 80%, collection costs reduced by 50%, freeing up more resources for core operations. Improved cash flow: Net operating cash flow turned positive, effectively alleviating financial pressure and reducing financing needs. Company A’s case demonstrates that small and medium-sized manufacturing enterprises can effectively mitigate bad debt risks, improve cash flow conditions, and enhance overall operational efficiency by establishing systematic accounts receivable risk control systems. Its successful experience provides valuable references for similar enterprises. 6. Conclusion and Outlook Accounts receivable risk management for small and medium-sized manufacturing enterprises is a systematic project involving multiple aspects of enterprise management,

requiring coordinated advancement across three dimensions: philosophy, systems, and technology. This paper analyzes the characteristics and causes of accounts receivable risks in manufacturing industries, combines them with the latest policy environment to construct a full-process risk control system, and validates its effectiveness through practical case studies. Research findings indicate that SMEs in the manufacturing sector should prioritize four key aspects for accounts receivable risk management: First, strengthen preventive measures by establishing scientific credit evaluation systems and contract management protocols to control risks at their source. Second, enhance real-time monitoring through aging analysis, early warning mechanisms, and interdepartmental collaboration to promptly identify and address risks. Third, employ diversified approaches including debt collection strategies, financial instruments, and legal actions to minimize bad debt losses. Finally, accelerate digital transformation to leverage technology-driven improvements in operational efficiency and risk forecasting capabilities. Notably, with the implementation of policies like the “Regulations on Ensuring Payment of Accounts Receivable by Small and Medium Enterprises,” the legal framework protecting SMEs’ accounts receivable rights has been continuously strengthened. Manufacturing SMEs should fully capitalize on these policy benefits to boost their risk resilience. Meanwhile, as supply chain finance regulations become more standardized, the accounts receivable financing environment will further optimize, providing SMEs with diversified funding solutions. Looking ahead, advancements in digital technologies will enable smarter and more precise accounts receivable management. Technologies such as big data, AI, and blockchain can help enterprises build efficient and transparent management systems. Blockchain enables full traceability of accounts receivable ownership and transactions, preventing tampering and disputes. AI models can predict customer default probabilities with greater accuracy, enabling more effective risk alerts. In summary, strengthening accounts receivable risk control is essential for the stable operations and sustainable development of manufacturing SMEs. By building a whole-process risk control system and making full use of policy support and digital technology, small and medium-sized manufacturing enterprises can effectively respond to the risks and challenges of accounts receivable, improve the efficiency of capital use, and lay a solid foundation for enterprises to win competitive advantages in the complex market environment.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Huang, J. (2024). Enterprise accounts receivable management status and causes and countermeasures. *China Market*, (08).
- [2] Zhu, Z. (2024). Risk control in the context of enterprise accounts receivable management path. *Accounting Learning*, (13).
- [3] Zhang, W., Lv, Z., Shi, H., & Li, L. (2024). Blockchain-enabled enterprise financial sharing model: Accounts receivable management. *Journal of Xidian University (Social Science Edition)*, (01).
- [4] Wei, Q. (2024). Enterprise accounts receivable management problems and countermeasures. *Business 2.0*, (25).

The Impact of Corporate Governance and Internal Control on Accounting Information Disclosure: Evidence from the Textile Industry

Chenxi Cao*

College of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710000, China

**Corresponding author: Chenxi Cao*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Against the backdrop of global economic transformation, the textile industry, a traditional pillar sector in many economies, faces immense pressure to upgrade. High-quality accounting information disclosure is fundamental for efficient capital allocation and investor protection. This paper investigates the joint impact of corporate governance and internal control mechanisms on the quality of accounting information disclosure, with a specific focus on listed companies in the textile industry. Grounded in Agency Theory, Information Asymmetry Theory, and Signalling Theory, this study constructs an analytical framework to dissect the interplay between corporate governance structures (ownership concentration, board characteristics, executive incentives) and internal control effectiveness. Through a critical analysis of the textile industry's unique characteristics—such as overcapacity, intense competition, high inventory risk, and environmental pressures—the paper identifies inherent vulnerabilities that may lead to earnings management and selective disclosure. The findings reveal that robust corporate governance, characterized by effective board oversight and appropriate incentive alignment, coupled with a well-designed and implemented internal control system, serves as a dual defense line for enhancing information transparency. The study concludes with targeted recommendations for textile firms, including optimizing ownership structures, strengthening board independence, refining internal control over key business cycles (e.g., inventory and revenue recognition), and adapting external regulatory frameworks to industry specifics. This research provides valuable theoretical insights and practical guidance for regulators and corporate managers aiming to foster transparency and sustainable development within the textile sector.

Keywords: Corporate Governance; Internal Control; Accounting Information Disclosure; Information Quality; Textile Industry; Listed Companies

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.813>

1.Introduction

Accounting information disclosure is a cornerstone of modern capital markets, serving as the primary channel through which firms communicate their financial performance and operational status to external stakeholders (Healy & Palepu, 2001). The quality of this disclosure directly influences market efficiency, investment decisions, and corporate valuation. However, recurring financial scandals worldwide underscore persistent deficiencies in internal governance and control mechanisms, eroding market confidence.

The textile industry represents a critical sector in the global manufacturing landscape, renowned for its significant contributions to employment, export revenues, and economic development, particularly in emerging economies. Despite its importance, the industry is fraught with challenges, including fierce price competition, overcapacity, thin profit margins, and increasing environmental and social governance (ESG) scrutiny. This operating environment creates substantial performance pressure on listed textile companies, potentially incentivizing managerial opportunism, such as earnings manipulation and the withholding of unfavorable information.

The intrinsic characteristics of the textile industry—such as high inventory volatility, complex global supply chains, and substantial investment in sustainability and technological upgrades—add layers of complexity to financial reporting. These factors make the industry a compelling context for examining the determinants of disclosure quality. While extensive literature has explored the relationship between corporate governance, internal control, and information disclosure in a general context, industry-specific studies, particularly on traditional manufacturing sectors like textiles, remain relatively scarce.

This paper aims to fill this gap by conducting a focused analysis of how corporate governance and internal control jointly shape the accounting information disclosure practices of textile listed companies. By integrating established theoretical frameworks with the industry's practical realities, this study seeks to provide a nuanced understanding of the mechanisms at play. The insights generated are expected to assist textile firms in strengthening their internal governance, enhance regulatory effectiveness, and ultimately, contribute to building a more transparent and resilient industry.

2. Theoretical Framework and Literature Review

2.1 Theoretical Foundation

Agency Theory: This theory posits a conflict of interest between managers (agents) and shareholders (principals) due to the separation of ownership and control (Jensen & Meckling, 1976). Managers may prioritize personal gains (e.g., bonuses, job security) over shareholder wealth maximization, leading to actions that distort accounting information. Effective corporate governance and internal controls are mechanisms designed to monitor and align managerial behavior with owner interests, thereby promoting transparent disclosure.

Information Asymmetry Theory: Managers inherently possess superior information about the company's prospects compared to outside investors. This imbalance can lead to adverse selection and moral hazard. High-quality disclosure is the primary tool for mitigating this asymmetry, and robust internal systems are the guarantors of the information's reliability.

Signalling Theory: In an environment of information asymmetry, high-quality firms have an incentive to signal their superior status to the market through more transparent and timely disclosure (Spence, 1973). Consequently, strong corporate governance and effective internal controls can themselves be powerful signals of firm quality and integrity.

2.2 Literature Review

2.2.1 Corporate Governance and Disclosure Quality

A substantial body of research confirms the pivotal role of corporate governance in ensuring high-quality information disclosure.

Ownership Structure: Moderate ownership concentration, particularly the presence of institutional investors or blockholders, can provide effective monitoring of management, thereby improving disclosure quality. However, excessive concentration may lead to “tunneling” and the expropriation of minority shareholders, resulting in opaque information practices.

Board of Directors: The independence and expertise of the board are critical. A higher proportion of independent directors and a competent audit committee are consistently associated with stronger oversight of the financial reporting process and a reduction in financial misstatement (Beasley, 1996). Board financial expertise and meeting frequency are also positively correlated with disclosure quality.

Executive Incentives: Compensation structures that tie executive wealth to long-term firm value (e.g., through stock options) can reduce the incentive for short-term earnings management and encourage more truthful disclosure.

2.2.2 Internal Control and Disclosure Quality

Internal control is a process designed to provide reasonable assurance regarding the reliability of financial reporting. The

Sarbanes-Oxley Act (2002) significantly elevated the importance of internal controls worldwide.

Empirical studies demonstrate that material weaknesses in internal control are strongly associated with lower earnings quality and a higher incidence of accounting restatements (Doyle et al., 2007). An effective internal control system directly enhances the accuracy and completeness of financial data at its source, throughout the generation, processing, and reporting cycles.

2.2.3 The Interplay of Governance and Control

Corporate governance and internal control are not independent; they are deeply intertwined. The board of directors, especially the audit committee, sets the “tone at the top” and is responsible for the oversight of the internal control system. In turn, a robust internal control system provides the board with reliable information to fulfill its monitoring duties. They form a synergistic “Dual Defense Line” that safeguards the quality of accounting information.

3. The Textile Industry Context and Its Implications for Disclosure

The specific attributes of the textile industry present unique risks for accounting information disclosure:

Performance Pressure and Earnings Management: Low entry barriers and product homogenization lead to brutal price competition and slim profit margins. This intense pressure increases the temptation for management to engage in earnings management to meet market expectations, for instance, through aggressive revenue recognition or manipulation of provision estimates.

Inventory and Asset Impairment Risks: The seasonality and fast-changing trends in fashion result in high risks of inventory obsolescence and price declines. The valuation of inventory and the timing of impairment losses are areas susceptible to managerial judgment and potential manipulation.

Environmental and Social Disclosure: The dyeing and finishing segments face stringent environmental regulations. Disclosure of environmental penalties, investments, and compliance is highly sensitive. Companies may have incentives to conceal or downplay negative environmental information (“greenwashing”).

Supply Chain Complexity and Related-Party Transactions: The long and fragmented supply chain creates numerous opportunities for related-party transactions. Ensuring the fairness of these transactions and their transparent disclosure is a significant challenge.

Accounting for Transformation Costs: Investments in automation, R&D for new materials, and brand building involve significant costs. The accounting treatment of these items—particularly the capitalization vs. expensing of R&D costs—requires complex judgments, increasing the scope for subjective and potentially misleading reporting.

4. Case Analysis: A Representative Scenario

Consider a hypothetical, yet representative, listed textile company, “TextileCo.” Facing declining profits due to market oversupply, TextileCo is under pressure to secure a bank loan.

Weak Governance/Control Scenario: TextileCo has a dominant controlling shareholder who also serves as the CEO. The board is passive, with a weak audit committee. Internal controls over inventory management are lax. To inflate profits and secure the loan, management might: 1) Overstate inventory value by delaying write-downs for obsolete fabrics. 2) Accelerate revenue recognition by recording sales upon shipment to distributors, even if terms include a right of return. The weak board fails to challenge these practices, and the internal control system does not flag the deviations from accounting standards. The resulting financial statements present a misleadingly healthy picture.

Strong Governance/Control Scenario: TextileCo has a diversified ownership structure with an active institutional investor. Its board has a majority of independent directors, and the audit committee includes a financial expert. The company has a robust ERP system and clear policies for inventory valuation and revenue recognition. When management faces the same performance pressure, the strong control environment prevents the initiation of fraudulent reporting. The audit committee would scrutinize any proposed aggressive accounting treatments. The internal control system would require rigorous inventory aging reports and enforce strict revenue recognition criteria based on actual transfer of control. Consequently, the disclosed financial information, while perhaps reflecting poor short-term performance, would be accurate and reliable, building long-term credibility.

5. Conclusion and Implications

This study establishes that the quality of accounting information disclosure in the textile industry is not an isolated outcome but the result of a synergistic relationship between sound corporate governance and effective internal control. The industry's specific challenges amplify the need for these robust internal mechanisms.

5.1 Theoretical and Practical Implications

Theoretically, this paper enriches the existing literature by applying and contextualizing agency and signalling theories within the distinct operational reality of the textile sector. Practically, it offers a clear roadmap for practitioners:

For Companies: Textile firms should prioritize board independence and expertise, particularly in the audit committee. Executive compensation should be linked to long-term, sustainable performance metrics. Internally, controls must be strengthened over high-risk areas like inventory management, revenue cycles, and impairment testing.

For Regulators and Standard-Setters: Regulators should consider issuing industry-specific disclosure guidance for textiles, mandating clearer reporting on inventory risk, environmental compliance, and supply chain concentration. This would enhance comparability and transparency across the sector.

5.2 Limitations and Future Research

This study is primarily conceptual and based on a hypothetical analysis. Future research could employ large-scale empirical methods to quantitatively test the relationships proposed here across a global sample of textile firms. Furthermore, as ESG factors become increasingly critical, a promising avenue for future research would be to explore the interplay between corporate governance, internal control, and the quality of non-financial (ESG) disclosure within the textile industry.

In conclusion, for listed textile companies navigating a complex and competitive landscape, investing in superior corporate governance and internal controls is not merely a regulatory compliance issue but a strategic imperative for building trust, ensuring sustainable access to capital, and achieving long-term competitiveness.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Beasley, M. S. (1996). An empirical analysis of the relation between the board of director composition and financial statement fraud. *The Accounting Review*, 71(4), 443-465.
- [2] Doyle, J., Ge, W., & McVay, S. (2007). Determinants of weaknesses in internal control over financial reporting. *Journal of Accounting and Economics*, 44(1-2), 193-223.
- [3] Healy, P. M., & Palepu, K. G. (2001). Information asymmetry, corporate disclosure, and the capital markets: A review of the empirical disclosure literature. *Journal of Accounting and Economics*, 31(1-3), 405-440.
- [4] Jensen, M. C., & Meckling, W. H. (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, 3(4), 305-360.
- [5] Spence, M. (1973). Job market signaling. *The Quarterly Journal of Economics*, 87(3), 355-374.

Do Environmentally Conscious Executives Truly Promote Corporate Green Technology Innovation?—From the Perspective of Governance Pressure and Signaling

Yihang Tu*

School of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710600, China

*Corresponding author: Yihang Tu, 16639628625@163.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Combining higher-order theory and signaling theory, this study selects A-share listed companies from 2012 to 2022 as research subjects to empirically examine the intrinsic relationship between top management teams' environmental backgrounds and corporate green technology innovation. From the perspectives of governance pressure and resource-based view, the boundary conditions of this relationship are further explored. The findings reveal: (1) Top management teams' environmental backgrounds have a significantly positive impact on corporate green technology innovation. (2) Public environmental concern, analyst attention, corporate social responsibility information quality, and corporate social status all positively moderate the relationship between top management teams' environmental backgrounds and corporate green technology innovation. (3) In state-owned enterprises, the enhancing effect of top management teams' environmental backgrounds on green technology innovation is more pronounced compared to non-state-owned enterprises.

Keywords: Executive Environmental Background; Green Technology Innovation; Governance Pressure; Signaling

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.814>

1.Introduction

In the report of the 20th National Congress of the Communist Party of China, the concept of “promoting green development and achieving harmonious coexistence between humans and nature” was emphasized. In a market economy system, enterprises, as core participants, play a crucial role in promoting overall green development through their green innovation practices. Specifically, green technology innovation refers to a series of corporate behaviors aimed at reducing environmental pollution and opening up emerging market opportunities through technological and product innovation methods^[1]. Green technology innovation at the enterprise level constitutes a key path for promoting sustainable economic and social development and high-quality progress^[2]. It can not only promote the leap of enterprise transformation and upgrading, but also have a significant promoting effect on the achievement of the national goals of “carbon peak and carbon neutrality”^[3]. And further became the core driving force behind the global trend of green development. Given this, it is particularly important to explore effective strategies to motivate enterprises to implement green innovation activities.

Currently, research on the preconditions for the effectiveness of green technology innovation in enterprises mostly focuses on external dimensions, including institutional environment, market dynamics, and pressure exerted by stakeholders. In fact, compared to traditional technological innovation, green technological innovation represents a deep innovation of existing

technologies, which is more complex, expensive, and covers a wider range of knowledge systems. Therefore, relying solely on external forces to drive the green innovation process of enterprises may limit their effectiveness and make it difficult to fully guarantee their sustainable development^[4]. More importantly, enterprises need to start from within, implement green concepts from top to bottom, attach importance to the allocation of green resources, and provide strong support for green technology innovation activities, especially in key decisions and action plans. According to high-order theory, as the leader and promoter of enterprise development, if the senior management team of a company has an “environmental background”, it is highly likely to have a profound and comprehensive promoting effect on green technology innovation activities^[5]. Based on this, we speculate that senior management teams with environmental backgrounds demonstrate stronger willingness for green technology innovation. They value the long-term development and green transformation issues of the enterprise, and will provide solid support for the enterprise to carry out green technology innovation activities from multiple dimensions such as strategic planning, supply chain optimization, research and development activities, and production processes through decision-making and resource allocation, which is conducive to improving the enterprise’s green technology innovation performance. Unfortunately, there have been few scholars in previous studies who have delved into the impact mechanism of the environmental preferences of senior management teams on the effectiveness of green technology innovation. This provides an opportunity for this study to further explore the above issues.

At present, there is still a lack of exploration in the field of green technology innovation for enterprises. From the perspective of driving factors, the promotion of green technology innovation in enterprises is not only closely related to the characteristics of managers themselves, but also inseparable from the pressure exerted by external stakeholders and the resource capabilities of the enterprise itself^[6]. According to higher-order theory, the diversity of personality traits among senior management not only shapes their management style, but also guides the determination of corporate strategic direction and the selection of management measures, thereby profoundly affecting the performance of the enterprise^[7]. However, to fully leverage this influence, it also relies on the synergistic effect of external supervision and governance mechanisms. In this context, the public and analysts, as important components of informal supervision mechanisms, can exert significant influence on multiple dimensions such as business operations, implementation of environmental protection measures, and performance improvement. In addition, based on the resource-based theory, enterprises have different tangible and intangible resources that can be transformed into unique capabilities. Resources are non transferable and difficult to replicate between enterprises, and these unique resources and capabilities are the source of sustained competitive advantage for enterprises. From the perspective of signal transmission, organizations with higher status have a stronger ability to acquire opportunities and intangible or tangible resources than those with lower status^[8]. At the same time, good corporate social responsibility performance strengthens the connection between the company and stakeholders, not only optimizing the company’s public image, but also promoting the improvement of employee skills and labor input, which is conducive to winning the recognition and support of stakeholders and laying a solid foundation for obtaining various resources needed for green innovation.

In summary, the willingness, resources, and opportunities of executives with environmental backgrounds to carry out green technology innovation play an important role in promoting the green transformation of enterprises. This article takes Chinese A-share listed companies from 2012 to 2022 as the research object, and empirically tests the relationship between the background of environmental executives and corporate green technology innovation. The contribution of this article is: (1) This study enriches the scope of exploration on the influencing factors at the managerial level in corporate green innovation. (2) In depth exploration of the boundary conditions under which executive characteristics affect corporate green technology innovation activities in the context of environmental protection aims to provide theoretical insights and inspirations for effectively utilizing managers’ environmental tendencies and reducing potential obstacles to corporate green innovation.

2. Literature review and research hypotheses

2.1 Environmental background and green technology innovation of the executive team

Based on high-order theory, multiple factors such as age, gender composition, professional experience, length of service, and educational background of senior management personnel in enterprises have a shaping effect on their personal value orientation, management skills, and management background characteristics^[7]. These characteristics further affect the

leadership style of managers, the choice of corporate strategic direction, and the final management decision-making process, thereby deeply influencing the overall performance of the enterprise. In other words, the diversity of personal characteristics of executives not only shapes their management style, but also determines the strategic positioning and management actions of the enterprise, ultimately having a profound impact on enterprise performance. Therefore, this article believes that the environmental background of the executive team is beneficial for improving the performance of green technology innovation in enterprises.

The environmental background of the executive team brings abundant green resources to the enterprise, formulates and maintains policies and systems conducive to green technology innovation, tilts towards green innovation in internal management, and effectively predicts and controls the uncertainty of green innovation. Executives with environmental experience can obtain scarce green resources in social organizations through their social status, providing more abundant social resource guarantees for green technology innovation in enterprises and improving their green technology innovation performance^[9]. Corporate executives with environmental experience have a higher level of attention to sustainability activities within the company^[10]. Having a higher understanding and awareness of green innovation can better promote corporate green technology innovation strategies; Executives with environmental experience will also assist core members of the company in recognizing the necessity of legality and ethical standards for business operations, promoting the company to actively optimize energy technology and implement green management strategies from a long-term perspective^[11]; Zhong Jiayi^[12] It is believed that executives with environmental experience are more likely to trigger personal social responsibility and care more about the interests of the general public. Compared to executives without environmental backgrounds, they have a greater moral responsibility to protect the environment and are more likely to firmly implement the company's environmental policies. In terms of internal management, we will increase investment in green technology innovation. Business leaders with environmental experience not only focus on the immediate benefits of the enterprise, but also on long-term sustainable development, actively promoting the adoption of environmental protection technologies and investing in green projects to ensure that the enterprise occupies a favorable position in future competition, while also having a positive impact on society and the environment^[13]. Executives with environmental experience can effectively anticipate and handle various uncertain factors in the process of corporate green innovation^[14]. In order to enhance the success probability of green innovation projects, especially in the rapidly changing market environment, enterprises need to respond quickly and timely launch services and products that meet environmental standards^[15]. At this point, executives with environmental experience can fully utilize their experience and knowledge to assist companies in more accurately grasping market opportunities and further promoting green innovation.

Based on the above analysis, this article proposes the following hypotheses:

The environmental background of the H1 executive team can promote the performance of green technology innovation in enterprises.

2.2 Impact from the perspective of external governance pressure

2.2.1 The regulatory effect of public environmental concern

With the continuous progress of Internet technology and information technology, the restriction effect of public supervision on the main activities in various fields of social economy is increasingly significant. The high level of public attention to environmental issues reflects their preference for environmental quality, which, as an informal means of environmental regulation, has a profound impact on stakeholders' corporate evaluations and behavioral choices. Based on this, the degree of public attention to environmental issues can be regarded as an indicator to measure the level of public participation in environmental governance.

According to reputation theory and stakeholder theory, in order to enhance their overall performance level, companies need to shape a positive corporate public image by implementing green technology innovation measures. In this process, enterprises also need to fully consider the high vigilance of the public, a key stakeholder group, towards environmental protection issues, in order to obtain their resource support in multiple dimensions such as commodity markets and capital markets^[16]. Therefore, the public's deep concern for corporate green behavior can effectively activate the reputation protection mechanism of

enterprises, thereby prompting them to take green actions and strengthen their product market competitiveness^[17], And ultimately promote the development of green technology innovation in enterprises.

Based on the above analysis, this article proposes the following hypotheses:

The positive regulation of H2 public environmental concerns is related to the relationship between the environmental background of executive teams and the performance of green technology innovation in enterprises.

2.2.2 Moderation effects of analysts' attention

The core responsibility of an analyst is to evaluate the current operational status of a company and predict its future development prospects based on this, with the aim of providing decision support and selection recommendations for investors^{[18][19]}. Through analyst reports, the company's green innovation achievements can convey positive information to various stakeholders, which helps to enhance the company's green brand image^[20], And alleviate the financial pressure it faces^[21]. Therefore, when the analyst's attention is high, the management's willingness to engage in green innovation activities will be significantly enhanced. From this perspective, the tracking activities of analysts can be seen as an efficient external supervision mechanism that can focus public attention on the green innovation practices of enterprises, thereby incentivizing enterprises from an external perspective to carry out more green innovation activities in order to maintain a good reputation and social image, thereby improving the effectiveness of green innovation.

Based on the above analysis, this article proposes the following hypotheses:

H3 analysts focus on positively regulating the relationship between the environmental background of executive teams and the performance of green technology innovation in enterprises.

2.3 Impact based on signal transmission perspective

2.3.1 The moderating effect of corporate social responsibility information quality

From an essential perspective, corporate social responsibility is not only a core concept that drives companies towards sustainable development goals, but also deeply rooted in their strategic planning and governance practices. Based on this, if enterprises can actively fulfill their social responsibilities, they will be able to effectively respond to the diverse social needs of stakeholders in operational management. In the initial stage of investors making investment decisions, the return on investment of a company becomes a key factor that they must carefully evaluate. According to the theory of signal transmission, a positive corporate image can release positive signals to stakeholders, thereby helping companies to more smoothly obtain various resources necessary for promoting green innovation from stakeholders^[22], Furthermore, to a certain extent, it can alleviate the funding pressure faced by enterprises when carrying out high-risk green innovation activities^[23]. Compared to other companies, those with higher quality of social responsibility information disclosure have established a more harmonious relationship with investors, and investors therefore prefer companies that actively undertake social responsibility and seek green technology innovation, hoping that they can achieve more breakthroughs in the field of green technology.

Based on the above analysis, this article proposes the following hypotheses:

The positive moderating effect of H4 corporate social responsibility information quality on the relationship between the environmental background of executive teams and the performance of green technology innovation in enterprises.

2.3.2 The regulatory role of corporate social status

Merton (1987)^[24] The study suggests that high status enterprises have better external performance and reputation in the social system, and also transmit signals of high-quality products or behaviors. This means that high status enterprises may have a potential guarantee and reputation mechanism, which makes them more likely to meet the expectations of green investors and relevant departments, thereby enhancing the confidence of these departments or investors in high status enterprises to carry out green technology innovation, and thus more likely to receive richer support^[25].

Based on the above analysis, this article proposes the following hypotheses:

The positive adjustment of H5 corporate social status moderates the relationship between the environmental background of the executive team and the performance of corporate green technology innovation.

3. Research Design

3.1 Research Samples and Data Collection

This article selects all A-share listed companies in China from 2013 to 2022 as the research sample. To ensure the credibility and accuracy of research conclusions, we draw on the practices of existing literature^{[26][27]}. We have excluded the financial and real estate industries, ST and * ST companies with abnormal operations, and sample companies with severe data loss from this article. The data on the characteristics of corporate executives mainly comes from the Guotai An Financial Database (CSMAR), the variable data of corporate green technology innovation is obtained through the CNRDS (China Research Data Service Platform) database, the public environmental concern data comes from the search index disclosed on the Baidu website, and the social responsibility information data is obtained through the social responsibility research database in the Guotai An database and manually collected and organized. After matching the above data and filtering and processing the data, we finally obtained 28855 annual enterprise level observations. In order to ensure the accuracy of regression analysis and avoid extreme values interfering with the results, this study adopted tail truncation, which means truncating all continuous variables at the 1% and 99% quantiles. In the further moderation effect testing stage, in order to improve the stability and explanatory power of the model, we implemented decentralized processing on the explanatory and moderating variables to ensure the accuracy and reliability of the analysis results.

3.2 Model Design

This article establishes model (1) to test H1, and introduces moderating variable interaction terms based on equation (1) to test H2-H5.

$$GTI_{i,t} = \alpha_0 + \alpha_1 \text{Environ ratio}_{i,t} + \alpha_2 \text{Controls} + e_{i,t} \quad (1)$$

Among them, *i* and *t* represent the enterprise and year respectively, and *ei* and *t* are random interference terms.

3.3 Variable measurement

3.3.1 Explained variable: Green Technology Innovation (GTI).

Regarding the measurement of green technology innovation performance, draw inspiration from Zhao Shukuan et al^[28], This article uses the number of green patent applications to characterize the performance of green technology innovation. Patent data reflects the results of innovative activities and demonstrates the value of innovation. In addition, patent application data has high stability and reliability, which meets the needs of this study.

3.3.2 Core explanatory variable: Environmental background of the executive team.

Refer to Han Zhongxue and others^[29] And Kang Zhanjia and others^[30], If any of the following information is disclosed in the work experience column of the executive resume, it is considered an environmentally friendly executive: environmental protection, green, sustainable, low-carbon, energy-saving, new energy. The measurement standard for the environmental background of the executive team is the ratio of the number of executives with environmental backgrounds to the total number of executives in the executive team.

3.3.3 Adjusting Variables

(1) Public Environmental Attention: Based on Domestic and Foreign Literature Zheng et al^[31] Zheng Siqi and others^[32], This study used search data from residents in Baidu Index for specific environmental related keywords to construct an indicator system for measuring public environmental attention. The specific implementation steps are as follows: Firstly, using the Baidu search engine platform, targeting the keywords “environmental pollution” and “haze”, from 2012 to 2022, the average daily search frequency of various cities across the country will be captured through Python programming tools. Subsequently, these search frequencies were accumulated and their natural logarithm was taken by adding 1 to the total sum, as a substitute variable for measuring the level of public attention to environmental issues in each city.

(2) Analyst Focus: Measured by the natural logarithm of the number of analysts tracked plus one.

(3) Quality of Corporate Social Responsibility Information: Refer to Zou Ping^[33], In this study, we specifically selected the following twelve items from the “Basic Information Table of Social Responsibility Reports of Listed Companies” in the social responsibility research sub database of Guotai An Database as the core indicators for evaluating the quality of corporate social responsibility information: third-party institution verification, compliance with GRI’s “Sustainable Development

Reporting Guidelines”, disclosure of shareholder rights protection, disclosure of creditor rights protection, disclosure of employee rights protection information, disclosure of supplier rights protection, disclosure of customer and consumer rights protection, disclosure of environmental and sustainable development information, transparency of public relations and social welfare undertakings, disclosure of social responsibility system construction and improvement measures, disclosure of safety production information, and disclosure of existing problems of the company.

To quantify these standards, we use binary assignment method, which assigns a value of 1 to each of the above indicators if the enterprise meets or has disclosed them, and a value of 0 if not. Subsequently, we calculated the total score of each company on the twelve indicators mentioned above, with a score range between 0 and 12 points. For the convenience of subsequent data analysis and research, we will divide the total score by 12 for standardization, and the result obtained is the quantitative indicator of Corporate Social Responsibility Information Quality (CSRQUA). The higher the value of this indicator, the better the quality of the company’s social responsibility information.

(4) Corporate Social Status: Reference to Jiang Fuxiu and Liu Zhibiao^[34], This article uses the Herfindahl index to measure the level of competition in the product market, which also reflects its relative market position at the enterprise level (referred to as Market-Position i, t). Specifically, the higher the value of Market-Position i, t , the lower the level of competition in the product market, reflecting the more significant the enterprise’s advantageous position in the market. The detailed calculation method is described as follows:

$$Market_Position_{it} = (X_{it}/X)$$

Where X_i is the annual total operating revenue of enterprise i , and X is the sum of the annual total operating revenue of all enterprises in the industry.

3.3.4 Control variables

Total asset turnover ratio (ATO): operating revenue/average total assets; Growth rate of operating revenue: (amount of operating revenue in the current period - amount of operating revenue in the same period last year)/(amount of operating revenue in the same period last year); Management Expense Rate (MR): Management expenses/total assets; Asset liability ratio (Lev): total liabilities/total assets; Return on Assets (ROA): Net profit divided by total asset balance

4. Empirical analysis

4.1 Descriptive statistics

The descriptive statistical results are shown in Table 1. The preliminary results indicate that the standard deviation of the main explanatory variable, Green Technology Innovation (GTI), is greater than the mean, indicating significant differences in the level of green innovation among enterprises and the need for improvement in the degree of green innovation. The mean, standard deviation, maximum, and minimum values of the explanatory variable for the environmental background of the executive team are 0.034, 0.069, 0.4, and 0, respectively, indicating that there are significant differences in the number of executives with environmental backgrounds in each company’s executive team, and the proportion of executives with environmental backgrounds in the company’s executive team is relatively low.

Table 1 Descriptive Statistics

variable	sample size	mean	Std. Dev	minimum	maximum
GTI	28855	0.364	0.774	0	3.664
ER	28855	0.034	0.069	0	0.4
MP	28855	0.285	1.418	0	11.878
BI	28855	249.206	227.196	9.817	1147.888
CSRQUA	28855	0.472	0.238	0	0.833
Analyst	28855	1.306	1.185	0	3.784
LEV	28855	0.406	0.203	0.054	0.915
ROA	28855	0.037	0.067	-0.286	0.206

variable	sample size	mean	Std. Dev	minimum	maximum
ATO	28855	0.651	0.433	0.079	2.639
Growth	28855	0.159	0.387	-0.558	2.378
MR	28855	0.089	0.072	0.008	0.449

4.2 Regression analysis

4.2.1 Environmental background and green technology innovation of the executive team

Table 2 Model 1 examines the impact of explanatory variables on green technology innovation. According to Model 1 in Table 3, it can be seen that the environmental background of the executive team has a positive impact on green technology innovation, with a coefficient of 1.551, which is significant at the 1% level. Hypothesis H1 has been validated.

Table 2: Environmental Background and Green Technology Innovation of the Executive Team

GTI	
(1)	
ER	1.551*** (23.703)
Growth	-0.033*** (-2.735)
ATO	-0.058*** (-4.878)
ROA	0.914*** (11.597)
Lev	0.470*** (18.522)
MR	-0.489*** (-6.755)
_cons	0.172*** (9.825)
N	28855
R ²	0.040
F	202.026

***p<0.01, **p<0.05, *p<0.1

4.2.2 Public Environmental Concerns

The results in Table 3 show that the regression coefficients of the interaction term between the environmental background of the executive team and the public environmental concern are 1.592 and 0.002, respectively, with the same sign and significant at the 1% level. This indicates that public environmental concern has a moderating effect and positively moderates the relationship between the environmental background of the executive team and green technology innovation, and H2 has been validated.

4.2.3 Analyst Focus

The results of Model (2) in Table 3 indicate that analyst attention has a positive moderating effect on the relationship between the environmental background of the executive team and green technology innovation, supporting H3.

4.2.4 Disclosure of Social Responsibility Information

The results of Model (3) in Table 3 indicate that the higher the quality of corporate social responsibility information disclosure, the stronger the promotion effect of the environmental background of the executive team on green technology innovation, supporting H4.

4.2.5 Corporate Social Status

The results of Model (4) in Table 3 indicate that the regression coefficients of the interaction term between the environmental background of the executive team and the social status of the enterprise are significant at the 1% level. The higher the social status of the enterprise, the more favorable it is for executives with environmental backgrounds to promote green technology innovation. H5 has been validated.

Table 3 Adjustment Effect Test

	GTI			
	(1)	(2)	(3)	(4)
ER	1.592***(24.270)	1.568***(24.239)	1.507***(23.002)	1.581***(24.074)
BI	0.000***(6.915)			
ANALYST		0.103***(25.694)		
CSRQUA			0.257***(13.413)	
MP				0.023***(6.986)
ER*BI	0.002***(5.581)			
ER*ANALYST		0.308***(5.690)		
ER*CSRQUA			0.887***(3.214)	
ER*MP				0.197***(3.173)
Lev	0.464***(18.267)	0.398***(15.778)	0.459***(18.121)	0.455***(17.834)
ROA	0.889***(11.290)	0.233***(2.834)	0.879***(11.191)	0.892***(11.328)
ATO	-0.058***(-4.871)	-0.065***(-5.549)	-0.051***(-4.316)	-0.063***(-5.326)
Growth	-0.036***(-2.967)	-0.052***(-4.327)	-0.026***(-2.180)	-0.032***(-2.652)
MR	-0.551***(-7.522)	-0.519***(-7.254)	-0.323***(-4.408)	-0.489***(-6.761)
_cons	0.147***(8.256)	0.102***(5.824)	0.038*(1.869)	0.176***(10.028)
N	28855	28855	28855	28855
R ²	0.043	0.063	0.047	0.042
F	161.239	241.593	176.032	158.234

4.3 Robustness test

To ensure the reliability of the research results, this study conducted robustness tests by replacing the dependent variable. Learn from Qi Shaozhou and others^[35], This article uses the number of green invention patent applications as a substitute variable for the explained variable, and chooses patent applications instead of patent grants to measure it, because patent technology is likely to have an impact on business performance during the application process. Therefore, patent application data will be more stable, reliable, and timely than grant volume^[36]. Regression analysis is shown in Table 4. The results prove that the robustness test mentioned above is basically consistent with the previous text, further verifying the empirical results.

Table 4 Robustness Test

	GTI			
	(1)	(2)	(3)	(4)
ER	1.080*** (20.488)	1.061*** (20.425)	1.008*** (19.130)	1.074*** (20.340)
BI	0.000*** (9.433)			
Analyst		0.086*** (26.800)		
csrqua			0.213*** (13.867)	

GTI				
	(1)	(2)	(3)	(4)
MP				0.023*** (8.621)
ER*BI	0.001*** (4.788)			
ER*Analyst		0.301*** (6.926)		
ER*CSRQUA			0.869*** (3.914)	
ER*MP				0.164*** (3.279)
Lev	0.347*** (16.989)	0.293*** (14.437)	0.344*** (16.872)	0.337*** (16.458)
ROA	0.692*** (10.933)	0.149** (2.262)	0.691*** (10.936)	0.698*** (11.028)
ATO	-0.032*** (-3.322)	-0.036*** (-3.850)	-0.025*** (-2.610)	-0.036*** (-3.782)
Growth	-0.031*** (-3.196)	-0.044*** (-4.591)	-0.023** (-2.330)	-0.027*** (-2.798)
MR	-0.311*** (-5.280)	-0.261*** (-4.533)	-0.099* (-1.674)	-0.237*** (-4.068)
_cons	0.060*** (4.219)	0.028** (1.988)	-0.025 (-1.531)	0.091*** (6.441)
N	28855	28855	28855	28855
R ²	0.034	0.055	0.037	0.033
F	126.342	211.161	138.991	122.393

4.4 Heterogeneity analysis

The environmental background of the executive team has a significant positive impact on green technology innovation. Does this impact vary depending on the nature of the enterprise? In the context of low-carbon and green social development, as the actual controller of state-owned enterprises, the Chinese government to some extent requires state-owned enterprises to assume social responsibility^[37], Enable executives with environmental backgrounds to participate more effectively in corporate green technology innovation under pressure. Compared to state-owned enterprises, non-state-owned enterprises usually face more intense market competition and greater obstacles to innovation^[38], So it may be more difficult to promote green technology innovation in enterprises.

Based on this, this article draws inspiration from Tang Kai et al^[39], The differential impact of environmental background executives on green technology innovation in enterprises with different ownership attributes was examined, and the regression results are shown in Table 5. The regression coefficients of environmental background executives in state-owned enterprises for green technology innovation are higher than those in non-state-owned enterprises. Compared to non-state-owned enterprises, state-owned enterprises have a more significant positive effect in promoting green technology innovation through the environmental orientation demonstrated by their executive teams.

Table 5 Heterogeneity test

	GTI	
	State owned enterprises (1)	Non state-owned enterprises (2)
ER	1.625*** (12.941)	1.457*** (18.541)
Lev	0.436*** (8.735)	0.462*** (13.849)
ROA	1.115*** (5.693)	0.865*** (9.793)
ATO	0.023 (1.194)	-0.126*** (-7.832)
Growth	-0.098*** (-4.133)	-0.011 (-0.752)
MR	-0.889*** (-5.796)	-0.424*** (-4.754)
_cons	0.165*** (4.424)	0.204*** (9.570)
N	9206	16980
R ²	0.040	0.041
F	63.906	120.217

5. Conclusion

5.1 Research Conclusion

This article is based on high-order echelon theory, signal theory, etc., and uses regression analysis to deeply study how the environmental background of the executive team affects the performance of green technology innovation in enterprises. It also explores the boundary conditions of the relationship between executive environmental background and enterprise green technology innovation from the perspectives of governance pressure and resource base. Based on data from A-share listed companies from 2012 to 2022, empirical research shows that: (1) the environmental background of the executive team has a significant positive impact on corporate green technology innovation. (2) The public attention to the environment, analyst attention, corporate social responsibility information quality, and corporate social status have all strengthened the promoting effect of the environmental background of the executive team on corporate green technology innovation. (3) Compared to non-state-owned enterprises, the environmental background of the executive team in state-owned enterprises plays a more prominent role in promoting green technology innovation. Specifically, in the context of state-owned enterprises, the environmental protection concept upheld by the executive team has shown a more significant catalytic effect on enhancing the efficiency and effectiveness of green technology innovation compared to non-state-owned enterprises.

5.2 Theoretical contributions

Firstly, this study systematically explores the impact of the environmental background of the executive team on corporate green technology innovation, enriching the research perspective on the antecedents of green technology innovation. Through empirical analysis, it has been clarified that the environmental background of the executive team is an important driving factor for corporate green technology innovation, providing a new perspective for understanding how the characteristics of the executive team shape corporate green strategies. In addition, the results of this study provide crucial strategic guidance for business leaders, effectively helping them deepen their understanding of the core role of the executive team in driving the green innovation process, thereby promoting a significant improvement in the competitiveness of the enterprise.

Secondly, this study not only focuses on the internal characteristics of the executive team, but also deeply analyzes how external and internal factors such as public environmental concerns, analyst concerns, corporate social responsibility

information quality, and corporate social status strengthen the promoting effect of the executive team's environmental background on corporate green technology innovation. This discovery enriches the research framework on the influencing factors of green technology innovation in enterprises, providing a theoretical basis for understanding how external factors interact with internal factors and jointly promote green technology innovation.

Thirdly, this study compares and analyzes the impact of environmental backgrounds of executive teams in state-owned and non-state-owned enterprises on green technology innovation, revealing the unique advantages of state-owned enterprises in promoting green technology innovation. This discovery not only helps to understand the differences in green technology innovation among enterprises of different ownerships, but also provides targeted policy recommendations for policymakers to promote the balanced development of green technology innovation among various types of enterprises.

5.3 Practical Insights

5.3.1 Emphasize the environmental background construction of the executive team

Enterprises should actively select and cultivate executive team members with environmental backgrounds, as their professional knowledge and practical experience can significantly promote the development of green technology innovation in the enterprise. By enhancing the environmental awareness and capabilities of the executive team, companies can better respond to environmental challenges and achieve sustainable development.

5.3.2 Strengthen external supervision and information disclosure

Factors such as public environmental attention, analyst attention, quality of corporate social responsibility information, and corporate social status can strengthen the promotion of green technology innovation by the executive team's environmental background. Therefore, companies should actively respond to public concerns, strengthen communication with analysts, improve the transparency and quality of social responsibility information disclosure, and strive to enhance the company's social status and reputation. These measures help to establish an external supervision mechanism and encourage enterprises to pay more attention to green technology innovation and environmental protection practices.

5.3.3 Give full play to the leading role of state-owned enterprises in green technology innovation

The environmental background of the executive team in state-owned enterprises plays a more prominent role in promoting green technology innovation. This enlightens us that in the process of promoting green technology innovation, state-owned enterprises should play a demonstrative and leading role, and drive the entire industry towards green, low-carbon, and sustainable development through their own practical experience and resource advantages. At the same time, state-owned enterprises should actively learn from the innovation mechanisms and flexibility of non-state-owned enterprises, and continuously improve their own green technology innovation capabilities and levels.

5.3.4 Building a green technology innovation ecosystem

Enterprises should combine the environmental background of their executive team with external supervision, information disclosure, and state-owned enterprise leadership to jointly build an ecosystem of green technology innovation. In this ecosystem, various forces collaborate and promote each other, jointly promoting the development and application of green technology innovation. By strengthening industry university research cooperation and establishing green technology innovation alliances, enterprises can more effectively integrate internal and external resources, and improve the efficiency and effectiveness of green technology innovation.

5.4 Shortcomings and Prospects

Firstly, this article mainly examines the impact of the background traits of the executive team on green technology innovation. It cannot be denied that the cognitive traits of the executive team also have a significant impact on green innovation. Therefore, future research can study the influence of the executive team on psychological cognition and other aspects.

Secondly, although this study reveals the strengthening effect of factors such as public environmental concerns, analyst concerns, corporate social responsibility information quality, and corporate social status on the relationship between executive team environmental background and corporate green technology innovation, the research results may not fully reflect the actual situation of all industries, regions, and scale enterprises due to limitations in data availability and sample selection. Future research should expand the sample size to include enterprises from more industries and regions, in order to improve

the universality and applicability of research results.

Thirdly, the data for this study comes from sample companies in listed companies. Although this choice is based on sufficient consideration of the convenience of data acquisition, which facilitates the comparison and exchange of research results with peer research, its inherent limitations cannot be ignored. Specifically, this sample selection method may limit the generalizability of research results, as there may be differences in the situation of non listed companies.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Yang, X. H., & You, D. M. (2022). Research on enterprise green technology innovation decision making considering consumer environmental awareness and government subsidies. *China Management Science*, 30(09), 263–274.
- [2] Jie, X. M., & Han, Y. H. (2022). How can local manufacturing enterprises achieve a "magnificent transformation" in green innovation? —A multi case study based on the attention based view. *Management World*, 38(03), 76–106.
- [3] Ren, X. G., & Liu, F. (2024). Analysis of the trends, characteristics, challenges, and path selection of green technology innovation and development. *Science and Technology Management Research*, 44(03), 236–242.
- [4] Yin, J. H., & Shuangqi. (2023). The driving effect of CEO academic experience on corporate green innovation: a dual perspective of environmental attention allocation and industry university research cooperation empowerment. *Science and Technology Progress and Countermeasures*, 40(03), 141–151.
- [5] Wang, H., Lin, W. F., & Xie, R. (2022). Environmental background of executives and entry of green investors. *Quantitative Economics, Technology and Economics Research*, 39(12), 173–194.
- [6] Yang, T., Chen, J., & Ling, H. C. (2023). Media attention, environmental policy uncertainty, and corporate green technology innovation: empirical evidence from Chinese A-share listed companies. *Journal of Management Engineering*, 37(04), 1–15.
- [7] Sun, D. S. (2009). Executive team and corporate social responsibility: a perspective of higher-order theory. *Science and Technology Management*, 30(04), 188–193.
- [8] Phillips, D., & Zuckerman, E. (2001). Middle-status conformity: Theoretical restatement empirical demonstration in two markets. *American Journal of Sociology*, 107, 379–429.
- [9] Bi, Q., Li, H. Y., & Yu, L. C. (2019). The impact and mechanism of embedding executives' environmental experience on corporate green transformation. *Journal of Guangdong University of Finance and Economics*, 34(05), 4–21.
- [10] Lu, J. C., & Jiang, G. S. (2022). Can CEO's green experience promote green innovation in enterprises? *Economic Management*, 44(02), 106–121.
- [11] Du, J., & Gong, X. S. (2024). Energy efficiency "Leader" system and enterprise green innovation: The regulating role of government ecological environment attention and executive environmental experience. *Science and Technology Progress and Countermeasures*, 41(04), 141–150.
- [12] Zhong, J. Y. (2024). Environmental background executives and the quality of corporate environmental information disclosure. *Management and Technology of Small and Medium sized Enterprises*, (07), 44–47.
- [13] Yang, X. (2024). Research on the impact of executive environmental background on corporate green innovation: Empirical analysis based on listed companies. *Science and Technology for Development*, 20(01), 70–77.
- [14] Liu, X. H., & Hu, Z. F. (2024). Financial technology, executive environmental protection background, and corporate green innovation. *Economic System Reform*, (03), 77–84.
- [15] Xi, L. S., & Zhao, H. (2022). Executive dual environmental awareness, green innovation, and corporate sustainable development performance. *Economic Management*, 44(03), 139–158.
- [16] Wang, Y. Z., & Zhao, J. (2018). "Voting with money": The impact of public environmental attention on asset prices in different industries. *Management World*, 34(09), 46–57.

- [17] Ma, Y., Zhang, Q., & Yin, Q. (2021). Top management team faultlines, green technology innovation and firm financial performance. *Journal of Environmental Management*, 285, 112095.
- [18] Bing, G. A., Pc, B., & Ts, A. (2019). Firms' innovation strategy under the shadow of analyst coverage. *Journal of Financial Economics*, 131(2), 456–483.
- [19] Qian, C., Lu, L. Y., & Yu, Y. (2019). Financial analyst coverage and corporate social performance: Evidence from natural experiments. *Strategic Management Journal*, 40(1), 2271–2286.
- [20] Jie, X. M., & Zhu, Q. W. (2021). Research on the impact mechanism of compliance and strategic green innovation on corporate green image: Based on the perspective of optimal differentiation theory. *Research and Development Management*, 33(4), 2–14.
- [21] Zhang, Y. M., Xing, C., & Wang, Y. (2020). Does green innovation mitigate financing constraints? Evidence from China's private enterprises. *Journal of Cleaner Production*, 264, 121698.
- [22] Cox, P., & Wicks, P. G. (2011). Institutional interest in corporate responsibility: portfolio evidence and ethical explanation. *Journal of Business Ethics*, (1), 123–134.
- [23] Rangan, K., Chase, L. A., & Karim, S. (2012). Why every company needs a CSR strategy and how to build it. *Harvard Business School Division of Research*, 12(3), 1–30.
- [24] Merton, R. C. (1987). A simple model of capital market equilibrium with incomplete information. *Journal of Finance*, 42, 483–510.
- [25] Podolny, J. (2005). *Status signals: A sociological study of market competition*. Princeton University Press.
- [26] Jiang, F. X., Yi, Z. H., & Su, F., et al. (2009). Managerial background characteristics and overinvestment behavior of enterprises. *Management World*, (01), 130–139.
- [27] Xu, J. Y. (2018). Overseas returnees and enterprise export behavior: Micro evidence from China. *Financial Research*, (02), 118–134.
- [28] Zhao, S. K., Zhang, B. C., & Cai, J. M. (2022). The impact of green innovation on corporate performance: Based on panel data of Chinese listed companies. *Science and Technology Management Research*, 42(06), 211–220.
- [29] Han, Z. X., Cui, J. W., & Wang, S. (2014). Has technology executives improved the efficiency of enterprise technology? *Scientific Research*, 32(04), 559–568.
- [30] Kang, J. J., & Yang, X. G. (2024). Executive environmental background and corporate ESG rating. *Journal of Econometrics*, 4(02), 368–390.
- [31] Zheng, S., Wu, J., Kahn, M. E., et al. (2012). The nascent market for "green" real estate in Beijing. *European Economic Review*, 56(5), 974–984.
- [32] Zheng, S. Q., Wan, G. H., & Sun, W. Z., et al. (2013). Public demands and urban environmental governance. *Management World*, (6), 72–84.
- [33] Zou, P. (2018). Is it "consistent words and deeds" or "reciprocity"? —Corporate social responsibility information disclosure and actual tax burden. *Economic Management*, 40(03), 159–177.
- [34] Jiang, F. X., & Liu, Z. B. (2005). Industry characteristics, capital structure, and product market competition. *Management World*, (10), 74–81.
- [35] Qi, S. Z., Lin, Y., & Cui, J. B. (2018). Can the environmental rights trading market induce green innovation? —Evidence based on green patent data of listed companies in China. *Economic Research*, 53(12), 129–143.
- [36] Li, W. J., & Zheng, M. N. (2016). Substantive innovation or strategic innovation? —The impact of macro industrial policies on micro enterprise innovation. *Economic Research*, 51(04), 60–73.
- [37] Wang, J., Li, C. C., & Liu, M. Y. (2022). Research on the impact of executive equity incentives on corporate green innovation. *Business and Management*, 1–14. <https://doi.org/10.16517/j.cnki.cn12-1034/f.20240510.003>
- [38] Jia, Y. (2024). Does ESG promote green technology innovation in enterprises? *Technology and Industry*, 24(08), 35–41.
- [39] Tang, K., Liu, X. K., & Peng, Y. J. (2024). CEO's information technology background and corporate green technology innovation: Theoretical mechanisms and empirical tests. *Innovation and Technology*, 24(04), 78–90.

Promoting High-Quality Development of Shaanxi's Manufacturing Industry with Digital-Physical Integration as a New Feature

Jiahui Zhao, Tieshan Wang*, Tong Yang

College of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710000, China

**Corresponding author: Tieshan Wang*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: The Third Plenary Session of the 20th CPC Central Committee has arranged for “improving the system for deep integration of the real economy and the digital economy,” requiring continuous deepening of the integration of informatization and industrialization and vigorously advancing the high-quality development of the manufacturing industry. On the path of the new era and new guidelines, the key to implementing this arrangement lies in accelerating the popularization and application of a new generation of information technology across all fields and industrial chains, and fully unlocking the value of data elements. Promoting the deep integration of the real economy and the digital economy is a strategic choice to seize the opportunities of the new round of scientific and technological revolution and industrial transformation. It is also an indispensable path for building a modern industrial system and realizing the high-quality development of the manufacturing industry in the new development stage.

Keywords: Digital-Physical Integration; Manufacturing Industry; Digital Transformation; Digital Infrastructure; Industrial Chain Collaboration

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.815>

1. Overview of the Current Development of Digital-Physical Integration and Manufacturing Industry in Shaanxi

1.1 Shaanxi's Policies for the Development of Digital-Physical Integration

The Decision of the CPC Central Committee on Further Comprehensively Deepening Reform and Promoting Chinese-Style Modernization, adopted at the Third Plenary Session of the 20th CPC Central Committee, proposes to promote the deep integration of the real economy and the digital economy, and drive the high-end, intelligent, and green development of the manufacturing industry. The report of the 20th CPC National Congress also states that we should develop the digital economy, promote the integration of the digital and real economies, and build competitive digital industry clusters. From an overall perspective, the Party and the country have pointed out that digital-physical integration will give rise to new business forms, new scenarios, and new models, injecting strong impetus into economic and social development. In April 2022, Shaanxi Province issued the Implementation Plan for Accelerating the Development of the Digital Economy Industry in Shaanxi Province (2021-2025). To fully implement the strategic arrangements of the CPC Central Committee and the State Council on the development of the digital economy, as well as the 14th Five-Year Plan for the Development of the Digital

Economy in Shaanxi Province, the plan aims to seize the opportunities for the development of the digital economy industry, further implement the “Digital Shaanxi” strategy, and accelerate the high-quality development of the digital economy industry in Shaanxi Province. Its development directions include digital technology innovation and enabling applications, digital product manufacturing, digital technology application industries, and the digital transformation of the manufacturing industry. In January 2024, Shaanxi further issued the Policy Measures for Promoting the High-Quality Development of the Digital Economy to respond to and implement the decisions and arrangements of the CPC Central Committee and the State Council on developing the digital economy. This document accelerates the construction of new-type digital infrastructure across the province, simultaneously advances industrial digitalization, digital industrialization, data value activation, and digital governance, fosters a sound ecosystem, and empowers high-quality development.

1.2 Current Situation of Digital-Physical Integration Development in Shaanxi Province

Promoting the integration of the digital and real economies is a core path for implementing the national innovation-driven development strategy, accelerating high-quality development, and building a modern socialist country. Shaanxi Province has actively responded to the requirements of the central government, conformed to the trend of economic development, and promoted the integration of the digital economy and the real economy. In recent years, Shaanxi has issued a number of policy documents, including the 14th Five-Year Plan for the Development of the Digital Economy in Shaanxi Province and the Policy Measures for Promoting the High-Quality Development of the Digital Economy. These documents propose to focus on the construction of new-type infrastructure, enhance the supporting capacity for advancing industrial digitalization and digital industrialization, and further promote the in-depth integration of the digital economy and the real economy. At present, Shaanxi has achieved initial results in the development of the integration of the digital and real economies.

We will consolidate new-type digital infrastructure to provide strong support for the development of the integration of the digital and real economies. As of 2024, the number of 5G base stations put into operation in Shaanxi has exceeded 120,000, with a significantly expanded coverage. Key areas such as urban hotspots, industrial parks, and transportation hubs are covered, realizing the coexistence of multiple networks. These base stations cover fields including industrial internet, smart cities, and telemedicine, promoting the wide application of 5G technology in practical production activities. The province has built 22 data centers, which enhance computing power through new data infrastructure and provide strong support for data storage, processing, and application^[1]. The Internet of Things (IoT) has driven the intelligent transformation of traditional industries, with a total of 27.667 million end users accumulated in fields such as transportation, agriculture, and energy.

The scale of the digital industry continues to expand and grow stronger. Focusing on the layout of core industrial clusters, Shaanxi has concentrated on hard technology fields such as artificial intelligence, photonics, and third-generation semiconductors, forming multiple industrial clusters worth over 10 billion yuan. For example, Fast Group has significantly improved production efficiency through intelligent unmanned production technology, becoming a national pilot project for digital transformation. In addition, the computing power of Xi'an Future Artificial Intelligence Computing Center reaches 3 billion billion operations per second, ranking second in China, which provides strong support for the integration of the digital and real economies in Shaanxi.

The intelligent transformation of enterprises is advancing rapidly. Shaanxi emphasized the development of the digital economy in its 14th Five-Year Plan, and in the past two years, it has issued a number of policies to clarify the strategic direction of enterprise digital transformation. A total of 1,154 enterprises in the province have passed the national standard certification for the integration of informatization and industrialization, and 12 enterprises have become industrial internet benchmark enterprises. The sales volume of goods sold via public networks increased by 16.6% year-on-year, and the economic benefits of digital transformation are self-evident. Furthermore, Xi'an has been approved as a national pilot city for the digital transformation of small and medium-sized enterprises (SMEs) in the second batch, which validates the province's policies. Shaanxi should maintain strategic agility, strengthen strategic planning, further focus on innovation, enhance application, promote integration, and continuously accumulate new advantages for the development of the digital economy.

1.3 Current Situation of Shaanxi's Manufacturing Industry Development

In recent years, Shaanxi's manufacturing industry has made significant progress in terms of total scale, industrial structure,

and intelligent transformation, continuously promoting economic development.

1.3.1 Overall Scale

In 2024, the gross domestic product (GDP) of Shaanxi Province reached 3.553877 trillion yuan, with a year-on-year growth of 5.3%, which was higher than the national average, indicating a steady economic development trend of the province. The added value of industrial enterprises above the designated size in Shaanxi increased by 7.8% year-on-year, among which the equipment manufacturing industry grew by 7.1%. It is estimated that by 2026, the proportion of the manufacturing industry's added value in GDP will reach 23%, with an average annual growth rate of over 7%. Through technological innovation, digital transformation, and industrial cluster construction, Shaanxi's manufacturing industry has become a core engine for economic growth. In 2024, the scale of the digital economy reached 1.4 trillion yuan; the added value of the equipment manufacturing industry grew significantly; key industries such as semiconductors and new energy vehicles made outstanding contributions; and emerging industries such as photonics and robotics developed rapidly.

1.3.2 Industrial Structure

Shaanxi's manufacturing industry mainly consists of key industries and emerging fields. The province has actively responded to the "Data Element ×" three-year action plan, promoted the transformation and upgrading of traditional manufacturing industries, strengthened the cultivation of leading manufacturing enterprises, and carried out pilot upgrades to drive the overall transformation of the manufacturing industry toward intelligence, high-endization, and greenization ^[2]. In 2024, Shaanxi achieved remarkable results in manufacturing transformation: the added value of industrial enterprises above the designated size increased by 7.8% year-on-year, and fixed asset investment grew by 5.2%, providing strong support for the province's economy. The growth of new energy and high-tech industries was particularly prominent, with the proportion of clean energy power generation rising to 10.2%. Shaanxi focuses on both traditional manufacturing and emerging industries: For traditional manufacturing, take the capacity expansion base of Shaanxi Automobile Heavy Truck as an example. It has realized efficient mixed-line production through cloud platforms and smart manufacturing technologies, becoming a leader in smart factories in China's heavy truck sector. For emerging industries, green energy is the main focus. Represented by Longi Green Energy, its green and low-carbon transformation projects and pilot production line expansion projects have promoted the intelligent and green development of the photovoltaic industry, leading the domestic industry.

1.3.3 Improvement of Transformation Systems Accelerated by Digital-Physical Integration Policies

To respond to the national strategic deployment of developing the digital economy and promoting digital-physical integration, Shaanxi Province has issued a number of policies from the "14th Five-Year Plan" period to this year. Among them, the "14th Five-Year Plan for Digital Economy Development" clearly defines 139 tasks, of which 14 have been completed and 125 are still in progress. These tasks cover digital-physical integration, new-type infrastructure construction, digital industrial transformation, and other areas.

The province strongly supports enterprises' digital transformation through multiple channels, including financial subsidies, financing support, tax incentives, and talent support. During the transformation process, the government helps enterprises reduce financial pressure in technological upgrading and digital transformation projects through interest subsidies and grants. After enterprises achieve intelligent upgrading, they can reduce production costs and improve product quality, significantly enhancing their competitiveness in the industry. At the same time, in emerging industries, the government assists in promoting the transformation and industrialization of scientific and technological achievements, enabling industries to develop the latest technologies and apply them to other related industries, thereby advancing large-scale digital-physical integration.

2. Problems in Promoting High-Quality Development of Shaanxi's Manufacturing Industry Through Digital-Physical Integration

Based on an analysis of the current status of digital-physical integration and manufacturing development in Shaanxi using the 2024 Statistical Yearbook of Shaanxi Province, it is concluded that Shaanxi has achieved remarkable results in digital-physical integration. However, there are still many problems in the integration of the digital economy and the real economy, which need to be solved as soon as possible to accelerate economic development.

2.1 Incomplete Digital Industry Scale and Inadequate Infrastructure Unbalanced coverage of communication networks

The development level of digital technology in Shaanxi lags far behind that of developed regions such as the Beijing-Tianjin-Hebei region and the Yangtze River Delta. Although Shaanxi has made certain achievements in the overall construction of communication networks, it still needs continuous improvement compared with these regions. The construction of digital infrastructure is the foundation of digital transformation, determining the speed and quality of the digital transformation of the manufacturing industry.

Firstly, the basic capabilities of the digital government need to be enhanced. There are data sharing barriers between government system platforms in different cities and districts, resulting in slow cross-departmental processes. Secondly, the application depth of the industrial internet is insufficient. Currently, the penetration rate of platform applications is far lower than the target of 45%, and small and medium-sized enterprises (SMEs) have low enthusiasm for “migrating to the cloud and accessing platforms”^[3]. Finally, 5G network coverage is inadequate. The coverage targets focus on urban areas and key scenic spots, while the rural broadband access rate is much lower than that in developed regions, which hinders the development of smart agriculture and the digital economy.

2.2 Weak Technological Foundation Impeding the Integration of Informatization and Industrialization in Manufacturing

The existing technical equipment and systems of some manufacturing enterprises in Shaanxi are relatively outdated, making it difficult to meet the needs of digital transformation.

Firstly, the digital transformation of the manufacturing industry requires the integration of various advanced technologies, such as cloud computing, big data, artificial intelligence, and the Internet of Things. Shaanxi’s manufacturing industry relies heavily on foreign high-end industrial software (e.g., CAD/CAE/CAM/PLM/MES), with weak R&D capabilities for independent and controllable core industrial software and insufficient application depth. In particular, there is a lack of specialized software for specific industries. These technologies are inherently complex, and integrating them to work toward a unified goal during transformation further raises the capability requirements for technical teams. Moreover, different manufacturing industries face diverse scenarios in the production process, leading to variations in the application methods and difficulty of technologies^[4].

Secondly, some enterprises have outdated equipment, low automation levels, low numerical control rates and networking rates, and lack the basic conditions for data collection. Taking the integration of informatization and industrialization in manufacturing as an example, the development level of this integration in Shaanxi’s manufacturing industry is 49.2, ranking only 10th in China, which is significantly lower than that of developed regions such as Jiangsu (69.2). In terms of key indicators—including the penetration rate of digital R&D and design tools, the numerical control rate of key processes, and the penetration rate of digital operation and management—Shaanxi is obviously below the national leading level.

2.3 Shortage of High-Tech Talents and Unbearable Transformation Costs for Small and Medium-Sized Manufacturing Enterprises

The digital transformation of the manufacturing industry relies not only on interdisciplinary talents who master information and communication technology and are familiar with manufacturing knowledge but also on new systems and production equipment. This is one of the core bottlenecks restricting the depth of the integration of informatization and industrialization—enterprises struggle to find talents who can effectively apply information technology to specific production scenarios. Currently, universities and vocational schools have insufficient integration of theory and practical operations in teaching, resulting in a shortage of such interdisciplinary talents. This is a major challenge faced by most provinces in China. On the other hand, to improve efficiency and achieve high-quality economic development through digital transformation, enterprises need to digitally upgrade both production systems and equipment, and introduce corresponding interdisciplinary talents to meet production and development needs. This requires a large amount of capital and resource investment, which is difficult for SMEs to complete independently.

2.4 Need for Expansion of Digital-Physical Integration Platforms

Shaanxi is a major manufacturing province. The GDP created by the manufacturing industry accounts for approximately 40% of the province's total GDP, and the added value of the manufacturing industry accounts for more than 85% of the added value of the secondary industry. It is the core of the industrial system and plays a key supporting role in the province's economic growth. Shaanxi's manufacturing industry mainly includes the automobile manufacturing industry, energy and chemical industry, high-tech manufacturing, and aviation equipment. These industries have a high degree of dependence on digitalization, and thus have extremely high requirements for integrated industry cloud platforms. However, the current digital-physical integration platforms in the province have some problems.

For instance, data silos prevent management from obtaining comprehensive and real-time data support. When decisions are based on outdated or incomplete information, it is highly likely to lead to decision-making errors^[5]. When data cannot be shared, cross-departmental collaboration in production, sales, and supply chains will encounter problems. Information blockages disrupt the overall business processes of enterprises and even the entire industry. This not only affects the development of enterprises but also may prevent customers from selecting their preferred products.

2.5 Need for Enhanced Collaboration in the Manufacturing Industry Chain

The manufacturing industry chain is an interconnected whole, and collaborative cooperation between upstream and downstream enterprises is crucial for improving the efficiency and competitiveness of the entire industry chain. However, there is a large gap in the digitalization level of upstream and downstream enterprises in Shaanxi's manufacturing industry chain, especially for related enterprises in southern and northern Shaanxi. Additionally, there are obvious gaps in the industrial chain: Upstream enterprises mainly focus on energy, chemicals, and non-ferrous metals, but these enterprises have insufficient deep processing capabilities and rely on other provinces for high-end materials.

Midstream equipment manufacturing enterprises (such as those in the aerospace and automobile industries) have a certain foundation but low local supporting rates. Downstream end products are mainly used in military industry and electronic equipment, resulting in low market conversion efficiency. Some enterprises have already started digital transformation, while others still adhere to traditional production models. This leads to difficulties in industry chain collaboration and affects the overall effect of digital transformation^[6].

3. Policy Recommendations for Promoting High-Quality Development of Shaanxi's Manufacturing Industry Through Digital-Physical Integration

3.1 Improve Digital Infrastructure Construction and Promote Digital Transformation of the Manufacturing Industry

Massive data is the most prominent feature of the digital economy. The key to the digital economy empowering the high-quality development of the manufacturing industry lies in the reasonable collection, organization, analysis, and summarization of complex data, and then utilizing it as a new type of production factor in manufacturing. The realization of these effects is inseparable from the construction of digital infrastructure. Improving digital infrastructure can be approached from the following two aspects:

First, give full play to the advantages of existing digital infrastructure. The initial investment in digital infrastructure is huge, and the cycle for its construction, operation, and return on investment is relatively long. Therefore, it is practically challenging to build a large number of high-quality digital infrastructure facilities in the short term. Given this, priority should be given to relying on existing foundations (such as the 5G network already built in Shaanxi), focusing on optimizing the layout of communication networks, accelerating the introduction of new technologies, and strengthening the collaborative construction of computing infrastructure to maximize the efficiency of existing resources.

Second, actively guide the penetration of digital technologies such as 5G, big data, cloud computing, and industrial internet into traditional manufacturing. On one hand, carry out automated and intelligent transformation of traditional production equipment. For example, widely apply industrial robots in fields such as automobile manufacturing and mechanical processing to perform high-repeatability, high-intensity, or high-precision operations (such as welding and assembly), which significantly improves production efficiency and product consistency. On the other hand, build a digital production management system that runs through the entire process, realizing comprehensive information-based management from

production planning and dynamic scheduling to quality control. This system enables enterprises to grasp real-time production dynamics, continuously optimize processes, and greatly enhance the flexibility of production and the speed of market response.

By consolidating the foundation of digital infrastructure through the above two paths, we can effectively promote the value transformation of data elements, ultimately driving the manufacturing industry toward digitalization, intelligence, and networking, and creating new business forms and models required for high-quality development.

3.2 Improve Technical Standards and Promote the Integration of Informatization and Industrialization in the Manufacturing Industry

The core challenge for the integration of informatization and industrialization in Shaanxi's manufacturing industry lies in its weak technological foundation—a systemic shortcoming that covers multiple aspects. Shaanxi should focus on strategic emerging industries such as a new generation of information technology, new materials, high-end equipment manufacturing, new energy, and new energy vehicles, select key industrial parks as carriers of innovation clusters, and build a echelon development pattern of “10-billion-yuan improvement, 100-billion-yuan leap, and 1-trillion-yuan growth”.

Combined with Shaanxi's advantageous industries (such as aerospace, energy and chemicals, high-end equipment, and electronic information), concentrate resources to overcome core weak links. Encourage the introduction of advanced technologies and solutions from home and abroad, but on the basis of introduction, carry out digestion, absorption, and re-innovation to cultivate basic capabilities suitable for Shaanxi's local conditions. In addition, Shaanxi should accelerate the construction and application promotion of secondary nodes for industrial internet identifiers, and promote the in-depth coverage of 5G internet in key industrial parks and the application of typical scenarios ^[7].

Adopt a comprehensive strategy of “persisting in long-term key breakthroughs, ecological cultivation, and model innovation”, while attaching equal importance to consolidating the foundation of manufacturing technology and improving information technology capabilities, combining technology introduction with independent innovation, and balancing the building of benchmarks and benefiting small and medium-sized enterprises. Only by strengthening core technologies can we truly unlock the huge enabling potential of the integration of informatization and industrialization for the high-quality development of Shaanxi's manufacturing industry.

3.3 Cultivate a Team of High-Tech Talents

Talents are the key to driving the digital economy and empowering the high-quality development of the manufacturing industry. It is necessary to vigorously introduce and cultivate versatile “digital + manufacturing” talents and teams to promote the high-quality development of Shaanxi's manufacturing industry. Specifically, the principle of “introducing external talents and cultivating internal talents” should be adhered to in order to improve the talent team. First, formulate preferential policies from multiple aspects to attract outstanding digital technology talents and management talents at home and abroad to work in Shaanxi, providing talent support for digital platform construction and the digital transformation of the manufacturing industry. For example, in terms of salary and benefits, a certain proportion of salary subsidies can be given based on their work experience and professional and technical level; strengthen the protection of intellectual property rights for digital technology talents and provide them with services and support in patent application and rights protection; in terms of taxation, provide appropriate reductions and exemptions for personal income tax, and grant certain tax incentives to enterprises that introduce digital technology talents. Second, improve the industry-academia integration model for collaborative talent cultivation. On one hand, optimize the professional settings of universities in Shaanxi, promote universities to strengthen the construction of digital technology-related majors, optimize curriculum design, and cultivate professional talents who can adapt to digital platform construction and the digital transformation of the manufacturing industry. Encourage universities to cooperate with enterprises, carry out industry-academia-research cooperation projects, and cultivate digital talents with practical capabilities to provide talent support for the digital transformation of the manufacturing industry. On the other hand, in response to the needs of manufacturing enterprises, carry out digital technology vocational training to improve the digital skills of enterprise employees.

3.4 Build Diversified Digital Platforms and Accelerate the Digital Transformation of the Manufacturing

Industry

Shaanxi Province should seize the strategic opportunity of building a “Digital China” and promote the manufacturing industry to leap toward smart manufacturing with unprecedented efforts. By constructing multi-level and integrated digital platforms, new drivers for Shaanxi’s manufacturing industry will be fostered. The specific measures can be carried out as follows:

Concentrate core resources to build a “core hub” for regional digital transformation, which integrates the capabilities of core industrial software such as PLM (Product Lifecycle Management), MES (Manufacturing Execution System), and ERP (Enterprise Resource Planning). This hub will provide key services for manufacturing enterprises in the province, including cloud-based collaborative design, flexible production scheduling optimization, and supply chain visualization^[8]. At the same time, establish a “one platform per industrial chain” mechanism, focusing on advantageous industrial chains such as semiconductors, aerospace, and new energy vehicles to achieve precise development. This mechanism will realize the integration of equipment digitalization and physical operations, the accumulation of process knowledge, and the closed-loop of quality traceability, while accelerating upstream-downstream collaborative design, capacity sharing, and networked collaborative manufacturing in the industrial chain.

Activate new manufacturing platforms through technological empowerment: integrate AI into the core of manufacturing by embedding it in various production links, and use it to analyze management data for accurate decision-making and intelligent analysis. With platforms as the foundation, data as the lifeblood, and intelligence as the soul, we should promote the full-factor, full-process, and full-chain digital transformation of Shaanxi’s manufacturing industry, and accelerate its advancement toward the high end of the industrial chain and value chain.

3.5 Improve Policy Support

Formulate targeted policies to provide precise support for weak links. In terms of funding: Increase financial support and establish a special fund for the digital transformation of the manufacturing industry to support enterprises in carrying out digital upgrading and innovation. Optimize tax policies by offering tax incentives to enterprises engaged in digital technology R&D and application, so as to reduce the cost of enterprises’ digital transformation. Simplify approval procedures to lower the cost of enterprises’ digital upgrading^[9]. Provide high-quality and convenient financial services and resources to offer capital support for enterprise development. In terms of policies and regulations: Formulate and improve policies and regulations that support the digital upgrading of the manufacturing industry, and increase support for innovative enterprises and innovative projects. In terms of intellectual property rights: Establish and improve the intellectual property protection system, safeguard enterprise data security^[10], and encourage manufacturing enterprises to actively carry out digital reform, so as to realize the intelligent, green, and service-oriented transformation of the manufacturing industry.

4. Conclusion

As a core path to drive the high-quality development of the manufacturing industry, digital-physical integration has injected key momentum into the transformation and upgrading of Shaanxi’s manufacturing industry. Based on the previous analysis of the current development status and existing problems of digital-physical integration and the manufacturing industry in Shaanxi, it can be seen that in recent years, Shaanxi has achieved phased results in policy guidance, infrastructure construction, and industrial transformation: it has clarified the transformation direction by issuing policy documents such as the 14th Five-Year Plan for the Development of the Digital Economy in Shaanxi Province, built more than 120,000 5G base stations and 22 data centers to consolidate the foundation of digital infrastructure, and cultivated benchmark enterprises for digital transformation such as Fast Group and Longi Green Energy. In 2024, the scale of the digital economy reached 1.4 trillion yuan, key industries such as equipment manufacturing and new energy achieved significant growth, and the manufacturing industry has become a core support for the province’s economic growth.

However, in the process of promoting the high-quality development of the manufacturing industry through digital-physical integration, Shaanxi still faces multiple bottlenecks that need to be broken through urgently: the unbalanced urban-rural coverage of digital infrastructure and insufficient in-depth application of the industrial internet restrict the efficient circulation of data elements; the weak technological foundation of the manufacturing industry, with high dependence on foreign high-end industrial software, results in a significant gap in the development level of the integration of informatization and

industrialization (49.2) between Shaanxi and developed regions such as Jiangsu (69.2); there is a shortage of interdisciplinary “digital + manufacturing” talents, and small and medium-sized enterprises (SMEs) find it difficult to promote digitalization independently due to excessively high transformation costs; the digital-physical integration platforms suffer from the “data silo” phenomenon, and the digitalization level of upstream and downstream enterprises in the industrial chain varies greatly with weak collaboration capabilities. These problems collectively hinder the full release of the value of digital-physical integration.

In the future, Shaanxi needs to focus on targeted solutions to problems and promote the in-depth development of digital-physical integration through systematic measures. On the one hand, it should continue to improve digital infrastructure, optimize the layout of communication networks, and promote the penetration of 5G and industrial internet into traditional manufacturing. On the other hand, it should form a synergy through technological breakthroughs, talent cultivation, platform construction, and policy support: overcome the shortcomings of core industrial software, build a talent system of “introducing external talents and cultivating internal talents”, create an industrial collaboration model of “one platform per industrial chain”, and at the same time rely on policies such as special funds and tax incentives to reduce the burden of enterprise transformation. Only in this way can we fully activate the value of data elements, promote the in-depth transformation of Shaanxi’s manufacturing industry towards digitalization, intelligence, and greenization, truly realize the leap from a “major manufacturing province” to a “strong manufacturing province”, and provide “Shaanxi experience” for the high-quality development of the manufacturing industry empowered by digital-physical integration across the country.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Liu, J., Li, B. Y., & Meng, Q. Z. (2023). Digital Economy and High-Quality Economic Development in Western China: Theoretical Logic and Practical Paths. *Journal of Technoeconomics & Management*, (03), 14-20.
- [2] Li, Y. J., & Han, P. (2021). Mechanism and Path of High-Quality Development of Manufacturing Industry Under the Digital Economy. *Macroeconomic Management*, (05), 36-45.
- [3] Guo, H. (2020). Path of Promoting High-Quality Development Through the Integration of Digital Economy and Real Economy. *Journal of Xi'an University of Finance and Economics*, 33(02), 20-24.
- [4] Wang, J. (2024). Research on Promoting Institutional Opening of Pilot Free Trade Zones in Alignment with International High Standards—An Analysis of the Impact of RCEP Standards on Key Industries in China (Shaanxi) Pilot Free Trade Zone. *Social Scientist*, (05), 34-42.
- [5] Huang, Q. H., Yu, Y. Z., & Zhang, S. L. (2019). Internet Development and Manufacturing Productivity Improvement: Internal Mechanism and Chinese Experience. *China Industrial Economics*, (08), 5-23.
- [6] Xiong, Y., & Wu, T. T. (2023). Research on the Coupling Coordination and Evolution of Digital Innovation and High-Quality Development of Manufacturing Industry. *Science and Technology Management Research*, 43(11), 1-8.
- [7] Zhou, B. C., & Yin, Q. S. (2023). Research on the Impact of Digital Technology on the Efficiency of China’s Cultural Industry. *Journal of Shanxi University (Philosophy and Social Science Edition)*, 46(02), 120-130.
- [8] Wang, X. G., & Li, C. (2024). Analysis on the Path of Digital Economy Empowering the High-Quality Development of Jilin’s Manufacturing Industry. *Economic & Trade Update*, 21(08), 179-181.
- [9] Liu, S. H. (2024). Research on the Role of Digital Economy in Promoting China’s High-Quality Economic Development. *China Business and Market*, 33(16), 17-20.
- [10] Liu, X. X., & Hui, N. (2021). Research on the Impact of Digital Economy on the High-Quality Development of China’s Manufacturing Industry. *Reform of Economic System*, (05), 92-98.

A Study on the Relationship Between ESG Strategic Orientation and Corporate Green Innovation Performance

Yixue Li*, Xiaohong Wang, Meng Li

College of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710000, China

*Corresponding author: Yixue Li, 649344821@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This study examines the impact of corporate ESG performance on green technology innovation using A-share listed companies in China as research subjects from 2010 to 2024. The findings demonstrate a significant positive correlation between corporate ESG performance and value, indicating that better environmental, social responsibility, and governance practices correlate with higher overall value levels. Mechanism analysis reveals that strong ESG performance not only enhances digital transformation capabilities but also increases media attention, thereby boosting corporate value through information dissemination and image enhancement. Heterogeneity analysis shows that ESG's value-enhancing effects are more pronounced in non-state-owned enterprises and firms with higher rent-seeking tendencies, suggesting stronger regulatory and constraint functions under governance frameworks with weaker structures or greater external pressures. The research provides new empirical evidence for understanding ESG's mechanisms in green technology innovation and value enhancement, offering insights for sustainable development strategies and policy formulation across different enterprise types.

Keywords: Digital-Physical Integration; Manufacturing Industry; Digital Transformation; Digital Infrastructure; Industrial Chain Collaboration

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.816>

1.Introduction

In the context of China's economic development entering a new normal, environmental pollution and overcapacity have become prominent issues, making green development an essential requirement for high-quality growth. As a crucial pathway for achieving sustainable transformation, green technological innovation can reduce resource consumption and environmental impact. However, due to its "dual externalities," enterprises show limited enthusiasm for independent R&D efforts, and market mechanisms alone struggle to drive progress. In recent years, ESG (Environmental, Social, and Governance) has gradually emerged as a key benchmark for evaluating corporate sustainability and social responsibility, receiving both policy support and market attention in China. ESG not only provides value guidance for companies' green transition but also aligns with the development philosophy of green technological innovation. This study empirically examines the impact of ESG performance on green technological innovation using A-share listed companies from 2010 to 2024 as samples, offering theoretical and practical references for corporate strategic decisions, investor analysis, and government policy refinement. II. Literature

2.Review

2.1 Economic consequences of ESG performance

In recent years, as ESG has gained broader societal acceptance as a holistic concept, scholars have increasingly examined how corporate ESG performance impacts business outcomes. The majority of studies confirm that ESG contributes to improved corporate performance (Yoon et al., 2018; Taliento et al., 2019; Lin Lin et al., 2023; Broadstock et al., 2020). Existing research highlights three key dimensions: securing government policy support through exemplary ESG practices (Wang Zhi and Peng Baichuan, 2022), enhancing productivity through sustainable development strategies (Griffin et al., 2021), and driving innovation for long-term sustainability (Li Jinglin et al., 2021). However, some studies suggest that ESG initiatives may paradoxically hinder performance improvements. Grounded in shareholder-centric theories, early scholars viewed ESG activities—particularly CSR programs—as detrimental to shareholder interests (Barnea et al., 2010). This perspective stems from the inherent conflict between the capital-intensive nature of social responsibility initiatives and shareholders' fundamental pursuit of economic maximization. Furthermore, as the actual operators of enterprises, management teams bear dual pressures compared to shareholders: they not only shoulder capital investments related to social activities but also need to manage cash flow in fiscal revenue. These conflicting demands may trigger severe agency conflicts, increase agency costs, indirectly undermine long-term corporate benefits, and reduce shareholder wealth (Wang Shuangjin et al., 2022). Consequently, this creates a negative correlation between ESG-related initiatives and corporate performance.

2.2 Influencing factors of green technology innovation

Empirical studies on corporate characteristics primarily focus on executive traits and R&D investment. The Senior Management Tier Theory suggests that executives 'personal traits influence their assessment of business environments, thereby affecting corporate decision-making. As direct decision-makers in green technology innovation, the personal characteristics of listed company management directly impact the level of green technological innovation. Research indicates that executives' gender (Galbreath, 2019)^[10] and educational background (Yang Mei et al., 2023) foster broader management perspectives and environmental awareness, leading to higher green innovation consciousness among educated executives, which enhances corporate energy efficiency. Beyond personal attributes, executives 'personality traits and career experiences also influence green innovation decisions. Arena's (2017) study shows that arrogant executives tend to underestimate green innovation risks, thereby increasing project investments. CEOs' environmental leadership experiences grant them heightened attention to green technology projects and specialized expertise, making them more inclined to invest in such initiatives (Ling Hongcheng et al., 2024). Alongside executive talent, corporate financial capacity and R&D investment capabilities also significantly impact green technological innovation. Li et al. (2017) found that companies with better financial performance are more capable of funding green technology innovation projects and are more likely to engage in such initiatives^[14]. Wang Hui et al. (2024), using enterprise-level patent data, explored the driving effect of public research institutions' green R&D involvement on corporate innovation from the perspective of "dual externalities," revealing that such institutional engagement effectively enhances corporate green innovation capabilities^[23]. Finally, research on enterprise digital architecture demonstrates that corporate digital transformation improves green technology innovation levels by enhancing the quality of corporate surplus information and accelerating technological integration capabilities (Zhang Zenan et al., 2023).

3. Theoretical analysis and research hypothesis

3.1 ESG performance and enterprise green technology innovation

Unlike conventional corporate innovation, green technology innovation serves dual objectives of business growth and environmental protection. This requires enterprises to reduce emissions and improve resource efficiency through eco-friendly process innovations, while simultaneously enhancing competitiveness and economic performance via green product and service innovations. Third-party ESG ratings, as a non-market competitive strategy, drive companies to prioritize environmental protection, social responsibility fulfillment, and corporate governance during operations. Particularly under sustainable development frameworks, strong ESG performance aligns with corporate green transformation needs. Therefore, exemplary ESG performance inevitably drives enterprises to innovate in green technologies.

As stakeholder theory suggests, companies with strong ESG performance often attract more environmentally conscious stakeholders like green investors, eco-organizations, and consumers through their social responsibility commitments. These

stakeholders prioritize long-term growth potential over short-term profits. Consequently, ESG-performing firms not only secure sustainable funding but also leverage stakeholder support to boost competitiveness in green tech innovation, thereby enhancing innovation quality. This virtuous cycle ultimately drives companies to adopt higher quality standards in green tech development, making greater contributions to sustainable development.

In general, enterprises with good ESG performance can obtain more resources, reduce financing costs and attract long-term attention and investment from stakeholders by releasing the signal of green development, thus increasing the quantity and quality of green technology innovation. Based on this, the following hypotheses are proposed:

H1a: ESG performance has a positive impact on the number of green technology innovations;

H1b: ESG performance has a positive impact on the quality of green technology innovation.

3.2 ESG performance, digital transformation and green technology innovation

In the context of China's "Dual Carbon" strategy and the digital economy era, how enterprises can achieve deep integration between sustainable development and digital transformation has become a key focus in both academic and practical circles. Recent studies have increasingly demonstrated that corporate environmental, social, and governance (ESG) performance significantly drives digital transformation.

H2a: ESG performance can promote the number of green technology innovation of enterprises through digital transformation;

H2b: ESG performance can promote the quality of green technology innovation in enterprises through digital transformation;

3.3 ESG performance, media attention and green technology innovation

From the perspective of signaling theory, ESG performance serves as a credible and verifiable positive signal. This mechanism not only reduces information asymmetry between enterprises and their external environment but also enhances media attention and social image, thereby attracting more positive coverage. This demonstrates that ESG is not merely a tool for corporate social responsibility, but a strategic instrument for securing media resources and public support in the information age. Based on this analysis, we propose the following hypotheses:

H3a: ESG performance can promote the number of green technology innovation of enterprises through media attention;

H3b: ESG performance can promote the quality of green technology innovation of enterprises through media attention;

4. research design

4.1 Model setting and variable selection

4.1.1 model specification

In order to test the research hypotheses H1a and H1b, this paper sets up the following model:

$$GIZ_{i,t} = \alpha_0 + \beta_1 ESG + \sum \gamma X_{i,j,t} + \mu_i + \omega_t + \varepsilon_{i,t} \quad (1)$$

$$GIS_{i,t} = \alpha_0 + \beta_1 ESG + \sum \gamma X_{i,j,t} + \mu_i + \omega_t + \varepsilon_{i,t} \quad (2)$$

$$DCG_{i,t} = \alpha_0 + \beta_1 ESG + \sum \gamma X_{i,j,t} + \mu_i + \omega_t + \varepsilon_{i,t} \quad (3)$$

$$Media_{i,t} = \alpha_0 + \beta_1 ESG + \sum \gamma X_{i,j,t} + \mu_i + \omega_t + \varepsilon_{i,t} \quad (4)$$

In the model, $GIZ_{i,t}$ denotes the quantity of green technology innovation, and $GIS_{i,t}$ represents the quality of green technology innovation. μ_i and ω_t respectively denote unobservable individual fixed effects and time fixed effects, while $\varepsilon_{i,t}$ represents the random disturbance term. Model (1) is used to test Hypothesis H1a, Model (2) for Hypothesis H1b, and Model (3) for Hypotheses H2a and H2b. Model (4) is employed to test Hypotheses H3a and H3b. To reduce omitted variable bias, control variables are also included in the model.

4.2 variable selection

4.2.1 The explained variable: green innovation

The quantity of green technology innovations in enterprises (GIS). Drawing on the method of Li Wenjing and Zheng Manni (2016), the quantity of green innovations is measured by the number of green utility model patent applications with lower technical difficulty and lower patent technical level; the quality of green innovations is measured by the number of green

invention patent applications with the highest technical difficulty and the most complex patent technical level. Patent data are sourced from the China National Research Data Service Platform (CNRDS), and green patents are classified and identified according to the International Patent Classification Green List. Considering the right-skewed distribution characteristics of patent data, this paper applies a log-1 transformation to the number of green patent applications, to reduce data skewness and improve the accuracy and robustness of statistical analysis.

Green Innovation Quality (GIZ) of Enterprises. The Green Innovation Quality (GIZ) of Enterprises focuses more on the quality and practical value of corporate green technological innovations, aiming to evaluate the technical depth and innovation level of enterprises' green technological achievements. Following the approach of Li Wenjing and Zheng Manni (2016), GIZ specifically adopts the number of green invention patent applications as a measurement indicator. As invention patents typically represent higher levels of innovation and technological breakthroughs, selecting this metric better reflects the quality of corporate green innovations. Similarly, this study applies a logarithmic transformation with a +1 adjustment to the number of green invention patent applications.

4.2.2 Explanatory variable: ESG rating

According to previous studies, the Huazheng ESG rating combines mainstream international ESG evaluation perspectives with China's practical context, measuring corporate environmental responsibility, social responsibility, and corporate governance through 14 entities and 26 key indicators. It covers all listed companies with good data continuity and availability. Therefore, this paper adopts the Huazheng ESG rating as the measurement method for explanatory variables. The Huazheng ESG rating is divided into nine tiers: C, CC, CCC, B, BB, BBB, A, AA, and AAA. For empirical research and scholarly studies, scholars assign scores from 1 to 9 to measure the nine-tier C-AAA rating system. Higher scores indicate higher ESG ratings, reflecting better performance in environmental, social, and corporate governance aspects, and vice versa.

4.2.3 Mediating variables

Digital Transformation (DCG): This study draws on scholarly research and employs text analysis of corporate annual reports. Through CNRDS 'AKRD database, we conducted term frequency statistics for digital transformation-related keywords in listed companies' annual reports. The processed data from 2011 to 2022 was then analyzed by calculating logarithms of the adjusted term frequencies to measure corporate digital transformation.

Media Focus (Media): Existing literature measures media attention primarily through the number of news reports related to enterprises obtained via internet news search engines. This paper uses the total number of media coverage titles from quantitative statistics of newspaper and financial news and online news in China's research data service platform to measure the intensity of media attention received by heavily polluting enterprises.

4.3 Data sources and sample selection

This study conducts empirical analysis using data from Shanghai and Shenzhen A-share listed companies between 2010 and 2024. To ensure validity, we applied the following data processing principles: (1) Removing companies marked with ST or PT status; (2) Eliminating samples with missing data; (3) Excluding companies with less than one year of listing history; (4) Removing financial industry enterprises; (5) Filtering out insolvent companies; (6) Applying 1% and 99% trimming to all continuous variables to eliminate outliers. The final dataset comprises 18,057 valid observations.

Table 1 Descriptive statistics

Variable	N	Mean	SD	Min	Max
GIZ	18057	0.340	0.760	0	6.480
GIS	18057	0.610	0.990	0	6.210
ESG	18057	4.120	0.960	1	9.000
DCG	18057	1.170	1.270	0	4.960
Media	18057	3.740	1.820	0	14.19
Size	18057	22.82	1.410	19.88	26.71
Lev	18057	0.500	0.200	0.0700	0.930

Variable	N	Mean	SD	Min	Max
ATO	18057	0.680	0.500	0.0600	2.930
Cap1	18057	14.70	1.080	12.04	17.96
Growth	18057	0.140	0.400	-0.580	2.680
ROE	18057	0.0600	0.130	-0.680	0.390

Table 1 presents the descriptive statistics of key variables, with all continuous variables having undergone a 1% trimming. The Lev mean value is 0.5, though some companies exhibit an asset-liability ratio as high as 0.93. The ESG rating average stands at 4.12, with the highest value reaching 9. The mean values for the dependent variables—green technology innovation quantity and quality—are 0.34 and 0.61, respectively.

5. Empirical results and analysis

5.1 Results of benchmark regression

Regression analysis of the benchmark model using Stata 16.0 yielded results shown in Table 2. The findings indicate that: In Column (1), the regression coefficient of ESG rating on overall green innovation quality (GIZ) is 0.123, which is statistically significant at the 1% level, demonstrating that ESG rating significantly promotes corporate green innovation quality. Similarly, in Column (2), the coefficient for ESG rating on green innovation quantity (GIS) is 0.103, also significant at the 1% level, confirming that ESG rating substantially enhances the quantity of green innovation activities. These results validate Hypotheses H1a and H1b proposed in this study.

Table 2 Benchmark regression

	(1)	(2)
	GIZ	GIS
ESG	0.041*** (4.745)	0.026*** (2.607)
Size	0.170*** (7.570)	0.260*** (9.893)
Lev	-0.020 (-0.348)	-0.134* (-1.655)
ATO	-0.032 (-1.018)	0.053 (1.394)
Cap1	-0.026** (-2.063)	-0.059*** (-3.838)
Growth	-0.033*** (-3.438)	-0.022* (-1.716)
ROE	-0.086* (-1.880)	-0.011 (-0.180)
_cons	-3.402*** (-7.466)	-4.726*** (-8.418)
N	18057	18057
r ²	0.180	0.196
r ² _a	0.179	0.195

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

(1) Analysis of mediation effects

Regression of mediating effects in Table 3

	(4)	(4)
	DCG	Media
ESGmean	0.039*** (3.612)	0.020* (1.868)
Size	0.249*** (9.217)	0.184*** (7.318)
Lev	-0.217** (-2.076)	-0.008 (-0.085)
ATO	0.112** (2.524)	0.038 (0.881)
Cap1	-0.026 (-1.255)	-0.029 (-1.643)
Growth	0.007 (0.470)	0.025 (1.472)
ROE	-0.047 (-0.634)	0.329*** (4.936)
_cons	-4.902*** (-7.912)	-0.160 (-0.295)
N	18057	18057
r ²	0.364	0.780
r ² _a	0.363	0.780

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

This study employs the two-step method proposed by Jiang Ting (2022) to examine mediating effects. Using Stata 16.0 for regression analysis of digital transformation and media attention as mediating variables, the results are presented in Table 3. The F-values in all models remain statistically significant at the 1% level. Column (2) shows that ESG ratings significantly increase analyst attention (regression coefficient: 0.039 at the 1% level), confirming Hypotheses H2 and H3. Column (3) demonstrates that ESG performance positively correlates with media attention (regression coefficient: 0.02), further validating these hypotheses.

5.2 Robustness test

Replacement of explanatory variables

An alternative measurement method for constructing ESG1 was developed. Specifically, enterprises with an ESG rating of C-CCC receive a score of 1, those rated B-BBB receive 2, and those rated A-AAA receive 3. After implementing this revised measurement approach for explanatory variables, regression analysis of the sample data revealed that the updated results largely align with previous findings. This validation demonstrates the robustness of the study's conclusions.

Table 4 Replacement of explanatory variables

	(1)	(2)
	GIZ	GIS
ESG1	0.037*** (4.825)	0.025*** (2.794)
Size	0.171*** (7.613)	0.260*** (9.904)
Lev	-0.021 (-0.372)	-0.134* (-1.655)
ATO	-0.033 (-1.033)	0.053 (1.385)
Cap1	-0.027** (-2.075)	-0.059*** (-3.845)
Growth	-0.033*** (-3.447)	-0.022* (-1.714)
ROE	-0.087* (-1.886)	-0.011 (-0.186)
_cons	-3.397*** (-7.449)	-4.718*** (-8.403)
N	18057	18057
r2	0.179	0.196
r2_a	0.179	0.195

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

5.3 Elimination of extreme values

The method of removing extreme values is selected for robustness test in this paper. The specific test results are shown in Table 1. It can be seen that the regression coefficients in column (1) and column (2) correspond to the benchmark regression test results, so H1a and H1b can be further verified.

Table 5 Removal of extreme values

	(1)	(2)
	GIZ	GIS
ESG	0.042*** (4.709)	0.029*** (2.743)
Size	0.165*** (7.515)	0.264*** (9.896)
Lev	-0.016 (-0.275)	-0.158* (-1.935)
ATO	-0.030 (-0.962)	0.051 (1.351)
Cap1	-0.026**	-0.066***

	(1)	(2)
	GIZ	GIS
	(-2.033)	(-4.206)
Growth	-0.031***	-0.021
	(-3.228)	(-1.571)
ROE	-0.083*	-0.012
	(-1.819)	(-0.195)
_cons	-3.313***	-4.709***
	(-7.265)	(-8.359)
N	17756	17756
r2	0.173	0.197
r2_a	0.172	0.196

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.4 Heterogeneity analysis

5.4.1 The influence of property right nature on ESG value effect

First, the nature of ownership rights influences the motivations behind corporate ESG performance. As relatively pure market participants, non-state-owned enterprises primarily aim to achieve economic returns when enhancing ESG practices. In contrast, state-owned enterprises, possessing dual identities as both market players and state regulators, prioritize institutional policies, social impact, and public sentiment over economic gains in their ESG initiatives. Consequently, the focus of ESG practices differs between enterprises with different ownership structures: non-state-owned firms tend to prioritize stakeholders who generate greater economic benefits, while state-owned enterprises more often engage in ESG initiatives to comply with national directives. These differences in ESG motivations and implementation patterns result in stronger value-enhancing effects for ESG investments in non-state-owned enterprises. Second, ownership structure affects how enterprises leverage ESG to secure support from stakeholders like governments and financial institutions. State-owned enterprises inherently enjoy stronger political connections, making it easier to obtain support from governments and state-owned banks. Conversely, non-state-owned enterprises lack such “kinship ties” with government entities and banks, necessitating enhanced ESG practices to gain governmental and banking backing. Therefore, for both state-owned and non-state-owned enterprises, the marginal effect of improving ESG on acquiring resources from governments and state-owned banks remains relatively low. In summary, state-owned enterprises are expected to demonstrate smaller value-enhancing effects from ESG performance. Considering the characteristics of ownership structure as a grouping variable, this study employs group regression analysis for verification, with relevant results presented in Table 6. Columns (1) and (2) present the regression results for quality groups of green technology innovation, with Column (1) representing non-state-owned enterprises and Column (2) representing state-owned enterprises. Columns (3) and (4) demonstrate the quantitative group regression results, where Column (3) and Column (4) correspond to non-state-owned enterprises and state-owned enterprises respectively. In summary, compared with non-state-owned enterprises, state-owned enterprises exhibit a smaller enhancement effect of ESG on corporate value improvement.

Table 6. Influence of property right nature on ESG value effect

	(1)	(2)	(3)	(4)
	GIZ	GIZ	GIS	GIS
ESG	0.040***	0.038***	0.054***	0.004
	(3.449)	(3.330)	(3.753)	(0.275)

	(1)	(2)	(3)	(4)
	GIZ	GIZ	GIS	GIS
Size	0.178*** (6.135)	0.171*** (5.185)	0.245*** (6.202)	0.291*** (8.610)
Lev	-0.000 (-0.002)	-0.027 (-0.320)	-0.101 (-0.949)	-0.138 (-1.166)
ATO	-0.070* (-1.740)	-0.005 (-0.108)	0.012 (0.205)	0.086* (1.717)
Cap1	-0.044** (-2.473)	-0.014 (-0.796)	-0.048** (-2.109)	-0.070*** (-3.444)
Growth	-0.032** (-2.338)	-0.038*** (-2.806)	-0.044** (-2.405)	-0.013 (-0.720)
ROE	-0.031 (-0.529)	-0.147** (-2.233)	-0.055 (-0.726)	-0.013 (-0.160)
_cons	-3.257*** (-5.298)	-3.652*** (-5.561)	-4.563*** (-5.470)	-5.232*** (-7.198)
N	7230	10827	7230	10827
r2	0.161	0.197	0.160	0.230
r2_a	0.159	0.195	0.158	0.228

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

5.4.2 The influence of enterprise rent-seeking on ESG value effect

In corporate governance and policy environments, rent-seeking behaviors often indicate closer relationship networks between enterprises and governments or external institutions. These enterprises exhibit the following characteristics that enhance the marginal effects of ESG performance on green technology innovation. Specifically, rent-seeking enterprises communicate frequently with governments and rely more heavily on policy resources such as green subsidies, emission reduction incentives, and green credit. When demonstrating strong ESG performance, they are more likely to be recognized by governments as “compliant” or “exemplary” enterprises, thereby securing additional external resources for green R&D and driving green technological innovation. High rent-seeking enterprises, facing greater public and regulatory scrutiny, need to leverage ESG to rebuild their reputation and legitimacy. Compared to low rent-seeking enterprises, these companies show stronger motivation to implement ESG through visible green patents and process improvements, thereby sending credible “green signals” externally and enhancing green technology innovation outputs. In summary, high rent-seeking enterprises are expected to exhibit greater value-enhancing effects through ESG performance. This study employs grouped regression analysis for verification, with results presented in Table 7. Columns (1) and (2) report grouped regression results for green technology innovation quality, where Column (1) represents low rent-seeking enterprises and Column (2) represents high rent-seeking enterprises. Columns (3) and (4) present grouped regression results for green technology innovation quantity, with Columns (3) and (4) representing low and high rent-seeking enterprises respectively. In conclusion, compared to low rent-seeking enterprises, high rent-seeking enterprises demonstrate greater value-enhancing effects of ESG improvements.

Table 7 The effect of enterprise rent-seeking on ESG value effect

	(1)	(2)	(3)	(4)
	GIZ	GIZ	GIS	GIS
ESG	0.027*** (2.987)	0.051*** (3.766)	0.003 (0.249)	0.053*** (3.389)
Size	0.128*** (5.199)	0.155*** (4.417)	0.230*** (6.889)	0.214*** (5.515)
Lev	-0.076 (-1.209)	0.056 (0.578)	0.039 (0.431)	-0.294** (-2.223)
ATO	-0.013 (-0.289)	-0.069 (-1.492)	0.075 (1.441)	0.035 (0.629)
Cap1	-0.002 (-0.125)	-0.029 (-1.551)	-0.041* (-1.661)	-0.059*** (-3.064)
Growth	-0.006 (-0.430)	-0.044*** (-3.163)	-0.007 (-0.362)	-0.033* (-1.794)
ROE	-0.023 (-0.438)	-0.133* (-1.748)	0.033 (0.422)	-0.056 (-0.588)
_cons	-2.760*** (-5.128)	-3.095*** (-4.175)	-4.343*** (-6.397)	-3.666*** (-4.423)
N	9029	9028	9029	9028
r2	0.106	0.215	0.131	0.213
r2_a	0.104	0.213	0.129	0.211

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

6. POLICIES AND RECOMMENDATIONS

This study empirically examines the impact of corporate ESG performance on green technology innovation using A-share listed companies in China from 2010 to 2024. The findings reveal that better ESG performance correlates with higher corporate value. Mechanism analysis demonstrates that strong ESG performance enhances digital transformation capabilities and media visibility, thereby boosting corporate value. Further analysis shows that ESG's value-enhancing effect is more pronounced in non-state-owned enterprises and firms with higher rent-seeking tendencies. Policy implications emerge from these conclusions: First, empirical results confirm that exemplary ESG performance significantly elevates corporate value, indicating ESG has become a crucial lever for enhancing core competitiveness and market recognition. Second, ESG indirectly strengthens value creation capabilities by driving digital transformation and media engagement. Third, the value-enhancing effect is particularly evident in non-state-owned enterprises and firms with stronger rent-seeking tendencies, suggesting ESG's regulatory and constraint functions are more prominent in governance-deficient or high-pressure environments. The following policy recommendations are proposed for this study: First, enterprises should proactively establish a comprehensive ESG management system, integrating environmental responsibility, social responsibility, and corporate governance into long-term strategic planning to continuously improve ESG performance and achieve steady growth in corporate value. Second, when implementing ESG strategies, companies should deepen integration with digital transformation while enhancing transparency in information disclosure and media engagement to amplify the social impact of ESG achievements and gain greater recognition in capital markets. Third, regulatory authorities should strengthen supervision and policy guidance for non-state-owned enterprises and high-rent-seeking firms, encouraging them to enhance compliance

and innovation through ESG practices. Enterprises themselves should prioritize green technology innovation and compliance governance in their ESG investments, thereby achieving dual objectives of reputation enhancement and value creation.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Yoon B, Lee J H, Byun R. Does ESG performance enhance firmvalue? evidence from Korea[J]. Sustainability, 2018, 10(10): 3635-3652.
- [2] Taliento M, Favino C, Netti A. Impact of environmental, social, and governance information on economic performance: evidence of a corporate ‘sustainability advantage’ from Europe[J]. Sustainability, 2019, 11(6): 1738-1763.
- [3] Lin Lin, Yang Hongjuan, Yang Bin. Does Enhanced ESG Performance Improve Corporate Value in the Context of Carbon Peaking and Carbon Neutrality Goals? An Empirical Study Based on CSI 300 and CSI 500 Component Stocks [J]. Science Decision, 2023, (06):42-63.
- [4] Broadstock D C, Chan K, Cheng L T W, Wang X W. The role of ESG performance during times of financial crisis: evidence from covid-19 in China[J]. Finance Research Letters, 2020, 38: 101716.
- [5] Wang Zhi, Peng Baichuan. The Impact of Corporate ESG Performance on Innovation Performance [J]. Statistics and Decision, 2022(24):164-168.
- [6] Griffin D, Guedhami O, Li K.,et al. National culture and the value im-plications of corporate environmental and social performance[J]. Journal of Cor-porate Finance, 2021(1): 1 ~ 24.
- [7] Li Jinglin, Yang Zhen, Chen Jin, et al. Research on the Mechanism of ESG in Promoting Corporate Performance: An Innovation-Based Perspective [J]. Science Science and Technology Management, 2021,42(09):71-89.
- [8] Barnea, A. and Rubin, A. Corporate Social Responsibility as a Conflict Between Sharehold-ers[J]. Journal of Business Ethics, 2020, (1): 245~278.
- [9] Wang Shuangjin, Tian Yuan, and Dang Lili. Corporate ESG Responsibility, Competitive Strategy, and Financial Performance in Industrial Enterprises [J]. Accounting Research, 2022, (03):77-92.
- [10] Lelasi F, Capelli P, Russo A. Forecasting Volatility by Intergrating Financial Risk with Environmental, Social, and Governance Risk [J]. Corporate Social Responsibility and Environmental Management, 2021, 28(5): 1483-1495.
- [11] Dong Xiaohong, Sun Zhenghan. Turning Crisis into Opportunity or Backfiring: Can ESG Performance Reduce Corporate Operational Risks? [J]. Journal of Central University of Finance and Economics, 2023, (07):57-67.
- [12] Zhang J Y, De S, Jan S. Implied Tail Risk and ESG Ratings [J]. Mathematics, 2021, 9(14): 148-152.
- [13] Li D, Zheng M, Cao C, et al. The impact of legitimacy pressure and corporate profitability on green innovation: Evidence from China top 100[J]. Journal of Cleaner Production, 2017, 141:567-654.
- [14] Wang Hui, Feng Zheng, Yuan Li, et al. Green R&D Intervention in Public Research Institutions and Corporate Green Innovation: A Perspective Based on Environmental Externalities [J/OL]. China Industrial Economics, 2024, (09):81-995.
- [15] Zhang Zenan, Qian Xinyu, Cao Xinwei. The Green Innovation Effect of Enterprise Digital Transformation: Substantive Innovation or Strategic Innovation? [J]. Industrial Economics Research, 2023, (01):86-100.

Research on Digitalization and High-Quality Economic Development of Shaanxi Province

Ru Feng*

College of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710000, China

*Corresponding author: Ru Feng, 1649168763@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This study focuses on digitalization and the high-quality economic development of Shaanxi Province, conducting an in-depth exploration of the digital development in Shaanxi. Regarding the current development status, it first elaborates on the connotations of economic digitalization and the digital economy, and then analyzes Shaanxi's digitalization level, covering aspects such as its national ranking, digital infrastructure construction, scale of the digital economy, policy support, and achievements in digital industrialization and industrial digitalization. The analysis reveals that Shaanxi faces a series of problems in digital development: there are shortcomings in systematic planning, including deficiencies in top-level design, overall coordination, and the allocation of development goals, powers, and responsibilities; the development of new digital economy formats is unbalanced, manifested in uneven regional development and industrial integration, lagging legal supervision, and a severe digital divide; the development environment is unfavorable, with issues in the marketization of data factors, shortages in infrastructure and talents, sharing of government data, and information construction. Based on these findings, this study proposes suggestions such as strengthening top-level design, promoting university-enterprise cooperation, enhancing digital government construction, and accelerating the development of digital platforms, so as to drive the high-quality economic development of Shaanxi Province.

Keywords: Digitalization; Shaanxi Economy; High-Quality Development; Digital Economy; Digital Infrastructure Construction

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.817>

1. Definition of Core Concepts and Current Status of Shaanxi's Digital Development

1.1 Economic Digitalization and the Digital Economy

Economic digitalization refers to the transformation of production methods, operation models, and service approaches in traditional industries through the adoption of digital technology and information technology. The core of economic digitalization lies in the in-depth integration of digital technology with the real economy, thereby improving efficiency and optimizing the economic structure. Essentially, it represents an efficiency enhancement of traditional production models—empowering traditional enterprises with modern technological means to boost production efficiency and economic benefits. Unlike the digital economy, which forms an independent economic system, economic digitalization serves as a supplement and improvement to the existing economic system^[1].

The digital economy refers to a series of economic activities that take digitized knowledge and information as key factors of production, modern information networks as the main carrier, and realize efficiency improvement and economic structure

optimization through the effective application of information and communication technologies. It consists of two major components: digital industrialization and industrial digitalization. Digital industrialization mainly refers to the development of the information technology industry, such as the electronic information manufacturing industry and the software and information service industry; while industrial digitalization refers to the comprehensive transformation of traditional industries with the support of digital technology, enabling intelligent and digital upgrading. As a new economic form, the digital economy emphasizes that data has become a new factor of production, and information technology is deeply integrated with the real economy ^[2].

The digital economy is a form of expression and an advanced stage of economic digitalization. Through the application and innovation of digital technology, the digital economy promotes the optimization of the economic structure and the improvement of productivity, while economic digitalization provides the foundation and support for the development of the digital economy. The two complement each other and jointly drive the comprehensive digital transformation of the economy and society. However, the digital economy is an entirely new economic form, with data as its core factor of production, covering both digital industrialization and industrial digitalization, and featuring distinct digital, intelligent, and networked characteristics. In contrast, economic digitalization focuses more on the optimization and upgrading of traditional economic activities driven by digital technology, representing the process of transforming the traditional economy into a modern one. Although both rely on modern information technology means, they embody completely different production methods and economic development models.

1.2 Current Status of Shaanxi's Digitalization Level

1.2.1 Analysis of Shaanxi's National Ranking in Digitalization Level

According to the content released in the China Digital Economy Development Index Report 2023 by the Fifth Research Institute, at the national level, Shaanxi Province ranked 16th in the 2023 Digital Economy Development Index, standing at the forefront of the third tier nationwide, and demonstrating a certain degree of competitiveness in the national digital development landscape. Among the 12 provinces and autonomous regions in western China, Shaanxi, together with Sichuan and Chongqing, constitutes the first tier of digital economy development in the west, highlighting its significant advantages in digital development in western China. Specifically, Shaanxi has achieved remarkable results in the development of the digital economy, with both digital industrialization and industrial digitalization levels significantly improved. The total scale of its digital economy has successfully exceeded 1.4 trillion yuan, accounting for over 40% of its GDP, and ranking among the leading positions in western China.

1.2.2 Progress of Digital Infrastructure Construction in Shaanxi Province

Shaanxi has achieved remarkable results in the field of digital infrastructure construction. By the end of 2023, the province had built and put into operation a total of 88,000 5G base stations, realizing full 5G network coverage in administrative regions at and above the township level, with the 5G network coverage rate in administrative villages reaching 85%. Meanwhile, the coverage capacity of gigabit optical networks has exceeded 26 million households, and all prefecture-level cities in the province have met the gigabit city construction standards. Looking ahead to 2024, Shaanxi Province plans to build and put into operation more than 110,000 5G base stations, aiming to construct a layout across the province where "multiple networks coexist in high-traffic areas and a single network provides basic coverage in remote areas", so as to further optimize the digital infrastructure environment.

1.2.3 Development Trend of the Digital Economy Scale

The scale of Shaanxi's digital economy has continued to expand. In 2022, the total volume of the province's digital economy reached 1.2618 trillion yuan, accounting for 38.5% of the province's total GDP. By 2023, the scale of the digital economy exceeded 1.4 trillion yuan, accounting for over 40% of GDP. As the provincial capital, Xi'an has achieved outstanding performance in the digital economy, with a total volume of 524.9 billion yuan, accounting for 45.6% of the city's total GDP, and playing a crucial leading and supporting role in the development of the province's digital economy.

1.2.4 Policy Support for Digital Economy Development

Shaanxi attaches great importance to the development of the digital economy and has issued a series of policy measures

and plans to provide solid policy guarantees for the development of the digital economy. For example, the Shaanxi Digital Economy Development Plan clearly proposes that by the end of the 14th Five-Year Plan period, the output value of the province's electronic information manufacturing industry will reach 330 billion yuan, and the operating income of the software and information service industry will reach 500 billion yuan. In addition, the Shaanxi Provincial Party Committee and the Shaanxi Provincial Government have issued the Policy Measures for Promoting the High-Quality Development of the Digital Economy, putting forward 37 specific measures covering key areas such as the construction of new digital infrastructure, the digital transformation of industries, and the innovative development of digital industrialization, which point out the direction and provide strong support for the development of the digital economy.

1.2.5 Achievements in Digital Industrialization and Industrial Digitalization

Shaanxi has achieved remarkable results in digital industrialization and industrial digitalization^[3]. Xi'an has been successfully approved as a National Pilot Zone for the Innovative Development of the New Generation of Artificial Intelligence, injecting new impetus into the development of the digital industry. The number of enterprises "migrating to the cloud" in the province has exceeded 10,000, effectively promoting the digital transformation of enterprises. In the industrial field, Shaanxi has actively promoted digital construction. By the end of 2023, the number of enterprises in the province that have passed the certification of the upgraded version of the Integration of Informatization and Industrialization Management System had reached 1,690, ranking third in the country, which demonstrates a sound development trend of digitalization in the industrial field.

Shaanxi has achieved excellent results in the national and western regional rankings of the digital economy development index, and made significant progress in digital infrastructure construction, the expansion of the digital economy scale, policy support, as well as digital industrialization and industrial digitalization, demonstrating strong competitiveness and extensive influence in the national digital development landscape.

2. Analysis of Major Problems in the Digital Development Process of Shaanxi Province

Currently, the added value of the core digital economy industry in Shaanxi Province accounts for approximately 5% of the regional GDP. Although the digital economy in Shaanxi started relatively late, it has maintained a rapid development momentum, with the growth rate of its digital economy scale ranking among the top in western provinces and autonomous regions. Various cities in the province have shown bright spots in development, and achieved remarkable results in breaking through development difficulties. However, in the process of further promotion and development, it still faces a series of prominent problems that cannot be ignored.

2.1 Shortcomings in Systematic Planning

2.1.1 Inadequate Top-Level Design and Policy Guarantee System

Although Shaanxi has achieved certain development results in the field of the digital economy, its top-level design and policy guarantee system are still incomplete. This has led to the lack of a strategic plan for the development of the digital economy, making it difficult to clarify the goals and directions of industrial development and unable to provide solid and powerful guarantees for industrial development. Due to the lack of guidance from systematic top-level design, the development of the digital economy lacks unified layout and planning at the macro level, and it is difficult for the development of various fields and links to form a synergy effect.

2.1.2 Weak Overall Coordination

There are obvious deficiencies in overall coordination in promoting the development of the digital economy. The coordination and cooperation between different regions and departments are not close enough, resulting in poor information communication and difficulties in resource integration, which in turn leads to low overall development efficiency and unsatisfactory results. Different regions act independently in the development of the digital economy, lacking unified planning and coordination, which easily causes resource waste and redundant construction; the division of responsibilities between various departments is not clear enough, and there are phenomena of shirking responsibilities in the process of policy formulation and implementation, which affects the effective implementation of policies.

2.1.3 Unclear Development Goals and Allocation of Powers and Responsibilities

When formulating plans for the development of the digital economy, Shaanxi has failed to clarify specific development goals, and the allocation of powers and responsibilities is also not clear enough. This makes it difficult for various policy measures to be effectively implemented in actual operations. The lack of clear goal guidance makes it difficult for local governments and enterprises to determine their positioning and direction in the development of the digital economy; the unclear division of powers and responsibilities leads to confusion in project promotion and resource allocation, affecting the orderly development of the digital economy.

2.2 Imbalanced Development of New Digital Economy Formats

2.2.1 Prominent Problem of Unbalanced Regional Development

The development of the digital economy in Shaanxi shows an obvious distribution characteristic of “high in the central region and low in the northern and southern regions”. The Guanzhong region has a relatively high level of digital economy development, followed by northern Shaanxi, and southern Shaanxi has the lowest level. There is a large gap in digital development levels between cities in the province. Large cities such as Xi’an and Xianyang have achieved relatively rapid digital development, while some small and medium-sized cities are relatively backward. This unbalanced regional development leads to uneven distribution of resources and policies, further widening the gap in digital economy development between different regions. Relying on their sound industrial foundation, talent resources, and technological advantages, large cities have taken the lead in the development of the digital economy; while small and medium-sized cities are restricted by weak infrastructure and talent shortages in their digital economy development ^[4].

2.2.2 Imbalanced Development of Industrial Integration and Application

Although Shaanxi has achieved a relatively high score in the indicators of industrial development and integration application, it has a low score in the development environment indicator. This indicates that although some industries, such as the electronic information industry cluster, have achieved rapid development, there are still many deficiencies in the overall digital economy development environment. In terms of infrastructure, some regions have insufficient network coverage and limited bandwidth, which affects the widespread application of digital technology; in terms of innovation capabilities, enterprises have insufficient R&D investment and a shortage of innovative talents, resulting in low technological content of digital products and services; in terms of digital governance, the digital management level of government departments needs to be improved, and the mechanisms for data sharing and business collaboration are incomplete ^[5].

2.2.3 Lagging Legal System and Regulatory Capabilities

With the rapid development of the digital economy, the existing legal system and regulatory capabilities have failed to keep pace in a timely manner. There are obvious shortcomings, especially in data protection and privacy security. Incidents such as data leakage and abuse occur from time to time, which not only damage the legitimate rights and interests of consumers but also affect the healthy development of the digital economy. At the same time, in the face of emerging digital business formats, regulatory authorities lack effective regulatory means and experience, making it difficult to conduct comprehensive and effective supervision of digital economic activities, increasing the operational risks of enterprises.

2.2.4 Severe Digital Divide

Although the digital economy has brought new development opportunities to Shaanxi Province, the problem of the “digital divide” remains relatively prominent. In rural and remote areas, the unequal access to information and services has exacerbated the imbalance in regional economic development. Due to weak network infrastructure, low penetration rate of digital equipment, and low digital literacy of residents in these areas, it is difficult for them to enjoy the dividends brought by the digital economy. The existence of the digital divide not only affects the quality of life of rural residents but also restricts the economic development and social progress of rural areas.

2.3 The Need to Optimize the Digital Economy Development Environment

2.3.1 Difficulties in the Marketization of Data Factors

Although Shaanxi’s digital economy has developed rapidly, it has encountered many problems in the marketization of data factors. Issues such as inconsistent government data standards and poor data circulation are relatively prominent, which have hindered the effective utilization of data and the further development of the digital economy. The standards for government

data formats and coding between different departments and systems are inconsistent, making it difficult to integrate and share data; the data circulation mechanism is incomplete, and the data trading market is underdeveloped, making it difficult for data factors to flow freely and be optimally allocated in the market.

2.3.2 Infrastructure and Talent Shortages Restricting Development

Shaanxi has deficiencies in digital infrastructure construction, especially the low popularization rate of science and technology and cultural facilities in rural areas. Problems such as incomplete network coverage and slow broadband speed have affected the digital life of rural residents and the development of enterprises. In addition, insufficient R&D investment in the software industry, shortage of compound international talents, and low innovation capabilities of electronic information industry clusters have all become bottlenecks restricting the development of the digital economy. The shortage of R&D funds makes it difficult for enterprises to carry out cutting-edge technology research and new product development; the talent shortage makes enterprises lack motivation in digital technology innovation and business expansion; the low innovation capabilities of industrial clusters affect the competitiveness of the entire industry.

2.3.3 Imperfect Mechanism for Government Data Opening and Sharing

Although Shaanxi has made certain efforts to promote the integration, opening, and sharing of government data resources, the overall progress is relatively slow. There are problems such as unclear organizational management and incomplete policies and regulations. The opening and sharing of government data involves multiple departments and levels, and the lack of a unified organizational structure for coordination and management makes it difficult to effectively promote the work of data opening and sharing; the incomplete policies and regulations result in unclear provisions on the scope, methods, and security of data opening and sharing, increasing the risks of data opening and sharing.

2.3.4 Information Construction Lagging Behind the Growth of Demand

Compared with the eastern coastal provinces in China, the information construction of small and medium-sized enterprises in Shaanxi is lagging behind. The demand for informatization continues to grow, but the development level is limited, which reflects the deficiencies of Shaanxi in informatization construction and application. Due to restrictions in funds, technology, and talents, small and medium-sized enterprises have insufficient investment in informatization construction and low levels of informatization application. This not only affects the production efficiency and management level of enterprises but also restricts their market competitiveness.

3. Conclusions and Recommendations

3.1 Strengthen Top-Level Design and Improve the Regional Coordinated Development Mechanism

Establish a provincial-level leading group for digital economy coordination to coordinate the overall planning, policy formulation, and resource allocation of the province's digital economy development. Formulate differentiated digital development strategies based on the regional characteristics of Guanzhong, southern Shaanxi, and northern Shaanxi: the Guanzhong region focuses on building a highland for the digital industry and a source of innovation; southern Shaanxi focuses on the integration of ecological economy and digital technology; northern Shaanxi focuses on the digital upgrading and green transformation of the energy industry. At the same time, improve the joint meeting system of provincial departments, strengthen the linkage between regions in digital infrastructure, industrial cooperation, and data sharing, reduce the "digital fragmentation" between regions, and promote the formation of a province-wide integrated digital development pattern^[6].

3.2 Promote University-Enterprise Cooperation and Enhance the Ability to Attract Digital Talents

Fully tap the potential of Shaanxi's scientific and educational resources, encourage universities to set up majors related to the digital economy, and strengthen the cultivation of professional talents in the digital economy. Relying on professional research institutions such as the Western Digital Economy Research Institute, carry out forward-looking research on major topics and evaluation consulting on major projects^[7]. Introduce talents in key development areas such as digital economy infrastructure construction, digital economy industrial development, digital technology R&D, and digital industry application, and guide compound economic management talents and key scientific and technological innovation teams to start businesses in Shaanxi. Implement a coordinated development plan and a cultivation plan for professional talents in the digital economy

to further enhance the ability to attract digital talents.

3.3 Strengthen Digital Government Construction and Build a New-Type Smart City

With digital technology as the core, accelerate the construction of government service platforms to realize cross-regional, cross-level, and cross-departmental applications, enhance the province's government service capabilities, and achieve "one-stop online service". Build smart cities by leveraging big data, cloud computing, and intelligent technologies to construct urban perception platforms, and promote the development of a comprehensive governance system and smart communities. Promote the development of digital villages, plan a digital industrial economic system, cultivate rural digital economy talents, and improve the informatization level of rural services.

3.4 Accelerate the Construction of Digital Platforms and Improve the Innovation Capability of the Digital Economy

Data is one of the core elements of the digital economy, and acquiring data is the key to developing data mining capabilities and promoting the development and utilization of data resources. Therefore, it is necessary to establish a robust data market, avoid regional data fragmentation, and promote coordinated regional development^[8]. In view of the current situation of digital economy platform companies in Shaanxi, it is necessary to formulate standards to guide the collection, integration, and analysis of data, build a basic platform for scientific and technological innovation, integrate innovative resources, promote the integration of science and technology, finance, industry, and talents, and promote the transformation of scientific and technological achievements into actual productivity. Utilize public service, technology, and policy platforms to attract investment, gather talents and technologies, and create digital economy demonstration industrial parks, making them important bases for the digital economy and technological innovation.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Liu, J. H., & Zhou, Z. B. (2020). Economic digitalization and global tax governance: Background, dilemmas and countermeasures. *Macroeconomic Research*, (06), 49–60.
- [2] Jing, W. J., & Sun, B. W. (2019). How does the digital economy promote high-quality economic development: A theoretical analysis framework. *Economist*, (02), 66–73.
- [3] Zhang, P., Zhou, E. Y., & Liu, Q. L. (2022). Measurement of digital transformation level of equipment manufacturing enterprises: An empirical study based on survey data of Shaanxi Province. *Science & Technology Progress and Policy*, 39(07), 64–72.
- [4] Liu, J. L. (2023). Implementing the "4+X" project to vigorously promote the digital transformation of higher education in Shaanxi. *China Higher Education*, (02), 31–36.
- [5] Li, Z. X., & Yang, Q. F. (2021). How does the digital economy affect China's high-quality economic development? *Modern Economic Research*, (07), 10–19.
- [6] Zuo, P. F., & Chen, J. (2021). Digital economy and economic growth from the perspective of high-quality development. *Research on Financial and Economic Issues*, (09), 19–27.
- [7] Hu, H. B., Zhou, J., & Lu, H. T. (2022). Digital transformation promotes high-quality development of manufacturing enterprises: Foundation, challenges and countermeasures. *Enterprise Economy*, 41(01), 17–23.
- [8] Yang, Z. F. (2020). Models, shortcomings and countermeasures of China's industrial digital transformation. *China Business and Market*, 34(07), 60–67.

Comparative Analysis of Investment Environments for Chinese Auto Parts Enterprises in Mexico and Southeast Asia and Different Development Strategies

Xin Sun*, Tieshan Wang

College of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710000, China

*Corresponding author: Xin Sun, sunxin055@outlook.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This paper employs the PESTEL six-dimensional analytical framework to systematically compare the investment environments and strategic differences for Chinese automotive parts enterprises in Mexico and Southeast Asia. The study examines six dimensions—political, economic, social, technological, environmental, and legal—to analyze similarities and differences between the two regions in terms of policy stability, economic potential, social labor force structure, technological innovation capabilities, sustainable development policies, and legal safeguards. Results indicate that Mexico, leveraging its proximity to North American markets, industrial support systems, and free trade agreement networks, is well-suited for high-value-added and technology-intensive enterprises. Conversely, Southeast Asian nations offer greater appeal in terms of labor costs, policy flexibility, and market diversification. Based on these findings, this paper proposes that Chinese enterprises should adopt differentiated international investment strategies: strengthening supply chain coordination and smart manufacturing capabilities in Mexico, while prioritizing localized operations, environmental responsibility, and social governance in Southeast Asia. This dual-track approach will help build a competitive and resilient global development framework.

Keywords: Automotive parts Enterprises; Overseas Investment; PESTEL Analysis; Mexico; Southeast Asia

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.818>

1.Introduction

In recent years, the global automotive industry's shift toward electrification, automation, connectivity, and sharing (CASE) has been reshaping the entire supply chain, propelling vehicles from traditional mechanical products into high-tech, intelligent mobility platforms. ^[1]This shift not only alters how vehicles are powered and used but also fuels the rapid rise of China's new energy vehicle (NEV) industry. Leveraging first-mover advantages in NEVs and a rapidly expanding domestic market, Chinese auto parts companies have secured pivotal positions in the global automotive supply chain across critical sectors like power batteries, electric drive systems, and in-vehicle intelligent systems. They are now optimizing their industrial footprint, upgrading from "exporting products" to "exporting production capacity," thereby accelerating their internationalization.

Against this backdrop, two routes—North America and Southeast Asia—are simultaneously gaining momentum. Mexico, leveraging the zero-tariff access under the USMCA, its mature automotive industrial clusters, and rapidly expanding EV production capacity plans, has become a "bridgehead" for Chinese parts companies entering the North American market. Meanwhile, Southeast Asian nations like Thailand, Vietnam, Indonesia, and Malaysia are viewed as "cost basins" for hedging

against restrictions under the U.S. Inflation Reduction Act (IRA) and capturing market share in ASEAN and the broader Global South. This appeal stems from their RCEP tariff advantages, relatively low factor costs, and government-specific incentives for new energy vehicles and components.

Given the accelerating pace of overseas investment by Chinese enterprises, the Third Plenary Session of the 20th CPC Central Committee emphasized leveraging China's super-large market advantage to enhance openness through expanded international cooperation, build a new system for a higher-level open economy, and propel the automotive industry toward modernization.^{[2][3]} Therefore, building upon a thorough study and implementation of the spirit of the Third Plenary Session, this paper systematically compares institutional differences between Mexico and major Southeast Asian countries across six dimensions—political, economic, social, technological, environmental, and legal—to provide theoretical foundations and decision-making references for enterprises in establishing location priorities, investment pacing, and risk mitigation strategies. This aims to empower Chinese enterprises in successfully expanding into international markets and realizing their globalization strategies.

2. Current Status of Outbound Investment by Chinese Automotive Parts Companies

According to statistics from the Ministry of Commerce and the State Administration of Foreign Exchange, China's total outbound direct investment across all industries reached \$162.8 billion in 2024, marking a 10% year-on-year increase. Non-financial outbound direct investment amounted to \$143.9 billion, up 11% year-on-year, with non-financial direct investment in Belt and Road partner countries totaling \$33.7 billion, a 5% year-on-year increase. Chinese enterprises' direct investments in Mexico and Southeast Asia have fostered significant industrial clustering effects, forming large-scale and relatively complete automotive industry clusters. To meet international market demands, Chinese auto parts manufacturers are accelerating their overseas expansion, prompting domestic parts suppliers to establish "localized supply chains" for these enterprises, thereby achieving mutual development.

2.1 Investment by Chinese Parts Manufacturers in Mexico

In recent years, Chinese automakers have steadily increased their market share in Mexico. Companies such as BAIC, SAIC, Chery, and Changan have established production and sales bases in Mexico, competing with world-class automakers in overseas markets.^[4] This trend has also spurred Chinese auto parts manufacturers to expand into Mexico, aligning with their clients' global strategies to strengthen critical supply chain links and achieve localized parts sourcing.^[5] As shown in Table 1, investment projects by Chinese auto parts companies in Mexico have gradually increased, particularly around 2020, with expanding investment scales. However, these projects remain concentrated in "traditional components" such as automotive castings and other alloy parts.

Table 1 Investment History of Selected Chinese Automotive Parts Companies in Mexico

Year	Company Name	Investment Sector	Specific Investment Project	Investment Amount
2014	Ningbo IKD Co., Ltd.	Production Base	Built the IKD FAEZA plant in Mexico for auto parts production.	Not disclosed
2016	Yangzhou Rongtai (Jiangsu)	Aluminum Alloy Castings	Set up a Mexico subsidiary for precision aluminum castings..	Not disclosed
2019	Yangzhou Rongtai (Jiangsu)	Aluminum Alloy Castings	Expanded the Mexico plant to boost output and quality.	USD 61 million
2020	Wencan Group (Foshan)	High-Pressure Die-Casting Line	Introduced die-casting lines in Mexico after acquiring Le Bélier.	Not disclosed
2020	Lizhong Group (Shenzhen)	Lightweight Alloy Wheel Project	Built a Mexico plant for 3.6M ultra-light aluminum wheels.	USD 170 million
2020	Ningbo IKD Co., Ltd.	Production Base	Increased investment to expand Mexico plant capacity	Not disclosed
2021	Bethel Automotive (Wuhu)	Steering Knuckle Casting & Machining	Built 14 casting and 34 machining lines in Mexico.	USD 50 million
2021	Yangzhou Rongtai (Jiangsu)	Aluminum Alloy Parts	Expanded Mexico production of lightweight auto parts.	RMB 200 million

Source: Compiled by the author based on relevant corporate investment.

On the other hand, the ongoing intelligent electric transformation—driven by electrification, smart technology, and technological innovation—will rapidly boost penetration rates across numerous niche segments. This period of automotive industry transformation is poised to spawn high-market-cap parts manufacturers. Simultaneously, Mexico’s lack of a domestic new energy supply chain will catalyze the resurgence of its premium Tier 1 suppliers.

Consequently, Chinese auto parts companies are intensifying investments and overseas expansion in Mexico for products including lightweight structural components, housings, and new energy thermal management modules. Following Tesla’s official announcement in March 2023 to build a Gigafactory in Mexico, and BYD’s planned announcement by late 2024 of its first Latin American EV production facility location, these companies are leading the charge in expanding Mexico’s new energy vehicle capacity. This substantial production scale is expected to drive demand for components, accelerating the establishment of an overseas parts supply chain system. Leveraging their technological capabilities and prior experience, as shown in Table 2, domestic parts manufacturers have already begun proactive expansion. Companies like Rongtai Co., Ltd., AICODI, and Bertelli focus on lightweight structural components and housings, while Sanhua Intelligent Control, Yinlun Co., Ltd., and Top Group concentrate on new energy thermal management modules. New production capacity is expected to be concentrated in 2024-2025.

Table 2 Investment Layout of Chinese Auto Parts Enterprises in Mexico

Company	Main Products	Investment and Production Details	Investment Amount
Rongtai Co., Ltd.	Precision aluminum alloy castings	Phase II expansion for precision aluminum castings, output of 860,000 housings.	RMB 271 million
IKD Co., Ltd.	NEV structural & “three-electric” components	Produces 1.75M structural parts and 0.75M “three-electric” components.	RMB 1.23 billion
Bethel Automotive	Aluminum steering knuckles, lightweight parts	Produces steering knuckles, control arms, EPB and brake calipers.	USD 50 million
Xiangxin Technology	Metal assemblies, battery housings, energy storage parts	Set up Mexico subsidiary; clients include Tesla, Mercedes, BMW, etc.	USD 20 million
Sanhua Intelligent Controls	NEV thermal management systems	Produces pumps, cold plates, heat exchangers, and integrated modules.	RMB 1.05 billion
Yinlun Co., Ltd.	EV thermal modules and oil coolers	Supplies North American EV clients; full capacity by 2025.	RMB 270 million
Tuopu Group	Lightweight chassis, interiors, actuators	Built plant in Nuevo León to supply Tesla with shock absorbers.	Up to USD 200 million
Xusheng Group	Precision aluminum parts	Built Mexico plant for high-performance auto components.	USD 276 million

Source: Compiled by the author based on relevant corporate investment.

2.2 Investment by Chinese Parts Manufacturers in Southeast Asia

Currently, China’s investment in the ASEAN region is growing rapidly, primarily directed toward countries such as Singapore, Indonesia, and Thailand. An increasing number of Chinese automotive brands are entering the ASEAN market, becoming choices for consumers in ASEAN nations. In 2023, China’s automobile exports to ASEAN nations continued their rapid growth trajectory. Currently, multiple Chinese automakers have established production capacity for internal combustion engine vehicles in Southeast Asia. SAIC and Great Wall Motors are coordinating their layouts with affiliated parts suppliers, while BYD and other automakers plan to bring their production capacity online in 2024. This will drive rapid synergistic development in the metals and processing sectors. Specific investment details are shown in Table 3 below:

Table 3 Investment Layout of Automotive Component Enterprises in Four Southeast Asian Countries

Country	Company	Main Products	Project Description	Investment Amount
Thailand	CATL (Contemporary Amperex Technology)	Power batteries	WHA Industrial Park Phase I in Rayong, planned capacity of 40 GWh.	USD 730 million
	Sunwoda	Cell-to-pack integration	10 GWh cell-to-pack plant in EEC, Chon-buri.	USD 1.0 billion
	CALB (China Aviation Lithium Battery)	Power batteries	20 GWh power battery project in Rayong.	USD 500 million
	Gotion High-Tech	LFP batteries	15 GWh LFP battery production line in Rayong.	USD 210 million
	SVOLT Energy	Battery packs and modules	Pack + module plant in Rayong.	USD 250 million
	Ningbo Tuopu Group	Lightweight chassis and interiors	Lightweight chassis and interior plant in Rayong.	USD 300 million
Indonesia	CATL (Contemporary Amperex Technology)	Nickel-precursor-battery integration	Integrated nickel, precursor, and battery production base in Karawang.	USD 5.97 billion
	Gotion High-Tech	Batteries and precursors	10 GWh integrated battery and precursor project in Sulawesi.	USD 560 million
	Huayou Cobalt	Nickel and nickel sulfate precursors	Joint nickel-nickel sulfate-precursor complex in Morowali IWIP Industrial Park.	Over USD 3.0 billion
	Wuling Motors	Vehicles and components	Cikarang plant with annual capacity of 120,000 passenger vehicles and components.	USD 700 million
Malaysia	EVE Energy	Cylindrical batteries	20 GWh cylindrical battery production line in Kulim.	USD 420 million
	Tuopu Group	Lightweight chassis and thermal systems	Lightweight chassis and thermal management plant in Kedah.	USD 200 million
Vietnam	Gotion High-Tech	LFP batteries	5 GWh LFP battery project in Vung Ang Economic Zone, Ha Tinh Province.	USD 270 million
	Joyson Electronics	Smart cockpit and BMS	Smart cockpit and BMS production line in Dinh Vu, Hai Phong.	USD 150 million

Source: Compiled by the author based on relevant corporate investment

In summary, Chinese parts manufacturers are rapidly establishing production capacity in Mexico focused on lightweight components and chassis systems under the “North American tariff exemption” framework. Concurrently, they are building vertical integration from minerals to batteries to complete vehicles in Southeast Asia, leveraging the Regional Comprehensive Economic Partnership (RCEP) for multi-directional expansion. This dual-track approach creates a complementary overseas strategy: a “single-point breakthrough in North America” paired with “diversified markets plus resource security.”

3.Comparative Analysis of Investment Environments in Two Regions Based on PESTEL Framework

The current development status of Chinese auto parts enterprises in Mexico and Southeast Asia reflects strategic adjustments within the global automotive supply chain. So what exactly makes the investment environments in these two regions attractive to Chinese auto parts companies? This article conducts a systematic analysis from six PESTEL dimensions.

3.1 Analysis of Political Factors

First, the long-term stability of political relations.

China and Mexico have maintained diplomatic ties for over 50 years. Since establishing a comprehensive strategic partnership in 2013, bilateral relations have accelerated significantly, yielding fruitful results in mutually beneficial economic and trade cooperation. China has become Mexico's second-largest trading partner globally, while Mexico ranks as China's second-largest trading partner in Latin America.^[6] However, with López Obrador winning the presidential election, he is likely to maintain and develop the previous policy direction. In the economic sphere, he will strictly implement fiscal austerity measures and reduce government spending, which may weaken Mexico's attractiveness to foreign investment. Externally, López Obrador aims to maintain good relations with China, but pressure from the United States and Canada may lead to more challenges for Chinese enterprises investing in Mexico, which also impacts the entire supply chain for automotive companies. In Southeast Asia, Thailand, Indonesia, Malaysia, and Vietnam have established regional free trade networks through multilateral agreements like RCEP and CPTPP, effectively lowering tariff barriers and non-tariff restrictions. Thailand leverages its Eastern Economic Corridor to offer corporate income tax exemptions and infrastructure subsidies for high-end automotive and electronics industries. Indonesia focuses on streamlined investment approvals, large-scale special economic zones, and adjusting foreign ownership caps in resource-based sectors. Malaysia attracts international capital through its Bilingual Free Zone strategy, providing up to ten years of tax holidays. Vietnam offers tax-free periods in high-tech and export processing zones while maintaining foreign equity caps in select key industries. Overall, while Southeast Asian governments lag behind Mexico in political stability, transparency, and administrative efficiency, they are steadily enhancing their appeal to multinational investors through regional integration and innovative industrial policies.

3.2 Analysis of Economic Factors

First, sustained and stable economic and trade growth. As Latin America's second-largest economy and one of the world's top 15 economies, Mexico has maintained steady economic expansion in recent years. Its 2023 GDP reached approximately \$1.8 trillion, marking a 3.2% increase from the previous year. With a diversified economic structure, Mexico holds significant global standing in manufacturing, particularly automotive production. As a direct beneficiary of the U.S. "nearshoring" policy, Mexico has steadily enhanced its ability to attract foreign investment, providing sustained momentum for economic growth. This has driven the expansion of domestic automotive and parts production while continuously improving public infrastructure.^[7]

In contrast, Vietnam and Indonesia lead Southeast Asia with growth rates of 6.5% and 5.1% respectively—lower than China's coastal regions but still above the global average. Their manufacturing sector typically maintains monthly wages per capita between \$200 and \$300, approximately 50% of Mexico's level, significantly enhancing labor cost competitiveness. Malaysia and Thailand, leveraging well-developed financial markets and higher per capita income levels, have effectively controlled inflation below 3%. They balance economic stability and growth momentum through foreign exchange reserve management and capital account openness. The combined annual FDI inflows for these four countries exceed \$15 billion, reflecting external investors' confidence in the region's long-term prospects. However, challenges such as infrastructure development, financial inclusion, and regional economic imbalances necessitate more detailed cost-benefit analyses for investors establishing factories or branches.

3.3 Analysis of Social Factors

Mexico is situated between South America and North America, bordered by the Pacific Ocean to the south and west, the Gulf of Mexico to the east, and sharing a border with the United States to the north. The border between the two countries stretches over 3,100 kilometers. Its narrow, elongated shape from north to south makes it a bridge connecting South and North America.^[8] Its strategic location offers unparalleled logistical advantages: goods shipped from Mexico can reach any point on the U.S. mainland within 48 hours and easily access South American markets, facilitating expansion into this region.^[9] Additionally, Mexico boasts a substantial pool of young labor, with individuals aged 15 to 34 comprising approximately 50% of its population, providing sustained workforce support for manufacturing. However, a high informal employment rate of 55% and a national homicide rate exceeding 20 per 100,000 residents create significant challenges for businesses in labor

acquisition and management, leading to elevated recruitment, training, and security costs. Furthermore, powerful labor unions hold substantial bargaining power in negotiations. Failure to promptly fulfill collective bargaining agreements or comply with working hour and benefit agreements may expose companies to production disruptions or strike risks.

The four Southeast Asian nations also benefit from demographic dividends, with youth populations accounting for 50% to 55% of their total populations. However, significant differences exist among them in terms of social security systems and labor regulations. Thailand and Malaysia both maintain unemployment rates below 4%, with relatively high social security coverage and more formalized labor markets. Indonesia and Vietnam, despite rapid growth, still see the informal economy accounting for over 50% of activity, though both are advancing labor law reforms to strengthen employee protections. Additionally, Indonesia enjoys relatively stable public order, while Vietnam is accelerating efforts to build labor inspection and social mediation mechanisms.

This necessitates that investors, when formulating human resource strategies, not only consider local labor costs and skill levels but also prioritize social stability indicators and cultural differences to mitigate potential risks of labor disputes and community conflicts.

3.4 Analysis of Technical Factors

Mexico boasts the world's fifth-largest automotive parts industry base, featuring a comprehensive production network spanning Tier 1 to Tier 3 suppliers. In recent years, rapid advancements in automotive electronics, intelligent connectivity, and Industry 4.0 demonstration zones have significantly elevated automation rates and digitalization levels. However, it remains dependent on imports for high-end CNC equipment and semiconductors, with technology spillover constrained by supply chain bottlenecks. Approximately 35% of manufacturing processes have integrated robots and smart sensors. Multiple Fortune 500 parts suppliers have established local R&D centers in Mexico, continuously optimizing localized design and manufacturing processes through industry-academia-research collaboration. Concurrently, network coverage nears 60%, providing a solid foundation for vehicle-to-everything (V2X) and industrial internet applications.

In contrast, the four Southeast Asian nations are generally in the initial or acceleration phases of digital transformation. Thailand and Malaysia have promoted industrial IoT and cloud manufacturing platforms across multiple special economic zones, though automation rates remain between 15% and 20%. Industrial parks in Indonesia and Vietnam are attracting contract manufacturing projects from multinational corporations to drive the absorption and upgrading of local technical capabilities. Governments across the region have rolled out digital economic development plans—such as Indonesia's "Digital Blueprint 2025" and Vietnam's "National Strategy for the Fourth Industrial Revolution"—while encouraging private sector participation in 5G, artificial intelligence, and big data infrastructure development. Overall, while Mexico holds an early advantage in smart manufacturing, Southeast Asian nations demonstrate significant potential to rapidly narrow the technological gap through policy-driven initiatives and market scale.

3.5 Factors Analysis of Environmental

Mexico has proven lithium reserves of 1.7 million tons (ranking tenth globally), yet its water scarcity index places it among the top 20% worldwide. The combination of electricity shortages and hurricane disasters creates a dual constraint of "resources and ecology." Four Southeast Asian nations possess complementary resource endowments: Indonesia's laterite nickel deposits (holding 22% of global reserves), Thailand's natural rubber, and Malaysia's rare earth elements. Their renewable energy capacity growth rate (15–20%) also outpaces Mexico's (8%). Recent rapid development in automotive electronics, smart connectivity, and Industry 4.0 demonstration zones has significantly boosted automation rates and digitalization levels. Approximately 35% of manufacturing processes now incorporate robots and smart sensors. Multiple Fortune 500 parts suppliers have established local R&D centers in Mexico, continuously optimizing localized design and manufacturing processes through industry-academia-research collaboration. Concurrently, 5G network coverage nears 60%, providing a robust foundation for vehicle-to-everything (V2X) and industrial internet applications.

In contrast, the four Southeast Asian nations are generally in the initial or acceleration phases of digital transformation. Thailand and Malaysia have promoted industrial IoT and cloud manufacturing platforms across multiple special economic zones, though automation rates remain between 15% and 20%. Industrial parks in Indonesia and Vietnam are introducing

contract manufacturing projects from multinational corporations to drive the absorption and upgrading of local technical capabilities. Governments across the region have rolled out digital economic development plans—such as Indonesia’s “Digital Blueprint 2025” and Vietnam’s “National Strategy for the Fourth Industrial Revolution”—while encouraging private sector participation in 5G, artificial intelligence, and big data infrastructure development. Overall, while Mexico holds an early advantage in smart manufacturing, Southeast Asian nations demonstrate significant potential to rapidly narrow the technological gap through policy-driven initiatives and market scale.

3.6 Analysis of Legal Factors

Following constitutional amendments in 2014, including revisions to the Economic Competition Law and Industrial Property Law, Mexico extended the national treatment principle to cover the entire vehicle and parts sectors beyond the negative list. This was supplemented by a federal “one-stop” electronic registration system, bringing its institutional market access standards close to OECD benchmarks. However, the interplay between civil law traditions and federal governance structures has resulted in significant inter-state variations in rule enforcement. Judicial precedents indicate that the average enforcement cycle for commercial contracts in northern industrial states remains significantly higher than the Latin American average. Moreover, the timeliness of intellectual property remedies is rated as “insufficient” by most foreign manufacturers. In labor law, the federal code’s rigid requirements for severance pay and profit sharing have not been substantially relaxed by the 2019 union democratization reforms. Traditional unions retain *de facto* monopoly bargaining power in automotive supply corridors like Nuevo León and Coahuila, imposing institutional rigidity on enterprises adjusting capacity during order fluctuations. Compounded by the risk of policy retroactivity due to local government transitions, Chinese auto parts enterprises should employ a combination of state-level government contracts, international arbitration clauses, and investment insurance during the entry phase to create institutional buffers against administrative uncertainty.

Southeast Asia’s legal landscape exhibits “multiple legal sources—country-specific heterogeneity.” Automotive parts investments can be strategically positioned along a “market access—enforcement—labor flexibility” gradient. The region offers a diverse legal environment where “hard law” and “soft law” coexist. Thailand and Malaysia occupy the upper end of this institutional gradient: Thailand’s Eastern Economic Corridor legislation grants foreign investors 100% equity access for complete vehicles and core modules, while providing certainty through commitments on land ownership and income tax exemptions. Malaysia, underpinned by its common law tradition, aligns intellectual property rules with the CPTPP, offering institutional credibility for R&D in new energy “three-electric” systems. However, both countries’ labor laws maintain a “positive list” approach to grounds for dismissal and allow significant discretionary power at the state level, resulting in relatively high adjustment costs for labor and land resources. Vietnam and Indonesia, positioned at the lower end of the gradient, significantly reduced their negative investment lists through 2020 and 2021 reforms. They attract labor-intensive segments with “risk-based licensing” and two-hour registration procedures. Yet prolonged judicial cycles and uncertainties stemming from dual land ownership systems require investors to hedge potential risks through industrial park collective bargaining, renewable land leases, and international arbitration clauses. Overall, Chinese enterprises can locate high-value-added modules in Thailand and Malaysia to leverage their relatively mature legal frameworks, while assigning labor-intensive processes to Vietnam and Indonesia. This approach trades institutional innovation at the industrial park level for factor flexibility, achieving a balance between supply chain compliance and efficiency through a combination of regional legal tools.

In summary, PESTEL analysis reveals: Mexico secures the North American market through USMCA’s zero tariffs and mature supply chains, but faces high compliance costs and significant political/ecological risks. The four Southeast Asian nations excel with RCEP institutional dividends, low costs, and resource endowments, featuring rapid technological convergence and minimal institutional friction. These complementary regions enable a “North America-Diverse” dual-hub strategy.

4.Strategies for Chinese Auto Parts Companies Investing in Both Locations

Building upon the preceding PESTEL comparison of investment environments in Mexico and Southeast Asia, this section proposes three major categories of targeted strategies: differentiated initiatives focused on the distinct characteristics of the Mexican and Southeast Asian markets, alongside collaborative development plans that leverage their shared commonalities. These strategies aim to assist Chinese automotive parts enterprises in achieving high-quality cross-regional expansion and

steady growth.

4.1 Exclusive Strategy for the Mexican Market

The primary task for entering the Mexican market is to deeply align with the USMCA regulatory framework and establish localized production and supply chain coordination mechanisms. Companies should increase the proportion of locally sourced key components and enhance production capacity through capital and technology acquisitions, joint ventures, and collaborations, while meeting the 75% origin rule requirements. This approach not only reduces tariff costs but also fosters closer ties with North American automakers. Additionally, to address security and compliance risks, companies must establish a multi-layered risk prevention network. This includes hiring local security consultants, implementing third-party compliance audits, developing emergency response plans, and regularly assessing the impact of state and municipal policy changes on project operations to ensure business activities remain highly compliant with local laws and regulations.

The Mexican government has accelerated incentives for renewable energy and green manufacturing in recent years. Component manufacturers can leverage the federal carbon emissions trading market and industrial park environmental subsidies to advance smart production lines and energy-saving upgrades. Implementing automated assembly, online monitoring, and energy recovery systems not only helps meet Euro 6 emission standards and carbon reduction requirements but also effectively lowers per-unit energy consumption and environmental compliance costs over the long term. Simultaneously, strengthening partnerships with local technical universities and vocational training institutions to build localized R&D and skills training platforms can provide a steady stream of engineering talent proficient in automation and bilingual environments, further solidifying the industrial chain foundation.

4.2 Exclusive Strategy for the Southeast Asian Market

The core advantage of the Southeast Asian market lies in its combination of labour cost competitiveness and growth potential. Enterprises should fully leverage free trade agreements such as RCEP and CPTPP, establishing operations within special economic zones or industrial parks that offer tariff advantages and comprehensive supporting infrastructure. Priority should be given to deploying high-value-added component projects, including lightweight aluminium alloys and thermal management modules. Leveraging the region's low-cost labour base, companies should accelerate capacity expansion while harnessing the market reach across multiple nations to achieve rapid product distribution throughout the ten ASEAN countries and the South Asian sub-region.

Regarding technology and branding, enterprises must adapt their approach through localised R&D and market-specific customisation. For instance, establishing regional R&D centres or joint laboratories in collaboration with universities and research institutions in Thailand and Singapore would enable the co-development of cooling systems and material formulations suited to tropical climates and road conditions. Incorporate local cultural elements into design language to enhance product recognition among domestic vehicle manufacturers and the aftermarket. To mitigate social risks, it is advisable to strengthen research into informal employment and labour law reforms, establishing compliant human resource management systems encompassing contract administration, social insurance processing, and engagement with local trade unions. This ensures controllable labour costs while adhering to local regulations.

4.3 Synergy and Common Strategies Across Two Markets

Facing the global restructuring of supply chains and the digital transformation wave, Chinese parts manufacturers should establish cross-regional integrated operational platforms to achieve real-time coordination between Mexico and Southeast Asia facilities through digital technologies. Specifically, unified enterprise-level ERP and SCM systems should be adopted, combined with big data analytics and cloud-based collaboration tools, to enable centralized decision-making and risk alerts for raw material procurement, production scheduling, logistics distribution, and inventory levels. This approach enhances the overall flexibility and resilience of the supply chain.

Additionally, promoting talent sharing and knowledge accumulation across regions is recommended. Establishing an "International Talent Rotation Program" enables technical experts and managers to exchange and learn between Mexico and Southeast Asia. This not only deepens understanding of local regulations, market demands, and cultural differences but also fosters diverse innovative thinking. Finally, synchronously advance corporate social responsibility and sustainable

development strategies. Guided by environmental, social, and governance (ESG) metrics, establish unified performance evaluation standards for carbon emissions, resource consumption, and community engagement. This approach will shape a multinational brand image while elevating value and influence within the global supply chain.

5. Conclusion

Chinese automotive parts enterprises are encountering new strategic opportunities amid the global restructuring of industrial chains and the surge in new energy vehicles. This paper systematically compares the investment environments in Mexico and Southeast Asia, highlighting the distinct advantages and risks each region presents in political, economic, social, and technological aspects. Overall, Mexico's geographical proximity to the North American market and its potential for industrial chain synergy make it suitable for in-depth embedded investments by mid-to-high-end parts manufacturers, while Southeast Asian nations offer greater flexibility in labor and cost advantages, as well as regional diversification. Moving forward, Chinese auto parts companies should leverage their digital and smart manufacturing capabilities to pursue differentiated development under a "global footprint—local integration" strategy. By enhancing technological innovation, refining supply chain management, and strengthening cross-cultural operational capabilities, Chinese enterprises can achieve long-term, stable value growth in overseas markets.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] China Association of Automobile Manufacturers, China Automotive Technology & Research Center Co., Ltd., & Toyota Motor Corporation. (2020). China automotive industry development report (2020).
- [2] Yang, R. C., & Shi, Y. J. (2024, July 29). Transformation and overseas expansion: The Third Plenary Session of the 20th CPC Central Committee outlines the development blueprint for the automotive industry. *China Business Journal*, p. C05.
- [3] Wang, W. T. (2024). Improving the institutional mechanisms for high-level opening-up. *Qiushi Journal*, (16), 33–37.
- [4] Guan, K. J., Niu, R. F., & Peng, M. (2024, February 20). The growing global influence of Chinese automotive brands. *People's Daily*, p. 17..
- [5] Xianguang Think Tank. (2024). What trends are emerging in China's NEV exports? *Automobile & Parts*, (9), 46–47.
- [6] Yuan, Y. (2022, April 15). Mexico's economy struggles to reduce reliance on the U.S. *Economic Daily*, p. 4.
- [7] Gao, Q., & Wu, Y. (2024, April 18). Why is Mexico's economic growth leading Latin America? *People's Daily Overseas Edition*, p. 6.
- [8] Ministry of Commerce of the People's Republic of China, Chinese Academy of International Trade and Economic Cooperation, & Economic and Commercial Counsellor's Office of the Embassy of the People's Republic of China in Mexico. (2023). Country (region) guide for outward investment and cooperation: Mexico (2023 edition).
- [9] Zhang, M. T., & Wen, B. (2024). How to view Chinese companies entering the U.S. market via Mexico. *China Forex*, (9), 26–29.

Construction of Performance Management System in the Context of Digital Transformation

Yu Pang*

College of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710000, China

*Corresponding author: Yu Pang, 1084047992@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: With the continuous expansion of enterprise scale and the increasingly fierce market competition, performance management has become the key for enterprises to achieve strategic goals and enhance core competitiveness. From the perspective of digital transformation, this paper explores the construction of a performance management system. Firstly, it analyzes the problems existing in the traditional performance management system; secondly, it constructs the framework of a performance management system under the background of digital transformation; thirdly, it puts forward the problems encountered in the construction of the performance management system under the background of digital transformation and corresponding solutions; finally, through analysis, it summarizes the future development trend of the performance management system.

Keywords: Digital Transformation; Performance Management; System Construction

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.819>

Introduction

In the current environment of accelerating globalization and digital transformation, competition among enterprises has become increasingly fierce. Companies not only have to contend with domestic rivals but also face competition from international brands and the changing industrial landscape brought about by the continuous development of technology. Under such circumstances, the continuous improvement of enterprise performance has become the key to promoting business growth and enhancing market competitiveness. Performance management is no longer merely a “evaluation tool”, but a core link that runs through corporate strategy, resource allocation, and sustainable development. It not only focuses on employees’ work performance and results but also emphasizes how to comprehensively enhance employees’ overall quality and work capabilities through systematic means and methods, thereby creating greater value for the enterprise.

The traditional performance management system often has many problems, such as unreasonable goal setting, single evaluation indicators, and weak process control. These issues to some extent limit employees’ work enthusiasm and the overall performance improvement of the enterprise. To address these problems, we need to introduce the concepts and methods of systems engineering to comprehensively and deeply design and optimize the performance management system.

With the rapid development of digital technologies such as big data, artificial intelligence, and cloud computing, global enterprises are accelerating their entry into the digital transformation stage. According to the “2024 Global Digital Transformation Trends Report”, over 85% of enterprises have listed digital transformation as a strategic core task. As a core

link in enterprise management, the traditional model of performance management is difficult to adapt to the organizational form and working methods in the digital environment^[1]. The traditional performance management system is typically characterized by “annual assessment”, quantification, and manual operation, making it hard to meet the real-time and accurate management demands of enterprises in the digital context^[2]. This will lead to a discrepancy between the performance assessment results and the actual situation of the enterprise. Against this backdrop, reconstructing a performance management system that integrates digital technologies and meets the needs of digital organizations has become the key for enterprises to break through management bottlenecks and achieve continuous performance growth.

1.The Impact of Digital Transformation on Enterprise Performance Management

1.1 Promoting Changes in the Orientation of Performance Management

Traditional performance management centers on “annual assessment”, neglecting dynamic adjustments during the process. Digital transformation can drive a shift in management orientation^[3]. On one hand, digital transformation, through technologies such as the Internet of Things and big data, enables enterprises to collect key data during employees’ work processes, rather than relying on “post-event summaries” to judge performance. This transforms traditional performance management, which is centered on “annual assessment”, into a model of “real-time process control + dynamic results” optimization. On the other hand, digital transformation emphasizes the concept of “strategic dynamic alignment”, meaning that digital technologies can make strategic adjustments in enterprises more flexible, and performance management can be iterated in real time. This shift towards a combined assessment of “process and results” can address the shortcomings of traditional performance management, such as rigid goals and loss of process control, making performance management more in line with the operations of digital enterprises.

1.2 Optimizing the Relationship of Performance Management Objects

With changes in the business environment, managers have gradually realized that the key element for creating enterprise value is human capital. Therefore, the ultimate goal of enterprise management is to stimulate employees’ initiative and creativity. In traditional performance management, employees are in a passive role. However, digital transformation, through a more information-based management system design, can make employees active participants in performance management, thereby stimulating their enthusiasm in work and skill improvement^[4]. On one hand, digitalization brings transparency to performance data, making employees more actively involved in performance management. On the other hand, digital performance management can provide more timely feedback to employees, allowing them to proactively request feedback from colleagues and managers and respond to it.

1.3 Ensuring the Accuracy of Performance Appraisal

Digital transformation essentially brings an upgrade in digital technology, which has completely changed the low-efficiency model of “manual reporting” in traditional performance management. Traditional performance management often relies on subjective judgment and existing experience to make decisions, thus suffering from problems such as low efficiency and unobjective evaluation, making it difficult to adapt to market changes. In contrast, digital performance management can conduct data analysis based on digital technology. With the support of technologies like the Internet and big data, digital performance management is more objective and fair, and also helps in timely adjustment of performance goals, which is conducive to improving the quality of performance appraisal and effectively enhancing the accuracy of performance management^[5].

2.Construction of Enterprise Performance Management System under the Background of Digital Transformation

2.1 Construction principles of digital performance management system

(1) The principle of openness. The key to the principle of transparency in performance management is to solidify the core management elements in institutional form and establish clear standards for the entire assessment process. This standard provides assessors with a clear framework to follow and avoids subjective speculation; Make the assessed person clear about the direction of effort and evaluation criteria, and reduce cognitive bias. Ultimately, through transparent management,

fairness in performance evaluation is ensured from the source of the process, enhancing employees' trust in the performance management system^[6].

(2) The principle of differentiation. The principle of differentiation aims to avoid a one size fits all approach to performance management, ensuring that assessment standards are aligned with the business characteristics of different departments and positions, while allowing performance results to reflect differences in “more work, more pay, and better performance. In standard design, customized solutions should be based on “department functions+job attributes”:

(3) Principle of full participation. The principle of full participation is the key to ensuring the implementation of performance management. Only by transforming employees from “passive participation” to “active participation” can the feasibility of goals and the enthusiasm for implementation be improved. When setting goals, a communication model of “top-down” and “bottom-up” should be adopted to make them truly executable. Ultimately, employees should develop personal goals based on their own work and work together with managers to determine them in a timely manner. Only when all employees participate in the development of performance evaluation goals can they be highly recognized during implementation.

(4) The principle of regularity. It refers to transforming performance management from stage tasks to daily work tasks. Through continuous attention and intervention, the steady implementation of corporate goals can be ensured. On the one hand, managers integrate performance management into tracking the progress of daily work implementation goals, identifying problems in a timely manner and making adjustments. On the other hand, enterprises strengthen routine through systems and tools, incorporating performance management into managers' assessment standards to ensure the steady implementation of enterprise strategic goals, and managers at all levels regard performance management as routine management work.

(5) The principle of continuous communication. The principle of continuous communication is the main difference between performance management in the digital age and traditional performance management. The formulation of performance management goals, the formation of plans, and the implementation and adjustment of management goals require continuous communication between managers and subordinates. The focus and methods of communication at different stages should also be different.

2.2 Construction of Digital Performance Management System

2.2.1 Refactoring the Enterprise Strategic Guidance System

With the continuous development of enterprise digital transformation, there are new requirements for the strategic orientation of enterprise development. The traditional strategic orientation system based on “scale as the core and experience as the driving force” is no longer suitable for development. Enterprises should formulate enterprise strategic goals that adapt to the development of the times.

First of all, we should develop a dynamic adaptive digital strategic goal, which is the key driving force for its development. The digital strategic goal can break away from the traditional strategic goal, which is formulated in the mode of “experience decision-making”. Based on the development of big data and the Internet, enterprises should deeply analyze their own resources and industry competition trends to find more market possibilities. After clarifying the direction, we should use digital channels to expand business, expand market share through personalized marketing and accurate services, and at the same time strengthen product research and development investment to promote the intellectualization and service of products. At the same time, we should regard human resources as the most important digital resources, increase the training and introduction of digital talents, and improve the performance management system with the goal of “value creation”.

Secondly, enterprises should take “value creation” as the core activity and optimize their value enhancement path. Enterprises should place product research and development, user experience design, and other activities at the core of value creation. These activities are the key to forming product differentiation and gaining market share, directly determining the importance of enterprises in the value chain.

Finally, enterprises should set multidimensional growth capability strategic goals. The key to the sustainable development of enterprises lies in their own growth capability, which is multidimensional and measurable. Internally, enterprises optimize processes with customers at the center, taking providing high-quality products and service quality as the starting point, consciously improving customer relationships, focusing on high-value customer groups, and driving internal business

processes. Externally, learning should be the core of continuous evolution, and this growth ability should be transformed into specific measurable goals, such as the proportion of new product revenue. The reconstruction of strategic orientation system in the context of digitalization is a comprehensive improvement from static goals to dynamic measurable goals, from “linear value chain” to “networked value”, from single indicators to multi-dimensional capabilities. Enterprises should take data as the core, customer as the center, learn as the instinct, and form their own core competitiveness.

2.2.2 Building a digital performance management network platform

The traditional performance management system is no longer suitable for the requirements of performance management in the digital age. Building an integrated performance management network platform that is highly compatible with digitalization is the key cornerstone for implementing “digital performance management”.

The primary value of a performance management network platform is to provide a platform for digital performance management concepts. In traditional performance management models, there is often a lag in performance data collection, and there is information asymmetry between managers and managed individuals. However, the unified implementation of the network platform digitizes the entire process of setting performance goals, tracking results, and evaluating feedback, allowing performance data to be presented in real-time and transparently on the platform. This provides dynamic management capabilities for managers and clear performance goal guidance for employees, ensuring that all members work together with consistent goals. Traditional performance management has the disadvantage of “year-end summary”, while online platforms can provide timely communication feedback, goal updates, etc. Managers can inspect and provide feedback on employees’ work at any time, and employees can also raise questions in a timely manner. This efficient interaction can reduce communication costs for both management parties, thus building a digital bridge for sustainable communication and objective evaluation. The digital performance management network platform provides enterprises with the connectivity function of a “digital hub”. By integrating with other operational platforms, it solves the problem of data silos and realizes the automation and intelligence of performance management. The data collection, organization, and verification in performance management work increase the time cost of management, while the digital performance management network platform saves the work cost of managers through the application of digital technology, indirectly improving their production capacity. The digital performance management network platform, this integrated platform can achieve cross data correlation analysis, providing unprecedented depth of investigation for performance management. This multi-dimensional, full process big data analysis upgrades performance management from “one-sided results” to “full process evaluation”, thereby more accurately identifying the motives behind high-value behaviors and improving the quality of decision-making. When the performance management platform can obtain real-time operational data, it has the ability to predict, which enables managers to intervene in high-risk behaviors in advance, achieving a transition from “remedial measures” to “defense measures”, enhancing the organization’s defense capabilities in the face of uncertain risk behaviors, and endowing the organization with agility.

2.2.3 Establish a performance evaluation and feedback communication mechanism

Under the trend of digital transformation, the economic and innovation capabilities of enterprises have become the key to their core competitiveness. The true source of sustained competitive advantage for enterprises is human capital, rather than financial and material capital. This change requires managers to re-emphasize and systematically reconstruct the performance management system, and build a modern performance evaluation and feedback communication mechanism guided by development and aimed at empowerment^[7].

1、Refactoring the performance evaluation mechanism from one-way evaluation to multi-dimensional evaluation criteria. There is a contradictory relationship between the traditional performance evaluation system’s assessors and the assessed. The new economic evaluation mechanism should start and core with employee self-evaluation, such as guiding employees to conduct self-evaluation through ingenious design, enabling them to find key contribution points, clarify the specific reasons for their ability improvement, and promote deep self reflection. This process can gradually enhance employees’ self-awareness, self-management, and self ability improvement. The role of managers should shift from judges to process guides, helping employees to engage in self reflection. In cross departmental collaboration and project organization, the true contributions of individuals are often concealed in daily team activities, making it difficult for managers to observe all individual behaviors

and capture them comprehensively. Therefore, the performance management evaluation system introduces mutual evaluation among the assessed individuals, and conducts quantitative scoring and qualitative description of peer evaluation around multiple dimensions such as work completion. This mechanism not only provides more comprehensive and closer to the work scenario performance data, but also cultivates a team spirit of mutual responsibility and common progress, enabling employees to better join the overall collaborative work. Based on the evaluation of comprehensive managers and the determination of the final evaluation results, the performance management evaluation system can integrate multidimensional information such as self-evaluation and peer evaluation, and provide objective performance data on the basis of accurate evidence through the performance management network platform. The key to optimizing this system lies in the impact of manager evaluations, which do not determine the final evaluation results. The judgment of managers is an important component that constitutes the final evaluation conclusion.

2、Optimization of feedback communication and incentive mechanisms. If performance evaluation only stops at a specific data point rather than a new growth starting point, the value generated by performance management will be greatly reduced.

(1) Implement a feedback mechanism that combines online and offline channels. Timely and accurate feedback is the lifeline of performance management, which makes performance feedback more timely and accurate by fully utilizing the performance management platform. However, the feedback on this online platform is far inferior to face-to-face deep performance communication. Therefore, performance feedback should implement a “online+offline” dual combination model, strengthen consensus on performance results, and develop specific and measurable improvement plans.

(2) Improve diversified reward mechanisms to stimulate deeper level motivation. Enterprises should focus on building a comprehensive reward system that integrates spiritual rewards, monetary rewards, non monetary rewards, and purposeful rewards. These rewards can enable employees to meet their high-level needs for self-respect, belonging, and self realization, and can continuously and deeply stimulate their inner potential. By providing employees with autonomy and growth space, the overall human resource capabilities can be enhanced.

In summary, the construction of performance evaluation and feedback mechanisms is a dual transformation of organization and culture, achieving a shift from “controlling employees” to “developing employees”. Only when employees’ personal growth is integrated with organizational communication goals can we enter a virtuous development of mutual benefit between employees and the enterprise.

3.Problems and Solutions of Digital Performance Management System

Digital transformation provides enormous potential for performance management systems, helping enterprises overcome many problems of traditional performance management models. Make the performance management system more efficient, accurate, and flexible. However, enterprises still face some severe challenges ^[8-9]. Firstly, it is the operability of technical implementation. At present, many enterprises have undergone digital transformation, but the technological facilities for digital transformation of some small and medium-sized enterprises cannot support the operation of complex digital performance management systems. These enterprises also lack digital processing capabilities and computing platforms, and the cost of implementing digital performance management systems is high, which affects the efficiency of system use. In addition, the new digital performance platform cannot integrate with the core system and ultimately cannot obtain key data, requiring manual data entry, thereby increasing the burden on enterprises and forming digital formalism. Secondly, the issue of employee adaptability. Employees and managers may develop resistance and fear towards the reformed performance management system due to the lack of digital skills, which will result in low usage of new performance platforms and rendering advanced platforms virtually non-existent. Finally, data privacy and security issues. Comprehensive data collection brings accurate evaluation, but it may also touch on the red line of employee privacy. How to define the boundaries of data collection and ensure that personal information is not abused or leaked is not only a technical issue, but also a matter of organizational trust and corporate ethics.

4.Conclusion

The construction method of performance management system under the digital background can solve the problems of

traditional performance management system and improve the scientificity and effectiveness of performance management. The scientific, standardized, and efficient implementation of performance management system through systematic thinking and methods helps enterprises achieve strategic goals and enhance their core competitiveness. In the future, with the development of enterprises and changes in the market, digital performance management systems will need to be continuously improved and optimized to adapt to new environments and challenges.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Li, T. (2025). Digital transformation drives the transformation of performance management system: Empirical analysis and innovative path. *Liaoning Economy*, (07), 61–65.
- [2] Lou, C. Z. (2025). Research on performance management innovation practice of medium-sized enterprises in digital transformation. *Brand Marketing of Time-Honored Brands*, (13), 184–186.
- [3] Liu, X. P. (2025). Research on optimization of performance management system under the background of digital transformation. *Business 2.0*, (17), 136–138.
- [4] Zhao, Y. (2025). Optimizing the performance management system path under digital transformation. *Human Resources*, (10), 40–42.
- [5] Chen, B. (2025). Exploration of enterprise performance management under the background of digital transformation. *Business Observation*, 11(09), 35–38+42.
- [6] Feng, Y. (2021). Cost management innovation under the background of digital reform. *Finance and Accounting Monthly*, (23), 68–75.
- [7] Chen, J., Huang, S., & Liu, Y. H. (2020). From empowerment to empowerment: Enterprise operations management in a digital environment. *Management World*, 36(02), 117–128+222.
- [8] Li, S. (2011). Research on key issues of enterprise performance management system. *China Commerce and Trade*, (35), 97–98.
- [9] Peng, Y. (2011). Research on optimization of enterprise performance management system based on BSC and KPI. *Finance and Economics*, (07), 86–88.

How Local Government Policies Promote the Construction of Municipal Industry - Education Alliances——A Policy Text Study Based on Grounded Theory

Wenwen Sun*

College of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710000, China

**Corresponding author: Wenwen Sun, 970950972@qq.com*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: The construction of municipal industry-education alliance is an important measure to deepen education reform in China, and it is also an important innovation direction of industry-education integration and school-enterprise joint education. Its goal is to serve and lead the development of regional industries, cultivate excellent engineering talents and realize the deep integration of industry and education. At present, the construction of China's municipal industry-education consortium is steadily advancing in exploration and has achieved fruitful results. Based on the grounded theory research method, through the interpretation of the relevant policy texts of 18 local governments that have built national-level city-level industry-education associations, the policy support system of city-level industry-education associations is clarified, and the policy support model of local government policies to promote the construction of city-level industry-education associations is obtained. From the three levels of concept guidance layer, internal management layer and external support layer, it provides reference and reference for the construction of local city-level industry-education associations : giving full play to the leading role of the government in the process of association construction, improving the organizational system and optimizing internal management as the premise, and strengthening the external support of city-level industry-education associations as the guarantee. Participate in the co-construction of the city 's industry and education association, and promote the formation of a city-wide government-enterprise-school-research four-party governance pattern.

Keyword: City-wide Industry-education Association; Policy Supporting System; Grounded Theory; School-Enterprise Joint

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.820>

Introduction

Currently, there are more than 10,000 vocational colleges and universities in China, with over 30 million students. In terms of the scale of vocational education talent cultivation, it has already accounted for half of China's higher education. The integration of industry and education and the cooperation between schools and enterprises are the basic directions for the construction of China's vocational education system. Through practice in recent years, China's industry - education integration work has achieved remarkable results in terms of institutional mechanisms and cooperation models. It has built a positive development relationship where vocational education and industrial development promote each other, and has contributed to the formation of a new pattern of jointly serving economic and social development. As socialism with Chinese characteristics enters a new era, the process of a new round of scientific and technological revolution is accelerating. The development of

regional industries is rapidly upgrading from the low - end to the medium - and high - end, and this is accelerating the formation of a new industrial system. All these have brought a series of new issues, tasks, and challenges to the work of industry - education integration in schools. From an external perspective, there are contradictions between the supply side of technical and skilled talent cultivation and the demand side of industries in terms of structure, quality, and level, which are unbalanced and incompatible. From an internal perspective, higher vocational colleges have not yet established a long - term mechanism to attract industry enterprises to participate in school running and to achieve accurate connection and collaborative talent cultivation between schools and enterprises, and the depth and breadth of industry - education integration are still insufficient. At present, there are still some problems in the implementation of China's industry - education integration projects. For example, in most industry - education integration projects, the benefit distribution is uneven, making it difficult for enterprises to obtain profits. As a result, enterprises have low enthusiasm to participate, and most of the cooperation remains at a superficial level, which leads to the failure of fully integrating and circulating high - quality resources. In addition, in industry - education integration projects, the effect of talent cultivation is slow to show, and it is difficult to make profits. Therefore, the focus of the projects tends to shift to scientific and technological innovation that can bring quick profits, deviating from the fundamental goal of collaborative talent cultivation between schools and enterprises. Moreover, there are many subjects involved in industry - education integration projects, which makes management difficult. The lack of a sound supervision and evaluation mechanism leads to low efficiency of resource integration and insignificant results. Municipal industry - education alliances are an institutional arrangement that is based on local industries and educational resources for effective integration to achieve the coordinated development of industrial economy and vocational education. Taking industrial parks as the foundation, building municipal industry - education alliances with the participation of local governments, industry enterprises, schools, research institutions, and other parties is one of the important measures to deepen the reform of vocational education. Municipal industry - education alliances have the potential to solve problems such as “enthusiasm from schools but coldness from enterprises” and “connection in name only between schools and enterprises” in the integration of industry and education. They can gather resources from all parties and play a role in empowering and improving the quality of technical and skilled talent cultivation, technological innovation, and high - quality development of the industrial economy. In 2022, the General Office of the Communist Party of China Central Committee and the General Office of the State Council issued the “Opinions on Deepening the Reform of the Construction of the Modern Vocational Education System”, which put forward the strategic task of building municipal industry - education alliances. In 2023, the General Office of the Ministry of Education issued the “Notice on Carrying out the Construction of Municipal Industry - Education Alliances”, which launched the construction work of municipal industry - education alliances, made arrangements for the construction of municipal industry - education alliances, and proposed the work goal of building about 150 municipal industry - education alliances by 2025. Since then, the construction of municipal industry - education alliances has been advanced one after another in various regions. Local governments have successively issued implementation opinions and plans to promote the construction of municipal industry - education alliances to accelerate the construction process. How the policies successively issued by local governments promote the construction of industry - education alliances has become a hot topic in the academic circle.

From the review of existing literature, the current research by domestic scholars mainly focuses on the connotation and phased characteristics of municipal industry - education alliances^[1], the necessity of building industry - education alliances^[2], the internal logical connection in the construction of alliances^[3], the research on the value and path of alliance construction^[4], the policy connotation of alliance construction^[5], the governance model of alliance construction^[6], the exploration of the symbiotic model of alliance construction^[7], the research on the practical logic and mechanism of alliance construction^[8], and the problems and countermeasures in the process of alliance construction^[9]. Domestic research has increased rapidly with the rapid advancement of the construction of municipal industry - education alliances, and the research dimensions mainly focus on the practical paths and strategies of alliance construction. Although the above - mentioned research contents are relatively rich and reveal the relevant elements of the construction of industry - education alliances to a certain extent, providing

research support for the analysis of policies related to industry - education alliances, most of these studies focus on theoretical research. The countermeasures and suggestions in the research conclusions are not very operable, and there is no systematic sorting out of the element framework for local government policies to promote the construction of industry - education alliances. Based on this, this study adopts grounded theory and conducts a quantitative analysis based on the policy texts issued by local governments regarding the construction and development of industry - education alliances, in order to explain the internal mechanism of local government policies promoting the construction of industry - education alliances, construct a research framework for government support behaviors, and lay a foundation for subsequent research.

1. Materials and Methods

1.1 Source of Materials

In April 2023, the General Office of the Ministry of Education issued the “Notice on Carrying out the Construction of Municipal Industry - Education Alliances”, requiring the launch of the construction work of municipal industry - education alliances. Since then, local governments have responded to the central notice, issued local policies to promote municipal industry - education alliances, and launched and completed the construction of local municipal industry - education alliances, resulting in a number of municipal industry - education alliances that meet the requirements. In October 2023, the Ministry of Education announced the list of the first batch of 28 national - level municipal industry - education alliances. In this paper, the Internet is used to search the official websites of various local governments with the keyword “municipal industry - education alliance” to retrieve policy texts related to local municipal industry - education alliance policies, and 18 policy documents from the localities where the 28 national - level municipal industry - education alliances are located are selected for analysis. Policy documents are the true reflection and behavioral traces of the government in handling public affairs. They can effectively reveal the government’s behavioral logic, serve as a materialized carrier of observable policy information, and provide a data - based path for quantitative research in the field of public policy^[10]. By interpreting policy texts, we can explore the ideas and viewpoints of policy makers and predict the future development trend of things. Therefore, they are vividly known in the industry as “secrets extracted from public information”.

1.2 Research Methods

The grounded theory research method is based on text analysis^[11] and is a research method for constructing substantive theories from the bottom up. The basic operation method of this theory is that researchers generally do not have any theories or assumptions before the research. Through the hierarchical interpretation of the original materials word by word and line by line, they summarize the relevant concepts and categories, and then elevate them to theories^[12]. NVivo is one of the qualitative analysis software widely recognized and used in the academic circle. With its powerful coding function, it has become an important auxiliary tool for policy text analysis^[13].

2. Research Process

2.1 Open Coding

Open coding is a process in which the collected materials are broken down without any preset concepts, divided into meaningful words, sentences, or paragraphs, and then reorganized with new concepts for conceptualization and categorization. In this paper, the policy texts of 18 local governments for promoting the construction of municipal industry - education alliances in 2023 are imported into NVivo11 software for open coding. For example, the sentence “The main leaders should personally command and dispatch the construction work of the alliance, actively coordinate and study to solve the specific problems existing in the construction process of the alliance, and promote the long - term development and orderly progress of the construction of the industry - education alliance” is refined into the concept of “command and dispatch by main leaders”. After repeatedly organizing and analyzing the original materials, a total of 406 original sentences are extracted. To ensure the reliability of the coding results, this study only retains the concepts with 2 or more reference points, and then extracts 89 concepts (Table 1) and 27 categories (Table 2).

Table 1 Analysis of Local Government Policies on Municipal Industry - Education Alliances: Conceptualization Based on Open Coding

No.	Concept	No.	Concept	No.	Concept	No.	Concept
1	Implement the spirit of the Party	24	Implement preferential measures such as land use	47	Improve the entity operation mode	70	Include in the government work assessment indicators
2	Deepen education reform	25	Establish a reward and subsidy mechanism	48	Hold meetings to promote work	71	Incorporate into the education work assessment system
3	Guided by the Thought on Socialism with Chinese Characteristics for a New Era	26	Establish an assessment and incentive mechanism	49	Establish a council with multi - party participation	72	Basis for the distribution of educational funds, etc.
4	Implement the central guiding policies	27	Jointly build industrial colleges	50	The council exercises decision - making power	73	Implementation opinions
5	Respond to government notices	28	Build student training platforms	51	Take the lead in organizing the establishment and leadership	74	Implementation measures
6	Integration of science and education	29	Build staff training and learning platforms	52	Formulate articles of association and plans	75	School - local joint meeting system
7	Support education with industry	30	Conduct school - enterprise cooperative research	53	Regularly inspect and evaluate the operation status	76	Pilot zone construction plan
8	Promote industry with education	31	Carry out the through - train training model	54	Conduct targeted supervision	77	Measures for the management of teachers in higher vocational colleges
9	Foundation for alliance construction	32	Enterprises deeply participate in teaching	55	Accept social supervision	78	Documents regulating school - running behaviors
10	Foundation for alliance application	33	Implement the “apprenticeship” talent program	56	Real - time monitor the construction status	79	Documents on delegating school - running autonomy
11	The government assumes the main responsibility for construction	34	Schools undertake staff training work	57	Verify the application materials	80	Local relevant preferential policies
12	Command and dispatch by main leaders	35	Schools accept enterprise employees for study	58	Select and recommend the best for submission	81	Give preferential support to some projects
13	The working team implements specific tasks	36	Optimize teaching courses	59	Expert inspection and evaluation	82	Provide support through government procurement, etc.
14	The government conducts whole - process dynamic management	37	Build a talent exchange platform	60	Cancel the qualification of unqualified alliances	83	Increase financial support

No.	Concept	No.	Concept	No.	Concept	No.	Concept
15	Build local municipal industry - education alliances	38	Build a “double - qualified” teacher team	61	Clarify the rights and responsibilities of all parties	84	Give priority to educational funds for construction
16	Apply for national municipal industry - education alliances	39	Establish a two - way talent exchange mechanism	62	Clarify task division	85	Implement tax reduction and deduction measures
17	Focus on the development of regional key industries	40	Monitor the matching degree of industries and majors	63	Establish a performance appraisal system	86	Establish a fund to support project construction
18	Promote the transformation of scientific research achievements into production	41	Build a public technology service platform	64	Improve the evaluation system	87	Provide credit support for project construction
19	Reform the talent cultivation model	42	Build a big data platform	65	Establish task assessment and evaluation standards	88	Attract industrial capital investment
20	Jointly cultivate talents by schools and enterprises	43	Publish talent supply and demand information	66	Formulate teaching level evaluation standards	89	Attract social capital investment
21	Commend and reward relevant personnel in accordance with regulations	44	Coordinate and link multiple departments to carry out work	67	Formulate industry norms and product standards	90	-
22	Take the construction status as a reference for excellent evaluation	45	Performance evaluation and assessment	68	Formulate industry skill evaluation standards	91	-
23	Implement local incentive policies	46	Subdivide work contents	69	Talent cultivation standards in professional fields	92	-

Table 2 Analysis of Local Government Policies on Municipal Industry - Education Alliances: Categorization Based on Open Coding

No.	Concepts	Category	No.	Concepts	Category
1	1, 2, 3	Core Concepts	15	44, 45, 46, 47, 48	Working Mechanism
2	4, 5	Policy Response	16	49, 50, 51, 52	Management Mechanism
3	6, 7, 8	Industry - Education Mutual Promotion	17	53, 54, 55, 56	Supervision and Inspection
4	9, 10	Based on Industrial Parks	18	57, 58, 59	Verification and Confirmation
5	11, 12, 13, 14	Government Coordination	19	60, 61, 62	Accountability
6	15, 16	Specific Goals	20	63, 64	Improving Evaluation Mechanism

No.	Concepts	Category	No.	Concepts	Category
7	17, 18	Supporting Regional Industrial Development	21	65, 66, 67, 68, 69	Formulating Evaluation Standards
8	19, 20	Supporting Vocational Education Development	22	70, 71, 72	Impact of Assessment Results
9	21, 22, 23, 24	Incentive Measures	23	73, 74	Issuing Local Guiding Policies
10	25, 26	Incentive Mechanism	24	75, 76, 77, 78, 79, 80	Issuing Other Supporting Policies
11	27, 28, 29, 30	Linkage Forms	25	81, 82, 83, 84, 85	Financial Support
12	31, 32, 33, 34, 35, 36	Personnel Training	26	86, 87	Financial Services
13	37, 38, 39	Talent Exchange	27	88, 89	Attracting Investment
14	40, 41, 42, 43	Information Sharing	-	-	-

2.2 Axial Coding

Axial coding is a process of decomposing, analyzing, and connecting the independent categories obtained from open coding, fully exploring the meaning of the categories, constructing the correlation between each category, and extracting categories at a higher overall level^[14]. Generally, there are causal relationships, situational relationships, functional relationships, process relationships, chronological relationships, etc. between various categories. Through repeated thinking and analysis of the internal interrelationships between each category, 11 main categories are finally summarized, which are guiding ideology, implementation principles, implementation goals, personnel incentives, resource sharing, organizational system, supervision and accountability, assessment and evaluation, policy support, fund support, and public opinion building (Table 3). Among them, the material source and reference point are automatically counted by NVivo11 software during the coding process. The material source represents the number of materials containing the category in all materials, and the reference point represents the frequency of the category appearing in all materials.

Table 3 Analysis of Local Government Policies on Municipal Industry - Education Alliances: Main Categories Based on Open Coding

No.	Main Category	Reference Point	Material Source	Corresponding Category
1	Guiding Ideology	31	18	Core Concepts, Policy Response
2	Implementation Principles	36	18	Industry - Education Mutual Promotion, Based on Industrial Parks, Government Coordination
3	Implementation Goals	62	18	Specific Goals, Supporting Regional Industrial Development, Supporting Vocational Education Development
4	Personnel Incentives	20	18	Incentive Measures, Incentive Mechanism
5	Resource Sharing	109	18	Linkage Forms, Personnel Training, Talent Exchange, Information Sharing
6	Organizational System	47	18	Working Mechanism, Management Mechanism
7	Supervision and Accountability	29	18	Supervision and Inspection, Verification and Confirmation, Accountability
8	Assessment and Evaluation	17	18	Improving Evaluation Mechanism, Formulating Evaluation Standards, Impact of Assessment Results

No.	Main Category	Reference Point	Material Source	Corresponding Category
9	Policy Support	13	18	Issuing Local Guiding Policies, Issuing Other Supporting Policies
10	Fund Support	24	18	Financial Support, Financial Services, Attracting Investment
11	Public Opinion Building	18	18	Typical Demonstration, Publicity and Guidance

2.3 Axial Coding

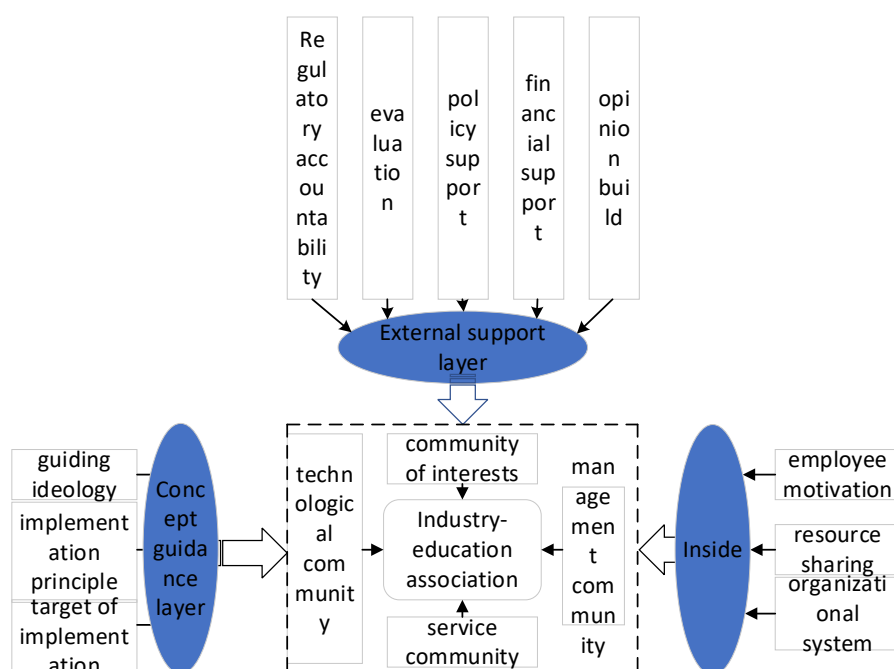
The main task of selective coding is to find one or several core categories with strong generalization ability, correlation ability, and high abstraction from the many main categories formed by axial coding, which is a more focused process. The core category can usually command other categories, be in the core position among all categories, and can reflect the prototype of the framework construction. The core category of this study is “local government policies promote the construction of municipal industry - education alliances”, among which local government policy support can be divided into three dimensions: the concept guidance level, the internal management level, and the external support level (Table 4).

Table 4 Analysis of Local Government Policies on Municipal Industry - Education Alliances: Core Categories Based on Open Coding

No.	Core Category	Reference Point	Material Source	Corresponding Main Category
1	Concept Guidance Level	129	18	Guiding Ideology, Implementation Principles, Implementation Goals
2	Internal Management Level	176	18	Personnel Incentives, Resource Sharing, Organizational System
3	External Support Level	101	18	Supervision and Accountability, Assessment and Evaluation, Policy Support, Fund Support, Public Opinion Building

In this study, by using grounded theory, the concepts, categories, and their internal logic are obtained, and a conceptual model of local government policies promoting the construction of municipal industry - education alliances is constructed (Figure 1).

Figure 1 Policy Support Model for Local Government Policies to Promote the Construction of Municipal Industry - Education Alliances



2.4 Saturation Test

The saturation test is an important sign to determine whether to continue or stop data collection. When the analysis of policy texts no longer produces new theoretical categories, the theory is saturated. In the formal coding process, the 18 policy texts are divided into two groups, Group A and Group B. Among them, 3 policy texts are randomly selected from Group B to check the saturation of the research results. After the analysis of the policy texts in Group A is completed, the policy texts in Group B are used for re - analysis, and no new categories or relationships are obtained. Therefore, the category coding and policy support model of this study are theoretically saturated.

3. Conclusions and Recommendations

3.1 Open Coding

This study uses grounded theory to conduct a content analysis of the policy texts on municipal industry - education alliances issued by local governments where the first batch of national - level municipal industry - education alliances are located, and constructs a policy support model for local governments to support the construction of municipal industry - education alliances. The research results show that the policy support model for local governments to promote the construction of municipal industry - education alliances is composed of the concept guidance level, the internal management level, and the external support level.

(1) Concept Guidance Level The concept guidance level is the action guide for the construction of industry - education alliances. It plays a macro - leading role in the construction of industry - education alliances, and is a principled consensus that different participating subjects adhere to when solving problems, which can minimize the obstacles in the process of policy implementation. The concept guidance level mainly includes three main categories: guiding ideology, implementation principles, and implementation goals. Among them, the guiding ideology is in line with the spirit of the 20th National Congress of the Communist Party of China, guided by the Thought on Socialism with Chinese Characteristics for a New Era, with deepening education reform as the core concept, and implements the central guiding policies. The implementation principles focus on giving play to the leading role of the government, taking industrial parks as the foundation, supporting education with industry and promoting industry with education. The implementation goals mainly include the specific goal of building provincial and national municipal industry - education alliances, and the core goal of supporting the development of regional economic industries and the high - quality development of vocational education, which describes a roadmap for the construction of industry - education alliances for local governments.

(2) Internal Management Level The construction of an industry - education alliance is a comprehensive innovative action that requires the joint participation of multiple subjects, resource sharing, joint management, shared responsibilities, and shared achievements. Its construction and operation require a sound internal management system as support. The internal management level is the core link for the industry - education alliance to realize resource integration. The internal management level includes three main categories: the organizational system of the industry - education alliance, resource sharing, and personnel incentives, which together construct the internal collaboration mechanism of the industry - education alliance. As a new type of organizational form, the legitimacy issue of the municipal industry - education alliance is the primary challenge in organizational construction. The improvement of system construction and the full compliance of the alliance's behaviors are the prerequisites for the industry - education alliance to have regulatory legitimacy from the perspective of stakeholders, and also an important basis for the internal members of the industry - education alliance to obtain identity recognition. Resource sharing is a key goal of the construction of industry - education alliances. To achieve resource sharing, it is necessary to take effective linkage forms, integrate resources for personnel training, ensure the two - way exchange of talents, and realize the interconnection and sharing of information among all parties. Personnel incentives are an effective way to mobilize the work enthusiasm of internal and external personnel of the alliance, and also an important measure to promote the efficient advancement of various tasks in the alliance construction. They are the concentrated embodiment of the dynamic flow mechanism and salary balance mechanism within the industry - education alliance, and an important means to realize the flow of high - quality industry - education resources. These three main categories help enterprises and schools in various industries form a service, responsibility, interest, and management community with a

complete system, clear division of labor, complementary functions, and close cooperation^[15].

(3) External Support Level The external support level is an important external guarantee for the construction of industry - education alliances. The external support level mainly includes five main categories: supervision and accountability, assessment and evaluation, policy support, fund support, and public opinion building. Supervision and accountability mainly include the specific arrangements of relevant local governments in the links of verification and confirmation, supervision and inspection, and accountability during the application and construction of the alliance. Assessment and evaluation refers to conducting fair assessment and objective evaluation of the construction work of each subject in the alliance by formulating evaluation standards and improving the evaluation mechanism, and conducting corresponding handling and accountability for the evaluation results to ensure the efficient advancement of various tasks in the alliance construction. Fund support includes three aspects: the government increasing financial support, promoting financial service support, and attracting industrial investment, which lays an economic foundation for the construction work of the industry - education alliance. Policy support is mainly manifested in the central government and the state issuing supporting policies in education and other aspects to assist the smooth progress of the construction work of the industry - education alliance. Public opinion building mainly improves the social recognition and acceptance of the construction of industry - education alliances by publicizing the construction status of the alliance, such as construction achievements, typical cases, and outstanding figures, enhances the social confidence and support for the construction of industry - education alliances, and ensures the transparency of the alliance construction work by making the construction work information public, so that the whole society can supervise and ensure the smooth progress of the construction.

3.2 Open Coding

To promote the construction of municipal industry - education alliances, we should adopt a work path of multi - party participation and multi - dimensional co - governance. The traditional administrative management system is obviously not suitable for alliance management. Therefore, we should establish and improve the alliance management mechanism and working mechanism, and promote the transformation of industry - education integration from loose connection to substantive integration. We should reverse the structural imbalance in the allocation of high - quality resources, effectively activate the existing high - quality resources, promote the upward and downward flow of high - quality resources, and help form a development pattern of efficient mutual promotion between industry and education. Based on the analysis and research conclusions of the policy texts of local governments on municipal industry - education alliances, and combined with the practical problems encountered by local governments in promoting the practice of municipal industry - education alliances, this paper puts forward policy recommendations for further improving the construction of municipal industry - education alliances.

In terms of the concept guidance level, the construction of industry - education alliances mainly explores the effective linkage between local enterprises and schools, and the two - way flow of industrial and educational resources, so as to promote the optimal allocation of the use of industry - education resources within the region. In the process of linkage between enterprises and schools, we must be highly vigilant against the abuse of power and corruption. At the same time, we must also prevent the emergence of passive and negative thoughts such as low enthusiasm of internal personnel in the alliance for construction and “waiting, relying, and asking for help”. The members of the industry - education alliance should adhere to the reform concept of “promoting industry with education and supporting education with industry”, take the initiative to build a resource sharing platform, realize the rational flow of high - quality resources, and let the achievements of reform benefit the local area.

In terms of the internal management level, the realization of integrated internal management of the industry - education alliance is a prerequisite for the smooth development of the industry - education alliance. At present, in the internal management process of the industry - education alliance, we should focus on overcoming the phenomenon of “connection in name only and lack of strength in action”. It is suggested that the industry - education alliance should be established under the leadership of a leading organization, with the participation of multiple parties to form a council, improve the management mechanism with the council as the decision - making body, implement the relevant articles of association and

plans, issue relevant policies and systems, and gradually realize the unified management of personnel, finance, and materials. It is suggested that the industry - education alliance should establish a coordinated and linked working mechanism, improve the entity operation mode, clarify the division of responsibilities, implement performance evaluation, and hold regular meetings to promote the work. We should issue incentive policies, implement incentive measures, and improve the incentive mechanism to fully mobilize the work enthusiasm of internal and external personnel of the alliance and promote the work process efficiently. Under the leadership of the regional administrative department in charge, we should build information platforms such as a data information platform, a platform for publishing talent supply and demand information, a platform for monitoring the matching degree of industries and majors, and a public technology service platform to realize the interconnection and sharing of industry - education information. We should promote the integration of industry and education through linkage forms such as the establishment of industrial colleges, the construction of training bases, and school - enterprise cooperative research. We should promote personnel training through forms such as the “through - train” training model and the “apprenticeship” training program. We should promote talent interaction by establishing a two - way talent exchange mechanism and building a “double - qualified” teacher team.

In terms of the external support level, the construction and operation of the industry - education alliance require strong external support. The government should increase its support for the establishment of municipal industry - education alliances and establish a sound fund support system from three aspects: financial support, financial service support, and attracting industrial investment. We should strengthen public opinion publicity, publicize outstanding figures and typical cases, promote practical experience in construction, and strengthen the leading role of models. We should strengthen public opinion guidance, publish information on construction work and construction progress, improve the public’s awareness and recognition of the alliance construction, and create a good atmosphere of broad social support. We should strengthen public opinion supervision and gradually establish a multi - subject supervision system with the government, enterprises, schools, and the public as the main bodies. We should strengthen supervision and accountability to ensure that all behaviors of the alliance are legal and compliant, formulate evaluation standards, improve the evaluation system, refine the division of tasks, and implement accountability.

This study provides an effective analysis framework for understanding the policy system of the construction of industry - education alliances in China, and can provide useful references for the government, enterprises, schools, and other departments to further improve the policies and supporting measures for industry - education alliances, which has certain theoretical significance and practical value. Policy texts are the result of conflicts and compromises among various interests, and the policy texts themselves are not equivalent to the policy effects covered by the policies themselves. When local governments implement policies, they often have policy deviations due to the influence of the policy field and the interest demands of stakeholders, which is also an issue that needs to be further explored in future research.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Ran, Y. F., Zhou, Z. Y., & Xu, L. B. (2023). The connotation and formation mechanism of municipal industry-education alliances from the perspective of inter-organizational network theory. *Vocational and Technical Education*, 44(25), 20–27.
- [2] Zhou, S., Li, L., & Gu, X. (2023). Research on building city-area industry-education consortium. *Adult and Higher Education*, 5(16).
- [3] Liang, C., & Liao, Y. Y. (2023). Rational review, logical connection and practical direction of high-quality construction of municipal industry-education alliances. *Education and Vocation*, (20), 5–12. <https://doi.org/10.13615/j.cnki.1004-3985.2023.20.014>
- [4] Su, X. L., & Cao, L. C. (2023). The value, goals and paths of the construction of municipal industry-education alliances

- in the new era. *Education and Vocation*, (22), 42–49. <https://doi.org/10.13615/j.cnki.1004-3985.2023.22.005>
- [5] Yu, C. (2024). The policy implications, theoretical logic and practical strategies of the construction of municipal industry-education alliances. *Research in Higher Education of Engineering*, (01), 144–150.
- [6] Hua, Y. L., & Jiang, S. Q. (2024). Contract-based governance: An economic and sociological analysis of the construction of municipal industry-education alliances in vocational education. *Education and Vocation*, (02), 37–42. <https://doi.org/10.13615/j.cnki.1004-3985.2024.02.001>
- [7] Wu, H. Y., & Gu, J. (2023). Research on the construction of municipal industry-education alliances based on symbiosis theory. *Education and Vocation*, (21), 58–62. <https://doi.org/10.13615/j.cnki.1004-3985.2023.21.010>
- [8] Tian, J., & Zhao, X. H. (2023). The internal logic, practical dilemmas and practical paths of the construction of industry-education alliances. *Education and Vocation*, (24), 43–49. <https://doi.org/10.13615/j.cnki.1004-3985.2023.24.010>
- [9] Chen, J. Y., & An, D. P. (2024). The construction of municipal industry-education alliances in vocational education: A theoretical analysis framework of task-oriented organizations. *Education and Vocation*, (01), 37–43.
- [10] Huang, C., Ren, T., & Zhang, J. (2015). Quantitative research on policy literature: A new direction of public policy research. *Journal of Public Management*, 12(2), 129–137.
- [11] Shao, H. Y., & Tao, P. (2017). The behavioral logic of community health service institutions under the new medical reform—a study based on the perspective of grounded theory. *Chinese Journal of Health Policy*, 10(3), 54–60.
- [12] Jing, H. B. (2017). The "theoretical gap" in grounded theory coding and the "Lei Gu Li" (Category, Cause, Principle) crossing. *Journal of Wuhan University (Philosophy and Social Sciences Edition)*, 70(6), 109–119.
- [13] Wang, H. X., Shao, J. L., & Zhang, W. J. (2017). The governance of idle land in China from the perspective of policy tools—an analysis of 192 policy documents (1992–2015). *Chinese Public Administration*, (3), 108–112.
- [14] Fei, X. D. (2008). The methodology of grounded theory research: Elements, research procedures and evaluation criteria. *Journal of Public Administration*, (3), 23–43.
- [15] Liu, L. H., & Yue, X. (2019). How local government policies promote the construction of medical alliances—a policy text study based on grounded theory. *Chinese Journal of Health Policy*, 12(09), 19–24.

How to Empower Green Technology Innovation of Private Enterprises by Environmental Protection Oriented Shareholders

Zeyu Tian*

College of Management, Xi'an Polytechnic University, Xi'an, Shaanxi, 710000, China

**Corresponding author: Zeyu Tian, 1055837621@qq.com*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Based on the fact that green shareholders and state-owned shareholders are generally considered as two types of shareholders to promote the performance of green technology innovation in enterprises, we know little about whether and how these two types of shareholders can play a synergistic effect in empowering the performance of green technology innovation in private enterprises under the background of vigorously promoting new quality productivity and emphasizing high quality and sustainable development in China. Based on the stakeholder and resource-based theory, this study empirically tests the impact of environmental oriented shareholders on the performance of green technology innovation of enterprises and the synergy effect of green shareholders and state-owned shareholders in the process, taking China's A-share private listed companies from 2012 to 2022 as the research sample. The results show that: (1) environmental oriented shareholders have a significant positive impact on private enterprises' green technology innovation, and the result is still valid after the robustness test; (2) Environmental protection oriented shareholders promote the green technology innovation performance of private enterprises by improving their risk-taking ability; (3) The proportion of environmental protection oriented shareholders strengthens the positive impact of environmental protection oriented shareholders on green technology innovation performance, and strengthens the intermediary role of enterprise risk-taking ability; (4) The heterogeneity test shows that among the eastern and central regions, non heavy pollution industries, large-scale and private enterprises with low separation of ownership and ownership, the positive effect of environmental protection oriented shareholders on green technology innovation is more significant. The main implications are as follows: (1) enterprises should pay attention to the role of environmental protection oriented shareholders in the green transformation, and actively attract the investment of such shareholders; (2) The synergy test results show that in the process of enabling the green technology innovation performance of private enterprises, the state-owned shareholders have crowding out effect on the green shareholders, and the green shareholders have complementary effect on the state-owned shareholders; (3) The results of heterogeneity analysis show that the crowding out effect of state-owned shareholders on green shareholders is more significant in the eastern region and heavy pollution industries; At the same time, it is found that the synergy effect of state-owned shareholders on green shareholders is complementary in the central region and enterprises with environmental protection background.

Keywords: State-Owned Shareholders; Green Shareholders; Green Technology Innovation; Substitution Effect; Complementary Effect

Published: Oct 26, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.821>

1.Introduction

In September 2023, General Secretary Xi Jinping first mentioned “new quality productivity” during his investigation in Heilongjiang, and repeatedly stressed that we should firmly grasp the primary task of high-quality development and develop new quality productivity according to local conditions. Green development is the base color of high-quality development, and new quality productivity itself is green productivity. The white paper “green development in China in the new era” proposed to promote green transformation with the goal of “carbon peaking and carbon neutralization”. As an important participant in emerging markets, private enterprises provide important support for China’s innovation and development strategy^[1]. At present, most of China’s state-owned enterprises have responded to the call of the state and are steadily promoting high-quality and green development. However, in the practice of green low-carbon transformation and development, there are some problems such as “neck sticking” risk in key links and key fields, insufficient investment in green development and technology transformation. Some private enterprises still face difficulties such as not wanting to turn, not daring to turn, and not turning. Due to their weak foundation, late start, lack of reform motivation, and financing difficulties, they are stagnant in the process of green transformation. In fact, the green technology innovation activities carried out by private enterprises can not only achieve the dual goals of ecological and economic benefits, but also an important way to achieve overtaking on curves and inject new momentum into the development of new productivity. Based on this background, it is of great practical significance to study the driving factors of green technology innovation in private enterprises.

The characteristics of green technology innovation, such as high complexity and long cycle, make it difficult to obtain sufficient financing from the traditional financial market. In addition, the opportunistic behaviors such as false propaganda and avoiding the important and ignoring the important increase the supervision cost of green technology innovation of private enterprises. Therefore, green technology innovation needs more independent and dedicated environmental protection investment. At this time, environmental protection oriented shareholders are particularly important. Different from shareholders who only aim at profit, environmental protection oriented shareholders, as special stakeholders with environmental protection tendency, pay more attention to the green technology innovation activities of enterprises and will not pay too much attention to short-term profits. They have a long-term vision and can provide special and long-term support for private enterprises to carry out green technology innovation activities. Then, which shareholders are included in the environmental protection oriented shareholders? This study believes that green shareholders and state-owned shareholders are shareholders with strong willingness and inclination to environmental protection. Green shareholders refer to specific investors who invest in green environmental protection. As a fund investor who takes into account environmental and social responsibilities^[2], green shareholders prefer green environmental protection projects in the process of investment. At the same time, green technology innovation, as a disruptive innovation, needs to be promoted from top to bottom within the enterprise. As the economic embodiment of the modernization of the national governance system and governance capacity, state-owned shareholders naturally have similar goals and attributes to the national strategy, and will follow the strategic guidance of the state that attaches importance to green development, reflecting the preference for green projects.

Furthermore, green shareholders are special stakeholders with environmental protection tendency within enterprises, and their particularity is reflected in “special investment”, that is, they are committed to promoting enterprises’ environmental performance, promoting the development of green industries and reducing environmental risks^[3]; State owned shareholders are the key stakeholders of enterprises. The key lies in their state-owned attributes, that is, state-owned shareholders have both economic and social goals, and have a strong willingness to perform social and ecological responsibilities. However, the existing literature has verified that green shareholders can play a positive role in promoting enterprise green governance and green technology innovation, but scholars’ views on how state-owned shareholders affect private enterprise technology innovation have not been unified. Some scholars believe that state-owned equity can enable private enterprises to overcome congenital weakness^[4], improve corporate governance, provide economic resources, and lay the foundation for high-quality development of enterprises; Some scholars also believe that the introduction of state-owned shareholders in private enterprises will aggravate the principal-agent problem, weaken the innovation willingness of the management^[1], squeeze the living space of private enterprises and reverse the market-oriented economic reform, which is unfavorable to the

development of innovation activities of private enterprises. So, is the state-owned shareholders' green technology innovation activities for private enterprises an "accelerator" or a "jammer"? Is there synergy between state-owned shareholders and green shareholders in influencing green technology innovation of private enterprises? Are there significant differences in the promotion or interference effects of state-owned shareholders in different regions, industries and different characteristics of executives? This paper will explore their comprehensive impact on the green technology innovation performance of private enterprises from the perspective of the interaction between green shareholders and state-owned shareholders, and then answer the above questions.

To sum up, based on the stakeholder theory and resource-based theory, this paper studies the relationship between environmental protection oriented shareholders and green technology innovation performance from the perspective of green shareholders and state-owned shareholders. On this basis, it further explores whether the substitution effect or complementary effect between green shareholders and state-owned shareholders can empower the green technology innovation performance of private enterprises, and analyzes the different effects they play in different situations. This paper is expected to make the following contributions: first, it enriches the research on the pre factors of green technology innovation from the perspective of environmental protection oriented shareholders, and provides new ideas for enterprises to better carry out green technology innovation. Second, it studies whether green shareholders and state-owned shareholders have synergistic effect in the Green Governance of private enterprises, and enriches the separate and joint governance effect of green shareholders and state-owned shareholders participating in the green technology innovation activities of private enterprises; Third, this paper analyzes the heterogeneity of the synergy effect of the two types of environmental protection oriented shareholders under different sizes, industries and executive characteristics, and proves that the introduction of state-owned shareholders' meeting in different situations has different effects. It provides a framework and model for the follow-up research on green technology innovation, and provides a systematic, contextualized and operable solution for enterprises to take into account stakeholders and internal governance structure.

2. Research theories and hypotheses

2.1 Environmental oriented shareholders and green technology innovation performance of private enterprises

Stakeholder theory is used to deal with the relationship between different stakeholders of enterprises and its impact on target management. It provides a framework for people to analyze the complex internal interest relationship so as to realize value exchange and co creation. When any enterprise carries out management activities, it is closely related to the input and participation of its various stakeholders, and there is bound to be interest interaction between the various subjects, which will affect the performance of the enterprise. Based on the stakeholder theory, environmental protection oriented shareholders are expected to focus on long-term and sustainable interests, and guide enterprises to carry out green technology innovation through environmental protection concerns and environmental protection resource integration.

Green shareholders mainly invest in sustainable development projects to guide enterprises to implement the green concept into their business operations^[5]. By combing the existing literature, it is found that most scholars regard green shareholders as green investors to study their impact on green technology innovation. In fact, within the enterprise, green shareholders do play a vital guiding role as special green investors. First of all, the green shareholders' meeting forms top-down environmental protection pressure within the enterprise. When shareholders exert environmental protection pressure, in order to meet the wishes of shareholders, the management will give priority to their environmental protection tendency and set assessment indicators when making decisions, and formulate green innovation policies for sustainable development, so as to promote green technology innovation. Secondly, as a special green investor, green shareholders have obvious advantages in information and capital. When he finds that enterprises invest in projects that are inconsistent with their own investment goals, he will collect entrusted voting rights and submit shareholder proposals to avoid these behaviors^[2]; At the same time, it will also play a signal transmission effect through stock selling behavior, that is, when enterprises carry out non environmental activities, green shareholders will send signals to other shareholders by selling their shares, and other shareholders will also follow the trend to sell shares due to herd behavior, so as to correct the deviation of the management through "voting

with hands” and “voting with feet”. Finally, as green shareholders prefer environmentally friendly and socially responsible projects, their entry sends a positive signal to the market, which is conducive to attracting more special funds and alleviating the plight of private enterprises’ lack of funds in carrying out green technology innovation. Therefore, green shareholders can affect the green technology innovation performance of private enterprises by formulating environmental protection policies, modifying management behavior and alleviating financing difficulties.

State owned shareholders have both the basic economic goal of maintaining and increasing value and the ecological governance goal of promoting green development of enterprises. They will focus on green development in corporate governance. On the one hand, state-owned shareholders represent the state and government, which have higher social status and reputation and lower credit risk^[4], so creditors are more inclined to allocate funds to private enterprises with state-owned shareholders. When the state-owned capital participates in private enterprises, it is equivalent to providing private enterprises with a “reputation endorsement”, which can send a positive signal of state support to banks and other financing channel^[6], which is conducive to the relief of their financing constraints, and thus improve the level of green technology innovation of enterprises; On the other hand, the Chinese government is vigorously promoting the development of green finance and implementing a series of policy guidance measures. The entry of state-owned shareholders makes the development of private enterprises more coordinated with the national strategy, which is conducive to enterprises’ more direct and rapid access to relevant information and resources through green finance and government linkages. It happens that green technology innovation focuses on environmental benefits, which is consistent with the national expectations and policy logic. Therefore, the entry of state-owned shareholders can promote the green technology innovation performance of private enterprises by easing financing constraints and strengthening government supervision.

Based on this, this paper puts forward the following assumptions:

H1a: Green shareholders promote the improvement of green technology innovation performance of private enterprises;

H1b: state owned shareholders promote the improvement of green technology innovation performance of private enterprises.

2.2 Substitution effect and complementary effect

Based on the resource-based theory, enterprises, as an open and non fully autonomous organization system, are faced with dynamic external environment and high dependence on external resources^[7]. The competitive advantage of enterprises comes from their unique resources and capabilities. State owned shareholders usually have rich resources and policy support; The special investment of green shareholders can also provide guarantee for enterprises to implement green actions and increase green expenditure. Then when there are both green shareholders and state-owned shareholders in an enterprise, they may have a synergistic effect on green technology innovation within the enterprise, and whether this synergy is manifested as a substitution effect or a complementary effect needs to be analyzed and discussed separately.

With the decrease of the shareholding ratio of state-owned shareholders, the role of green shareholders on the green technology innovation performance of private enterprises gradually increases. On the contrary, when the shareholding ratio of state-owned shareholders increases, the role of green shareholders in promoting the green technology innovation performance of private enterprises gradually weakens, that is, the crowding out effect of state-owned shareholders on green shareholders exists. On the one hand, state-owned equity and private enterprises complement each other on the basis of complementarity. With the increasing intensity of administrative intervention in the innovation of private enterprises, the rigid and inefficient organization and management elements of traditional state-owned enterprises may enter private enterprise^[8]. The stability brought about by the government background of state-owned shareholders and the disadvantages brought about by group decision-making also make private enterprises more conservative in the face of risk decision-making, unwilling to invest more resources in high-risk green environmental protection projects, thus inhibiting the efficiency of green shareholders in improving the performance of green technology innovation of enterprises; On the other hand, state-owned equity may become a “Curse of political resources”^[9]. Because private enterprises do not have resource advantages, they need to obtain competitive advantages by implementing differentiation strategies and other means. When the proportion of shares held by state-owned shareholders is high, the political resource advantages brought by them make enterprises tend to rely on government support rather than market incentives, which not only can not stimulate the innovation potential of enterprises^[10],

but also weaken the role of green shareholders in promoting private enterprises to carry out green technology innovation activities.

On the contrary, with the increase of the proportion of green shareholders, the role of state-owned shareholders in promoting the green technology innovation performance of private enterprises is gradually strengthened, that is, green shareholders have complementary effect on state-owned shareholders. On the one hand, green shareholders regard the compliance of the project with environmental testing standards, pollution control effect and ecological protection as an important premise when making investment. When the proportion of shares held by green shareholders increases, he can put forward green demands and environmental protection requirements for the pursuit of long-term value-added, and urge managers to pay attention to cleaner production. At this time, participatory state-owned equity can inhibit the excessive intervention of administrative power behind state-owned equity in the innovation management of private enterprises^[10], and improve the performance of green technology innovation of enterprises; On the other hand, the increase in the shareholding ratio of green investors may make the financial logic in the financial field a tool to achieve environmental goals, and its relationship with environmental logic becomes more compatible^[5]. That is to say, the capital market environment faced by private enterprises gradually tends to be green. At this time, with the addition of state-owned resources, participating state-owned equity can strengthen the market insight of private entrepreneurs^[10], help private enterprises integrate market innovation resources and create a better innovation support environment.

Based on this, this paper puts forward the following assumptions:

H2A: the state-owned shareholders have played a crowding out effect in the process of green shareholders' improving the green technology innovation performance of private enterprises;

H2B: Green shareholders have played a complementary effect in the process of state-owned shareholders' improving the green technology innovation performance of private enterprises.

3. Research design

3.1 Sample selection and data sources

This paper selects China's A-share private listed companies from 2012 to 2022 as the research sample. In order to ensure the continuity and reliability of the research data, the initial samples are screened as follows: (1) Due to the particularity of the industry, companies belonging to the financial industry are excluded; (2) Companies excluding ST* and PT; (3) Companies with missing data required for the 2012-2022 model are excluded; (4) In order to eliminate the influence of outliers, the tail of the main continuous variables is reduced by 1%. Green patent data comes from China research data service platform (CNRDS); Other data are from database (CSMAR). After the above processing, 18792 companies' annual observations were finally obtained.

3.2 Variable selection and description

3.2.1 Explanatory Variable – Enterprise green technology innovation performance(GI)

The existing research mainly measures green innovation from two aspects of innovation input and innovation output, in which innovation input is mainly the input of enterprise green technology innovation resources; Innovation output is mainly green patents and green new products of enterprises. The green products of listed companies are difficult to observe and green patents reflect the output of green innovation^[11], which can reliably measure the green innovation performance of enterprises. At the same time, the authorization of green patents often has time lag, and the number of green patent applications can better reflect the improvement of green innovation ability^[3]. Therefore, this paper uses the number of green patent applications to measure the green technology innovation performance of enterprises.

3.2.2 Explanatory Variable - Green shareholders (Green)

Through data acquisition, it is found that green investors hold all shares and are green shareholders of enterprises. Therefore, this paper studies green investors as alternative variables of green shareholders. Referring to the practice of existing literature^[6], obtain the Fund subject information table and stock investment details from the fund market series of the guotai'an database (CSMAR), and search the key words of its investment objectives and investment scope. If the words "ecological, environmental protection, green, sustainable" appear, the fund is recognized as a green investor. If there are green

investors in the listed company, the value is 1, otherwise it is 0.

Explanatory Variable - State owned shareholders (DS)

Referring to the method of zhuangzixuan et al. (2023), this paper sets the state-owned shareholders as a dummy variable. Specifically, if there are state-owned shareholders in the top ten shareholders, the value is 1, otherwise it is 0.

Explanatory Variable - Shareholding ratio of green shareholders (Ratio)

This paper uses the proportion of green investors' shareholding in the total number of shares of the company to measure the proportion of green shareholders' shareholding.

Explanatory Variable - Shareholding ratio of state-owned shareholders (Stater)

This paper uses the sum of the top ten Chinese shareholders' shareholding ratio to measure the shareholding ratio of state-owned shareholders.

Based on the research of scholars, this paper selects ownership concentration, shareholder size, two in one, cash flow, capital intensity, enterprise size and profitability as control variables. The definitions of the main variables involved in this article are detailed in Table 1.

Table 1 Definitions of major variables

Variable Name	Variable Symbol	Calculation Method
Green shareholders	Green	The green investor in the enterprise is 1, otherwise it is 0
State owned shareholders	DS	The state-owned shareholder in the top ten shareholders is 1, otherwise it is 0
Shareholding ratio of green shareholders	Ratio	Number of shares held by green investors/total number of shares in the company
Shareholding ratio of state-owned shareholders	Stater	The total shareholding ratio of top ten shareholders in China
Green technology innovation performance	GI	Number of green patent applications
Equity concentration	Fshare	Shareholding ratio of the largest shareholder
Shareholder size	Holder	The total number of shareholders of the enterprise is taken as the natural logarithm
Two in one	Dual	Whether the chairman and general manager are two in one. If they are the same person, the value is 1; otherwise, it is 0
Profitability	Roa	Return on total assets of the enterprise
cash flow	Cash	Net cash flow from operating activities
Capital intensity	Density	Total fixed assets/number of employees
Enterprise size	Size	Natural logarithm of total assets of the enterprise

3.3 Model design

To test the impact mechanism of environmental oriented shareholders on the green technology innovation performance of private enterprises, the specific model is set as follows:

$$GI_{i,t} = \beta_0 + \beta_1 \times Green_{i,t} + \beta_2 \times Control_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$GI_{i,t} = \beta_0 + \beta_1 \times DS_{i,t} + \beta_2 \times Control_{i,t} + \varepsilon_{i,t} \quad (2)$$

In order to investigate the synergy effect between green shareholders and state-owned shareholders, a total of 2838 observations of private enterprises with both green shareholders and state-owned shareholders were extracted. In the sub samples of

green shareholders and state-owned shareholders, the samples were divided into three groups according to the shareholding ratio of green shareholders and state-owned shareholders. The change trend of the impact of the shareholding ratio of green shareholders on the performance of green technology innovation was investigated when the shareholding ratio of state-owned shareholders was from low to high, and the change trend of the impact of the shareholding ratio of state-owned shareholders on the performance of green technology innovation when the shareholding ratio of green shareholders was from low to high. The setting model is as follows:

$$GI_{i,t} = \beta_0 + \beta_1 \times Ratio_{i,t} + \beta_2 \times Control_{i,t} + \varepsilon_{i,t} \quad (3)$$

$$GI_{i,t} = \beta_0 + \beta_1 \times Stater_{i,t} + \beta_2 \times Control_{i,t} + \varepsilon_{i,t} \quad (4)$$

Among them, models (1) and (2) are mainly to test research hypotheses H1a and H1B. The explanatory variables are enterprise green technology innovation performance (GI), and the explanatory variables are green shareholders (green) and state-owned shareholders (DS); Models (3) and (4) are based on two subsamples of both shareholders. The study assumes H2A and H2B, and the explanatory variables are the proportion of green shareholders (ratio) and the proportion of state-owned shareholders (stater); Control is the control variable selected in this paper; ε is interpreted as a random interference term.

4. Empirical results and analysis

4.1 Descriptive statistics

This paper gives the descriptive statistical results of the main variables, as shown in Table 2. Among them, the minimum value of the number of green patent applications is 0, the maximum value is 443, and the standard deviation is 12.07, indicating that the number of green patent applications varies greatly among private enterprises. The average value of state-owned shareholders is 0.412, which means that 41.2% of the top ten shareholders of private enterprises have state-owned shareholders; The average value of green shareholders is 0.315, which means that 31.5% of private enterprises have green shareholders.

Table 2 Descriptive statistics of the full sample size

Variable Name	Mean	Standard Deviation	Minimum	Maximum
GI	2.128	12.07	0	443
Green	0.315	0.465	0	1
DS	0.412	0.492	0	1
Fshare	31.54	13.61	1.844	88.24
Holder	10.03	0.877	1.386	13.95
Dual	0.406	0.491	0	1
Cash	3.857e+08	1.946e+09	-1.394e+10	1.408e+11
Density	12.37	1.080	6.451	18.27
Size	21.84	1.034	19.03	27.12
Roa	0.0450	0.0748	-1.240	0.759

4.2 Correlation analysis

Before the regression analysis, the correlation analysis of the main variables is carried out in this paper. See Table 3. The correlation test results show that the correlation coefficient between the main dependent variables, independent variables and control variables is small, so it can be considered that there is no serious multicollinearity problem between variables.

Table 3 Correlation analysis

	GI	DS	Green	Debt	Roa	Board	Indep	Age
GI	1							
DS	0.044***	1						
Green	0.112***	0.089***	1					
Debt	0.103***	0.099***	0.006	1				
Roa	0.005	-0.002	0.197***	-0.314***	1			
Board	0.000	0.121***	-0.024***	0.118***	-0.080***	1		
Indep	0.007	-0.071***	0.007	-0.033***	0.034***	-0.164***	1	
Age	-0.005	0.087***	-0.056***	0.134***	-0.066***	0.065***	-0.019***	1

4.3 Benchmark regression analysis

In order to verify the relationship between environmental protection oriented shareholders and green technology innovation of private enterprises, this paper conducts regression analysis on model (1) and model (2) through multiple regression model (OLS), and the results are shown in Table 4. Among them, the regression coefficient of green is significantly positive at the 1% level, that is, the green shareholders' meeting has a significant positive impact on the green technology innovation performance of private enterprises, and H1a is established; The regression coefficient of DS is significantly positive at the level of 1%, that is, the state-owned shareholders' meeting has a significant positive impact on the green technology innovation performance of private enterprises. Further comparison found that the regression coefficient of green shareholders is 1.461, which is greater than the regression coefficient of state-owned shareholders 0.534, indicating that compared with state-owned shareholders, the entry of green shareholders can promote the green technology innovation performance of private enterprises to a greater extent.

Table 4 Benchmark regression

Variable Name	GI	GI
DS	0.534***	
Green		1.461***
Debt	4.240***	3.994***
Roa	5.652***	3.080***
Board	-0.216	-0.071
Indep	-0.144	-0.320
Age	-0.033***	-0.023***
N	19392	19392
R ²	0.027	0.042

Note: the values of T corresponding to each coefficient are shown in brackets, ***, **, * are significant at the confidence levels of 1%, 5% and 10%, respectively, the same as the following table.

4.4 Robustness check

First of all, considering that after the environmental protection oriented shareholders exert their influence, private enterprises

may need a period of time to adjust their strategies, obtain resources, carry out R&D and implement green technology innovation, and its entry and influence will take time to show. Therefore, in order to test the actual impact of environmental protection oriented shareholders on green technology innovation of private enterprises and avoid the confusion of causality in time, this paper lags behind the green technology innovation performance variables by one period and re regresses the models (1) and (2). The results are shown in Table 5. The significance of the regression coefficients of DS and green remained unchanged, which proved the robustness of the results.

Further, considering that the measurement method of green technology innovation performance in this paper may be biased, this paper uses the number of green patent authorizations (gi_1) as an alternative variable for green technology innovation performance, and re regresses the models (1) and (2). The results are shown in Table 6: it can be found that the regression coefficients of state-owned shareholders and green shareholders are 0.561 and 1.631 respectively, which are significant at the 1% level, and can produce significant promotion effect, and the results are stable.

Table 5 Robustness check

Variable Name	GI_1	GI_1
DS	0.561***	
Green		1.631***
Debt	4.496***	4.164***
Roa	7.481***	4.492***
Board	-0.260	-0.117
Indep	-0.023	-0.190
Age	-0.041***	-0.031***
N	16317	16317
R ²	0.028	0.045

Table 6 Replace explained variable

Variable Name	GL	GL
DS	1.003***	
Green		2.290***
Debt	8.495***	8.149***
Roa	5.931***	1.952**
Board	0.483**	0.744***
Indep	-1.793***	-2.125***
Age	0.027***	0.044***
N	19392	19392
R ²	0.059	0.077

5. Empirical results and analysis

5.1 Crowding out effect of state owned shareholders on green shareholders

In the subsample of private enterprises with both state-owned shareholders and green shareholders, after dividing the shareholding ratio of state-owned shareholders into three groups according to size, it can be found from table 7 that with

the increasing shareholding ratio of state-owned shareholders, the regression result of the shareholding ratio of green shareholders is gradually not significant, indicating that in the practice of enabling green technology innovation in private enterprises, state-owned shareholders have crowding out effect on green shareholders, and H2A is assumed to be true.

Table 7 Crowding out effect of state owned shareholders on green shareholders

Variable Name	GI		
	Low state-owned shareholder shareholding	Middle state-owned shareholder shareholding	High state-owned shareholder shareholding
Ratio	1.089***	0.798***	0.651
Fshare	-0.024	0.004	0.078
Holder	0.359	0.080	0.363
Dual	0.842	2.093***	0.595
Cash	0.000***	0.000***	0.000***
Density	-0.620**	-0.619*	-2.416***
Size	0.781**	1.379***	3.397***
Roa	-16.278***	-15.609**	-10.537
N	946	946	946
R2	0.131	0.154	0.096

5.2 The complementary effect of green shareholders on state-owned shareholders

In the sub sample of private enterprises with both state-owned and green shareholders, after dividing the shareholding ratio of green shareholders into low, medium, and high groups according to size, Table 8 shows that as the shareholding ratio of green shareholders continues to increase, the significance of the regression results of state-owned shareholder shareholding ratio gradually increases, indicating that green shareholders have a significant complementary effect on state-owned shareholders in promoting the green technology innovation performance of private enterprises.

Table 8 The complementary effect of green shareholders on state-owned shareholders

Variable Name	GI		
	Low green shareholder shareholding	Middle green shareholder shareholding	High green shareholder shareholding
Stater	0.071**	0.178***	0.529***
Fshare	-0.023	0.019	0.020
Holder	0.089	0.456	0.831
Dual	-0.433	0.866	4.334***
Cash	0.000***	0.000***	0.000*
Density	-0.789***	-1.405***	-1.484**
Size	0.246	1.297**	3.544***
Roa	-4.460	-16.053**	-24.603**
N	946	946	946
R ²	0.084	0.186	0.143

6. Heterogeneity analysis

6.1 Regional heterogeneity

According to the classification criteria of the National Bureau of Statistics, this article divides the research sample into three regions: East, Central, and West. The results of the grouped regression are shown in Table 9: the crowding out effect of state-owned shareholders on green shareholders is most significant in the East region, not significant in the West region, and shows a complementary effect in the Central region. The possible explanation is as follows: due to different cultural concepts and uneven resource allocation in the eastern, central, and western regions of China, the degree of emphasis on green technology innovation varies in different regions, and the crowding out effect of state-owned shareholders on green shareholders may also differ among private enterprises in different regions. Specifically, compared to the central and western regions, the eastern region has a more developed economy and greater competitive pressure. Private enterprises in the eastern region generally face more risks and challenges, and are more flexible and innovative. They will rely more on market incentives and other means rather than relying on state-owned capital to obtain resource advantages. When state-owned shareholders hold a large proportion of shares, the “political resource curse” they bring is more obvious compared to the central and western regions, which suppresses the promotion of green technology innovation by green shareholders. Based on the characteristics of China’s regional economy, the central region is highly dependent on high emission traditional manufacturing industries and faces the current situation of strengthened environmental supervision. The increase in the shareholding ratio of state-owned shareholders will strengthen the supervision of enterprises, adopt green environmental protection measures, and work together with green shareholders to provide more resources and policy support for private enterprises.

Table 9 Regional heterogeneity

Variable Name	Eastern region			Central region			Western region		
	Low	Middle	High	Low	Middle	High	Low	Middle	High
Ratio	0.841**	0.065	-0.189	4.490**	7.009***	16.659***	0.293	1.131	0.714
Fshare	-0.063**	-0.032	-0.115**	0.041	0.204**	0.793***	-0.013	0.067	-0.073
Holder	0.452	0.425	-0.359	-1.003	1.163	8.354**	-0.555	-0.917	0.091
Dual	1.066	1.557*	1.287	2.852	4.547**	-8.978*	-0.872	-1.085	2.360
Cash	0.000***	0.000***	0.000***	-0.000	0.000	-0.000**	0.000	0.000	0.000**
Density	-0.554	-0.380	-1.556**	0.594	-1.448	-3.550	-0.307	-1.206*	-0.746
Size	0.132	0.798	2.057**	4.011**	1.452	7.385**	0.952	2.109**	0.265
Roa	-21.437***	-12.057	-16.991	-10.938	-49.342*	43.644	-17.435	2.900	-24.177
N	592	609	539	106	116	169	70	62	87
R ²	0.184	0.188	0.173	0.189	0.308	0.342	0.099	0.338	0.163

6.2 Industry heterogeneity

Referring to the practice of panailing et al. (2019), this paper divides industries with different pollution levels into heavy pollution industries and non heavy pollution industries. The test results are shown in table 10: compared with non heavy pollution industries, the crowding out effect of state-owned shareholders on green shareholders in private enterprises in heavy pollution industries is more significant. The possible explanation is that in heavy pollution industries, private enterprises’ green technology innovation activities are faced with strict environmental regulations and policy constraints. When the proportion of state-owned shareholders is large, the state-owned shareholders’ meeting has greater decision-making power and influence in this process, which will affect the implementation and promotion of the project. In this case, the promotion role of green shareholders may be limited by the requirements of government and industry regulatory policies. If these requirements are inconsistent with the actual demand for green technology innovation, the promotion role of green

shareholders will be inhibited by state-owned shareholders.

Table10 Industry heterogeneity

Variable Name	Heavy pollution industry			Non heavy pollution industry		
	Low	Middle	High	Low	Middle	High
Ratio	1.521***	0.131	0.374	0.908**	1.213***	0.746
Fshare	0.038**	-0.009	0.013	-0.048*	-0.008	0.098
Holder	-0.522	0.203	-0.763	0.560	0.267	0.602
Dual	-0.799*	-0.002	-2.878**	1.222*	2.295***	0.984
Cash	-0.000	0.000	-0.000	0.000***	0.000***	0.000***
Density	0.367	0.062	0.303	-0.553	-0.120	-2.111***
Size	0.834**	0.026	1.948*	0.646	1.205**	3.267***
Roa	-0.076	-0.293	20.187	-18.901***	-17.030**	-14.122
N	154	178	127	792	768	819
R ²	0.284	0.055	0.108	0.195	0.195	0.104

6.3 Heterogeneity of executive background

Referring to the method of Wang Hui et al. (2022), this paper divides senior executives into those with and without environmental protection background. The test results are shown in Table 11: in private enterprises without senior executives with environmental protection background, the substitution effect of state-owned shareholders on green shareholders is not significant; In private enterprises with senior executives with environmental protection background, there is a complementary effect between state-owned shareholders and green shareholders. The possible explanation is that senior executives with environmental protection background in private enterprises usually have strong environmental awareness and professional ability of green technology innovation, and they are more inclined to carry out green technology innovation activities in Enterprises to promote the research and development of green technology. Therefore, executives with environmental protection background have high cognition and sensitivity to the development of environmental protection policies and green technologies, and can make decisions conducive to the green transformation of enterprises. With the increase of the shareholding ratio of state-owned shareholders, the resource support effect and signal transmission effect brought by state-owned capital provide corresponding support for executives to make green environmental protection decisions, which is consistent with the long-term thinking and environmental protection purpose of green shareholders.

Table11 Heterogeneity of executive background

Variable Name	environmental protection background			Non environmental protection background		
	Low	Middle	High	Low	Middle	High
Ratio	12.015	4.654**	4.241**	0.488	0.547	0.001
Fshare	-0.551	-0.043	0.035	-0.042	0.002	0.012
Holder	8.689	1.493	-8.545**	0.470	-0.488	0.243
Dual	37.136**	2.507	16.329***	1.779*	2.654***	-0.487
Cash	0.000	-0.000	0.000	0.000***	0.000***	0.000***
Density	-16.672*	-2.012	1.438	-0.770*	-1.099**	-2.819***
Size	20.900**	-0.099	7.846***	1.403**	0.073	2.198**

Variable Name	environmental protection background			Non environmental protection background		
	Low	Middle	High	Low	Middle	High
Roa	-68.159	-1.063	28.320	-12.297*	-22.212**	-15.577
N	59	76	88	887	870	858
R ²	0.453	0.089	0.331	0.094	0.392	0.195

7. Conclusions and prospects

7.1 Research conclusion

Based on the stakeholder theory, this paper empirically tests the impact relationship between environmental protection oriented shareholders and green technology innovation performance of private enterprises, as well as the synergy effect between the two types of environmental protection oriented shareholders. The research conclusions are as follows: (1) environmental oriented shareholders have a significant positive impact on green technology innovation of private enterprises, and compared with state-owned shareholders, green shareholders have a stronger role in promoting green technology innovation performance of private enterprises; (2) The synergy test results show that in the process of enabling the green technology innovation performance of private enterprises, the state-owned shareholders have crowding out effect on the green shareholders, and the green shareholders have complementary effect on the state-owned shareholders; (3) The results of heterogeneity analysis show that the crowding out effect of state-owned shareholders on green shareholders is more significant in the eastern region and heavy pollution industries; At the same time, it is found that the synergy effect of state-owned shareholders on green shareholders is complementary in the central region and enterprises with environmental protection background.

7.2 Management enlightenment

First, the government and enterprises need to take measures to ensure that enterprises guide private enterprises to improve the performance of green technology innovation through the way of environmental protection oriented shareholder investment. From the perspective of enterprises, we should improve the internal governance mechanism, fully identify the environmental protection orientation of shareholders, pay attention to the environmental protection promotion role of state-owned and green shareholders, establish and improve the communication channels with environmental protection oriented shareholders, mobilize them to participate in the process of Green Governance of enterprises, actively attract such shareholders' investment in the green transformation stage of enterprises, give full play to the support and protection role of these shareholders for green technology within enterprises, curb the shortsightedness of enterprise management, and actively respond to the call of the state to vigorously develop new quality productivity; From the perspective of the government, we should further improve the green financial policy to encourage green investors to enter the market, and promote the reverse mixed reform process to guide state-owned shareholders to enter private enterprises. At the same time, we should further strengthen the green regulatory system to ensure that enterprises follow the laws and standards of environmental protection while attracting environmental oriented shareholders and pursuing green technology innovation performance.

Second, the vitality of green technology innovation of private enterprises can be fully released by adjusting the combination of ownership structure. The high shareholding ratio of state-owned shareholders will swallow up the innovation vitality of private enterprises, thus inhibiting the promoting effect of green shareholders on the green technology innovation performance of private enterprises. Therefore, the introduction of state-owned equity in private enterprises can promote the green technology innovation performance of private enterprises through reverse mixed reform, but we should pay attention to controlling the shareholding ratio of state-owned shareholders, carefully consider the promoting role of state-owned shareholders, and clarify the management boundary of state-owned shareholders, so that the resources brought by state-owned shareholders can play a supporting role rather than a "political resource curse". At the same time, from the perspective of adapting productivity to production relations, in order to improve the green technology innovation performance of enterprises, it is necessary to change the internal ownership structure of enterprises to adapt it to the new quality productivity,

so as to completely realize the green transformation of enterprises.

Third, when considering the change of shareholding ratio between state-owned shareholders and green shareholders, enterprises should fully consider the heterogeneity of environment and their own characteristics. From the research results of regional heterogeneity, the enterprise management should adjust the shareholding ratio of the two types of shareholders according to the technological development level and innovation environment in different regions and the support of government policies in different regions, so as to improve the efficiency of green technology innovation; From the perspective of industry heterogeneity, the crowding out effect of state-owned shareholders on green shareholders is more obvious in enterprises in non heavy pollution industries. In view of this, private enterprises in heavy pollution industries should strengthen communication and cooperation with green shareholders and state-owned shareholders to ensure that the goals of green shareholders and state-owned shareholders in green technology innovation can be coordinated, so as to avoid excessive control of state-owned shareholders and ensure the effective implementation of green innovation projects; From the perspective of the heterogeneity of senior executives' backgrounds, in enterprises with senior executives with environmental protection backgrounds, state-owned shareholders and green shareholders have complementary effects rather than crowding out effects. Therefore, when selecting talents, enterprises should give priority to senior executives with environmental protection backgrounds, and enhance their voice and competitiveness within the enterprise, so as to provide sufficient protection for state-owned shareholders and green shareholders to jointly promote green technology innovation.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Bai, J., Liu, Y. Y., & Qiu, S. Y. (2018). Does state-owned capital participation promote technological innovation in private enterprises? *Journal of Economics and Finance*, (09), 38–45.
- [2] Cai, H. B., & Rao, P. G. (2015). Institutional investors, tax administration, and corporate tax avoidance. *Accounting Research*, (10), 59–65.
- [3] Gao, H. W. (2024). Financial agglomeration, basic support, and urban green innovation: Empirical evidence from the Yangtze River Economic Belt. *Research on Economics and Management*, 45(5), 96–113.
- [4] He, D. X., Zeng, M., & Zhang, S. N. (2022). How does state-owned capital participation affect private enterprises——Research based on the perspective of debt financing. *Management World*, 38(11), 189–207.
- [5] Jiang, G. S., & Lu, J. C. (2023). Logical compatibility: Green investors, environmental regulations, and corporate green innovation. *Economic Management Journal*, 5(9), 68–87.
- [6] Jiang, G. S., Lu, J. C., & Li, W. A. (2021). Do green investors play a role——Research on the experience of enterprises participating in green governance. *Journal of Financial Research*, (5), 117–134.
- [7] Li, Q., & Chen, L. (2024). Research on the impact of ESG rating uncertainty on corporate green innovation. *Chinese Journal of Management*, 21(2), 1–10.
- [8] Li, W. G., & Shao, Y. P. (2016). Industrial policies and nationalization of private enterprises. *Journal of Financial Research*, (09), 177–192.
- [9] Li, H. M., Lan, Y. T., & Xiang, H. L. (2023). Can state-owned capital participation empower high-quality development of private enterprises? *Nankai Economic Studies*, (12), 199–217.
- [10] Liu, N., & Zhang, H. L. (2022). Is it suitable for control or participation? Dual innovation of state-owned equity and private enterprises: from the perspective of reverse mixed ownership reform. *Science & Technology Progress and Policy*, 39(18), 77–87.
- [11] Ling, H. C., Yang, Z., & Xu, R. Q. (2024). CEO's diversity in public environmental experience and corporate green technology innovation. *Science of Science and Management of S.&T.*, 45(3), 189–210.

The Impact of Financial Misallocation on Corporate ESG Performance

Hongli Guo *

School of Finance, Yunnan University of Finance and Economics, Kunming, 650000, China

*Corresponding author: Hongli Guo, bonusg@163.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Against the strategic backdrop of green finance promoting the achievement of the “dual carbon” goals, enhancing corporate ESG performance has become an important pathway for achieving sustainable development. However, the widespread phenomenon of financial misallocation, particularly the structural imbalance in the allocation of green credit resources, significantly constrains corporate ESG performance. Based on data from China’s A-share listed companies from 2009 to 2022, this study examines the impact of financial misallocation on corporate ESG performance. The results indicate that financial misallocation significantly inhibits corporate ESG performance, a conclusion that remains valid after robustness tests. Mechanistically, financial misallocation hinders ESG improvement by exacerbating supply chain concentration, increasing financing costs, and suppressing green innovation. Heterogeneity analysis further reveals that the negative effect of financial misallocation is more pronounced in non-state-owned enterprises with insufficient green finance coverage, high-carbon emission industries, and the western region. This research provides important theoretical support and policy insights for enhancing corporate ESG performance by optimizing the allocation of green financial resources and correcting credit discrimination.

Keywords: Financial Misallocation; Financing Constraints; Green Finance; Supply Chain Concentration; Nature of Ownership

Published: Oct 27, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.822>

1.Introduction

Enhancing corporate ESG performance requires substantial resource support, with financial resources being paramount to corporate survival. However, financial misallocation remains pervasive in China, where a significant proportion of financial resources flows not to high-efficiency sectors but concentrates in enterprises with lower returns on capital, thereby deviating from the efficiency principle. Although financial market reforms have deepened in recent years, institutional factors such as excessive regulatory intervention continue to exacerbate resource misallocation^[1]. Government intervention, credit discrimination, and an underdeveloped market mechanism collectively intensify financing constraints, increase supply chain concentration, and worsen the information environment^{[2][3][4]}. In particular, financial misallocation significantly inhibits the green innovation capacity of small and medium-sized enterprises (SMEs). Moreover, “ownership discrimination” and “scale discrimination” further distort resource allocation: private enterprises face financing bottlenecks, whereas state-owned and large enterprises gain easier access to funds due to their creditworthiness and scale advantages^[5]. Regional disparities in

policies and resources also aggravate financial development imbalances^[6].

Based on this analysis, this study uses a sample of A-share listed companies on the Shanghai and Shenzhen stock exchanges from 2009 to 2022 to examine the impact of financial misallocation on corporate ESG performance and to elucidate the underlying mechanisms. We explore the mediating roles of supply chain concentration, debt financing costs, and green innovation in the relationship between financial misallocation and ESG performance. Furthermore, by introducing three moderating variables—operational risk, corporate transparency, and information disclosure quality—we investigate how they moderate the relationship between financial misallocation and corporate green innovation. This approach not only enhances the understanding of the channels and conditional effects through which financial misallocation influences ESG performance but also, through heterogeneity analysis, helps raise corporate awareness of ESG responsibilities and deepens the understanding of the intrinsic logic behind ESG performance. The findings offer practical insights for enterprises, investors, and policymakers.

2. Theoretical Analysis and Research Hypotheses

2.1 Financial Misallocation and Corporate ESG Performance

Financial misallocation refers to the phenomenon where financial resources fail to achieve Pareto-optimal allocation. In China, this is primarily manifested as non-market-based resource allocation caused by government intervention and policy distortions. State-owned enterprises (SOEs), due to their inherent ties with state-owned banks and administrative intervention, have easier access to low-cost capital, leading to low investment efficiency and overcapacity. In contrast, private enterprises face difficulties in obtaining financing and higher financing costs, which suppresses their technological innovation and performance improvement. This structural imbalance in resource allocation reduces overall efficiency and hinders corporate sustainable development.

In summary, the overallocation of financial resources to SOEs and the underallocation to private enterprises reflect a structural imbalance in financial resource distribution, which in turn leads to low utilization efficiency of financial resources and adversely affects the performance of both SOEs and private enterprises. Therefore, this study proposes the following research hypothesis:

H₁ : Corporate Financial Misallocation Suppresses ESG Performance

2.2 Mediating Effects Between Financial Misallocation and Corporate ESG Performance

Financial misallocation primarily suppresses corporate ESG performance by intensifying supply chain concentration, increasing debt financing costs, and reducing green innovation.

2.2.1 Mediating Effect of Supply Chain Concentration

Financial misallocation drives resources toward large enterprises, increasing supply chain concentration, weakening bargaining power, and raising operational redundancy. Redundant resources crowd out ESG investments, while exacerbated agency problems reduce motivation for corporate social responsibility, thereby inhibiting ESG performance. Comprehensive understanding and disclosure of ESG information related to the supply chain are challenging for companies. These risks hinder scientific assessment of suppliers' environmental performance, making green innovation more difficult and costly. Thus, supply chain concentration impedes companies' ability to mobilize financial resources for green innovation, thereby lowering ESG performance. Based on this analysis, this study proposes the following research hypothesis:

H_{2a}: Financial misallocation inhibits corporate ESG performance by exacerbating supply chain concentration.

2.2.2 Mediating Effect of Debt Financing Costs

Increased financial misallocation raises financing difficulties and costs for private enterprises and SMEs. To obtain scarce credit resources, companies incur substantial rent-seeking costs or resort to high-interest informal financing, equivalent to reduced financial resource accessibility and heightened financing constraints.

The escalation of financial misallocation exacerbates corporate financing constraints, which in turn diminishes the scale of physical investment and ultimately reduces innovation efficiency. Within China's current financial landscape, numerous enterprises universally face financing constraints—whether moderate or severe—that restrict their ability to secure capital at relatively low costs. Such constraints inhibit firms from expanding production scales and broadening investment scope. In

cases of extreme financing constraints, companies may be forced to forgo financing and fundraising opportunities altogether, likely impairing capital allocation efficiency, depressing performance, and even triggering capital chain ruptures. As one of the four major corporate costs—alongside core business costs, administrative expenses, and sales expenses—debt financing cost is a critical factor influencing corporate performance. Based on the above analysis, this study proposes the following research hypothesis:

H_{2b}: Financial misallocation inhibits corporate ESG performance by increasing debt financing costs.

2.2.3 Mediating Effect of Green Innovation

A theoretical model demonstrates that financial misallocation suppresses green innovation capability, thereby affecting ESG performance. Assuming information asymmetry raises external financing costs above internal financing costs, companies pay a premium C_1 for external funds. With financial misallocation, an additional cost C_2 is incurred, making total cost $C = C_1 + C_2 > 1$. The fixed cost of innovation is F_I . Companies with sufficient internal funds innovate with probability q , while those requiring external funds innovate with probability $1 - q$. External factors reduce internal liquidity with probability P_L , where $P_L \in \{0, \overline{P_L}\}$. Let π_i denote profits without innovation, where $i = 0$ for internal funds and $i = C$ for external funds, so $\pi_0 > \pi_C$. Similarly, π_i^1 denotes profits with innovation, where $\pi_i^1 > \pi_i$.

Innovation profits decrease with financing costs. The expected profit without innovation is:

$$E(\pi) = (q - P_L)\pi_0 + (1 - q + P_L)\pi_C$$

With innovation, the probability of using internal funds decreases by P_I , so the probability becomes $q - P_I - P_L$ for internal funds and $1 - q + P_I + P_L$ for external funds. The expected profit with innovation is:

$$E(\pi^1) = (q - P_I - P_L)\pi_0^1 + (1 - q + P_I + P_L)\pi_C^1$$

The incentive to innovate is the difference in expected profits:

$$\Delta_\pi^I \equiv E(\pi^1) - E(\pi)$$

Innovation occurs only if $\Delta_\pi^I > 0$.

The innovation incentive decreases with external financing costs:

$$\frac{\partial \Delta_\pi^I}{\partial P_L} < 0$$

Similarly, higher misallocation cost C_2 reduces the innovation incentive:

$$\frac{\partial \Delta_\pi^I}{\partial C_2} < 0$$

Thus, financial misallocation discourages innovation. Since green innovation directly impacts environmental performance, social responsibility, and governance efficiency, it is a key pathway to improving ESG performance. Based on this analysis, we propose:

H_{2c}: Financial misallocation inhibits corporate ESG performance by suppressing green innovation capability.

2.3 Moderating Effects Between Financial Misallocation and Corporate ESG Performance

2.3.1 Moderating Effect of Operational Risk

Operational risk reflects a company's ability to cope with uncertainties and maintain stability. Financial misallocation exacerbates credit resource imbalances, leading to over-leverage in SOEs and large enterprises (increasing interest burdens and reducing investment efficiency) and credit rationing for private enterprises and SMEs (weakening risk resilience). Both over-leverage and under-leverage elevate operational risk, amplifying default probabilities and volatility under external shocks. According to risk transmission theory, higher operational risk discourages long-term investments like ESG, as management prioritizes short-term actions. Thus, we propose:

H_{3a}: Operational risk negatively moderates the relationship between financial misallocation and corporate ESG performance.

2.3.2 Moderating Effect of Corporate Transparency

Corporate transparency measures the comprehensiveness and accessibility of information disclosure, affecting external investor supervision. High transparency alleviates information asymmetry, reduces market evaluation uncertainty, and enhances the credibility and recognition of ESG practices. Under financial misallocation, companies may reduce disclosure to

conceal financial distress, worsening resource misallocation. Transparent companies can attract long-term green investments by signaling ESG efforts, mitigating financing pressures. Moreover, high transparency improves governance and social responsibility, indirectly enhancing ESG management. Thus, we propose:

H_{3b}: Corporate transparency positively moderates the relationship between financial misallocation and corporate ESG performance.

2.3.3 Moderating Effect of Information Disclosure Quality

Information disclosure quality reflects the level of non-financial information disclosure. High-quality ESG disclosure reduces information barriers, enhances reputation, and builds investor trust. It alleviates agency conflicts, improves green investment matching, and reduces resource waste from misallocation. It also signals compliance and sustainability, helping companies secure favorable terms in green credit and bonds, countering financial misallocation's negative effects. As China's ESG disclosure system improves, high-quality disclosers gain more policy support and market recognition, increasing resilience to resource misallocation. Thus, we propose:

H_{3c}: Information disclosure quality positively moderates the relationship between financial misallocation and corporate ESG performance.

3. Research Design

3.1 Sample Selection and Data Sources

The sample comprises A-share listed companies in Shanghai and Shenzhen from 2009 to 2022, screened as follows: (1) Exclude financial firms due to specialized accounting; (2) Exclude ST and ST* companies with abnormal financial or trading status; (3) Exclude samples with missing key variables; (4) Winsorize continuous variables at 1% and 99%. The final sample includes 29,369 observations. Data on financial misallocation (FM) is from CSMAR and Wind databases; ESG data uses Hua Zheng ESG ratings from Wind; financial expense data (interest, fees) is from Wind; other data from CSMAR. Statistical analysis uses Stata 17.0.

3.2 Regression Model

3.2.1 Baseline Regression Model

To test H1, we estimate:

$$ESG_{tij} = \beta_0 + \beta_1 FM_{tij} + \beta Control_{tij} + \delta_i + \theta_t + \tau_j + \varepsilon_{ijt} \quad (3-1)$$

Where ESG_{tij} is ESG performance, FM_{tij} is financial misallocation, δ_i is firm fixed effects, θ_t is year fixed effects, τ_j is industry fixed effects, and ε_{ijt} is the error term.

3.2.2 Mediation Effect Model

To test H2a–H2c, we use a three-step approach:

$$M_{tij} = \alpha_0 + \alpha_1 FM_{tij} + \alpha Control_{tij} + \delta_i + \theta_t + \tau_j + \varepsilon_{ijt} \quad (3-2)$$

$$ESG_{tij} = \gamma_0 + \gamma_1 FM_{tij} + \gamma_2 M_{tij} + \gamma Control_{tij} + \delta_i + \theta_t + \tau_j + \varepsilon_{ijt} \quad (3-3)$$

Where M_{it} represents mediators: supply chain concentration (SCC), debt financing cost (Dcost), or green innovation (GreenInnovation).

3.2.3 Moderation Effect Model

To test H3a–H3c, we add interaction terms:

$$ESG_{tij} = \omega_0 + \omega_1 FM_{tij} + \omega_2 D_{it} * FM_{tij} + \omega_3 D_{it} + \omega Control_{tij} + \delta_i + \theta_t + \tau_j + \varepsilon_{ijt} \quad (3-4)$$

where D_{it} represents moderators: operational risk (Z-Score), corporate transparency (Opacity), or information disclosure quality (Tran).

3.3 Variable Definitions

3.3.1 Dependent Variable

The explanatory variable in this study is corporate ESG performance. Currently, China lacks a unified ESG indicator system, and ESG performance data is primarily obtained from third-party research institutions. Domestically recognized ESG rating agencies include the Social Value Investment Alliance, SynTao Green Finance, Wind, and Hua Zheng. As Hua Zheng's ESG rating data is more aligned with the Chinese market, offers broader coverage, and provides higher timeliness, this study

adopts Hua Zheng's ESG ratings and dimensional assessments for constituents of the CSI 300 Index as the standard for measuring corporate ESG performance.

3.3.2 Independent Variable

Financial misallocation (FM), measured as the deviation of a firm's capital cost (interest expense / (liabilities - accounts payable)) from the industry average. Drawing on the methodologies of Ning Xueping & Zhang Qingjun^[7], Shao Ting^[8], and Zhou Yuhao et al.^[9] Higher deviation indicates greater misallocation.

3.3.3 Control Variables

Firm age (ListAge, log of years since IPO), size (Size, log of revenue), profitability (ROA, net income / total assets), cash flow (Cashflow, operating cash flow / total assets), leverage (Lev, total liabilities / total assets), growth (Growth, revenue growth rate), and ownership concentration (Top1, percentage of shares held by largest shareholder).

3.3.4 Mediating Variables

Supply chain concentration (SCC): Average of top 5 suppliers' purchase ratio and top 5 customers' sales ratio.

Debt financing cost (Dcost): Net financial expenses (interest + fees) / total liabilities.

Green innovation (GreenInnovation): Number of green patent applications.

3.3.5 Moderating Variables

Operational risk (Z-Score): Altman Z-Score model^[1].

Corporate transparency (Opacity): 1 if audited by Big Four, else 0.

Information disclosure quality (Tran): 1–4 based on Shenzhen Stock Exchange ratings (fail, pass, good, excellent).

Table 3-1 Variable Definitions and Measurement Methods

Category	Variable Meaning	Variable Symbol	Measurement Method
Dependent Variable	Corporate ESG Performance	ESG	Hua Zheng ESG ratings and dimensional assessments for constituents of the CSI 300 Index
Independent Variable	Financial Misallocation	FM	(Firm's capital cost – Industry average capital cost) / Industry average capital cost
	Firm Age	ListAge	$\ln(\text{Current year} - \text{Listing year} + 1)$
	Firm Size	Size	$\ln(\text{Total Assets})$
	Return on Assets	ROA	Net Profit / Average Total Assets
Control Variables	Cash Flow Ratio	Cashflow	Net Cash Flow from Operating Activities / Total Assets
	Asset-Liability Ratio	Lev	Year-end Total Liabilities / Year-end Total Assets
	Revenue Growth Rate	Growth	$(\text{Current Year Operating Revenue} / \text{Previous Year Operating Revenue}) - 1$
	Shareholding Ratio of Largest Shareholder	Top1	Number of Shares Held by the Largest Shareholder / Total Shares
	Supply Chain Concentration	SCC	Average of the sum of the proportions of purchases from the top 5 suppliers and sales to the top 5 customers
Mediating Variables	Debt Financing Cost	Dcost	$(\text{Interest Expense} + \text{Handling Charges} + \text{Other Financial Expenses}) / \text{Total Liabilities at Period End}$
	Green Innovation	GreenInnovation	Number of Green Patent Applications Filed by the Enterprise in the Current Year
	Operational Risk	Z-Score	Calculated with reference to the Z-Score model proposed by Altman ^[1]
Moderating Variables	Corporate Transparency	Opacity	Equals 1 if the company hired a Big Four accounting firm as its annual report auditor in the current year, otherwise 0
	Information Disclosure Quality	Tran	Assessment results of corporate information disclosure quality from the Shenzhen Stock Exchange regulatory information disclosure system

3.4 Empirical Analysis

3.4.1 Descriptive Statistics

The sample contains 37,098 observations. Descriptive statistics are reported in Table 4-1.

Table 4-1 Descriptive Statistics

Variable	N	Mean	p50	SD	Min	Max
ESG	28992	4.043	4	1.108	1	8
FM	28992	0.0380	-0.0780	1.011	-4.747	17.78
Size	28992	22.11	21.92	1.266	19.41	26.45
Lev	28992	0.405	0.395	0.203	0.0270	0.927
ROA	28992	0.0420	0.0420	0.0690	-0.382	0.255
Cashflow	28992	0.0480	0.0460	0.0690	-0.224	0.283
Growth	28992	0.164	0.109	0.383	-0.653	3.894
Top1	28992	0.333	0.310	0.144	0.0810	0.758
ListAge	28992	2.025	2.079	0.896	0	3.401

3.4.2 Correlation and Multicollinearity Analysis

Correlation coefficients (Table 4-2) show no severe multicollinearity (all VIFs < 2, mean VIF = 1.39).

Table 4-2 Correlation Matrix of Main Variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) FM	1.000							
(2) Size	0.041***	1.000						
(3) Lev	0.233***	0.503***	1.000					
(4) ROA	-0.240***	-0.014**	-0.373***	1.000				
(5) Cashflow	-0.093***	0.085***	-0.149***	0.390***	1.000			
(6) Growth	-0.041***	0.042***	0.028***	0.275***	0.033***	1.000		
(7) Top1	-0.123***	0.128***	0.015***	0.150***	0.088***	0.013**	1.000	
(8) ListAge	0.085***	0.477***	0.384***	-0.255***	0.026***	-0.076***	-0.096***	1.000

Note: *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 4-3 Results of Multicollinearity Test

Variable	VIF	1/VIF
Lev	1.73	0.576559
Size	1.72	0.582584
ROA	1.65	0.604641
ListAge	1.47	0.680241
Cashflow	1.22	0.819869
Growth	1.12	0.894901
FM	1.10	0.906307
Top1	1.08	0.927473
Mean VIF	1.39	

3.4.3 Baseline Regression Results

We examined the direct impact of financial misallocation (FM) on corporate ESG performance. Table 4-4 reports the regression results. Column (1) presents estimates based on a random-effects model without incorporating control variables, showing a coefficient of -0.1615 for FM's effect on ESG, which is significant at the 1% level. Column (2) reports estimates without control variables but with time effects controlled. Column (3) lists estimates without control variables but accounts for industry effects. Column (4) provides estimates without control variables while considering city effects. Building on these findings, we further investigated the correlation between FM and ESG, as shown in Column (5). Finally, all control variables were integrated into the baseline model in Column (6), where the estimated coefficient for FM is -0.1165. The results indicate that the core variable's coefficient is negative and significant, passing the 1% significance test, thereby reinforcing Hypothesis H1. These findings demonstrate that the widespread issue of FM in enterprises significantly suppresses corporate ESG performance.

Table 4-4 Regression Results of FM on ESG

	(1) ESG	(2) ESG	(3) ESG	(4) ESG	(5) ESG	(6) ESG
FM	-0.1615*** (0.010)	-0.1632*** (0.010)	-0.1629*** (0.010)	-0.1458*** (0.010)	-0.1509*** (0.009)	-0.1165*** (0.009)
Size						0.2868*** (0.007)
Lev						-0.5931*** (0.043)
ROA						1.5232*** (0.120)
Cashflow						0.2142** (0.100)
Growth						-0.0404** (0.017)
Top1						0.3348*** (0.046)
ListAge						0.0637*** (0.010)
_cons	4.0489*** (0.006)	4.0490*** (0.006)	4.0489*** (0.006)	4.0484*** (0.006)	4.0486*** (0.006)	-2.3619*** (0.133)
Year		√			√	√
Industry			√		√	√
province				√	√	√
N	28992.0000	28992.0000	28992.0000	28959.0000	28959.0000	28959.0000
r2	0.0217	0.0408	0.0484	0.0932	0.1375	0.2291

Note: Figures in () are robust standard errors *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively. Results in columns (1) – (5) do not include control variables.

3.4.4 Mediation Effect Tests

To examine the mediating role of supply chain concentration (SCC) in the relationship between FM and ESG, this study employs a mediation effect testing approach. The results show that the direct effect of FM on ESG is -0.1165. The coefficient of FM on SCC is 0.8685, indicating that financial misallocation significantly increases supply chain concentration. After including both FM and SCC in the model, SCC exerts a significant negative impact on ESG, and the absolute value of the FM coefficient decreases, suggesting that SCC plays a partial mediating role between FM and ESG. When all mechanism

variables are incorporated into the model simultaneously, the coefficient of FM further declines, again supporting the validity of SCC's mediating effect.

Table 4-5 The Mediating Role of SCC

	(1) ESG	(2) SCC	(3) ESG	(4) ESG
FM	-0.1165*** (0.009)	0.8685*** (0.118)	-0.1113*** (0.008)	-0.0895*** (0.009)
SCC			-0.0059*** (0.000)	-0.0056*** (0.000)
Dcost				-2.1324*** (0.546)
GreenInnovation				0.0966*** (0.008)
_cons	-2.3619*** (0.133)	109.2184*** (2.136)	-1.7128*** (0.139)	-1.0384*** (0.149)
Covariates	√	√	√	√
Year	√	√	√	√
province	√	√	√	√
Industry	√	√	√	√
N	28959.0000	28959.0000	28959.0000	28959.0000
r2	0.2291	0.2705	0.2352	0.2406

Note: Figures in () are robust standard errors *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Debt Financing Cost (Dcost). Both FM and the mechanism variable (Dcost) exert adverse effects on ESG (as shown in Column (3)). Moreover, the absolute value of the FM coefficient in Column (3) is smaller than that in Column (1), indicating that Dcost plays a mediating role in the FM–ESG relationship. Furthermore, after incorporating all mechanism variables into the equation to observe changes in the FM coefficient, we found a slight decrease in its absolute value. In summary, these results support the mediating effect of Dcost between financial misallocation and corporate ESG performance.

Table 4-6 The Mediating Role of Debt Financing Cost

	(1) ESG	(2) Dcost	(3) ESG	(4) ESG
FM	-0.1165*** (0.009)	0.0093*** (0.001)	-0.0932*** (0.010)	-0.0895*** (0.009)
Dcost			-2.5127*** (0.612)	-2.1324*** (0.546)
SCC				-0.0056*** (0.000)
GreenInnovation				0.0966*** (0.008)
_cons	-2.3619*** (0.133)	0.0070*** (0.002)	-2.3443*** (0.133)	-1.0384*** (0.149)
Covariates	√	√	√	√
Year	√	√	√	√
province	√	√	√	√
Industry	√	√	√	√
N	28959.0000	28959.0000	28959.0000	28959.0000
r2	0.2291	0.3734	0.2304	0.2406

Note: Figures in () are robust standard errors *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Third, Green Innovation (GreenInnovation). Both FM and the mechanism variable, green innovation, exert adverse effects on ESG (as shown in Column (3)). Furthermore, the coefficient of FM in Column (3) is smaller than that in Column (1), indicating that green innovation plays a mediating role in the FM–ESG relationship. Additionally, when all mechanism variables are incorporated into the equation to examine changes in the FM coefficient, a slight decrease in its absolute value is observed. In summary, these results support the mediating effect of green innovation between financial misallocation and corporate ESG performance.

Table 4-7 The Mediating Role of Green Innovation

	(1)	(2)	(3)	(4)
	ESG	GreenInnovation	ESG	ESG
FM	-0.1165*** (0.009)	-0.0240*** (0.005)	-0.1141*** (0.009)	-0.0895*** (0.009)
GreenInnovation			0.1022*** (0.008)	0.0966*** (0.008)
SCC				-0.0056*** (0.000)
Dcost				-2.1324*** (0.546)
_cons	-2.3619*** (0.133)	-7.1569*** (0.143)	-1.6303*** (0.144)	-1.0384*** (0.149)
Covariates	√	√	√	√
Year	√	√	√	√
province	√	√	√	√
Industry	√	√	√	√
N	28959.0000	28959.0000	28959.0000	28959.0000
r2	0.2291	0.3222	0.2339	0.2406

Note: Figures in () are robust standard errors *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively.

3.4.5 Moderation Effect Tests

This study introduces three moderating variables—operational risk (Z-Score), corporate transparency (Opacity), and information disclosure quality (Tran)—to examine their influence on the relationship between financial misallocation (FM) and corporate ESG performance. As shown in Table 4-8, the interaction term between operational risk and FM has a coefficient of 0.0011, significant at the 1% level, indicating that lower operational risk amplifies the positive impact of financial misallocation on corporate ESG performance, thus supporting H3a. The interaction term for corporate transparency shows a coefficient of -0.0796, significant at the 5% level, suggesting that higher transparency significantly mitigates the negative effect of financial misallocation, validating H3b. In contrast, the interaction term for information disclosure quality has a coefficient of 0.0309, significant at the 5% level but contrary to expectations, implying that higher disclosure quality strengthens the negative impact of financial misallocation. A possible explanation is that while enhanced disclosure improves information availability, it also intensifies external pressure, prompting firms to adopt short-term strategies or conceal substantive issues to manage stakeholder scrutiny, ultimately adversely affecting ESG performance.

Table 4-8 Regression Results of Moderating Effects

	(1) ESG	(2) ESG	(3) ESG
FM	-0.1250*** (0.009)	-0.1145*** (0.009)	-0.1884*** (0.041)
Z-Score	0.0004 (0.000)		
Z-Score*FM	0.0011*** (0.000)		
Opacity		0.0293 (0.030)	
Opacity*FM		-0.0796** (0.037)	
Tran			0.4072*** (0.011)
Tran*FM			0.0309** (0.013)
_cons	-2.3561*** (0.134)	-2.3102*** (0.139)	-2.2629*** (0.128)
Year	√	√	√
Industry	√	√	√
province	√	√	√
N	28,959	28,959	28,959
r ²	0.2294	0.2293	0.2685

Note: Figures in () are robust standard errors *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively.

3.4.6 Heterogeneity Analysis

3.4.6.1 Firm Size

Given that enterprises of different sizes vary in financial capacity and development strategies, the constraining effect of FM on ESG may also differ. This study examines the heterogeneous impact of firm size on corporate ESG performance. Based on the annual average size of listed companies, firms with an average size greater than the median value of 22.093 are classified as large-scale enterprises, while those with an average size less than or equal to the median value of 22.109 are classified as small-scale enterprises. A grouped regression of Model (4-1) was conducted, with results presented in Table 4-9. The FM coefficient for large enterprises is -0.132, and for small and medium-sized enterprises it is -0.107, both statistically significant at the 1% level, indicating that FM has a more pronounced negative impact on the ESG performance of large enterprises.

The reasons for this discrepancy may include the following: First, although large enterprises have easier access to financing, financial misallocation may lead to capital surplus, resulting in resource waste or increased non-ESG investments. Second, large enterprises face more severe agency problems, where management may prioritize short-term gains over long-term investments such as ESG initiatives. Third, the complex organizational structures of large enterprises make the implementation and monitoring of ESG measures more challenging. Fourth, large enterprises are often concentrated in traditional high-pollution industries, where transition costs are high, and financial misallocation further undermines their motivation for green transformation. Finally, large enterprises tend to rely more heavily on traditional financing channels, lacking intrinsic incentives to access sustainable financial resources by improving their ESG performance.

Table 4-9 Heterogeneity Analysis: Grouped Regression by Firm Size

VARIABLES	(1) Large Firms	(2) SMEs
FM	-0.132*** (-9.20)	-0.107*** (-10.26)
Size	0.336*** (30.17)	0.329*** (20.16)
Lev	-0.516*** (-7.48)	-0.632*** (-11.01)
ROA	2.446*** (12.68)	0.982*** (6.43)
Cashflow	0.066 (0.44)	0.200 (1.49)
Growth	-0.114*** (-4.93)	0.019 (0.78)
Top1	0.196*** (3.04)	0.476*** (7.08)
ListAge	0.029* (1.65)	0.094*** (6.96)
Constant	-3.497*** (-14.75)	-3.279*** (-9.73)
Observations	12,643	16,295
R-squared	0.283	0.190

Note: Figures in () are robust standard errors *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively.

3.4.6.2 Ownership Nature

To examine the impact of ownership nature on the relationship between FM and ESG, this study conducts grouped regressions for state-owned enterprises (SOEs) and non-state-owned enterprises (non-SOEs). The results (Table 4-10) show that the coefficient of financial misallocation is -0.0696 for SOEs and -0.1221 for non-SOEs, both significant at the 1% level, indicating that financial misallocation has a stronger inhibitory effect on the ESG performance of non-SOEs. This finding, to some extent, validates the existence of “ownership discrimination.”

The main reasons for this difference may be as follows: SOEs, due to their state-owned attributes, have easier access to formal financing channels and government subsidies, resulting in a higher degree of resource redundancy. Meanwhile, SOEs bear more policy and social responsibilities (e.g., carbon neutrality, employment security), and their ESG behaviors are often incorporated into government assessment systems. Consequently, management tends to prioritize long-term strategies and social objectives, ensuring ESG-related investments even under financial misallocation. Additionally, SOEs are subject to stricter regulatory and policy constraints, which strengthen their motivation for ESG governance. In contrast, non-SOEs are more market-driven and, under financial misallocation, tend to focus on short-term profits, making them more likely to reduce long-term investments such as ESG initiatives.

Table 4-10 Heterogeneity Analysis: Grouped Regression by Ownership Type

VARIABLES	(1)	(2)
	SOEs	Non-SOEs
FM	-0.0696*** (0.014)	-0.1221*** (0.010)
Size	0.3291*** (0.010)	0.2563*** (0.009)
Lev	-0.7554*** (0.074)	-0.5180*** (0.053)
ROA	1.4956*** (0.252)	1.5153*** (0.137)
Cashflow	-0.1005 (0.170)	0.2826** (0.122)
Growth	-0.0783*** (0.030)	-0.0134 (0.020)
Top1	0.1775** (0.083)	0.1857*** (0.059)
ListAge	0.0716*** (0.023)	0.0546*** (0.014)
Constant	-3.1823*** (0.218)	-1.6686*** (0.186)
Observations	8,104	20,849
R-squared	0.3824	0.2052

Note: Figures in () are robust standard errors *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively.

3.4.6.3 Region

To examine the impact of regional differences on the relationship between financial misallocation and corporate ESG performance, this study divides the sample into three subsamples based on company location—eastern, central, and western regions—for regression analysis. The results (Table 4-11) are as follows:

Table 4-11 Heterogeneity Analysis: Grouped Regression by Firm Location

VARIABLES	(1)	(2)	(3)
	Eastern	Central	Western
FM	-0.1063*** (0.010)	-0.1578*** (0.022)	-0.1722*** (0.037)
Size	0.2816*** (0.008)	0.2786*** (0.017)	0.3139*** (0.020)
Lev	-0.5999*** (0.053)	-0.7669*** (0.109)	-0.4295*** (0.128)

VARIABLES	(1)	(2)	(3)
	Eastern	Central	Western
ROA	1.6307*** (0.146)	0.7661** (0.298)	1.4654*** (0.368)
Cashflow	0.3300*** (0.124)	0.0273 (0.232)	-0.2274 (0.314)
Growth	-0.0265 (0.022)	-0.0402 (0.037)	-0.0843* (0.044)
Top1	0.4046*** (0.057)	0.0463 (0.113)	0.1382 (0.142)
ListAge	0.0767*** (0.013)	0.0749*** (0.026)	0.0049 (0.031)
Constant	-2.2631*** (0.164)	-2.1020*** (0.350)	-2.9304*** (0.409)
Observations	19,203	4,821	3,174
R-squared	0.2157	0.2790	0.3036

Note: Figures in () are robust standard errors *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively.

As shown in Table 4-11, the FM coefficient is -0.1063 in the eastern region, -0.1578 in the central region, and -0.1722 in the western region, all statistically significant at the 1% level. This indicates that the inhibitory effect of financial misallocation on ESG increases progressively from east to west, with the most pronounced impact observed in the western region.

The primary reasons for this regional disparity are as follows: In the western region, the financial system is relatively underdeveloped, capital markets are less mature, and financing channels are limited. Credit allocation tends to favor state-owned enterprises or large-scale projects, exacerbating financing constraints and resource misallocation for small and medium-sized enterprises (SMEs), thereby significantly restricting their ESG investments. Additionally, the western economy relies heavily on resource-intensive industries, which inherently entail higher ESG risks. Financial misallocation further channels funds toward high-pollution and high-energy-consumption sectors, intensifying environmental pressures and suppressing overall ESG. In contrast, the eastern region benefits from a more advanced economy, superior institutional environments, and stronger government support. Enterprises there possess greater motivation and resources for ESG implementation, and their industrial structure is more diversified and environmentally oriented, which helps mitigate the negative impact of financial misallocation to some extent. Consequently, the inhibitory effect of financial misallocation on ESG is more pronounced in the western region.

3.4.7 Endogeneity Tests

3.4.7.1 Interactive Fixed Effects

This study may still suffer from bias due to omitted variables. Additionally, potential reverse causality between FM and ESG cannot be ruled out. To mitigate the impact of endogeneity on the conclusions, beyond the firm and time fixed effects controlled for earlier, we further incorporate industry-year interaction fixed effects to re-estimate the baseline regression, thereby accounting for unobserved heterogeneity. As shown in Column (1) of Table 4-12, the core variable FM remains significantly negative.

Table 4-12 Regression Results with Interactive Fixed Effects

VARIABLES	(1) ESG	(2) ESG
FM	-0.1202*** (0.009)	-0.1165*** (0.009)
Size	0.2837*** (0.006)	0.2868*** (0.007)
Lev	-0.5919*** (0.042)	-0.5931*** (0.043)
ROA	1.6054*** (0.120)	1.5232*** (0.120)
Cashflow	0.3948*** (0.099)	0.2142** (0.100)
Growth	-0.0917*** (0.017)	-0.0404** (0.017)
Top1	0.2894*** (0.045)	0.3348*** (0.046)
ListAge	0.0320*** (0.010)	0.0637*** (0.010)
Year	×	√
Industry	×	√
province	×	√
Year*Industry	√	×
N	28,992	28,959
r2	0.9407	0.2291

Note: Figures in () are robust standard errors *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively.

3.4.7.2 Instrumental Variables (IV)

To address potential measurement errors in the FM indicator, this study employs an instrumental variable (IV) approach for re-estimation. A new proxy variable for financial misallocation (FM2) is constructed, defined as the deviation of a firm's capital cost from the industry average, scaled by one minus the industry percentile of the firm's earnings before interest and taxes (EBIT) return rate. After applying two-stage least squares (2SLS) regression, FM2 remains significantly negative at the 1% level, indicating that the inhibitory effect of financial misallocation on corporate ESG performance remains robust after controlling for measurement errors, thereby further supporting the baseline conclusions.

Table 4-13 Instrumental Variable Regression Results

	(1)	(2)
	First Stage	Second Stage
VARIABLES	FM	ESG
FM		-0.201*** (0.0335)
FM2	0.772*** (0.1569)	
Size	0.002 (0.0225)	0.292*** (0.0219)
Lev	0.768*** (0.0819)	-0.918*** (0.0829)
ROA	-1.215*** (0.1338)	0.0544 (0.132)
Cashflow	0.709*** (0.1264)	-0.220** (0.103)
Growth	-0.072*** (0.0148)	-0.0267* (0.0149)
Top1	-0.595*** (0.1192)	1.183*** (0.148)
ListAge	-0.049* (0.0268)	0.721*** (0.0299)
Year	√	√
Industry	√	√
province	√	√
N	28,579	28,579
r ²		0.118
F-value		42.83
Kleibergen-Paap rk LM		118.314
underidentification		[0.000]
Kleibergen-Paap rk Wald F		24.183
weak instrument		{16.38}
Hansen J		0.000

Note: Figures in () are robust standard errors *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively. Values in [] represent the p-values of each statistic, while values in { } indicate the critical values of the Stock-Yogo test at the 10% significance level.。

To validate the effectiveness of the instrumental variables, this study conducted underidentification, weak instrument, and overidentification tests. The Kleibergen-Paap rk LM test rejected the null hypothesis of “instrumental variable underidentification” ($p=0.000$). The Kleibergen-Paap rk Wald F statistic was 24.183, exceeding the Stock-Yogo test critical value at the 10% level, thus ruling out weak instrument concerns. The Hansen J test indicated that the instrumental variables are exogenous ($p=0.000$). In the first stage, FM2 showed a significant correlation with FM. In the second stage, the coefficient of FM was -0.201 and significant at the 1% level, demonstrating that the inhibitory effect of financial misallocation on corporate ESG performance remains robust after controlling for endogeneity.

3.4.7.3 Propensity Score Matching (PSM)

To mitigate the endogeneity arising from firm characteristic differences affecting ESG performance, this study employs the Propensity Score Matching (PSM) method to address sample selection bias. Firms in the top 10% of ESG scores are designated as the treatment group, with the remainder serving as the control group. Covariates including firm size, leverage, profitability, cash flow, growth, ownership concentration, and listing age are used to estimate propensity scores via a logit model. Nearest-neighbor matching is then applied to construct a comparable sample with similar characteristics, enabling a more accurate identification of the net effect of financial misallocation on ESG performance.

Using the above PSM approach, 4,857 matched samples are obtained. As shown in Table 4-14, the balance tests indicate that after matching, the p-values of all characteristic variables are insignificant, demonstrating a successful matching outcome with no significant differences in the covariates between the treatment and control groups.

Table 4-14 PSM Balance Test

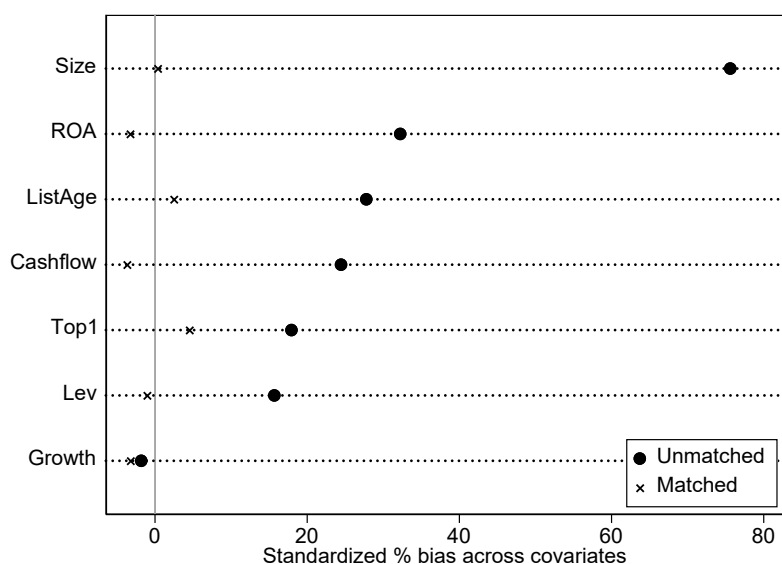
Covariate	Matching Status	Mean			t-test	
		Treatment	Control	%Bias	t-value	p-value
Size	U	23.072	22.012	75.6	42.36	0.000
	M	23.072	23.067	0.3	0.11	0.909
Lev	U	0.43346	0.40234	15.7	7.53	0.000
	M	0.43346	0.43555	-1.1	-0.38	0.707
ROA	U	0.06037	0.03991	32.2	14.58	0.000
	M	0.06037	0.06244	-3.3	-1.25	0.211
Cashflow	U	0.0628	0.04621	24.4	11.91	0.000
	M	0.0628	0.06531	-3.7	-1.32	0.188
Growth	U	0.15875	0.16498	-1.8	-0.80	0.425
	M	0.15875	0.16986	-3.2	-1.29	0.196
Top1	U	0.35754	0.33063	17.9	9.16	0.000
	M	0.35754	0.35076	4.5	1.58	0.113
ListAge	U	2.24	2.0033	27.8	13.00	0.000
	M	2.24	2.2189	2.5	0.91	0.360

Subsequently, this study conducts a regression based on the propensity score-matched sample using Model (4-1), with the results presented in Table 4-15. The coefficient for FM is -0.1052 and remains significant at the 1% level, indicating that even after controlling for differences in the main characteristic variables of enterprises with varying ESG performance, actively mitigating financial misallocation can still enhance ESG performance. This finding confirms that the research conclusions drawn from the full-sample model analysis are robust.

Table 4-15 Propensity Score Matching: Regression Results of Financial Misallocation on Corporate ESG Performance

	(1)	(2)
VARIABLES	Full Sample	PSM Matched Sample
	ESG	ESG
FM	-0.1165*** (0.009)	-0.1052*** (0.026)
Size	0.2868*** (0.007)	0.1358*** (0.020)
Lev	-0.5931*** (0.043)	-0.3388** (0.147)
ROA	1.5232*** (0.120)	0.4718 (0.439)
Cashflow	0.2142** (0.100)	0.3388 (0.335)
Growth	-0.0404** (0.017)	-0.0666 (0.064)
Top1	0.3348*** (0.046)	0.2850** (0.122)
ListAge	0.0637*** (0.010)	0.1150*** (0.032)
Constant	-2.3619*** (0.133)	1.5969*** (0.391)
Year	√	√
Industry	√	√
province	√	√
N	28,959	4,553
r ²	0.2291	0.2331
F	474.73	17.55

Note: Figures in () are robust standard errors *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively.



3.4.8 Robustness Checks

3.4.8.1 Alternative ESG Measures

The dependent variable in this study is ESG. To conduct robustness checks, alternative measures of ESG are employed. First, the scoring method for Hua Zheng ESG ratings is modified: whereas the original rating scale (C to AAA) was assigned values from 1 to 9, the revised approach groups CCC, CC, and C as 1; BBB, BB, and B as 2; and AAA, AA, and A as 3, resulting in the variable ESG_2. Second, the one-period lagged Hua Zheng ESG rating is used as an alternative measure, denoted as L.ESG. Table 4-17 reports the regression results using these alternative dependent variables. The coefficients for FM are -0.0271 and -0.0560, respectively, both remaining significantly negative. These results further support Hypothesis 1, indicating that financial misallocation inhibits corporate ESG performance.

Table 4-16 Robustness Test: Replacing the Dependent Variable

VARIABLES	(1) ESG_2	(2) L.ESG
FM	-0.0271*** (0.003)	-0.0560*** (0.007)
Size	0.0915*** (0.003)	0.2900*** (0.008)
Lev	-0.2560*** (0.018)	-0.5323*** (0.047)
ROA	0.7667*** (0.051)	1.2668*** (0.128)
Cashflow	-0.0603 (0.040)	0.2328** (0.112)
Growth	-0.0426*** (0.007)	-0.0495*** (0.019)
Top1	0.0722*** (0.018)	0.2676*** (0.051)
ListAge	-0.0849*** (0.003)	0.0308** (0.013)
_cons	-0.0303 (0.054)	-2.3917*** (0.149)
Year	√	√
Industry	√	√
province	√	√
N	28,959	24,082
r2	0.1713	0.2126

Note: Figures in () are robust standard errors *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively.

3.4.8.2 Lagged FM

The core explanatory variable in this study is FM. Given that many economic and social phenomena exhibit time-lagged effects, the current period's dependent variable may be influenced not only by contemporaneous explanatory variables but also by their past values. To account for this dynamic, the one-period lagged FM (L.FM) is used as an alternative explanatory variable. As reported in Table 4-17, the coefficient of L.FM is -0.0874, which remains significantly negative at the 1% level. This result is consistent with previous findings and provides further support for Hypothesis H1.

Table 4-17 Robustness Test: Replacing the Explanatory Variable

VARIABLES	(1) ESG
L.FM	-0.0874*** (0.007)
Size	0.3223*** (0.007)
Lev	-0.7314*** (0.044)
ROA	2.1710*** (0.125)
Cashflow	-0.2349** (0.102)
Growth	-0.1097*** (0.018)
Top1	0.2800*** (0.046)
ListAge	-0.2296*** (0.010)
_cons	-2.3672*** (0.137)
Year	√
Industry	√
province	√
N	24,082
r2	0.2722

Note: Figures in () are robust standard errors *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively.

4. Conclusions and Policy Implications

4.1 Conclusions

Based on an empirical analysis of data from China's A-share listed companies spanning 2009 to 2022, this study demonstrates that financial misallocation significantly inhibits corporate ESG performance—a conclusion that remains robust after a series of rigorous tests. Mechanistically, financial misallocation impedes ESG development primarily through three channels: intensifying supply chain concentration, increasing debt financing costs, and suppressing corporate green innovation. Moderating effect analysis reveals that corporate operational risk exacerbates this negative impact, whereas corporate transparency and information disclosure quality effectively mitigate the adverse effects of financial misallocation. Heterogeneity analysis further indicates that the inhibitory effect of financial misallocation is more pronounced in non-state-owned enterprises, large firms, and enterprises located in the western region, reflecting the profound constraints imposed by

“ownership discrimination,” “scale discrimination,” and regional financial development disparities on ESG practices.

4.2 Policy Recommendations

Based on the research findings, this study proposes the following policy recommendations: Governments should deepen green financial reforms, improve the development of green credit and green bond markets, and guide more capital toward enterprises with leading ESG performance and green innovation sectors, thereby enhancing the efficiency of financial resource allocation at the source. Differentiated support policies should be implemented, such as establishing specialized green credit programs and fiscal incentives for non-state-owned enterprises, small and medium-sized enterprises, and firms in the western region, to alleviate their financing constraints and enhance their ESG implementation capabilities.

Simultaneously, regulatory oversight of corporate ESG information disclosure and transparency should be strengthened, promoting the establishment of a unified and comparable ESG evaluation system to reduce information asymmetry and bolster market confidence. Furthermore, enterprises should be encouraged to optimize their supply chain structures, foster regional collaboration, and advance green industrial transformation. By integrating capacity-building initiatives, performance incentives, and ESG metrics into corporate evaluation systems, a virtuous cycle of “innovation–disclosure–financing” can be established, comprehensively elevating the sustainable development capacity of enterprises.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Altman, E. I. (1968). Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *The Journal of Finance*, 23(4), 589–609.
- [2] Wang, Z. J., Liu, S., & Wang, Z. Q. (2022). Leverage misestimation, stock pricing errors, and credit misallocation. *Modern Finance and Economics*, 42(6), 72–90.
- [3] Zhang, L., & Fan, J. J. (2022). How financial resource misallocation hinders technological innovation: A perspective based on technological gaps. *International Business*, (3), 87–105.
- [4] Zhong, T., & Wang, C. Y. (2017). Financial development and corporate innovation output: A comparative perspective based on different financing modes. *Journal of Financial Research*, (12), 127–142.
- [5] Bu, Y., Du, X., Wang, Y., Liu, S., Tang, M., & Li, H. (2024). Digital inclusive finance: A lever for SME financing? *International Review of Financial Analysis*, 93, 103115.
- [6] Bai, H., Wu, Y., & Wang, R. (2023). Does digital financial inclusion lead to regional differences in trade credit financing? A quasi-natural experiment. *Economic Analysis and Policy*, 80, 1475–1489.
- [7] Ning, X. P., & Zhang, Q. J. (2020). Enterprise leverage level, leverage transfer, and financial misallocation: Evidence from China’s Shanghai and Shenzhen A-share listed companies. *Nankai Business Review*, 23(2), 98–107+120.
- [8] Shao, T. (2010). Financial misallocation, ownership structure, and capital return rate: Evidence from China’s industrial enterprises (1999–2007). *Journal of Financial Research*, (9), 51–68.
- [9] Zhou, Y. H., & Zhang, S. Y. (2014). Financial misallocation, asset specificity, and capital structure. *Accounting Research*, (8), 75–80+97.

A Study on the Theoretical Evolution, Practical Dilemmas, and Policy Innovations in Enhancing Rural Social Welfare

Yuan Wei*

The General Office of the Shaanxi Provincial People's Government, Shaanxi Xi'an, 710000

**Corresponding author: Yuan Wei*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: China's long-standing social welfare system has exhibited a distinct urban bias, resulting in institutional segmentation between urban and rural welfare frameworks. Consequently, rural residents experience significantly lower levels of social security and public services compared with their urban counterparts. Guided by the macro policy orientation of the Rural Revitalization Strategy, this paper examines the theoretical foundations and explores the policy innovation pathways for improving rural social welfare. Existing research indicates that the current rural welfare system faces three major issues: first, the overall level of welfare provision remains low, with a pronounced urban–rural gap; second, the structure of welfare providers is highly homogeneous, characterized by “remedial” and “relief-oriented” features; and third, the welfare content lacks multi-dimensionality, as economic subsidies continue to dominate the social security system, with insufficient comprehensive social support. Based on the conceptual connotations and functional definitions of social welfare, this study explores the institutional logic and practical feasibility of reform. On this basis, it compares two pathways for improvement—enhancing the degree of rural-to-urban integration (“rural population urbanization”) and strengthening local rural welfare development—by examining their respective advantages and limitations. Finally, the paper proposes targeted policy recommendations for optimizing the rural social welfare system, with the goal of offering theoretical insights and practical guidance for achieving welfare equality between urban and rural areas and advancing the overarching goal of common prosperity.

Keywords: Social Welfare; Urban–Rural Integration; Rural Revitalization; Socialization of Welfare

Published: Oct 27, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.823>

1. In trodution

Social welfare, distinct from social insurance and social assistance, refers to the rational allocation of social resources under the guarantee of public policy. Its purpose is to promote the continuous improvement of the quality of life of social members and, to a certain extent, to maintain social justice and harmonious order^{[1][2]}. As an important component of the social security system, the social welfare system serves as one of the core indicators for assessing the level of social development and the government's governance capacity^[3]. However, due to the dual urban-rural structure formed under the influence of policies during the planned economy period, China's social welfare system has exhibited a “urban-centered, rural-peripheral” pattern. This has resulted in institutional and structural disadvantages for rural areas in terms of welfare coverage and social service provision^[4]. Therefore, this paper aims to explore the theoretical evolution and practical challenges of China's rural social welfare system and propose institutional innovations for promoting welfare equality between urban and rural areas.

From a historical perspective, the development of China's social welfare policies can be characterized by an institutional feature of "urban priority and rural lag." This feature can be traced back to the differentiated welfare systems implemented since the 1950s—an urban welfare system based on work units and a rural welfare system centered on collective mutual aid and family support^{[5][6]}. Admittedly, this system effectively maintained regional and social stability during long-term urban-rural governance^[7]. However, with profound changes in the economic structure and human capital mobility, the drawbacks of such a differentiated system have gradually emerged. A state of relative deprivation^[8] has become concentrated in rural residents' access to education, healthcare, and elderly care. This "institutional exclusion" not only widens the urban-rural gap but also hinders the modernization of rural society to a certain extent^[9].

At the new stage of development, with the deep transformation of the social structure and the rapid advancement of new productive forces, public demands have gradually shifted from securing basic subsistence to pursuing fairness and shared prosperity. This transformation—from "basic protection" to "developmental welfare"—requires social policy and public governance to achieve comprehensive and multidimensional improvements in quality of life, social participation, and human dignity^[10]. The report of the 19th National Congress of the Communist Party of China proposed the Rural Revitalization Strategy, which provides strong policy support by emphasizing the establishment and improvement of institutional mechanisms and policy systems for integrated urban-rural development^[11]. This strategy not only provides an essential foundation for advancing agricultural and rural modernization but also offers an institutional opportunity to balance the urban-rural welfare gap and reconstruct the rural social welfare system^[12].

From a policy perspective, rural social welfare demonstrates several characteristics. With the continuous advancement of fiscal reform and the equalization of public services, the guiding ideology of national welfare construction has shifted from "urban priority" to "urban-rural coordination"^[13]. This transformation is reflected in the expansion of the rural minimum living security system and the institutional development of rural medical and pension insurance, which have collectively laid the groundwork for the overall improvement of the social welfare system^[14]. Nevertheless, the current institutional design still lacks adequate consideration of the specific characteristics of rural society. Therefore, within the macro policy context of rural revitalization, exploring the theoretical logic and institutional innovation pathways to enhance rural social welfare is both an urgent practical task and an issue of significant academic value. Methodologically, this study adopts a historical institutional and policy analysis approach, combining theoretical review with policy document analysis to examine the evolution, dilemmas, and reform paths of China's rural welfare system.

2. Theoretical Evolution

The evolution of the social welfare system is often related to the logic of national governance, social transformation, and ideology, and it is dynamically adjusted based on these factors^[15]. In general, the localization of China's social welfare development has gone through three stages: the initial stage of introducing the concept of the welfare state and adapting it to socialism with Chinese characteristics; the institutional construction of the social security system; and the new stage of welfare diversification. During this process, the policy transformation from state dominance to social coordination and from relief-based protection to developmental welfare has been manifested.

2.1 Planned Economy Period: Nationalization of Welfare Concepts and Institutional Dependence

In the early years after the founding of the People's Republic of China, social welfare theory was influenced by the Soviet Union and showed state-dominated institutional characteristics. During this period, social welfare functioned as an auxiliary component of the state's distribution structure, with the aim of maintaining social stability. Due to the underdeveloped productivity and low population mobility in rural areas, welfare systems were primarily dependent on people's communes and collective economic organizations, focusing on collective mutual assistance and self-protection. From a theoretical perspective, when welfare is embedded as a component of the planned economic system, it reflects the state's distributive justice and political will rather than an independent social power structure. In light of the resource allocation mechanisms under the planned economy, the core of welfare nationalization lies in the fact that social welfare is not determined by social needs but allocated by political authority to serve the goals of national production. Although this distributive model significantly enhanced social stability, particularly in grassroots governance during the early period of nation-building, its

structural deficiencies created potential risks of urban-rural disparity.

2.2 Since the Reform and Opening-up: Marketization of Welfare Institutions and Reconstruction of Social Policy

During the market-oriented economic transformation that began in the 1980s, the core of social welfare gradually shifted from state protection to social sharing. At the same time, Deng Xiaoping's new development strategy—allowing some people to become rich first—placed welfare system development in a secondary position to economic growth. Research on social welfare during this period focused more on adaptive reforms of welfare policies within the market mechanism, and arguments such as “social welfare should serve economic reform” began to emerge. The people's commune system completely collapsed under the impact of the market economy, and rural grassroots governance was reconstructed by the state into a family-centered support network. The government supported this reform process through social assistance, medical cooperatives, and the minimum living allowance system, thereby forming a “tiered and gradual” rural welfare structure. From this period onward, social understanding of welfare theory shifted from a focus on distributive mechanisms (economic subordination theory) to recognizing welfare as a supporting factor for social stability and development (social development theory), with increasing advocacy for policies that promote social integration.

2.3 Since the New Era: Transformation from Relief-based to Developmental Social Welfare

Since the 18th National Congress of the Communist Party of China, China's social welfare theory has entered a new stage of “developmental welfare.” The core is to integrate social welfare into the modernization governance system and achieve inclusive and balanced urban-rural development through policy innovation. Social welfare is no longer a passive relief mechanism but is endowed with active functions that promote social equity and support rural revitalization. At this stage, new concepts such as “socialization of welfare” and “universal services” have been proposed, reflecting a shift from policy dominance to multi-party collaboration. “Balancing equity and development” has become the underlying tone of governance in this period.

Within the context of rural social welfare, the state has utilized the institutional advantages of socialism with Chinese characteristics to reform rural public services and protection systems, constructing a comprehensive and multidimensional welfare framework that continues to be improved. Meanwhile, under the guidance of the rural revitalization strategy, welfare research has shifted its focus toward “empowerment-based development,” marking the evolution of China's social welfare system from “state-dominated welfare” to “social governance-oriented welfare,” and gradually building a localized theoretical framework centered on the integration of state governance, social participation, and welfare diversification.

3. Historical Dilemmas of China's Rural Social Welfare

3.1 Low Welfare Level and Significant Urban–Rural Disparity

As one of the key institutional structures shaping China's social welfare system in the early years after the founding of the People's Republic, the dual urban–rural system, together with the resource allocation preference toward “urbanization–industrialization” during the stage of rapid development, placed rural development issues at the margins of the national development framework. For a long time, agriculture functioned as the “blood transfusion” sector for industry within the social structure. As mentioned earlier, during the planned economy period, the work-unit-based social welfare system provided urban residents with a comprehensive welfare supply structure jointly supported by the state and enterprises, covering housing, employment, healthcare, and pensions. Compared with the collective land economy represented by people's communes, this urban welfare model—with its broad coverage and strong guarantee capacity—had more abundant financial resources and higher public service capabilities.

After the reform and opening-up, the further widening of the urban–rural gap led to a massive and rapid inflow of rural labor and human capital into cities. Urbanization accelerated significantly, and industrial agglomeration and economies of scale flourished, providing a solid material foundation for the continuous development of the urban welfare system. However, during the period of relatively stable human capital stock, the expansion of the urban population and labor force meant that rural areas suffered from serious aging and labor hollowing, which ultimately caused the construction of the rural welfare system to lag far behind the level of regional economic development. Policies such as rural medical insurance and the

minimum living security system have served as effective measures for improving rural welfare, yet they face challenges regarding sustainable funding and service quality. Significant disparities still exist between urban and rural residents in education, healthcare, elderly care, and social services. This imbalance in social welfare has become a major obstacle to achieving rural revitalization and the goal of common prosperity.

3.2 Single Supply Entity and the Prominent “Residual” Nature of Welfare

For a long time, China’s rural grassroots welfare system has relied on government macro-regulation, providing a single-source supply through special subsidies and transfer payments. However, this welfare model—characterized by the absence of active social participation—has led to low sensitivity in resource allocation and limited service capacity. In contrast, the urban welfare system features multiple providers, including enterprises and social capital, resulting in higher efficiency and service quality. Yet, rural areas, constrained by natural geographic disadvantages and weak infrastructure, lack the prerequisites for attracting participation from social capital and social organizations.

Moreover, the rural land system has exerted a profound psychological and structural influence on both the supply and demand sides of welfare. Under the influence of smallholder agriculture, Chinese farmers tend to view land as a natural security resource, while the state and enterprises regard it as a safeguard for farmers’ livelihoods. This preconception has led to relatively reduced direct investment in rural welfare systems during policy resource allocation. However, the inherent limitations of smallholder agriculture—relying on natural conditions for survival—and the ongoing reform of the land transfer system have gradually weakened the land’s security function. Before gaining access to urban welfare systems, rural residents have already been exposed to growing social risks. The current rural social welfare system exhibits a clear “residual” characteristic. Although this model can maintain basic living stability in the short term, it fails to meet the multidimensional welfare demands of rural populations in education, health, culture, and social participation.

3.3 Single-layered Supply Structure Focused on Economic Welfare

Social welfare exhibits stage-specific differences in the process of individual development. Specifically, at the stage of survival security, welfare demands focus mainly on economic and material assistance; whereas at the stage of new development, welfare content expands beyond basic survival to encompass political, social, cultural, and ecological dimensions. With the completion of the key task of poverty alleviation, rural socioeconomic development has gradually shifted from basic survival needs to welfare in areas such as political participation, cultural life, and ecological environment. However, the current rural welfare supply in China remains concentrated on economic welfare, primarily through fiscal transfers and income subsidies that provide “material security.” The degree of welfare provision has become disconnected from the actual needs of the population, leading to structural imbalances characterized by “economic support dominance and spiritual welfare deficiency,” particularly in areas such as cultural resources, educational opportunities, and public services compared with cities.

Meanwhile, in contrast to cities—the final destination of human capital inflow—rural areas currently face dual pressures of resource outflow and ecological degradation. From the perspective of national security, rural regions also serve as the protectors of the country’s cultivated land red line and executors of ecological restoration responsibilities. Under such multiple pressures and overlapping roles, policy designs and implementation strategies that remain focused solely on financial subsidies are evidently inefficient. The administrative effectiveness of the state in the soft governance domain cannot be advanced merely through economic means. Therefore, future rural social welfare reform should transform from “single-layer economic protection” to “multidimensional social development,” emphasizing coordinated progress in political empowerment, cultural participation, and ecological sharing.

4. Two Approaches to Enhancing the Social Welfare Level of Rural Populations

In view of the significant disparity between urban and rural social welfare levels, as well as the strategic goals of achieving common prosperity and integrated urban–rural development, improving the social welfare level of rural populations has become a crucial focal point. The academic community has formed two representative approaches to address the core question of “how to enhance” welfare: the urban absorption model, characterized by the emphasis on human capital mobility and structural redistribution, and the rural endogenous model, which focuses on improving local welfare supply capacity through rural industrial upgrading and institutional innovation^[17]

4.1 Urban Absorption Model: Achieving Welfare Integration through Population Mobility

This approach advocates further expansion of urbanization pathways to promote the continuous migration of rural populations to cities. The inflow of labor leads to both the optimization of resource allocation and the enhancement of economic growth, which, in turn, can generate more social wealth through industrial agglomeration and economies of scale. On this basis, the state continues to optimize and implement fiscal transfer payment mechanisms, channeling multiple forms of resources back to rural areas to improve the overall social welfare level. Under this model, the rural social welfare protection system relies more heavily on the spillover effects of the urban economy, balancing existing structural disparities through an “industry-supports-agriculture” mechanism^[16].

However, in practice, it is necessary to consider local conditions such as the carrying capacity of urban areas, regional cultural differences that affect farmers’ willingness to migrate, and the fiscal pressures arising from economic fluctuations. If urban public service systems fail to achieve equalization, migrant farmers may find it difficult to integrate into urban society and instead fall into a state of “semi-urbanization”. Particularly during macroeconomic downturns, migrant workers’ employment opportunities and social security may face greater uncertainty. Therefore, while this model possesses certain efficiency advantages, it remains limited in terms of social sustainability and fairness.

4.2 Rural Endogenous Model: Strengthening Welfare Supply Capacity through Rural Development

In contrast to the previous approach, the rural endogenous model focuses on guiding the inflow of human capital and emerging technologies into rural areas, thereby channeling key development factors from cities toward the countryside to promote comprehensive revitalization of rural industries and social systems. This concept aligns with the policy direction proposed in the report of the 19th National Congress of the Communist Party of China, which emphasizes transforming rural development from “blood transfusion” to “blood creation.” Its goal is to stimulate the autonomous generation of social welfare through the enhancement of local productivity in rural areas.

Under this framework, the importance of two-way factor flows between urban and rural areas will further increase: cities enhance rural economic vitality by channeling back human and technological capital, while rural regions contribute their resource endowments to support the sustainable development of urban areas. Theoretically, this model aligns more closely with the long-term goal of “integrated urban–rural development.” It also helps preserve the welfare protection function of rural land, safeguarding farmers’ basic livelihoods and reinforcing their social identity^[8].

Although this model is relatively more sustainable, its effectiveness largely depends on whether local rural areas can genuinely overcome development bottlenecks and break through the long-standing “ceiling effect.” In other words, industrial upgrading and institutional reform in rural regions determine the feasibility of factor backflow. The rural endogenous path is more consistent with the principle of social equity, yet its efficiency and replicability still require sustained institutional innovation and policy support for assurance^[20].

4.3 Comparative and Integrative Reflections

In summary, the two approaches to improving social welfare represent the respective logics of efficiency and equity. The urban absorption model improves welfare distribution by enhancing allocative efficiency, while the rural endogenous model embodies the principle of social equity within integrated urban–rural development. These two approaches are not mutually exclusive but rather complementary within the broader framework of balanced urban–rural development. Policy design should optimize the allocation of human and material resources while coordinating urban and rural development, balancing economic growth with social equity, and ultimately forming a closed-loop mechanism for enhancing rural social welfare characterized by human capital output → urban resource feedback → endogenous resource regeneration. This dynamic interaction provides the theoretical foundation for the subsequent policy recommendations.

5. Policy Recommendations

5.1 Adapting to Local Conditions and Creating an Enabling Development Environment

Building upon the two approaches to enhancing rural social welfare discussed earlier, and considering the complexity of China’s regional development patterns, a single, uniform model may prove ineffective in different areas due to local variations. For instance, in the vast rural regions of central and western China, achieving large-scale urbanization of the population in the short

term is unrealistic. Cities in these areas also lack the capacity to accommodate a large influx of labor or non-labor populations. In contrast, rural areas in the more developed eastern regions already possess economic and social development conditions comparable to urban areas. Therefore, exploring region-specific strategies for improving rural social welfare levels based on local development realities is an effective path toward promoting integrated urban–rural development^[17].

More specifically, it is essential to improve urban public service systems while enhancing their capacity to accommodate incoming labor. At the same time, policies such as “talent returning to hometowns” and “capital flowing into rural areas” should be effectively implemented to strengthen the endogenous driving force behind rural social welfare development^[18]. Regardless of which approach is adopted, the fundamental objective remains the same: to build a sustainable social welfare supply system based on regional economic growth^[19].

5.2 Leveraging the “Three Rights Separation” Reform to Revitalize the Welfare Function of Farmland

Since rural residents enjoy stronger security through land ownership compared to urban residents without property, some scholars have expressed concerns about whether rural residents can obtain social welfare benefits equivalent to those in cities. However, with the deep upgrading of the rural industrial structure and the continuous strengthening of non-agriculturalization trends, the security function of land has gradually weakened, and its economic output is increasingly insufficient to sustain daily living expenses. In this context, deepening the reform of the “Three Rights Separation” (ownership, contracting, and management rights) provides a new institutional opportunity to reactivate the welfare function of farmland.

This mechanism allows farmers to retain contracting rights while gaining stable income through the transfer of management rights, thus institutionalizing property-based income derived from farmland. Once land is operated on a larger and more intensive scale, overall production efficiency can be improved, and through the extension of industrial chains and the optimization of profit distribution mechanisms, farmers can receive more stable and sustainable economic returns. Therefore, it is necessary to further advance the “Three Rights Separation” reform, improve the land income distribution system and legal protection framework, and transform farmland from a “subsistence guarantee” into a “welfare asset,” thereby making it a key lever for enhancing rural social welfare^[20].

5.3 Promoting Urban–Rural Integration and Developing Socialized Welfare

Under the goal of common prosperity with Chinese characteristics, the ultimate objective of constructing a social welfare system should be the universality and fairness of welfare benefits. Regardless of the policy path adopted, this process depends on the free flow of factors between urban and rural areas and the institutional integration of public services. Consequently, removing institutional barriers and communication obstacles between urban and rural regions, and promoting the balanced regional allocation of public resources such as infrastructure, education, science, culture, and healthcare, should become a key policy focus^[21].

At the same time, reforms on the supply side should continue to advance, guiding diverse social actors—including enterprises, social organizations, communities, and individuals—to jointly participate in the provision of social welfare. Gradually, a socialized welfare structure featuring “government leadership, social coordination, and market participation” should be established. By constructing a multi-level, multi-channel, and all-dimensional welfare supply system, it is possible to both reduce fiscal pressure on the government and enhance the flexibility and sustainability of the rural social welfare system^[22].

6. Conclusion

As an essential component of the social welfare system under the goal of common prosperity with Chinese characteristics, the improvement of the rural social welfare system represents the people’s active pursuit of sharing the fruits of social development amid new opportunities and a new development paradigm in the new era. Within the framework of the Rural Revitalization Strategy, it is crucial to follow the principles of local adaptation and gradual advancement while continuously exploring effective pathways to enhance rural social welfare. By narrowing urban–rural disparities and optimizing the allocation of social resources, the rights and opportunities of rural residents to participate in and benefit from development can be more effectively safeguarded. Only in this way can China achieve progress toward overall social equity and realize the fundamental goal of common prosperity. In sum, the reform of China’s rural social welfare system exemplifies the evolving balance between efficiency and equity in the nation’s pursuit of common prosperity and provides valuable insights for welfare

reform in developing economies.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Titmuss, R. M. (1975). *Social policy: An introduction*.
- [2] Spicker, P. (2014). *Social policy: Theory and practice*. Policy Press.
- [3] Esping-Andersen, G. (1990). *The three worlds of welfare capitalism*. Princeton University Press.
- [4] Smart, A., & Smart, J. (2001). Local citizenship: welfare reform urban/rural status, and exclusion in China. *Environment and Planning A*, 33(10), 1853-1869.
- [5] Whyte, M. (2010). *Myth of the social volcano: Perceptions of inequality and distributive injustice in contemporary China*. Stanford University Press.
- [6] Pinker, R., & Wong, L. (2005). *Marginalization and social welfare in China*. Routledge.
- [7] Duckett, J. (2012). *The Chinese state's retreat from health: Policy and the politics of retrenchment*. Routledge.
- [8] Gao, Q. (2017). *Welfare, work, and poverty: Social assistance in China*. Oxford University Press.
- [9] Chen, K. Z., Mao, R., & Zhou, Y. (2023). Rurbanomics for common prosperity: new approach to integrated urban-rural development. *China Agricultural Economic Review*, 15(1), 1-16.
- [10] Feng, Z., Robinson, G. M., & Tan, Y. (2025). Rural Revitalization in China: Reversing Rural Decline and Eliminating Poverty. *Geography Compass*, 19(7), e70039.
- [11] Liu, J., Wei, K., & Shuai, Q. (2025). Impact of the new round of Hukou system reforms on rural household development resilience in China. *Scientific Reports*, 15(1), 17098.
- [12] Wang, Z., Liu, C., & Tian, Y. (2025). The Effect of Urban–Rural Public Service Gaps on Consumption Gaps Under the Perspective of Sustainable Development: Evidence from China. *Sustainability*, 17(13), 6148.
- [13] Zhao, X., Yang, S., Li, S., & Gao, Q. (2025). More urban-rural integrated Chinese social welfare: how do the education benefits improve the picture?. *Journal of Asian Economics*, 101940.
- [14] Chen, D., & Fang, X. (2025). Social assistance and non-agriculture employment in rural China: evidence from the Rural Minimum Living Security (Rural Dibao). *Humanities and Social Sciences Communications*, 12(1), 1-11.
- [15] Han, Y., & Huang, J. (2019). Evolution of social welfare in rural China: A developmental approach. *International Social Work*, 62(1), 390-404.
- [16] Pan Jinyun, & Li Yanshu. (2009). Modern agricultural service industry: An industrial path to promote agriculture through industry. *Economist*, 9, 61-67.
- [17] Ma, L., He, Q., Long, H., Zhang, Y., & Liao, L. (2024). Rural return migration in the post COVID-19 China: Incentives and barriers. *Journal of Rural Studies*, 107, 103258.
- [18] Sun, J., Chen, S., & Tian, M. (2024). Retain in the city, return flow, or blind direction: a study on the differentiation mechanism of migrant workers' migration willingness under the background of China's strategy for Integrated Urban–Rural Development. *Sustainability*, 16(19), 8304.
- [19] Chen, L., Li, M., & Huang, Y. (2025). From industry to education-driven urbanization: A welfare transformation of urbanization in Chinese counties. *Habitat International*, 155, 103248.
- [20] Xiang, Q., Li, J., & Liu, G. (2024). The impact of rural collective property rights reform on income and poverty reduction: Evidence from China's rural regions. *Plos one*, 19(9), e0308393.
- [21] Dunford, M. (2022). The Chinese path to common prosperity. *International Critical Thought*, 12(1), 35-54.
- [22] Zhang, Y. (2025). The dual-track paradox in social welfare—a layered governance perspective. *Humanities and Social Sciences Communications*, 12(1), 1-14.

Problems and Countermeasures of the Profit Model of Sanquan Food

Tongtong Han*

School of Management, Xi'an Polytechnic University, Xi'an, 710048, China

**Corresponding author: Tongtong Han*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In the fierce competition of the past few years, the profit model of the frozen food industry has shortcomings, with declining profitability. The profit model urgently needs to be optimized to expand profits and maintain the long development of the enterprise. This article takes Sanquan Food as a typical example and studies the profit model of Sanquan Food based on a review of domestic and foreign literature and related concepts. This article starts from the five components of the profit model and, based on the financial data of Sanquan Food from 2018 to 2022, conducts a financial analysis of each component of its profit model. According to analysis, it was found that the profit model of Sanquan Food has a serious homogenization of profit points, mainly concentrated in traditional rice and noodle products; The source of profit is single, with the main revenue being distributed by major offline retail supermarkets; The cost of various expenses has sharply increased, and the proportion of expenses such as raw materials and transportation has increased; At the same time, the cost of profit leverage is high. Based on a comprehensive analysis of the company's financial situation, suggestions were made to address the issue, suggesting that Sanquan Food actively develop new products and seek new profit growth points; Enriching business methods to create profit sources; Controlling costs and utilizing profit leverage to increase profits; Expand customers and improve customer loyalty; Innovate marketing methods, expand sales channels, improve logistics and transportation systems, and strengthen core competitiveness.

Keywords: Profit Model; Financial Analysis; Competitive Advantage

Published: Oct 27, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.824>

1. Introduction

In recent years, due to changes in market demand, the food industry has expanded rapidly. In 2019, under the impact of the COVID-19 pandemic, the development and difficulties of the food industry and the scale and speed of the logistics industry are obvious to all. As a quick-freezing industry, Sanquan enterprises face both opportunities and challenges under the premise of the epidemic. It is very important to use the current situation of the enterprise, the market development environment, etc. to adjust its own management mode, profit model, capital utilization, etc., use new and old customers to successfully realize it, and rely on its own brand benefits to improve competitive advantage. For Sanquan, the improvement of the logistics system, the improvement of financing capacity, and the strengthening of the supply chain are very important to create a profit model suitable for itself.

In the past period of time, most enterprises only care about their own profits, that is, they blindly pursue to make money, and

their development momentum is insufficient. The most intuitive manifestation of the profit model is to make a profit and make a profit. The analysis of the profit model can be analyzed through profit sources, profit leverage and other components. There is still a gap between the commodity supply and the innovative supply of Sanquan Food, and the problems of low profits and high costs need to be solved urgently. This article takes Sanquan Food as the research object, analyzes the elements of its profit model, conducts financial analysis of its factors, studies the profit model of Sanquan Food, analyzes the obstacles that affect its business development, explores the problems and shortcomings of its profit model, puts forward relevant suggestions and solutions to promote its own development and profit. Good profit model to maintain competitive advantage.

2. Analysis of the Current Situation of the Profit Model of Sanquan Food

2.1 Analysis of the factors of Sanquan Food's profit model

2.1.1 Profit point

The profit point is the value provided by the enterprise's products and services to consumers. In this industry, the value of Sanquan Food is as follows.

Table 2-1 Table of the proportion of operating income of each part of Sanquan Food in 2022 (unit: 100 million yuan)

Product type	Rice noodle products	Quick-frozen modulation products	Refrigeration and short-term warranty
Sum of money	64.38	8.38	1.04
Proportion (%)	87	11.27	1.23

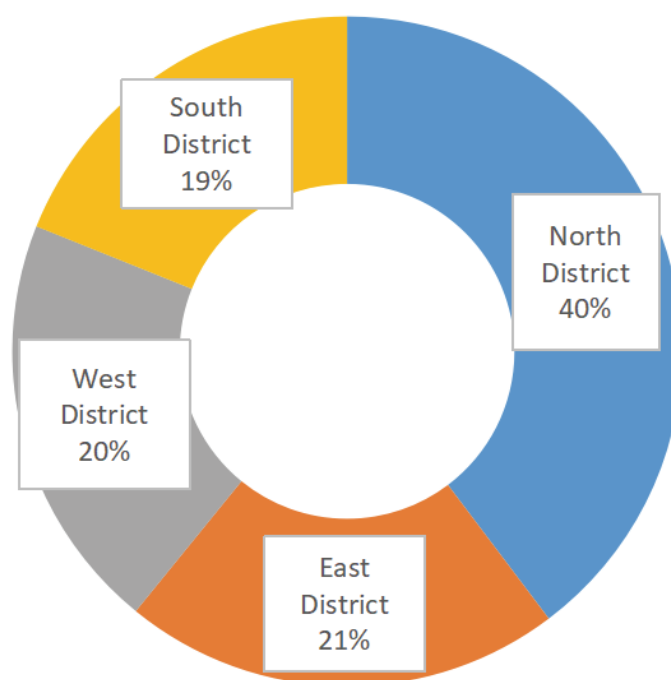
Source: Sanquan Food's 2022 Annual Report

Analyzing the relevant data of Sanquan Food, it can be seen that Sanquan Food's main business has always been concentrated on noodle and rice products, followed by quick-frozen prepared products. The difference between the two data is quite different, accounting for 87% and 11.27% respectively, and the proportion of refrigeration and short-term insurance is only 1.23%. Among them, noodles and rice products are favored by consumers, the three traditional foods of dumplings, dumplings and dumplings, reaching 4.378 billion yuan in 2022, accounting for the highest proportion of operating income. It is not difficult to see that Sanquan Food has always taken traditional noodle and rice products as a development feature and the company's positioning. At the same time, Sanquan mainly promotes the sales of noodles and rice products with high gross margins through seasonal restrictions and other marketing methods. Related products continue to extend from basic to high-end, and launches children's series of dumplings, high-end squid dumplings and other products. With the improvement of our logistics cold chain system, the fast-paced life of residents, many consumers favor instant food products, coupled with the dietary effect brought about by the epidemic, Sanquan Food grasps the continuous development of profit points, creates more products and services, seizes and traps the stomachs of consumers, and constantly improves operating income.

2.1.2 Profit object

The consumption of Sanquan food has been increasing in recent years, and different consumer groups have gradually formed. Consumers in various industries and regions are complicated. Among them, the northern region has formed a large consumer market, Beijing, Henan and other places are mature business areas, and Shandong and other places are also becoming potential areas. Because Sanquan Food is a fortune in Henan, consumers have better viscosity. Moreover, Henan is a large agricultural province in China. It is a high-quality wheat processing site, and it also provides high-quality raw materials for the large-scale development of quick-frozen products. Beijing and other first-tier cities have a fast pace of life. Choosing simple and fast frozen food has become the first choice for most working people, fast-paced families, etc. Choosing frozen food that can satisfy hunger and nutrition has become the main theme of such people. At the same time, in order to attract more young people and middle and high-end people, Sanquan Food is also expanding the research and development of Italian breakfast, and actively launching co-branded products with Mixue Ice City, Wal-Mart and other brands. In general, Sanquan Food has been developing new consumer groups on the basis of maintaining existing customers.

Table2-2 The proportion of operating income in Sanquan Food area in 2022



Source: Sanquan Food's 2022 Annual Report

2.1.3 Source of profit

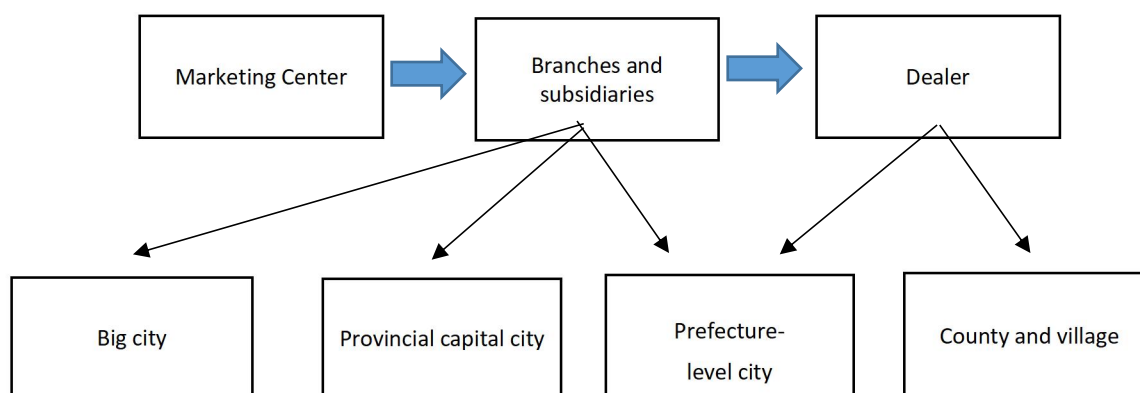
The source of profit refers to the channels and means for enterprises to obtain income. The sales profit of Sanquan Food is mainly offline, but also includes a small number of online business. Affected by its cold chain transportation costs, online sales time costs, etc., Sanquan Food has always focused on offline operating income, accounting for more than 90%. Offline sales are mainly distributed by retailers, agricultural wholesalers, and hotel catering mainly in supermarkets, accounting for more than 70%, and the proportion of cooperation with large supermarkets and large customers is about 20%. Online sales are divided into five parts. One is to rely on e-commerce platforms mainly on JD.com and Tmall, the second is to rely on TikTok Kuaishou's live e-commerce, the third is fresh e-commerce, the fourth is the e-commerce community, Meituan preferential, etc., and the fifth is a small number of store-to-home e-commerce services. Driven by the epidemic in 2019-2020 and the wave of customers' online consumption, the profit source of Sanquan Food has expanded. With a perfect cold chain transportation system, Sanquan Food can fully and efficiently realize cargo transportation, and its contribution to enterprise profits is higher than in previous years.

2.1.4 Profit leverage

Sanquan Food has taken a series of specific measures to drive profit growth, including improving the cold chain transportation system, adopting comprehensive marketing methods, strengthening food safety supervision, etc. to maintain its competitive advantage. In terms of warehousing and transportation, quick-frozen food is very demanding on temperature and other conditions in the process of transportation and warehousing. Both online and offline sales have high requirements for logistics and transportation. In today's increasingly perfect food safety system^[1], Sanquan Food has been monitoring and supervising in real time to ensure quality and safety, and quality is guaranteed. For the factory inspection of products, precision analytical instruments are also used for safety testing. During transportation and terminal storage, Sanquan Food conducts technical tracking and uses electronic labels, temperature alarms, etc. to strictly monitor the temperature.

In terms of marketing channels, Sanquan Food's subsidiaries and branches cover provinces, cities and counties across the country. In the long-term development, it has formed its own unique channel model. The marketing center manages and analyzes, controls subsidiaries, subsidiaries and branches, and then controls distributors. Marketing centers, subsidiaries, branches and dealers will then manage big cities, provincial capital cities, prefecture-level cities, counties and townships respectively, as shown in Figure 3-2.

Table2-3 Structure diagram of Sanquan food marketing channels



Source: Sanquan Food Comprehensive Management Department

3. Financial Analysis of Sanquan Food Profit Model

3.1 Specific financial analysis of the elements of Sanquan Food's profit model

3.1.1 Financial analysis of profit points

In the analysis of the profit points of Sanquan Food, it is mainly analyzed from the proportion of product operating income. Sanquan Food has long been focusing on quick-frozen and refrigerated rice products, including traditional products such as dumplings and dumplings. Next, there are also quick-frozen and refrigerated food, including prefabricated ingredients, prefabricated dishes and meals, shabu-shabu, microwave series, air fryer series and other products. Sanquan Food selects raw materials, selects high-end ingredients, improves food taste, and innovates product packaging. It has created a series of high-quality products of Sanquan fresh food "raw" mainly in the categories of dumplings, wontons and steamed buns, which have been recognized by consumers. Focusing on the characteristics of fashionable and convenient products, it has successively launched air fried Pot series products and microwave series products create a good consumption experience for young consumers.

Table3-1 Analysis of the relevant indicators of Sanquan Food's operating income in 2022

	Proportion (%)	Gross profit margin (%)	Operating income increased or decreased compared with the previous year (%)
I. Quick-frozen rice products	87	30.49	6.73
Dumplings	68	33.25	3.92
Snacks and noodles	19	24.61	13.24
II. Quick-frozen products	11.27	10.42	12.27
New products such as shabu-shabu	11.27	10.42	12.27
III. Refrigeration and short-term warranty	1.73	2.43	-15.36

Source: Sanquan Food's 2022 Annual Report

Table3-2 The level of change in the gross margin of various products of Sanquan Food

product category	2020	2021	2022
I. Quick-frozen rice products	-5.54	-1.93	1.33
Dumplings	-6.01	-0.94	2.04
Snacks and noodles	-4.69	-3.72	0.2
II. Quick-frozen products	2.47	-7.25	-1.51
III. Refrigeration and short-term warranty	14.12	-2.4	-7.70

Source: Sanquan Food's 2022 Annual Report

From the annual report data of Sanquan Food, it can be clearly seen that 2020 is the turning point of Sanquan Food. Quick-frozen modified hot pot products and refrigerated short-term warranty products are actively invested in research and developed. Under the background of the epidemic in 2020, it has indeed won the favor of some consumers. The gross profit of refrigerated and short-term fresh products The growth rate increased, while the traditional products declined, and the growth rate of the gross margin of the three major products showed a negative value. However, in general, the income of Sanquan Food still depends on the three traditional products, and has always accounted for a large proportion of revenue. In the later stage of the epidemic, there will be a recovery in 2022, and the gross profit margin will rise in the same period. On the other hand, the gross profit margin of quick-frozen pre-cooked vegetables and short-term insurance products has declined, so the overall income level is also It has a negative impact. Affected by the dividends of the epidemic in 2020, Sanquan Food relies on its own advantages of cold chain warehousing and transportation to double-sided offline and online sales. Sanquan Food can seize the opportunity to develop new products on the market, but it is only a short-lived “flipping”.

3.1.2 Financial analysis of profit sources

The sales of Sanquan Food are mainly online sales and offline sales, among which offline sales include distribution and direct sales. Sanquan Food has many branches and subsidiaries, and the dealer model has built sales channels and networks covering all provinces, cities and counties across the country to ensure that products can be promoted to markets all over the country. Let's analyze from various sources of profit.

From the analysis of the profit source of Sanquan Food, the total revenue of Sanquan Food is divided by 2020. The operating income of online sales in 2020 increased by 204.55% compared with 2019. After the epidemic, the recovery is still dominated by offline sales. In general, offline distribution has maintained a large proportion. In 2022 The offline distribution revenue of Sanquan Food reached 5.644 billion yuan, an increase of 10.15% year-on-year. In recent years, Sanquan Food has followed the development of the social market and expanded online sales while maintaining the traditional sales mode. In recent years, it has made progress. Through online and offline synchronous unified layout and sales, consumers increasingly choose emerging forms of consumption such as mobile phone ordering and community group purchase. Coupled with the after-equelae of the epidemic, consumers' willingness to hoard has increased, which accelerates the sinking of the online sales market, expands the sales scale of Sanquan Food, and increases the proportion of online revenue.

3.1.3 Financial analysis of profit leverage

Profit leverage reflects a series of relevant measures to drive profit growth and maintain one's competitive advantage[8]. With the continuous expansion of the scale of Sanquan Food, the cost of each period has also changed. Between 2018 and 2022, with the continuous expansion of Sanquan Food throughout the country, more facilities are needed, the cost continues to increase, and the management cost of Sanquan Food continues to rise. Sales expenses and financial expenses show a downward trend. In 2019, R&D expenses rose by 151.24% year-on-year, and in 2022, R&D expenses decreased by 15.60% year-on-year. R&D expenses fluctuated greatly, while sales expenses have been on a downward trend in the past five years. Because the large investment in early sales expenses led to the slowdown of the current marketing strategy, phase Guan's internal marketing layout has been saturated. Therefore, the marketing of Sanquan Food has not been one of the levers to leverage profits in the past two years.

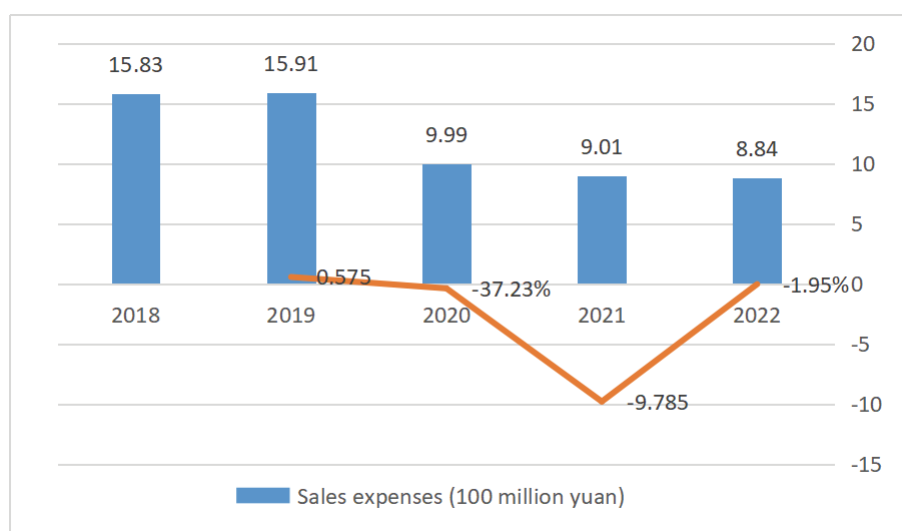
Table3-3 Composition of Sanquan Food's operating expenses (unit: 100 million yuan)

Types of expenses	2019	2020	2021	2022	2023
Management expenses	2.20	2.34	1.97	2.18	0.77
Sales expenses	15.91	9.99	9.01	8.84	3.97
Research and development expenses	0.47	0.48	0.55	0.46	2.55
Financial expenses	-0.11	-0.65	-0.09	-1.25	-0.12

Data Source: Sanquan Food 2019-2023 Annual Report

Sanquan Food's sales expenses have steadily declined in recent years, with the largest decline in sales expenses in 2020, mainly due to the slowdown of marketing strategies due to the current situation of "demand explosion" in the market, and the early marketing strategy has achieved good results. However, the decline in the later stage was large, the expansion pace of Sanquan Food slowed down, and the sales enthusiasm was poor. This is closely related to the fact that the company's transformation to high-end requires a large number of talents and technology. The layout of Sanquan's internal marketing strategy should find new breakthroughs on a stable basis to seize sales opportunities. In addition, the R&D expenditure of Sanquan Food tended to stabilize after experiencing a sharp increase in 2019. As a leading enterprise in the quick-frozen food industry, Sanquan Food has always won with three traditional rice noodle products. In the face of strong competitors: Anjing Group, Miss, etc., quick-frozen refrigerated hot pot series, short-term food, etc. have never been able to occupy a place in the market, and sell well in the innovation of traditional products of dumplings and dumplings, such as early dazzling dumplings, children's dumplings, etc.

Table4-4Sanquan food sales expenses and growth rate in the same period



Data Source: Sanquan Food 2019-2023 Annual Report

4.Problems in the Profit Model of Sanquan Food

4.1 Traditional business is weak, and products are homogenized

From the preliminary data analysis, the main income of Sanquan Food comes from the three traditional businesses of dumplings, dumplings and dumplings. In recent years, the proportion of dumpling business in the overall revenue is shrinking. Under the impact of factors such as the upgrading of customer group consumption and the rise of the takeaway market, the improvement of consumers' food safety and health awareness, more attention is paid to the freshness and quality of food ^[2]. Today, the rapid development of the three traditional businesses in the quick-freezing industry is obviously weak and lack of motivation. The products launched by Sanquan Food have a high degree of homogeneity. Some emerging pre-made dishes, modified products, etc. lack uniqueness and differentiation, and cannot meet the personalized needs of consumers. The two traditional products of dumplings and dumplings are stuck in the bottleneck of market share. During the epidemic, the growth of public demand also brought about a rebound in sales, and there was a downward trend in the later stage of the epidemic. In addition, the raw material expenditure, management expenses and other expenses of the quick-frozen industry are relatively large. Finally, transportation and logistics rely on cold chains, which is equivalent to raising costs. Coupled with the channel costs invested by manufacturers in supermarkets, the profit margin of quick-frozen food is lower. The cost of the profit point has been high for a long time, so the gross margin of sales has been low. It can be seen that the traditional business of Sanquan Food is weak, and it is urgent to overcome to find new profit points on the basis of cost control.

4.2 The cost of enterprise development strategy is high.

Through the above financial analysis of the profit leverage of Sanquan Food, it can be seen that the management and sales

expenses of Sanquan Food are relatively high. Among them, the management expenses increased year by year with the expansion of the enterprise's production scale, reaching 234 million yuan in 2020, and the sales expenses also reached 1.591 billion yuan in 2019, which reflects the large amount of expenses incurred by Yonghui Supermarket in the process of profit leverage adjustment, such as advertising expenses invested in publicity, before In the past two years, it has frequently appeared in major media, as well as promotional offers and other promotional means provided by various platforms, which have affected the profit performance of Sanquan Food^[11]. Sanquan Food is an enterprise that mainly produces and sells frozen food. In terms of inventory management, Sanquan Food requires the adoption of an advanced logistics and warehousing management system to ensure the safety, quality and validity of the products. Moreover, Sanquan Food has been in the expansion stage. Although it has slowed down in the past two years, it has generated infrastructure, personnel remuneration and other expenditures, thus consuming a large amount of costs and increasing the relevant period expenses. Therefore, Sanquan Food's profit leverage cost problem hinders its development and expansion^[12].

5. Suggestions for Optimizing the Profit Model of Sanquan Food

5.1 Control costs and accurately locate

Sanquan Food should greatly reduce costs, improve the capital supply chain, and realize the efficient capital turnover cycle^[3]. Sanquan's costs have been rising in recent years, and it has been in a high position in the same industry. In the future, the raw materials and manpower costs of the quick-freezing industry will rise. Therefore, Sanquan should improve its core competitiveness through material procurement management and the production of diversified quick-frozen finished semi-finished products at the same time. Sanquan Food should use its expanding strategic activities to expand the economy of scale and reduce transaction costs. In addition, on the basis of certain management ability, coordination ability and operation ability, the layout of the whole industrial chain should be carried out, market demand should be examined in product research and development^[9], and the waste of funds and resources caused by decision-making errors should be avoided in store layout, while maintaining the connection between existing industrial chains. With the deepening of Internet technology, the continuous expansion of e-commerce^[4], and the development of online sales. In the marketing process, we can appropriately reduce commercial expenses, use more funds to arrange online business, continue to strengthen business cooperation with some fresh e-commerce, and establish a supply chain management system to ensure the accurate and timely supply of raw materials, so as to create maximum value with less capital.

5.2 Find new profit growth points

Under the current situation of homogenization in the quick-freezing industry, Sanquan Food should formulate clear strategic goals, form a differentiated brand strategy, create a unique brand effect, and control the cost of profit points in the process^[10]. According to the profit weight of the main business^[5], under the maintenance of its own advantages, Sanquan Food should continue to subdivide new consumption categories, carry out new product development and traditional product upgrading according to the subdivision and classification of consumer demand, and continue to strengthen its own brand, innovate and develop popular products, and pay attention to market change and other hot issues. Upgrade and improve. For example, in order to meet the dietary needs of more and more consumers who tend to eat less oil and salt and reject fried food, promote the greening of products, such as designing low-sugar food for patients with diseases, creating some Internet-famous products, etc., to meet the increasingly personalized needs of consumers. Within the enterprise, it is also necessary to pay attention to the construction of corporate culture, which can directly improve the image of the enterprise. A good working environment is conducive to the enthusiasm and cohesion of employees^[6], thus improving the overall strength of the enterprise. Subdivide the market, market accurately, enhance the flow of people in stores and the love and loyalty of consumers, and achieve new growth in profit points^[7]. In offline operation, we should open up online and offline user feedback channels, formulate a reasonable complaint management system, respond to customer feedback and complaints in a timely manner, and provide compensation. So as to win the favor of more consumers and increase sales.

6. Conclusion

This article takes Sanquan Food as the research object, and uses the five profit model components of profit source, profit

point, profit lever, profit barrier and profit object to study its profit model. It is found that the problems and shortcomings in its profit process are mainly due to serious product homogeneity, insufficient profit source, excessive product cost, and development. Due to the problem of excessive cost, Sanquan should improve sales strategies on the basis of improving capital utilization and controlling costs, actively research and develop differentiated operation of new products, strengthen cooperation with suppliers, expand online sales, and improve their competitive advantages.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Ben-Hsienhao. (2018). The business model: Recent developments and future research. *Journal of Management*, 37(4).
- [2] Wise Geek. (2020). The relationship among environment performance, R&D expenditure and corporate performance: Using simultaneous equation model. *Quality & Quantity*.
- [3] Yan, P. (2019). Competing with dual business models: A contingency approach. *Academy of Management Executive*, 18(3), 26–36.
- [4] Buzacott, J. A., & Zhang, R. Q. (2004). Inventory management with asset-based financing. *Management Science*, 50(9), 1274–1292.
- [5] Wei, S. U. N., et al. (2004). Business models and solution architectures for SMB financing in a supply chain ecosystem. In *The proceedings of the IEEE International Conference on E-Commerce Technology for Dynamic E-Business* (pp. 130–133). China.
- [6] Stiglitz, J. E., & Weiss, A. (1981). Credit rationing in markets with imperfect information. *The American Economic Review*, 71(3), 393–410.
- [7] Hartley-Urquhart, R. (2006). Managing the finance supply chain. *Supply Chain Management Review*, (9).
- [8] Aberdeen Group. (2006). Supply chain finance benchmark report [Report].
- [9] Kaplinsky, R. (2000). Globalization and unequalisation: What can be learned from value chain analysis? *Journal of Development Studies*, 37(2).
- [10] Arndt, S., & Kierzkowski, H. (Eds.). (2001). *Fragmentation: New production patterns in the world economy*. Oxford University Press.
- [11] Kaplan, R. S. (2002). Building strategy focused organizations with the balanced scorecard. *Balanced Scorecard Collaborative, Inc.*
- [12] United Nations Industrial Organization. (2002). Industrial development report 2002/2003 overview [Report].

The Moderating Role of Consumer Digital Trust in the Relationship Between AI Anchors and the Intention to Purchase Agricultural Products

Yingying Cai*

School of Economics and Management, Guangdong Open University, Guangzhou, 510091, China

*Corresponding author: Yingying Cai

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: The widespread application of artificial intelligence technology in the e-commerce field has brought new development opportunities for agricultural product e-commerce through AI digital anchors, but it has also inevitably led to “trust” issues due to the characteristics of the products. Based on the Technology Acceptance Model and trust theory, this paper proposes a theoretical framework with perceived usefulness and perceived ease of use as independent variables, intention to purchase as the dependent variable, and digital trust as the moderating variable. Empirical analysis results show that the perceived usefulness and perceived ease of use of AI anchors have a significant positive effect on consumers’ purchase intention for agricultural products. The level of consumers’ digital trust exerts a positive moderating effect on the relationship between perceived usefulness and purchase intention. The higher the level of digital trust, the more prominent the effect of perceived usefulness on purchase intention. Similarly, the level of digital trust also has a positive moderating effect on the relationship between perceived ease of use and purchase intention. Therefore, establishing consumers’ digital trust in agricultural product live-streaming e-commerce can turn the technological advantages of AI anchors into actual purchasing behavior, which has theoretical and managerial significance.

Keywords: AI Anchors; Digital Trust; Intention to Purchase; Technology Acceptance Model; Agricultural Product E-commerce

Published: Oct 24, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.843>

Introduction

In recent years, the convergence of the digital economy and artificial intelligence technology has prompted AI digital anchors to enter the e-commerce live-streaming industry, injecting new vitality into traditional agricultural product e-commerce ^[1]. Compared with traditional human anchors, AI anchors have the advantages of working day and night without fatigue, maintaining a unified image, transmitting accurate product information, and being replicable in different platforms. These characteristics make the time and space constraints of agricultural product sales markets disappear, and the sales channels for agricultural products are further extended. However, agricultural products are typical experiential products. Customers have high requirements for the quality, safety, and authenticity of the origin of agricultural products. It is difficult for customers to directly perceive agricultural products in virtual live-streaming e-commerce, and consumer trust is the most important factor limiting consumers’ purchasing behavior.

This paper constructs a research framework combining Technology Acceptance Model and trust theory, and explores whether there will be a positive effect when the degree of digital trust enhances the positive effects of advantages of AI anchors on consumers' purchase intentions in online live-streaming sales of agricultural products? Or there will be mitigate the negative impact caused by the limitations of technology.

1.Theoretical Foundations

1.1 Technology Acceptance Model

Technology Acceptance Model (TAM) is an important theoretical basis for explaining that users will use new technologies. In this model, perceived usefulness and perceived ease of use are important factors that affect users' intentions. In the case of AI anchors, perceived usefulness means that customers believe that AI anchors can help improve efficiency and decision-making quality, enrich the shopping experience and select agricultural products. For example, AI anchors can provide customers with round-the-clock product consultation services, provide customers with personalized nutritional recommendations based on big data, and accurately display product inspection reports, etc., to enhance customers' perception of the usefulness of AI anchors. Perceived ease of use refers to customers' perception of ease of use in the process of communicating and collecting information from AI anchors and completing transactions. An AI anchor with an intuitive interface, high degree of voice recognition and fast response speed can reduce users' training costs and operating difficulties, and increase the probability of use.

1.2 Trust Theory and Its Dimensions

Trust is generally defined as positive expectations and reliance that one party holds toward the other in the face of risk. In the case of e-commerce, customer trust includes the following dimensions. According to the characteristics of AI anchors, consumer online trust can be divided into three parts:

- (1) Competence Trust: It is the level of trust that consumers have in the professional knowledge, skills and performance of AI anchors. In the live streaming of agricultural products, this is manifested in the ability of AI anchors to answer professional questions about origin, variety, growth cycle, cooking methods and nutritional values of agricultural products, as well as the logic and truth of recommendations.
- (2) Integrity Trust: It is the trust that consumers have in the AI anchors and operators to keep their promises, be honest, and provide true and unbiased information. In the sale of agricultural products, this is manifested in the authenticity of product descriptions and presentation, the accuracy of prices, and the fulfillment of promotional statements. Regarding the integrity trust, because the program controls AI, consumers will suspect that the information is "programmed" by the merchant to cover up the shortcomings. Therefore, establishing integrity trust is very important.
- (3) Benevolence Trust: It is the belief that customers hold that AI anchors and their affiliated companies care about consumer rights and will assist consumers when problems occur. For example, when consumers ask questions, can the AI anchor be patient and empathetic? Or after the sales of agricultural products, whether the after-sales service terms are clear and advantageous to consumers? Although AI does not have feelings, it can also be designed to show care and empathy, so as to establish benevolence trust.

1.3 The Moderating Role of Digital Trust

In an environment with high digital trust, consumers are more likely to perceive the information conveyed by AI anchors as credible and to view the convenient operational experience as considerate service, which can facilitate the occurrence of purchasing behavior. Conversely, in a low digital trust scenario, even if the AI anchor is highly functional and easy to use, consumers may still distrust the provided information or worry about the lack of after-sales service guarantees, thereby hindering the formation of purchase intentions. Therefore, digital trust is not merely a simple antecedent factor but plays a role in enhancing or diminishing the impact of technological features on purchase intentions^[2-3].

2.Research Hypotheses

Based on the above theoretical basis, this paper proposes the following four research hypotheses to establish the logical relationships between the characteristics of AI anchors, digital trust and purchase intention.

According to the Technology Acceptance Model, if users believe that a technology can help improve work performance, their intention to use that technology will be enhanced. Taking AI anchors as an example, perceived usefulness is manifested in three aspects. First, the depth and breadth of information^[4]. AI anchors can use vast databases to quickly answer consumers' complex questions about the origin tracing, organic certification, nutritional value, and storage methods of agricultural products, providing more professional information than ordinary anchors can master, thereby reducing the cost for customers to obtain information. Second, intelligent decision-making assistance. For example, based on the consumers' health conditions or family situations, recommend the most appropriate kinds and quantities of agricultural products, achieve the combination of customization and optimization, and assist in decision-making.

Third, rationality and reliability of service. AI anchors will not be emotionally excited or depressed. They can always answer questions logically and deliver high-quality information. Especially when consumers buy agricultural products in a rush, the quality of agricultural products is very important. At this time, AI anchors can always provide fair and consistent consulting services. Therefore, the more practical benefits customers get from AI anchors when buying agricultural products, the more likely they will buy.

Based on the above analysis, the following research hypothesis is proposed.

H1: The perceived usefulness of AI positively affects consumers' intention to buy agricultural products.

Perceived ease of use refers to the ease of using technology, which is extremely important for the consumers of agricultural products of all ages. Simplify the operation process. As mentioned above, there must be a natural interaction interface. If the AI anchor can realize the smooth voice communication and image recognition function, such as "scan this fruit and then know its freshness," and answer the questions based on local pronunciation, it can reduce the operation process of users. Second, the information architecture must be clear. It is decisive for consumers whether the information they need to browse the product directly to the product details and then place an order are simple and clear. If the process is complicated and the instructions are unclear, it will make users confused and then abandon the order. In addition, the ability to respond quickly and solve the problem is also the important content of perceived ease of use. It is very important whether the AI customer service can quickly find out the reason and give clear answers to users doubts in the payment process or the order. An AI anchor platform with high easiness of use allows consumers to focus on the product without thinking about the process of operation, so as to make the shopping process more focused and promote the increase of purchase intention.

Based on the above analysis, the following research hypothesis is proposed.

H2: The perceived ease of use of AI anchors positively influences consumers intention to purchase agricultural products.

In order for perceived usefulness to be converted into purchasing behavior, the prerequisite is that consumers "trust" that this useful information is true and reliable. If consumers are in a situation of high digital trust: when AI anchors provide useful information such as "This apple is produced in the 37°N latitude golden zone and is rich in anthocyanins" (high perceived usefulness), consumers, based on their trust in the familiar degree of AI (agricultural knowledge) and integrity (truth of information), will accept this information without reservation and treat it as a strong purchase reason to buy, so as to significantly enhance the intention to buy. Conversely, in a low digital trust scenario: even if AI anchors provide equally detailed and professional information (high perceived usefulness), consumers may suspect that this is "marketing jargon" written by merchants, and the data may be fabricated, thus triggering a psychological defense mechanism that greatly reduces the persuasiveness of the useful information and severely weakens its positive impact on purchase intention. Therefore, digital trust determines the strength of the "useful information" credit endorsement and regulates the efficiency of its conversion into behavior.

Based on the above analysis, the following research hypothesis is proposed:

H3: Consumer digital trust plays a positive moderating role in the relationship between perceived usefulness and purchase intention. That is, the higher the level of digital trust, the stronger the positive impact of perceived usefulness on purchase intention^[5-6].

An easy-to-use system can bring a sense of pleasure, but whether this pleasure can lead to a transaction is also subject to trust constraints. In a high digital trust scenario, smooth interaction and the convenience of one-click ordering (high perceived

ease of use) will be interpreted by consumers as “thoughtful and efficient service design.” They will confidently entrust their personal information and payment security to this system, and thus the convenience directly translates into purchasing power. They believe that even with a simple process, after-sales service and rights protection are guaranteed (high benevolence trust). In a low digital trust scenario, however: an overly simple operational process may instead trigger consumers’ insecurity and doubts. For example, “It was so quick to buy? Are there any hidden terms?” “It’s so easy to get my address, is my information secure?” At this time, the convenience brought by ease of use is overshadowed by the perceived risks generated by distrust. Consumers may deliberately slow down the process, double-check, or even abandon the transaction due to distrust. Therefore, digital trust provides a psychological safety cushion for the “easy-to-use experience.” Only when consumers trust the entity behind the system can the convenience of operation be seamlessly translated into the convenience of purchasing.

Based on the above analysis, the following research hypothesis is proposed:

H4: Consumer digital trust plays a positive moderating role in the relationship between perceived ease of use and purchase intention. That is, the higher the level of digital trust, the stronger the positive impact of perceived ease of use on purchase intention.

3. Empirical Analysis and Hypothesis Testing

3.1 Variable Selection

The core variables involved in this study include independent variables (perceived usefulness, perceived ease of use), dependent variable (purchase intention), moderating variable (digital trust), and control variables. All constructs are measured using established scales, which are appropriately adjusted to fit the context of this study (AI anchors, agricultural products) to form the final survey questionnaire. The questionnaire employs a 5-point Likert scale for measurement, where 1 represents “strongly disagree” and 5 represents “strongly agree.”

Independent Variable 1: Perceived Usefulness. Referring to Davis’s Technology Acceptance Model scale, four items are set, such as “I believe that using AI anchors to select agricultural products can help me understand product information more quickly” and “AI anchors can provide me with valuable suggestions for selecting agricultural products.”

Independent Variable 2: Perceived Ease of Use. Similarly, referring to the Technology Acceptance Model scale, four items are set, such as “I believe that interacting with AI anchors is clear and easy to understand” and “It is easy for me to learn how to ask questions to AI anchors.”

Moderating Variable: Digital Trust. Drawing on McKnight et al.’s trust scale and combining it with the AI context, six items are set to measure digital trust from three dimensions: ability, integrity, and benevolence. For example, “I believe that this AI anchor has rich professional knowledge of agricultural products (ability),” “I believe that the information provided by this AI anchor is true and reliable (integrity),” and “I believe that this AI anchor and its platform will protect my consumer rights (benevolence).”

The dependent variable is purchase intention. Referring to the purchase intention scale designed by Dodds et al., three items are set, such as “If I learn about agricultural product information through AI anchors, I am very likely to make a purchase decision” and “I tend to choose agricultural products recommended by AI anchors first.”

To control for other potential factors, the gender, age, monthly income, and live-stream shopping frequency of the respondents are included as control variables in the model.

3.2 Reliability and Validity Testing

The purpose of reliability analysis is to examine the consistency and stability of the scale. This study selects Cronbach’s α coefficient and composite reliability (CR) as evaluation indicators. Generally speaking, when the Cronbach’s α coefficient and CR value exceed 0.7, it indicates that the scale has good reliability. This analysis was conducted using SPSS 26.0 and AMOS 26.0 software, and Table 1 presents the results of the reliability and validity testing. The Cronbach’s α coefficients of each latent variable range from 0.841 to 0.892, and the CR values range from 0.843 to 0.894, all of which are above the standard of 0.7, indicating that the measurement tools used in this study have high internal consistency and reliability.

Table 1: Results of Reliability and Validity Tests

Variables	Number of Items	Cronbach's α	Composite Reliability (CR)	Average Variance Extracted (AVE)
Perceived Usefulness (PU)	4	0.867	0.869	0.629
Perceived Ease of Use (PEOU)	4	0.841	0.843	0.574
Digital Trust (DT)	6	0.892	0.894	0.586
Purchase Intention (BI)	3	0.854	0.856	0.523

3.3 Hypothesis Testing

3.3.1 Main Effect Test

First, the control variables (gender, age, monthly income, and frequency of live-stream shopping) were included in the regression model (Model 1). Subsequently, the two independent variables (Perceived Usefulness (PU) and Perceived Ease of Use (PEOU)) were added to the model (Model 2). The regression results are shown in Table 2, with $N=389$, $*p<0.05$, $**p<0.01$, $***p<0.001$. Model 2 indicates that, after controlling for demographic variables, Perceived Usefulness ($\beta=0.328$, $p<0.001$) and Perceived Ease of Use ($\beta=0.271$, $p<0.001$) both have significant positive effects on purchase intention. Therefore, Hypotheses H1 and H2 are supported by the data.

Table 2: Regression Results

Variables	Model 1 (Control Model)	Model 2 (Main Effect Model)
Control Variables	-	-
Gender	-0.042	-0.035
Age	0.068	0.051
Monthly Income	0.095	0.062
Frequency of Live-Stream Shopping	0.183**	0.121*
Independent Variables	-	-
Perceived Usefulness (PU)	-	0.328***
Perceived Ease of Use (PEOU)	-	0.271***
Model Statistics	-	-
R^2	0.048	0.337
Adjusted R^2	0.038	0.326
ΔR^2	-	0.289***
F value	4.792**	32.874***

3.3.2 Moderating Effect Test

To test the moderating role of digital trust (DT), based on Model 2, the moderating variable digital trust was first introduced (Model 3), followed by the interaction terms “PU×DT” and “PEOU×DT” (Model 4). Table 3 presents the hierarchical regression analysis results for the moderating effect of digital trust. It can be observed that the regression coefficient of the interaction term “PU×DT” is 0.152, which is significant at the $p<0.01$ level. Hence, digital trust has a significant positive moderating effect on the relationship between perceived usefulness and purchase intention. That is, when consumers digital trust level is high, the positive impact of perceived usefulness on purchase intention is stronger. Therefore, Hypothesis H3 is supported. The regression coefficient of interaction term “PEOU×DT” is 0.118, which is significant at the $p<0.05$ level. It also indicates that digital trust has a significant positive moderating effect on the relationship between perceived ease of use

and purchase intention. That is, when consumers digital trust level is high, the positive impact of perceived ease of use on purchase intention is stronger. Therefore, Hypothesis H4 is supported.

Table 3 Results of Hierarchical Regression Analysis for the Moderating Effect of Digital Trust

Variables	Model 2 (Main Effect)	Model 3 (Adding Moderator)	Model 4 (Interaction Effect)
Control Variables	-	-	-
Gender	-0.035	-0.029	-0.031
Age	0.051	0.037	0.033
Monthly Income	0.062	0.045	0.041
Frequency of Live-Stream Shopping	0.121*	0.098	0.094
Independent Variables	-	-	-
Perceived Usefulness (PU)	0.328***	0.265***	0.251***
Perceived Ease of Use (PEOU)	0.271***	0.221***	0.210***
Model Statistics	-	-	-
Digital Trust (DT)	-	0.348***	0.335***
Interaction Terms	-	-	-
PU×DT	-	-	0.152**
PEOU×DT	-	-	0.118*
Model Statistics	-	-	-
R ²	0.337	0.431	0.462
Adjusted R ²	0.326	0.421	0.450
ΔR ²	-	0.094***	0.031**
F value	32.874***	43.561***	38.922***

4. Conclusion

Based on Technology Acceptance Model and trust theory, this study empirically studies the relationships between the perceived usefulness and ease of use of AI anchors, consumer digital trust and intention to purchase agricultural products. The main conclusions are as follows.

(1) Technical features of AI anchors are basic factors that stimulate consumers to generate purchase intentions. Perceived usefulness and ease of use have a positive effect on consumers' purchase intention of agricultural products. Thus, it is recommended that agricultural product sellers enhance the information communication function, advisory function, and smoothness of interaction of AI anchors to stimulate consumers' shopping desires.

(2) Digital trust not only directly strengthens the effect of perceived usefulness on purchase intention, but also improves the effectiveness of digital trust converting the convenience achieved from perceived ease of use into consumers' purchasing behavior. That is, in the context of agricultural products, which has relatively high perceived risks, technical superiority without support of digital trust is not stable and effective. The level of consumers' trust in the ability, integrity, and benevolence of AI anchors constitutes the psychological security threshold for accepting technological recommendations and completing transactions.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Lu, J. Y., & Huang, F. (2025). The mechanism of AI anchor empathy affecting live broadcast economic performance under the background of digital economy. *China Economic and Trade Herald*, (18), 37–39.
- [2] Geng, X. H. (2025). The influence of online word-of-mouth on consumer purchase intention under the digital economy perspective: The role mechanism of customer trust. *Commercial Economic Research*, (03), 65–68.
- [3] Wang, H., & Chen, Y. (2024). The impact of trust on the purchase intention of the elderly group in digital consumption: Taking e-commerce live broadcast as an example. *Cultural Industry Research*, (02), 134–155.
- [4] Li, Y. Y. (2025). Exploring the relationship between podcast audience motivation, perception, and continuous listening intention: Based on structural equation model. *CaiXie Bian*, (10), 35–40.
- [5] Zhang, B., Huang, Y. H., & Zhu, J. C. (2025). The impact of green interaction on consumer value co-creation behavior under the community supported agriculture model. *China Circulation Economy*, 39(01), 86–99.
- [6] Lin, A. S., & Liu, S. J. (2025). Digital identity: The construction of consumer trust in e-commerce live broadcast. *Study and Exploration*, (06), 93–100+175.

The Development Status, Challenges and Countermeasures of Investment Banks in China

Yongdong Xu*

School of Economics and Management, Guangdong Technology College, Zhaoqing, 526000, China

*Corresponding author: Yongdong Xu

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This paper conducts an in-depth examination of the development status of investment banks in China, analyses existing challenges, and proposes corresponding countermeasures. Through a review of relevant literature, it outlines the developmental trajectory, business models, and market competition landscape of Chinese investment banks. Drawing upon practical case studies and data analysis, it identifies deficiencies in risk management, innovation capabilities, and talent cultivation within the sector. Finally, it proposes countermeasures to promote the sustainable development of Chinese investment banks, focusing on improving the regulatory framework, strengthening innovation-driven approaches, and enhancing talent quality.

Keywords: Chinese Investment Banks; Current Development Status; Challenges; Countermeasures

Published: Oct 24, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.726>

1.Introduction

Investment banks constitute a category of financial institutions distinct from commercial banks, representing the quintessential form of investment-oriented financial institutions. Generally speaking, investment banks are financial institutions that provide intermediary services in capital markets for enterprises issuing bonds and shares to raise long-term capital. Their primary activities encompass securities issuance, underwriting, trading, corporate restructuring, mergers and acquisitions, investment analysis, venture capital, and project financing.

The classification and nomenclature of investment banks vary across nations. In the United States and continental Europe, they are commonly termed ‘investment banks’; in the United Kingdom, they are known as ‘merchant banks’; while in China and Japan, they are referred to as ‘securities companies’. China’s four major investment banks are China International Capital Corporation Limited (CICC), China Merchants Securities (a financial enterprise under China Merchants Bank), Guosen Securities, and Haitong Securities. Among these, CICC is the sole institution holding an international investment banking licence.

Internationally, four primary definitions of investment banks exist: First, any financial institution conducting Wall Street financial activities may be termed an investment bank; second, only institutions engaged in some or all capital market operations qualify; third, those specialising in securities underwriting and corporate mergers and acquisitions are designated investment banks; fourth, solely those underwriting securities in primary markets and trading them in secondary markets are classified as investment banks.

Investment banks are distinct from commercial banks. The primary difference lies in their respective coverage of financial markets. Commercial banks primarily operate within the money market, generating profits mainly through the interest rate spread on deposits and loans. Investment banks, conversely, focus on the capital market, engaging in activities such as securities issuance, underwriting and trading, corporate restructuring, mergers and acquisitions, investment analysis, venture capital, and financing. Their profits are primarily derived from commissions (service fees).

As vital participants in financial markets, investment banks play a pivotal role in economic development. With China's rapid economic growth and the continuous refinement of its financial markets, Chinese investment banks have made significant strides. Nevertheless, compared to internationally advanced counterparts, Chinese investment banks still face numerous challenges in their development. Conducting in-depth research into the current state, issues, and countermeasures for Chinese investment banks holds considerable significance for promoting the healthy development of China's financial markets and enhancing the competitiveness of its economy.

2.Literature Review

2.1 Research on the Current State of China's Investment Banks

Numerous scholars have conducted in-depth studies on the development status of China's investment banks. Wang Xiaoming (2020) noted that while Chinese investment banks have achieved significant accomplishments in terms of business scale, market competition, and business innovation, substantial gaps remain when compared to internationally advanced investment banks. Li Hua (2021) contends that China's investment banks face challenges including intense market competition, insufficient innovation capacity, and talent shortages. Addressing these requires strengthening risk management, enhancing innovation capabilities, and improving talent cultivation.

2.2 Research on the Problems Facing Chinese Investment Banks

Scholars have extensively examined the issues confronting Chinese investment banks. Zhang Yu (2022) highlighted inadequate risk management capabilities, manifested in weak risk awareness, outdated risk assessment methodologies, and a shortage of risk management professionals. Liu Min (2023) contends that insufficient innovation capacity—characterised by limited innovation incentives, constrained innovation capabilities, and an imperfect innovation environment—constrains their development.

2.3 Research on Development Strategies for Chinese Investment Banks

Addressing these challenges, scholars have proposed corresponding countermeasures. Zhao Qiang (2023) recommends that Chinese investment banks should strengthen risk management by enhancing risk awareness, refining risk assessment methodologies, and cultivating risk management talent. Wang Li (2024) contends that these institutions must elevate their innovation capabilities through boosting innovation motivation, improving innovation capacity, and optimising the innovation environment.

3.Current Development Status of Chinese Investment Banks

3.1 Continuous Expansion of Business Scale

In recent years, the business scale of Chinese investment banks has sustained growth. Regarding equity financing, with the ongoing development of domestic capital markets, the volume of initial public offerings (IPOs) and refinancing activities has increased annually. In bond financing, the issuance scale of corporate bonds and company bonds has continually expanded. Concurrently, investment banks have actively broadened their business scope into areas such as mergers and acquisitions restructuring and financial advisory services, providing enterprises with comprehensive financial solutions.

3.2 Intensifying Market Competition

Amidst financial market liberalisation and heightened competition, Chinese investment banks face fierce challenges from both domestic and international players. Domestic financial institutions such as securities firms and trust companies have increasingly ventured into investment banking, intensifying the battle for market share. Concurrently, internationally renowned investment banks have significantly increased their investment in the Chinese market, exerting considerable competitive pressure on domestic counterparts through their advanced technologies and management expertise.

3.3 Continuous Advancement in Business Innovation

To meet clients' diverse needs and enhance market competitiveness, Chinese investment banks are driving ongoing business innovation. In product innovation, they have introduced novel financial instruments such as asset securitisation, convertible bonds, and preferred shares. Regarding service innovation, they are actively developing internet finance and wealth management services to deliver more convenient and efficient financial solutions to clients.

3.4 Accelerated Internationalisation

With China's economic globalisation and financial market liberalisation, domestic investment banks have accelerated their internationalisation. On one hand, they actively expand overseas markets by establishing branches abroad and participating in international mergers and acquisitions to enhance global influence. On the other, international investment banks increasingly enter the Chinese market, collaborating with domestic counterparts to jointly advance the internationalisation of China's financial sector.

4. Issues Facing Chinese Investment Banks

4.1 Inadequate Risk Management Capabilities

Some investment banks fail to recognise the importance of risk management, lacking effective risk management systems and early warning mechanisms. In pursuing business expansion, they overly prioritise short-term gains while neglecting potential risks.

Outdated Risk Assessment Methods

Currently, Chinese investment banks primarily rely on traditional financial analysis and experiential judgement for risk assessment, lacking scientific and systematic risk evaluation models. This hinders accurate risk identification and quantification, diminishing risk management effectiveness. Consider the bankruptcy of Lehman Brothers as an example. As a globally renowned investment bank, Lehman Brothers exhibited severe deficiencies in risk management. On one hand, it over-engaged in high-risk subprime mortgage-related activities, underestimating market risks. When the real estate market crisis emerged, its substantial holdings of subprime-related assets rapidly depreciated, resulting in substantial losses. Furthermore, its risk assessment framework failed to accurately predict and quantify risks, lacking effective early warning mechanisms. Consequently, when the crisis struck, timely and effective countermeasures could not be implemented, ultimately leading to bankruptcy.

This case offers profound lessons for Chinese investment banks. Firstly, investment banks must prioritise risk management, avoiding blind pursuit of business expansion at the expense of potential risks. Secondly, they must establish scientifically sound risk assessment frameworks to accurately quantify risks and promptly identify and alert against potential threats. Finally, they should cultivate and recruit specialised risk management professionals to enhance risk governance capabilities.

Shortage of Risk Management Talent

Effective risk management requires personnel with specialised knowledge and extensive experience. However, Chinese investment banks currently face a relative shortage of such talent, struggling to meet the demands of business expansion.

4.2 Insufficient Innovation Capacity

Constrained by traditional business models and regulatory policies, some investment banks lack the impetus for innovation. During business expansion, they overly rely on conventional sectors while insufficiently exploring and innovating in emerging areas.

Limited Innovation Capabilities

Chinese investment banks lag significantly behind their international counterparts in innovation. Regarding product innovation, they lack independent R&D capabilities, often replicating foreign financial products. In service innovation, they fail to offer personalised, differentiated services, struggling to meet clients' diverse needs. Internationally renowned investment banks such as Merrill Lynch, Morgan Stanley, and Goldman Sachs not only possess distinct advantages in core businesses but also demonstrate formidable competitiveness in differentiation and personalisation.

Furthermore, international investment banks exhibit diversified and continuously innovative business portfolios, whereas Chinese counterparts maintain relatively traditional business structures with room for improvement in innovation capabilities.

For instance, foreign investment banks outperform their Chinese counterparts in complex product design, regional coverage scope, and financial product diversity.

Incomplete Innovation Environment

Innovation requires a favourable policy and market environment. Currently, China's financial market regulations are relatively stringent, with insufficient support for innovation. Concurrently, market competition remains inadequate, lacking both the impetus and pressure for innovation.

4.3 Pronounced Talent Shortage

Investment banking operations are characterised by high specialisation, broad knowledge requirements, and significant technical complexity, necessitating professionals with expertise spanning finance, accounting, law, and other disciplines. However, China's investment banks currently face a relative shortage of such professionals, struggling to meet business development demands.

Due to intense industry competition and factors like remuneration packages, China's investment banks suffer significant talent attrition. Top professionals are frequently poached by internationally renowned investment banks or other financial institutions, adversely affecting the development of domestic investment banks.

Inadequate Talent Development Mechanisms

Presently, China's investment banking sector lacks robust talent development frameworks. The absence of systematic training programmes and career progression pathways hinders the cultivation of high-calibre professionals.

4.4 Regulatory Framework Requires Enhancement

As financial markets evolve and innovate, existing regulatory frameworks frequently fail to keep pace with market dynamics. In emerging business domains, regulatory gaps or ambiguities create uncertainty for investment banking operations.

Investment banking activities span multiple financial sectors, necessitating collaborative oversight from various regulatory bodies. However, coordination mechanisms among China's financial regulators remain underdeveloped, resulting in regulatory overlaps or gaps that diminish oversight efficiency.

China's financial regulation currently relies predominantly on administrative measures and on-site inspections, representing a relatively narrow range of tools. The absence of effective market discipline mechanisms and risk early-warning systems hinders the achievement of robust oversight over investment banks.

5.Strategic Recommendations for the Development of Investment Banks in China

5.1 Strengthening Risk Management

Enhancing Risk Awareness

Investment banks should heighten their focus on risk management and cultivate a sound risk mindset. Robust risk management systems and early warning mechanisms must be established to improve the identification, assessment, and control of risks.

Refining Risk Assessment Methods

Advanced risk assessment techniques and methodologies should be adopted to develop scientific and systematic risk assessment models. Quantitative analysis of various risks—including market risk, credit risk, and operational risk—should be strengthened to enhance the effectiveness of risk management.

Cultivating Risk Management Talent

Strengthen the training and recruitment of risk management professionals to elevate the expertise of risk management teams. Establish robust incentive mechanisms to attract and retain outstanding risk management talent.

5.2 Enhancing Innovation Capabilities

Boosting Innovation Drive

Investment banks should proactively transform their business philosophies, breaking free from the constraints of traditional business models. Increase investment in innovation, establish incentive mechanisms for innovation, and encourage employees to actively engage in innovative activities.

Enhancing Innovation Capabilities

Strengthen research and development in financial innovation to improve independent innovation capabilities. Actively draw upon the innovative experiences of leading international investment banks, adapting them to the realities of the Chinese market to launch financial innovation products and services with distinctive Chinese characteristics.

Optimising the Innovation Environment

Government and regulatory authorities should increase support for financial innovation and refine the policy environment for innovation. Strengthen the development of financial market infrastructure, enhance market transparency and efficiency, and create a favourable market environment for financial innovation.

5.3 Strengthening Talent Development

Recruiting Specialised Talent

Investment banks should intensify efforts to recruit specialised professionals, attracting high-calibre individuals with multidisciplinary expertise in finance, accounting, law, and related fields. Offer competitive remuneration packages and career progression opportunities to attract and retain outstanding talent.

Preventing Talent Drain

Establish robust talent incentive mechanisms to enhance employee benefits and job satisfaction. Strengthen corporate culture development to foster a positive working environment, thereby increasing staff belonging and loyalty.

Refining Talent Development Mechanisms

Develop systematic talent cultivation plans, intensify staff training and career planning. Establish internal talent mobility mechanisms to provide employees with greater development opportunities and scope.

5.4 Enhancing the Regulatory Framework

Refining Regulatory Policies

Government and regulatory bodies should strengthen research and monitoring of financial markets, promptly adjusting and refining regulatory policies. Intensify oversight of emerging business sectors, clarifying regulatory standards and norms to prevent financial risks.

Strengthen Regulatory Coordination

Establish robust financial regulatory coordination mechanisms to enhance communication and collaboration among regulatory bodies. Clarify the responsibilities and division of labour among regulators to avoid overlapping or gaps in oversight, thereby improving regulatory efficiency.

Diversify Regulatory Approaches

Employ a comprehensive mix of administrative, market-based, and legal regulatory tools to strengthen oversight of investment banks. Develop effective risk warning mechanisms and market discipline systems to achieve efficient regulation of investment banking activities.

6. Conclusion

Chinese investment banks have achieved remarkable progress in their development, yet they also face numerous challenges. Insufficient risk management capabilities, inadequate innovation capacity, talent shortages, and an imperfect regulatory framework constrain the sustainable development of Chinese investment banks. To foster the healthy growth of these institutions, efforts must be intensified in strengthening risk management, enhancing innovation capabilities, improving talent cultivation, and refining the regulatory system. Concurrently, the government and regulatory authorities should increase support for financial innovation, optimise the financial market environment, and create favourable conditions for the advancement of Chinese investment banks.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Wang, X. M. (2020). Current status and countermeasures for the development of investment banks in China. *Financial Markets*, (5), 45–48.
- [2] Li, H. (2021). Challenges and solutions facing the development of investment banks in China. *Finance Forum*, (3), 67–70.
- [3] Zhang, Y. (2022). Research on risk management issues in Chinese investment banks. *Financial Research*, (2), 34–38.
- [4] Liu, M. (2023). Research on the innovation capabilities of Chinese investment banks. *Modern Economic Exploration*, (4), 56–59.
- [5] Zhao, Q. (2023). Policy recommendations for strengthening risk management in Chinese investment banks. *Financial Supervision*, (6), 23–26.
- [6] Wang, L. (2024). Strategies for enhancing the innovation capabilities of Chinese investment banks. *Financial Innovation*, (2), 18–21.

Clarifying Four Key Issues Regarding Letters of Credit: The Most Important International Payment Method

Yongdong Xu*

School of Economics and Management, Guangdong Technology College, Zhaoqing, 526000, China

*Corresponding author: Yongdong Xu

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: As one of the most significant payment methods in international trade, letters of credit have greatly facilitated the settlement of international trade transactions and promoted the development of global commerce. This paper examines four key aspects of letters of credit. Firstly, their origins and evolution: from the Roman Empire to 19th-century Britain, culminating in the implementation of UCP600 on 1st July 2007, letters of credit have undergone extensive development throughout human history. Secondly, the issuance of letters of credit is subject to stringent restrictions and requirements. Upon the applicant's submission of an application, the bank verifies their qualifications and creditworthiness. If compliant, the issuing bank issues the letter of credit upon the applicant's deposit of a security deposit. Thirdly, the fundamental principles of letters of credit are central to our profound understanding of their core and essence. Letters of credit constitute a documentary transaction, necessitating documentary consistency and documentary compliance. Finally, examining the operational procedures of letters of credit aids in comprehending how they facilitate international trade settlements.

Keywords: International Payment Methods; Letters of Credit; Origins; Fundamental Principles; Operational Procedures

Published: Oct 25, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.725>

1. The Origins and Development of Letters of Credit

In the mid-fifth century BC, ancient Roman law established provisions governing the property rights and obligations pertaining to commodities: written instruments of credit could be employed in the exchange of goods and currency to demonstrate the commercial credibility of both parties involved.

The letter of credit, substituting bank credit for commercial credit, was jointly devised by bankers and merchants. The earliest letters of credit emerged in 12th-century Europe. At that time, when popes, princes, and other rulers dispatched envoys on missions abroad, they would issue and sign public notices for convenience, pledging unconditional repayment to any party willing to advance funds to their envoys. This notice resembled our modern traveller's letter of credit and represents the earliest form of such instruments. Practical application can be traced back to the 14th century, with traveller's letters of credit (Travelers' Letter of Credit) used in European cities such as Venice, Genoa, and Florence in Italy. A defining characteristic of the traveller's letter of credit was that the applicant, beneficiary, and traveller were one and the same person. Historically, this type of credit document was termed the original letter of credit. Subsequently, letters of credit found commercial application. Formally, they included not only open letters of credit but also so-called special letters of credit, wherein the issuing bank required its overseas representative or a co-operator to advance funds to its dispatched agent. However, such letters of credit were all documentary letters of credit without shipping documents attached, and they were not necessarily based on a sales

contract. The circulation of the letter of credit was also not tied to the movement of goods.

By the mid-19th century, the establishment of regular shipping routes, advances in marine insurance, and the subsequent development of bills of lading and insurance policies into negotiable instruments gave rise to the documentary credit – the precursor to the modern letter of credit.

In 1880s Britain, letters of credit were first employed as a means of settling payments in international trade.^[1]

Following the First World War, documentary credits became the predominant method for international trade payments. In early 1920, the Bankers' Committee on Commercial Credit in New York (led by Citibank and comprising 34 financial institutions) adopted and promulgated the 'Rules for the Application of Export Credits' (RAECC). Revised provisions of the RAECC were formally signed in 1926, taking effect on 1 July. The period around the Second World War witnessed vigorous expansion in letter of credit operations.

Since the 1980s, numerous developing nations have utilised the letter of credit mechanism for foreign trade, with documentary letters of credit now extensively employed in international commerce. Particularly with the advent of standby credits, their applications have become even more widespread.

The identity of the world's first letter of credit issuer or the first bank to issue such a document remains unverifiable. However, the modern letter of credit is demonstrably an invention of the British. In the preface to the first edition of his work *The Law of Bankers' Commercial Credit*, the Englishman H.C. Gutteridge wrote: 'The method of financing the import and export of goods through bankers' commercial credit, in its modern form, is the creation of British commercial ingenuity.' On this basis, we may provisionally consider modern letters of credit to have originated in Britain. One point remains undeniable: modern letters of credit were indeed introduced to China from the West. Initially rendered as '信用状' (xin yong zhuang), they are now universally termed '信用证' (xin yong zheng) internationally.^[2]

The emergence of letters of credit undoubtedly accompanied the development of international trade. The inherent contradiction between the socialisation of capitalist production and the private ownership of the means of production, coupled with the inherently greedy nature of merchants, rendered international trade fraught with risks and challenges. Bankruptcy, breach of contract, refusal of payment, and fraud were commonplace occurrences. Under such circumstances, traditional payment methods based on commercial credit, such as remittances and collections, could no longer accommodate the rapidly expanding international trade landscape and severely impeded its development. Consequently, a payment method emerged that detached itself from commercial credit and was entirely based on bank credit: the bank letter of credit.

The advent of letters of credit greatly facilitated international trade settlements and powerfully propelled the growth of global commerce. By the late 19th century, documentary credit had gained considerable practical application. However, early letters of credit lacked unified international rules. Merchants in different countries interpreted credit terms based on their own national laws, regulations, judicial systems, and customs, leading to constant disputes, conflicts, and litigation. This objectively hindered the widespread adoption of letters of credit. In response, banks in numerous countries successively formulated their own letter of credit practices. Yet these remained confined to limited application, failing to gain widespread acceptance or resolve the fundamental issues.

Consequently, many nations recognised the imperative for a unified set of rules and standards governing letters of credit to address the challenges of international trade settlement. Driven by this awareness, letters of credit entered a phase of rapid development, undergoing roughly eight stages and six revisions. The final revision was designated the *Uniform Customs and Practice for Documentary Credits, 2007 Revision* (ICC Publication No. 600), commonly known as 'UCP 600'. It came into force on 1 July 2007. Given the significance and central role of UCP600, its revision also spurred corresponding updates to eUCP (UCP Supplement for Electronic Presentation), ISBP (International Standard Banking Practice for the Examination of Documents under Documentary Credits), SWIFT (Society for Worldwide Interbank Financial Telecommunications).^[3]

2. Opening of Letters of Credit

Application for Issuance

Upon agreement between the exporter and importer to settle via documentary credit, the importer assumes responsibility for initiating the credit. The first step involves completing the application form, which establishes a legal relationship between

the applicant and the issuing bank. Consequently, this application form constitutes the most critical document in the credit opening process.

Requirements for the Application

The requirements for a letter of credit application are clearly stipulated in UCP 600, and the importer must communicate these precisely to the bank. Instructions for opening the credit must be complete and unambiguous. The applicant must always bear in mind that documentary credit transactions deal with documents, not goods. Bankers are not merchants; therefore, the applicant should not expect bank staff to fully comprehend the technical terminology of every transaction. Even if the applicant incorporates all terms from the sales contract into the letter of credit, full protection cannot be guaranteed should the beneficiary (exporter) seek to defraud. This necessitates collaborative effort between the bank and applicant, employing common sense to avoid issuing letters of credit that appear cumbersome to all parties. Banks should also discourage applicants from replicating the terms of previously issued letters of credit (known as ‘copy letters’) when applying for new ones.

Security of Letter of Credit Issuance

Upon receiving complete instructions from the applicant, the bank must immediately issue the letter of credit accordingly. Conversely, the bank retains the right to require the applicant to deposit a specified sum of funds or assets (including assets held in other forms) as security for the bank’s execution of its instructions.

Under current regulations, foreign exchange held by local authorities, departments, and enterprises in China must typically be deposited with Chinese banks. Should certain entities require importing goods or technology via documentary credit payment, Chinese banks will freeze funds equivalent to the credit amount in their accounts as a letter of credit guarantee deposit.

If the applicant lacks an account with the issuing bank, the latter may require the applicant to deposit funds equivalent to the full credit amount prior to issuance. Such security may be provided through mortgage or pledge arrangements. Banks may also provide financing secured against the goods being traded. The issuing bank must first investigate the marketability of these goods; if the goods are readily marketable, the financing amount provided to the client against the letter of credit will be significantly higher than for slow-moving commodities.

3.Principles of Letters of Credit

Principle One: Upon concluding a contract, the importer requests their local bank to act as guarantor and issue a letter of credit to the exporter. Armed with this document, the exporter may arrange for goods delivery and payment collection through the bank, with the importer prohibited from reneging or interfering mid-transaction.

Principle One indicates the eligibility criteria for accepting and operating letters of credit:

Domestic manufacturers, companies, or even individual industrial and commercial households possessing independent export rights may open a US dollar account with a bank to accept and operate letters of credit through their account-holding bank.

Manufacturers without export rights who export through foreign trade companies may likewise request the foreign trade company to handle the letter of credit on their behalf. In such cases, however, the exporter named on the letter of credit will be the foreign trade company, which will accept and operate the letter of credit through its US dollar-denominated account bank. As with standard agency export operations, the foreign trade company handles the business while the exporter bears the risk.

Principle Two of Letters of Credit: In documentary credit transactions, the exchange involves documents.

Principle Two addresses how banks oversee exporters’ shipments under this payment method.

Foreign banks only disburse funds upon the exporter’s fulfilment of delivery obligations. Given the vast diversity of industries and products in international trade, and banks’ limited product expertise, how can banks verify shipment compliance and ensure delivery? Consequently, banks must rely on the supporting documentation accompanying the goods.

In a sense, foreign trade exports involve the buying and selling of documents, a characteristic particularly pronounced in letters of credit. In L/C operations, banks must first ensure the exporter delivers goods on time, in the correct quantity, and of the specified quality before making payment. However, banks worldwide handling related foreign trade business process thousands of letters of credit daily, involving products ranging from Philippine pineapples and Bordeaux red wine to

Christmas trees from Yiwu, Zhejiang, China... Banks lack the time, resources, and specialised expertise to physically inspect goods. How then do they verify shipments and facilitate delivery? The solution lies in international trade's 'documentary transactions'. In foreign trade, a set of documents represents the actual goods, typically comprising:

1. Commercial Invoice. This is not a domestic tax invoice but a document prepared by the exporter detailing the goods' description, quantity, unit price, and total value.
2. Packing list. Prepared by the exporter, detailing the number of packages, external markings, net weight, gross weight, and dimensions.
3. Bill of lading. Specifically the ocean bill of lading, a document of title issued by the shipping company. This document carries internationally recognised legal title to the goods; whoever holds the bill of lading is the owner of the shipment.

These three documents constitute the fundamental set under a letter of credit. In international trade, the party holding this documentation in good faith (excluding cases of finding or theft) is entitled to collect the goods.

To verify quantity, quality, and import/export eligibility, supplementary documents may include:

4. Quality/Quantity Certificate. Issued by statutory bodies (e.g., China Commodity Inspection and Quarantine Bureau) or private agencies (e.g., SGS, the Swiss General Notary Office specialising in international goods inspection) commissioned by the exporter or importer. This document certifies that the goods meet specified quality and quantity requirements following inspection.
5. Certificate of Origin. Verifies the goods' country of origin, primarily used for claiming preferential import/export tariffs.
6. Additional documentation detailing the consignment's particulars may be required depending on industry and national regulations.

With this comprehensive set of documents, all parties involved in international trade—whether importers, exporters, or intermediaries—need not remain tied to the goods or endure the hassle of repeated shipments. Goods may be temporarily stored in warehouses while parties trade these documents among themselves. Ultimately, whoever secures the full set of documents proceeds to the warehouse to collect the goods, thereby saving substantial transportation and handling costs. This exemplifies the 'documentary transaction' characteristic of international trade.

In a letter of credit, delivering goods to the bank entails submitting this complete set of trade documents.

Principle Three of Letters of Credit: Banks process goods delivery and payment solely based on the documents. Payment is made only when the documents are in order and consistent with each other.

This principle underscores that trade documents are the lifeblood of letters of credit. In practice, submitting documents to the bank is equivalent to delivering goods. If the bank finds no issues upon examination, payment is released. The critical importance of documents in letters of credit is thus self-evident.

Given their significance, banks naturally specify in detail within the letter of credit the types of documents required, the party responsible for issuing them, and their validity periods. Occasionally, to facilitate processing, banks may even request additional documentation.

As this is a documentary transaction, banks involved in L/C operations do not concern themselves with the quality or nature of the imported or exported goods. They solely verify whether the complete set of trade documents complies with the L/C terms and is valid. Banks do not even undertake to authenticate the documents; provided the documents 'appear' to meet the L/C requirements, they accept them and make payment. It is conceivable for an exporter to fabricate the entire set of documents. This refers to a beneficiary of the letter of credit obtaining payment under the credit by fraudulently presenting forged documents that superficially match the credit requirements, thereby inducing the bank to make unconditional payment despite the goods not existing. This constitutes fraudulent activity by the exporter and is a criminal offence.^[4]

Consequently, the critical importance of documents under letter of credit terms becomes readily apparent. To put it starkly, if an exporter can procure a complete set of documents conforming to the letter of credit requirements, they could receive payment even if they shipped a load of rubbish to the importer. Conversely, even if the exporter's goods are flawless, non-compliance of the documents with the letter of credit stipulations will result in non-payment. Banks adhere strictly to this principle: they recognise documents, not goods, nor individuals.

Principle Four of Letters of Credit: Should errors occur in the export documentation, the bank may refuse payment and impose penalties on the exporter. The subsequent course of action following a bank's refusal of payment requires separate negotiation.

This principle underscores that when handling trade documents under a letter of credit, meticulous preparation is essential to avoid errors. What consequences arise if discrepancies occur? The letter of credit specifies detailed requirements for the full set of trade documents. Any aspect of the documents submitted to the bank that fails to meet these requirements is termed a 'discrepancy' (Discrepant). Upon identifying such discrepancies, the bank retains the right to withhold payment.

Subsequent handling involves the bank consulting both the importer and exporter. Should the importer accept the discrepancy, the bank may proceed with payment as normal. Should the importer object, the exporter must decide whether to withdraw the documents and recall the goods, thereby terminating the transaction; or negotiate a resolution with the importer, potentially involving price reductions, compensation, or other terms.

Regardless of the final resolution, the bank will impose a penalty on the exporter whenever discrepancies arise. This penalty is termed a forfeit. The amount of each forfeit is stipulated in advance within the letter of credit. Exporters should not entertain any notion that forfeits can be avoided by the transaction falling through, as this is impossible since the documents remain in the bank's possession. Such is the nature of international trade: the documents represent the goods, and the goods represent the payment.

Principle Five of Letters of Credit: Once a letter of credit is issued, the importer cannot unilaterally breach the contract or demand amendments. The exporter may refuse to utilise the letter of credit or request modifications before submitting the trade documents to the bank.

This principle underscores that letters of credit serve to safeguard the exporter's interests.

Given the critical importance of trade documents, exporters must exercise caution. What if the documentary requirements stipulated in the letter of credit are unfeasible for the exporter? The solution is straightforward: the exporter may request the importer to amend the relevant terms of the letter of credit. Once issued, the importer cannot breach the contract or unilaterally demand alterations, whereas the exporter retains the right to request modifications. This underscores that letters of credit fundamentally safeguard the exporter's interests. When an importer opens a letter of credit through a bank, the exporter may accept it, decline it, or request amendments to its terms until the exporter agrees. Naturally, once the exporter submits documents to the bank for payment, this is deemed acceptance of the letter of credit. At this stage, the exporter cannot request further amendments unless both parties consent.

Note that even after accepting the letter of credit, should unforeseen circumstances arise or significant changes occur in the export situation, the exporter may refrain from proceeding with the transaction before submitting documents to the bank. The letter of credit will then expire automatically. The exporter bears no liability towards the bank in such cases and may simply return the original letter of credit. The designation of the exporter as the 'beneficiary' in the letter of credit is entirely apt, as the initiative lies squarely with the exporter at this stage.

4. The Operational Process of Letters of Credit

In international trade, what constitutes the most reliable method of payment? Undoubtedly, it is cash payment – goods exchanged for money on the spot. However, this form of cash transaction proves exceedingly difficult to implement within the complexities of international commerce, encountering numerous obstacles. For instance, vast geographical distances often prevent buyers and sellers from conducting face-to-face transactions where money changes hands immediately for goods. Moreover, transaction values are often substantial, frequently reaching millions, tens of millions, or even hundreds of millions of pounds. The transportation and security of such vast sums of cash alone present significant challenges, and in some cases, are simply impracticable.

A letter of credit serves as a payment method within international trade, or alternatively, it can be understood as a means of receiving payment. In certain respects, a letter of credit offers reliability comparable to cash payment. Provided it is operated correctly and without breach, a letter of credit is as secure as cash payment. This is why the phrase 'paying for goods via letter of credit' is commonplace in the foreign trade industry. In essence, a letter of credit is a method for receiving payment in

international trade. Since exporters and importers often lack mutual trust in each other's integrity, this mechanism establishes a framework of mutual confidence. It is based on trust in each party's respective banks, which also maintain cooperative relationships with one another.

Let us examine the fundamental operational process of letters of credit as an international trade payment method through a concrete case study.

China's BYD Company Limited exports 10,000 new energy vehicles to a British firm, valued at £200 million. The trade contract stipulates payment via letter of credit. How does BYD recover payment through this method?

Step One: The UK company (importer) first remits payment to its local Barclays Bank branch to apply for a letter of credit.

Explanation: The importer submits an application to its local bank (the issuing bank), completes a letter of credit application form in accordance with the contract, and pays a credit guarantee deposit or provides other collateral to request the bank (issuing bank) to issue the credit. The credit guarantee deposit is determined by the issuing bank based on an assessment of the enterprise's qualifications, reputation, and operational status. This evaluation establishes the enterprise's creditworthiness, which in turn determines the required deposit percentage. Enterprises with stronger creditworthiness pay a lower deposit percentage, typically equivalent to the value of the letter of credit being issued. For instance, if the letter of credit is for £200 million and the bank deems the client's creditworthiness high, it may require the client to deposit a certain percentage (20%) as a guarantee, amounting to £40 million, held in a dedicated guarantee account. Naturally, this requires the applicant to maintain an account with the issuing bank. Should the client be deemed less creditworthy, the bank may require a maximum deposit of 100% of the letter of credit amount, i.e., £200 million.^[5]

Step Two: Barclays Bank in the UK conducts a credit investigation and extends credit to the applicant (the importer). Upon receiving the importer's deposit and reviewing the applicant's letter of credit application, Barclays issues the letter of credit to the beneficiary following approval. The letter of credit is then transmitted via the dedicated SWIFT system to the China Construction Bank branch in Shenzhen, where BYD is located.

Explanation: Based on the application details, the issuing bank opens the letter of credit in favour of the exporter (beneficiary) and forwards it to the branch or correspondent bank in the exporter's location (collectively termed the advising bank). Once issued, the letter of credit constitutes an agreement independent of the underlying sales contract.

Step Three: Upon receiving the letter of credit, China Construction Bank (the advising bank) notifies BYD Company to collect the letter of credit.

Explanation: Upon receipt, the advising bank must immediately verify the signature or secret code on the letter of credit. Following successful verification, it must review the terms of the letter of credit. Provided the terms are complete and clear, the advising bank must promptly deliver the letter of credit to the beneficiary (exporter), retaining a duplicate or photocopy. Letters of credit are typically issued as electronic documents transmitted via telegram. The issuing bank first transmits the letter of credit details in a standardised format to the advising bank (usually a bank with which it shares a shared secret). Upon receipt, the advising bank verifies the shared secret to authenticate the letter of credit's validity, then examines the terms. If no discrepancies are found, it contacts the beneficiary to collect the original letter of credit, retaining a copy or duplicate for its records. Thus, the issuing bank issues the letter of credit to the beneficiary, not to the advising bank.

Step Four: Upon receiving the collection notice from China Construction Bank, BYD Co., Ltd. dispatches personnel to collect the letter of credit from the bank.

Step Five: After receiving the letter of credit, BYD verifies its compliance with the contract terms. It then prepares goods in accordance with contractual requirements, dispatches the shipment, obtains all relevant shipping documents, and issues a draft. Within the letter of credit's validity period, it submits these documents to the bank authorised by the issuing bank (the negotiating bank) for negotiation.

Explanation: Upon verifying compliance with the letter of credit terms, the negotiating bank advances the payment to the exporter, deducting interest from the draft amount. This process is also termed bill discounting.

The negotiating bank is typically the exporter's local bank, though the advising bank may occasionally serve this function. The negotiating bank refers to the institution authorised by the issuing bank to purchase drafts and documents presented

by the beneficiary that conform to the letter of credit specifications. Pursuant to the Domestic Letter of Credit Settlement Measures: The negotiating bank must be the beneficiary's account-holding bank designated by the issuing bank. Banks not designated for negotiation, or designated negotiating banks that are not the beneficiary's account-holding bank, shall not conduct negotiation. Where a letter of credit does not expressly permit negotiation, no bank may undertake negotiation. Where negotiation is permitted, if the issuing bank designates only one negotiating bank, banks not designated as negotiating banks may not undertake negotiation; the designated negotiating bank may decide at its discretion whether to undertake negotiation.

Negotiation refers to the act whereby the negotiating bank designated under the letter of credit, upon presentation of documents in compliance with the terms, pays the beneficiary the value of the documents after deducting negotiation interest. Simply put, it constitutes the purchasing of documents by the negotiating bank. Negotiation may be either at sight or at a forward date. The beneficiary may present the documents, the original letter of credit, and the letter of credit notification to the negotiating bank during the presentation period or within the validity period of the letter of credit. They shall complete the Letter of Credit Negotiation/Collection Application Form and the Negotiation Voucher to request negotiation.

UCP600 defines negotiation as follows: Negotiation means the purchase by the nominated bank of drafts and/or documents under a complying presentation, by advancing or agreeing to advance funds to the beneficiary on or before the banking day on which reimbursement is due to the nominated bank.

Negotiation under a letter of credit: Whilst the issuing bank or the paying bank (confirming bank) is the entity that ultimately pays the beneficiary, the exporter (beneficiary) typically presents documents to a local bank (negotiating bank). Upon verifying the documents' compliance, this bank may advance the letter of credit amount to the exporter. The negotiating bank then presents the documents to the paying bank to claim payment. Should the paying bank honour the payment, no issues arise. Should the paying bank refuse payment, the negotiating bank retains the right to seek recourse from the exporter. This form of financing under a letter of credit with recourse is termed export discounting, which corresponds to the textbook definition of negotiation (export discounting constitutes a method of financing that may operate under either letters of credit or collections).

However, in practical operations, the concept of domestic negotiation predominantly refers to the exporter submitting documents to the exporting bank (the negotiating bank). This bank assists with document examination and forwards them to the paying bank without providing the exporter with financing. The negotiating bank acts as an agent. Should the paying bank refuse payment, it notifies the exporter, who must then negotiate with their customer to resolve the issue. Should the paying bank honour the payment, the negotiating bank informs the exporter that funds have been received and credited. This arrangement appears virtually risk-free for the bank, though termed "negotiation", it essentially constitutes document submission by proxy.^[6]

Step Six: China Construction Bank presents the documents submitted by BYD to Barclays Bank in the UK for payment.

Explanation: The negotiating bank forwards the draft and shipping documents to the issuing bank (or its designated paying bank) for payment.

Step Seven: Upon verifying the accuracy of the documents submitted by China Construction Bank, Barclays Bank in the UK transfers the funds to China Construction Bank.

Explanation: The issuing bank typically pays the paying bank after deducting any margin deposited by the applicant (with overpayments refunded and shortfalls collected), provided the documents are verified as correct by the issuing bank (or its designated paying bank).

Step 8: Upon receiving funds from Barclays Bank UK, China Construction Bank notifies BYD Company Limited to process the foreign exchange settlement at the bank. At this point, BYD receives payment for the exported new energy vehicles.

Explanation: As mentioned earlier regarding negotiation, in actual practice, the negotiating bank acts solely as an agent and does not advance funds to the exporter. Upon successfully obtaining payment from the issuing bank, it notifies the exporter to process the settlement. Naturally, the negotiating bank earns a commission. Should the negotiating bank advance funds to the exporter, this constitutes export discounting.

Step Nine: Barclays Bank notifies the UK importer to make payment to redeem the documents.

Explanation: This essentially means the issuing bank instructs the importer to settle the full remaining balance of the goods, excluding any initial deposit. Unless a 100% deposit was paid upfront, the issuing bank will only release all documents to the importer upon full payment. These documents are essential for the importer to complete customs clearance and collect the goods. Should the importer fail to make payment for the documents, they naturally cannot obtain the documents from the issuing bank and thus cannot collect the goods. Given this incentive, the issuing bank can naturally recover the payment from the importer.

Step Ten: After the UK importer makes payment to Barclays Bank and obtains the shipping documents, they can then present these to the carrier to collect the goods.

Conclusion

As a vital payment method in international trade, the development of letters of credit is intrinsically linked to global trade demands. Originating from medieval European merchants' need to mitigate risks in cross-border transactions, it has evolved over time into a globalised, standardised system, becoming the core mechanism for circumventing credit risks between buyers and sellers. During the application phase, the applicant must submit documentation and provide a security deposit to the issuing bank. This step ensures the bank's risk remains manageable while establishing a foundation of trust for subsequent transactions.

Fundamentally, letters of credit substitute commercial credit with bank credit, achieving risk isolation through the principle of 'documentary exchange'. Provided the beneficiary submits documents conforming to the terms, the issuing bank is obligated to make payment, effectively resolving the core issue of mutual distrust between buyers and sellers. Operationally, the process from opening and advising the letter of credit to presenting, examining, and paying documents forms an interlinked chain. Clear roles are assigned to entities such as the issuing bank, advising bank, and negotiating bank, ensuring transactional efficiency while mitigating fraud risk through rigorous documentary scrutiny.

In summary, through its clear origin logic, standardised application mechanism, reliable underlying principles, and rigorous operational procedures, the letter of credit has become a pivotal instrument for stabilising international trade order. It safeguards the interests of both buyers and sellers while propelling the secure and efficient development of global commerce.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Legal Express Network. (2020, July 16). What is a letter of credit? <https://www.lawtime.cn/info/maoyi/dzdz/201412093310550.html>
- [2] Huang, H. T. (2009). The 6-hour guide to letters of credit (in Chinese). China Customs Press.
- [3] Ding, X. (1995). Comparison and analysis of the US Uniform Commercial Code – Letters of Credit and the ICC Uniform Customs and Practice for Documentary Credits (in Chinese). Foreign Trade and Economic Practice, (1), 18–19.
- [4] Chen, G. C. (2005). Risk identification and prevention in commercial banks' international settlement operations (in Chinese). Reform and Strategy, (1), 109.
- [5] Chen, P. (2021). International trade practice (3rd ed., in Chinese). China Renmin University Press.
- [6] Wang, T., & Cao, H. B. (2013). Mastering letters of credit (2nd ed., in Chinese). China Customs Press.

From Hamilton to Trump: Examining the Evolution, Logic and Resurgence of US Tariff Policy

Yongdong Xu*

School of Economics and Management, Guangdong Technology College, Zhaoqing, 526000, China

*Corresponding author: Yongdong Xu

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Tariff policy, enshrined as a core economic instrument in the US Constitution from the nation's inception, has evolved to profoundly mirror shifts in America's economic structure, political dynamics and national strategy across distinct historical eras. From Alexander Hamilton's 'protective tariffs' designed to establish the fledgling republic's fiscal foundations and shield nascent industries, through the 19th-century partisan clashes between Republicans and Democrats over 'high tariffs' versus 'low tariffs', to the 20th-century rise of free trade ideology and the 21st-century resurgence of tariffs under Donald Trump's 'America First' banner, American tariff policy has traversed a complex trajectory marked by spiralling escalation and cyclical oscillations. This paper aims to trace the historical trajectory of American tariff policy from 1789 through Trump's first and second terms, analysing its underlying economic logic and political motivations. It focuses on comparing the similarities and differences between Hamilton's 'developmental protectionism' and Trump's 'confrontational protectionism', ultimately revealing the enduring role tariff policy has played in America's nation-building and the evolution of its global role.

Keywords: US Tariff Policy; Hamilton; Trump; Protectionism; Free Trade; Industrial Development; Political Manoeuvring

Published: Oct 25, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.727>

Introduction

In 1787, the framers of the United States Constitution faced the formidable task of establishing a robust and effective central government for a nation that had only recently cast off colonial shackles, was financially depleted, and operated under a loose confederation. Among the powers granted to the federal government, the authority to levy taxes was accorded paramount importance. Article I, Section 8 of the Constitution explicitly states: Congress shall have the Power... to lay and collect Taxes, both direct and indirect, and Excise, and other Taxes for the Repayment of the Public Debt, and for the common defence and public welfare of the United States, 'and to 'regulate Commerce both with Foreign Nations, and among the several States, and with the Indian Tribes.'" This constitutional mandate not only provided the federal government with a stable source of revenue but, more significantly, established a national-level economic regulatory tool: the tariff.

Since then, tariffs have run like a golden thread through American history, sometimes taut, sometimes slack, but never broken. They have served as the fiscal 'lifeblood,' the industrial 'protective umbrella,' the political 'barometer,' and the 'flashpoint' for regional tensions. From Hamilton's Report on Manufactures to Trump's trade wars, every major shift in tariff policy has been accompanied by profound debates concerning America's economic identity, national interests, and global role. This article first traces the foundation and evolution of US tariff policy from the nation's early years to the pre-Civil War era. It

then examines the peak and controversies of the high tariff system from the Civil War to the early 20th century. Finally, it focuses on the resurgence and mutation of tariff policy during the Trump era. Through this historical lens, it scrutinises the intrinsic logic and epochal imprint of American tariff policy, addressing a central question: Are Trump's tariff policies a distant echo of the Hamiltonian spirit, or a wholly new strategic reconfiguration grounded in 21st-century realities?

1.The Founding Cornerstone: Hamilton's 'Development-Oriented Protectionism' (1789–1860)

The smoke of the American War of Independence had long since cleared, yet what remained was a nation scarred beyond recognition. War debts mounted, the Confederation government proved incapable of repayment, and the credit system teetered on the brink of collapse. Simultaneously, Britain, leveraging its formidable industrial advantage, flooded the American market with cheap goods, dealing a severe blow to the nascent “infant industries” that had begun to sprout during the conflict. The trade imbalance with Britain was rapidly undermining America's fledgling industries and eroding confidence in the dollar. Against this backdrop, Alexander Hamilton, the first United States Secretary of the Treasury, demonstrated remarkable foresight by devising an economic development blueprint centred on tariffs.

1.1 The Dual Objectives of the Hamilton Tariff: Fiscal Revenue and Protectionism

In 1789, the Tariff Act, spearheaded by Hamilton and signed by President Washington, became the first significant legislation passed by the United States Congress. Its primary and most immediate objective was to resolve the fiscal crisis. During the early days of the federal government, customs duties constituted virtually the sole reliable and readily collectable source of taxation. Prior to 1860, American tariff revenues accounted for 80-95 per cent of the federal government's total income. This revenue proved vital for ‘maintaining expenditures, honouring federal debts in full, and settling obligations owed by the states during the American War of Independence.’ Hamilton firmly believed that full debt repayment was the cornerstone for establishing national fiscal credibility and earning international respect, with tariffs serving as the foundation for achieving this objective.

Yet Hamilton's vision extended far beyond finance. In his renowned Report on Manufactures, he systematically articulated a more profound objective: to foster American industrialisation through protective tariffs. He astutely observed that amidst the late-18th-century industrial revolution, America remained virtually absent in a pivotal sector—textiles. The British government fiercely maintained its industrial monopoly by prohibiting the export of technology, machinery, and skilled labour. British textiles were ‘more than thirty times cheaper,’ rendering American handicraft production utterly uncompetitive. Hamilton contended that relying solely on the ‘invisible hand’ of the market would condemn American industry to perpetual stagnation. He therefore advocated ‘using protective tariffs as a lever for rapid industrialisation.’ High tariffs would not only ‘increase American revenues’ but also ‘protect and subsidise the early endeavours of American manufacturing,’ creating a ‘greenhouse environment’ where domestic enterprises could survive, learn, and ultimately grow to rival Britain.

As economic historian Douglas Irwin observes, Hamilton's report laid the theoretical foundation for a century of American protectionism. Its central thesis—that state intervention is essential for fostering industrial competitiveness in late-developing nations—proved profoundly influential.^[1]

1.2 The Early Practice and Controversy of Protectionism

Hamilton's vision was swiftly validated in practice. In 1790, Samuel Slater, an immigrant skilled worker who had entered the country illegally, established America's first successful cotton mill in Rhode Island, bringing the spark of the Industrial Revolution to the United States. While the initial cost of his products was slightly higher than those from Britain, it was tariffs that provided crucial protection. During the War of 1812, Britain's naval blockade unexpectedly acted as a catalyst for American industrial development. The increasingly acute shortage of imported goods provided powerful impetus for industrial growth in several northeastern states. After the war, although roughly half of the nascent enterprises collapsed, the survivors laid the foundations for America's future industrial boom by ‘enhancing skill sets, updating knowledge, and improving organisational structures’.

This era also saw early social tensions arising from tariff policies. For instance, the excise tax on whiskey sparked the Whiskey Rebellion of 1794, exposing conflicts between federal taxation authority and local interests. Overall, however,

protectionist tendencies in tariff policy intensified from the nation's founding through the pre-Civil War period. Advocates of the 'American System,' represented by Henry Clay and John C. Calhoun, regarded high tariffs, internal improvements, and a national bank as the three pillars driving national modernisation. They asserted that possessing a domestic industrial base was 'essential to averting wartime shortages.'

Yet this protectionism came at a cost. From its inception, it sowed the seeds of regional division. Industrialists and labourers in the Northeast sought high tariffs to ward off British competition, while Southern plantation owners vehemently opposed them. The Southern economy, dominated by agriculture with a weak industrial base, relied heavily on importing cheap manufactured goods and exporting raw materials like cotton. Raising tariffs would increase their cost of living and risk retaliation from trading partners, harming export interests. This fundamental structural economic disparity elevated the tariff issue from an economic matter to a sharply divisive political one. By 1828, tariff rates peaked at an average exceeding 25%, derisively dubbed the 'Tariff of Abominations' by Southerners. This directly precipitated South Carolina's 'Non-Execution Crisis,' marking the first separatist stirrings where state power challenged federal authority.

Historian Charles Beard, in his seminal work *The Economic Interpretation of the Constitution of the United States*, interpreted such conflicts as struggles between competing economic factions, arguing that tariffs served as a crucial instrument for Northern industrial and commercial interests to suppress Southern agricultural interests through state power.^[2] Although the crisis ultimately concluded with compromise, the rift between North and South over tariffs proved irreparable, ultimately becoming one of the deep-seated causes that ignited the Civil War.

2.The Republican Era of High Tariffs: Industrial Peak and Political Solidification (1861–1912)

In 1861, the outbreak of the American Civil War fundamentally altered the political landscape of the United States. The secession of Southern states and the withdrawal of their representatives from Congress cleared the path for the Republican Party to implement its long-standing high tariff policy. Thereafter, America entered a period of Republican-dominated high tariffs that would endure for over half a century. The logic underpinning this era's tariff policies evolved from Hamilton's 'developmental protectionism' into a more complex form of 'mature protectionism' serving specific interest groups and ideologies.

2.1 Wartime requirements and post-war consolidation

Following the outbreak of war, the federal government experienced a surge in fiscal revenue requirements. In March 1861, after the withdrawal of Southern representatives, Congress swiftly passed the Morrill Tariff Act, significantly raising customs duty rates. Throughout the conflict, tariffs were repeatedly increased, alongside excise duties and income taxes, to fuel the war machine. Although wartime revenues primarily relied on bonds, the fiscal function of tariffs remained indispensable.

Of more enduring significance was the persistence of high tariffs after the war's conclusion. Historians such as Howard Beard contend this resulted from Northern industrial capitalists perpetuating the tariff regime to safeguard their interests. They achieved this by exerting control over the Republican Party and supporting policies for Southern reconstruction. Industries such as steel and wool formed tightly organised interest groups that successfully lobbied politicians to transform high tariffs into their own 'moat'. They argued to voters that high tariffs protected workers' high wages and created a prosperous 'domestic market', thereby securing broad support across the Northeast, including among some farmers.

2.2 The “Success” and “Alienation” of Protectionism

By the late 19th century, American industrialisation had achieved remarkable progress. Protected by high tariffs, US steel production surged from 22,000 tonnes in 1867 to over 11.4 million tonnes by 1900 – a five-hundredfold increase. America transformed from a steel importer to an exporter, with its products even being dumped back into Britain at prices below those in the UK itself. This prompted the *London Daily Mail* to marvel that America had comprehensively surpassed Britain in fields such as electric motors, locomotives, and steel rails.

However, this 'success' also brought about the 'alienation' of protectionism. By the 1880s, American industry had become the world's most efficient and lowest-cost producer, and within its vast domestic market, it feared no foreign competition whatsoever. By this time, the economic rationale for tariffs—namely, protecting 'infant industries'—had largely evaporated.

Tariffs no longer served to cultivate competitiveness but rather to safeguard established monopolies and excessive profits. They had evolved into an ideological relic, a form of ‘legitimate extortion’ serving specific vested interests.

Democrat Grover Cleveland emerged as the most vocal critic of high tariffs during this era. He denounced them as the root of ‘inefficiency and corruption,’ a ‘guilty betrayal of American fairness and justice.’ He contended that high tariffs drove up commodity prices, created excessive government fiscal surpluses, and stifled economic development. The presidential elections of 1888 and 1892 effectively served as national referendums on tariffs. Despite Cleveland’s two terms in office, his efforts to reduce tariffs were repeatedly thwarted. Upon Republican William McKinley’s accession in 1897, the Dingley Tariff Act swiftly restored rates to 50%, marking the zenith of the high-tariff regime.

McKinley’s declaration – ‘Free trade hands over our money, our manufacturing, and our markets to other nations... We must protect... to keep them within our borders’ – perfectly encapsulated the Republican Party’s protectionist logic of the time. While this rationale may have held sway in the late 19th century, the unprecedented strength of the American economy increasingly exposed the insularity and self-interest inherent in such policies, laying the groundwork for a shift in trade policy during the 20th century.

3.From Liberalism to Reversal: Trump’s ‘Confrontational Protectionism’

Entering the twentieth century, particularly after the Second World War, the United States, leveraging its unparalleled economic and military superiority, emerged as the principal advocate and architect of the global free trade system. The establishment of the General Agreement on Tariffs and Trade (GATT) and the World Trade Organisation (WTO) signalled America’s transformation from a bastion of high tariffs to a champion of barrier reduction.

However, this trajectory underwent a dramatic reversal in the second decade of the 21st century. In 2016 and 2024, Donald Trump ascended to the White House twice under the banner of ‘America First’ and the slogan ‘Make America Great Again’. The core of his economic policy lay in the revival and radical deployment of the ancient tool of tariffs, each application more audacious and perilous than the last. Particularly concerning China, at the outset of Trump’s second term, tariffs of up to 145% were imposed on virtually all Chinese imports, while simultaneously imposing high tariffs on the vast majority of countries worldwide, triggering a full-scale tariff war.

The Chinese government responded to this unilateral economic bullying by the United States with resolute and forceful reciprocal countermeasures, leading to a full-scale escalation of the Sino-US trade war. This signifies that the global trade war and tariff war triggered by the Trump administration will inevitably reshape the existing global economic order and trade landscape.

3.1 The Context and Rationale Behind Trump’s Tariffs

Trump’s tariff policy did not emerge in a vacuum, but rather represents a fierce response to socio-economic shifts in the United States since the late 20th century. Its underlying logic shares similarities with that of Hamilton and 19th-century Republicans, yet also exhibits fundamental differences.

1. Resentment towards globalisation and anxieties over industrial hollowing-out: Following the Cold War, the tide of globalisation swept across the world. In pursuit of lower costs, American capital relocated vast swathes of manufacturing overseas, particularly to China. This led to the decline of traditional manufacturing, factory closures, and worker unemployment across the United States, especially in the ‘Rust Belt.’ Trump adeptly tapped into the anger and sense of abandonment felt by this segment of society ‘left behind’ by globalisation, attributing the problems to ‘unfair trade agreements’ and the ‘cheating’ of trading partners. Political scientist Elizabeth Engel, in her work *Rust Belt Awakening*, offers a profound analysis of this phenomenon. She observes that voters in the Rust Belt feel betrayed by both globalisation and liberal elites, with their economic suffering and cultural anxieties converging to fuel robust support for populist leaders like Trump.

2. Obsession with Trade Deficits: Unlike previous administrations focused on industrial protection, Trump views trade deficits themselves as a sign of national failure and a threat to economic security. He contends that substantial deficits signify the ‘theft’ of American wealth and jobs by other nations. Consequently, a primary objective of his tariff policy is to wield the tariff stick to compel trading partners—particularly China—to reduce exports to the US and increase imports from it, thereby

‘balancing’ trade.

3. The broadening of ‘national security’: The Trump administration extended the concept of ‘national security’ beyond traditional military domains into the economic sphere. Its landmark move—imposing steep tariffs on steel and aluminium products under Section 232 of the 1962 Trade Expansion Act, citing ‘national security’ concerns—embodies this approach. This expanded security logic provides protectionism with seemingly legitimate and hard-to-refute justification.

3.2 Hamilton and Trump: Two Paradigms of Protectionism

Comparing Trump’s tariff policy with Hamilton’s reveals that although both employed the instrument of “tariffs”, their underlying logic, strategic objectives and implementation methods differ like night and day.

Comparative dimensions	Hamilton’s ‘developmental protectionism’	Trump’s ‘Confrontational Protectionism’
Core Objective	Nurturing and Development: Protecting nascent industries, enabling them to emerge from nothing, grow from weakness to strength, and ultimately achieve national industrial self-reliance.	Revival and Rebalancing: For mature industries that have declined or face intense competition, employing tariff barriers to compel their return or restore competitiveness.
Strategic Vision	Forward-looking and constructive: Focusing on the nation’s long-term development, utilising tariffs as a strategic tool for achieving industrialisation and modernisation.	Retrospective and adversarial: Focusing on resolving current economic woes (unemployment, deficits), employing tariffs as a punitive measure against opponents and a negotiating tool to extract concessions.
Implementation targets	Universality and Systemic Nature: The imposition of tariffs on a broad range of imported manufactured goods establishes a systemic protective framework designed to elevate the overall industrial standard.	Selectivity and precision: primarily targeting specific countries (China) and specific products (steel, aluminium, high-tech goods), with a pronounced bilateral confrontational character.
Economic rationale	Endogenous growth drivers: It is believed that protection can stimulate endogenous innovation and learning, ultimately enabling industries to achieve international competitiveness. Protection serves as a temporary “incubator”.	External pressure as a driver: The belief that external pressure (tariffs) can alter other nations’ behaviour or compel businesses to relocate back home, with protection serving as a persistent “shield” or “big stick”.
Political foundation	National Elite Consensus: Driven by the founding elite class, it aims to establish a robust federal state and an independent economic system.	Populist mobilisation: centred on blue-collar workers marginalised by globalisation as its core supporters, gaining political momentum by stoking nationalism and economic populism.
Global Role	Emerging Followers: As latecomers, they adopted defensive strategies to ensure their survival and development in the face of British industrial supremacy.	The Hegemon’s Corrector: As the dominant force within the global system, it seeks to amend existing rules deemed ‘unfair’ through unilateral and disruptive means.

In short, Hamilton’s protectionism was a “strategy for a rising power”, aimed at transforming a weak nation into a strong one; whereas Trump’s protectionism more closely resembles an expression of “hegemonic anxiety”, designed to restore the perceived decline of an already powerful nation. Hamilton’s tariffs were inward-looking and constructive, intended to strengthen the nation’s foundations; Trump’s tariffs are outward-looking and confrontational, seeking to reshape the external world. As international relations scholar John Ikenberry has analysed, Trump’s unilateralism and protectionism represent a profound challenge to the liberal international order the United States itself established after the Second World War. This stems from domestic political polarisation and discontent with globalisation within America.^[3]

Conclusion: Echoes of History and Variations of the Times

From Hamilton to Trump, the history of American tariff policy spanning over two centuries constitutes a grand narrative of national development, conflicting interests, and strategic choices. This history reveals several core, enduring themes:

First, tariffs have consistently served as a regulator of American national interests. Whether raising funds for the fledgling

republic, shielding nascent industries, consolidating monopolies for mature industries, or launching trade wars to counter globalisation challenges, each pivot in tariff policy has been rooted in America's evolving definition of its national interests across different eras. It has served multiple objectives: nation-building, economic development, political mobilisation, and global strategy.

Second, tariff policy has been a focal point of domestic political contestation. From the North-South divide of the nineteenth century, through twentieth-century partisan rivalries, to the twenty-first-century fractures between urban and rural areas, blue-collar and elite factions, tariffs have consistently provided a stage for competing forces. They reflect conflicts over the distribution of benefits among different regions, industries, and social classes, becoming a central issue in electoral politics. Trump's success stemmed precisely from his adept mobilisation of support among groups harmed by globalisation, transforming tariff issues into a political 'culture war'.

Thirdly, US tariff policy exhibits cyclical fluctuations. History does not advance in a linear fashion. America has oscillated between protectionism and free trade. When the nation is in a catch-up phase or confronts external crises, protectionist tendencies resurface (as during the Hamilton era, the Civil War period, the Great Depression, and the Trump administration); conversely, when the nation holds global supremacy and seeks to expand overseas markets, calls for free trade intensify (as post-World War II). This oscillation fundamentally reflects America's strategic balancing act between 'openness' and 'autonomy,' "cooperation" and 'confrontation' under varying historical conditions.

Fourthly, Trump's tariff policy is both an echo of history and a variation of its times. It inherits the core spirit of Hamilton's protection of domestic industries and defence of national economic sovereignty, representing a distant resonance with America's founding principles. However, its contemporary context, targeted adversaries, political foundations, and confrontational tactics fundamentally distinguish it from Hamilton's 'developmental protectionism.' Trump's 'America First' represents a radical, unilateral, and uncertain modern interpretation of traditional protectionism—unfolding against a backdrop of deeply integrated global supply chains, relative decline in American hegemony, and China's emergence as a new variable.

Looking ahead, what path will US tariff policy take? Has Trump's trade war truly achieved 'Making America Great Again'? Historical experience suggests that while protectionism may offer short-term political appeasement and localised gains, it risks long-term efficiency losses, rising inflation, and the fragmentation of the global trading system. Yet the deep-seated socioeconomic contradictions driving Trump's tariff policies—such as industrial hollowing-out, widening wealth disparities, and regional development imbalances—remain unresolved. This implies that regardless of who occupies the White House, the debate over America's role in the global economy will persist. Tariffs, this ancient instrument, will persist as an indispensable yet contentious element on America's political and economic stage. The evolution from Hamilton to Trump is not merely an economic chronicle but a mirror reflecting how the United States, through over two centuries of trials and tribulations, has continually defined itself, shaped the world, and in doing so, perpetually engaged in dialogue and struggle with its inherent contradictions.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Owen, D. A. (2017). Trade in conflict: Two hundred years of American trade policy (Jiang, Y., Trans.). CITIC Press.
- [2] Beard, C. A. (1989). The economic vision of the American constitution (Xizi, H., Trans.). Commercial Press.
- [3] Ikenberry, G. J. (2018). The end of the liberal international order? *International Outlook*, (1), 1–23.

Research on Risk Identification and Regulation of Binance from a Global Regulatory Perspective

Xiayi Zhang, Jiawei Xi*

School of Economics, Guangzhou College of Commerce, Guangzhou, 511363, China

*Corresponding author: Jiawei Xi

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: This study systematically analyzes the compliance, technical, market, and legal risks faced by the Binance exchange from a global regulatory perspective. By examining Binance's operational practices in multiple countries and incorporating case studies such as the substantial U.S. settlement and the EU's MiCA regulatory framework, it reveals three core contradictions within the existing regulatory system: the lag of regulatory tool iteration behind technological innovation, inefficiencies in cross-border law enforcement coordination mechanisms, and institutional deficiencies in investor protection. Based on this analysis, the paper proposes a three-dimensional optimization path centered on the unification of global standards, the deepening of regulatory technology, and the institutionalization of transnational coordination, emphasizing the need to balance risk prevention and control with innovation tolerance when constructing a dynamic compliance framework. The research concludes that effective cryptocurrency regulation must seek a dynamic balance between risk governance and innovation incentives, and that establishing a global regulatory coordination mechanism is key to solving the problem of cross-border regulatory arbitrage.

Keywords: Risk Identification; Regulatory Mechanism; Binance; Cryptocurrency Exchange; FinTech Regulation

Published: Nov 2, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.839>

1.Introduction

Cryptocurrency exchanges, serving as the core infrastructure for digital asset trading, have positioned risk management and regulatory compliance at the forefront of global financial oversight. Binance, as one of the world's largest cryptocurrency exchanges by trading volume and global reach, presents a critical case study due to its significant market share and operational scale. Since its inception in 2017, Binance has experienced meteoric growth, concurrently facing escalating regulatory scrutiny worldwide. The 2023 settlement with U.S. authorities, involving a substantial financial penalty and the departure of its founder Changpeng Zhao, marked a pivotal moment, signaling a new era of intensified global regulatory focus on the sector. The inherent tension between rapid technological innovation and slower-moving regulatory frameworks is acutely manifested in Binance's cross-border operations, highlighting an urgent need for comprehensive scholarly examination.

2.Global Operations Overview of the Binance Platform

2.1 Development History of Binance

Founded in 2017 by Changpeng Zhao, Binance initially established its headquarters in China before relocating to the Cayman

Islands in response to evolving regulatory environment. The platform demonstrated remarkable user acquisition, growing its base from 2 million to 5 million users within its first six months, swiftly ascending to a leadership position in the global cryptocurrency market. By 2021, Binance had evolved into a comprehensive ecosystem offering a diverse suite of services, including spot and derivatives trading, staking, lending products, and its proprietary stablecoin, Binance USD. Its native token, BNB, achieved a peak market capitalization ranking third among all cryptocurrencies, trailing only Bitcoin and Ethereum.

2.2 Global Layout and Regulatory Response

Binance's operational model is characterized by a decentralized, multi-jurisdictional structure without a single, definitive global headquarters. Following regulatory restrictions in China, the entity strategically shifted its nominal base through various locations, including Hong Kong, Japan, and Malta. This agile, jurisdiction-hopping strategy exemplifies a form of regulatory arbitrage, enabling it to navigate diverse regulatory pressures while simultaneously attracting persistent challenges from national regulators worldwide.

In Asia, Binance encountered warnings from Japan's Financial Services Agency for unregistered operations (2018) and was placed on the investor alert list by Singapore's Monetary Authority (2021). In Western markets, the UK's Financial Conduct Authority prohibited its regulated activities, and multiple U.S. agencies initiated protracted investigations. Regulatory bodies in emerging markets, such as Malaysia's Securities Commission, have also enforced restrictive measures against Binance's local operations.

3. Risk Identification of the Binance Platform from a Global Regulatory Perspective

3.1 Compliance Risks: Cross-border Regulatory Arbitrage and Legal Classification Divergence

A primary source of Binance's compliance risk stems from the profound international divergence in the legal classification of digital assets. Its native BNB token, for instance, has been deemed an unregistered security by the U.S. Securities and Exchange Commission, classified as a virtual commodity in China, and categorized under the broader "crypto-asset" definition within the EU's MiCA framework. This lack of a unified legal characterization subjects Binance to conflicting regulatory obligations across different jurisdictions.

The platform has historically leveraged a structure that decouples its legal registration domicile from its primary operational and market presence. This allowed it to operate in markets like the U.S. through subsidiaries, sometimes without securing requisite licenses, such as the Money Services Business registration from the Financial Crimes Enforcement Network. The 2023 U.S. Department of Justice investigation, which concluded that Binance willfully enabled U.S. users to bypass restrictions, culminating in a record \$4.3 billion penalty for violations including the Bank Secrecy Act, starkly illustrates the vulnerabilities and ultimate unsustainability of this arbitrage-based model.

3.2 Technical Risks: Systemic Vulnerabilities and Deficiencies in Reserve Proofs

Binance's hybrid technical architecture, blending centralized infrastructure with blockchain elements, introduces inherent security vulnerabilities. The platform has suffered several high-profile security breaches, including a 2019 hot wallet compromise leading to significant Bitcoin theft and subsequent incidents involving API vulnerabilities. Concurrently, metrics indicating a decline in transaction processing throughput and increasing user complaint resolution times suggest a growing strain between its technological infrastructure and expanding operational scale.

Regarding user asset safeguarding, while Binance employs a Merkle-tree-based Proof-of-Reserves system, its credibility is undermined by low audit frequency and a self-selected audit partner model. The 2025 de-pegging event of the FDUSD stablecoin raised serious questions, with on-chain analytics suggesting a concerning over-reliance on the platform's own funds within its purported reserves, pointing to potential structural weaknesses in its custody and transparency practices.

3.3 Market Risks: High-Leverage Products and Market Integrity Concerns

Binance's market risk profile is significantly shaped by its offering of extremely high-leverage products—up to 125x—which amplify systemic fragility during periods of volatility. Instances of "cascading liquidations" triggered by coordinated selling from large holders have resulted in substantial losses, particularly for retail investors, underscoring deficiencies in the platform's risk disclosure and investor suitability protocols.

Furthermore, regulatory filings, such as those from the SEC, have alleged that entities closely affiliated with Binance engaged in wash trading to artificially inflate trading volumes and manipulate prices. A perceived lack of robust market surveillance and failure to intervene in markets with highly concentrated token ownership have raised significant concerns about the platform's commitment to market fairness and integrity.

3.4 Legal Risks: Anti-Money Laundering Failures and Cross-Jurisdictional Enforcement Challenges

Binance has faced severe legal repercussions for systemic failures in its Anti-Money Laundering and Counter-Financing of Terrorism controls. U.S. authorities determined that, for years, the platform knowingly processed transactions for entities in sanctioned jurisdictions, leading to a major penalty. Audits under the EU's AML directive also flagged anomalously high customer verification pass rates for high-risk regions, indicating lax Know Your Customer procedures. While Binance has since enhanced its identity verification with advanced biometric checks, challenges remain in effectively monitoring transactions involving anonymous wallet addresses.

Its globally distributed server infrastructure and lack of a clear central headquarters create substantial legal complexity. Cross-border investigations are frequently hampered by jurisdictional conflicts and data sovereignty laws (e.g., clashes between the U.S. CLOUD Act and EU's GDPR), leading to protracted delays and limited access to crucial evidence. This enforcement fragmentation effectively reduces the deterrence power of national regulators.

4. Global Regulatory Status and Core Issues

4.1 Comparative Analysis of Major National Regulatory Approaches

Regulatory responses to Binance have varied significantly across major economies. The United States has pursued a coordinated, multi-agency approach. The SEC has focused on securities law violations, the CFTC on derivatives trading, and the Department of Justice on criminal charges related to money laundering and sanctions violations. The resulting \$4.3 billion settlement is viewed as a watershed moment, establishing a precedent of severe consequences for compliance failures^[4].

The European Union has opted for a preemptive, legislative strategy with the Markets in Crypto-Assets regulation. This comprehensive framework establishes uniform licensing, governance, and consumer protection rules for crypto-asset service providers across the EU, aiming to reduce regulatory arbitrage opportunities within the single market.

Asian regulators demonstrate a spectrum of stances. Singapore maintains a calibrated approach, placing Binance on an alert list while permitting its local subsidiary to pursue licensing. China enforces a comprehensive ban. Japan has progressively integrated crypto exchanges into its regulated financial landscape via amended legislation, whereas countries like Malaysia have opted for outright prohibitions. This diversity reflects differing national priorities in balancing financial innovation with systemic risk control^[9].

4.2 Core Deficiencies in Existing Regulatory Mechanisms

4.2.1 Regulatory Tool Lag

Traditional financial regulatory instruments often prove inadequate for the unique attributes of the crypto market. Prudential requirements like capital adequacy ratios, designed for traditional banks facing credit and liquidity runs, fail to accurately capture the distinct risks of exchanges, such as those related to crypto-asset custody and settlement in a 24/7 market^[5]. The 2025 FDUSD incident highlighted the absence of real-time tools for monitoring the composition and liquidity of exchange reserves.

From a technological standpoint, the rapid evolution of blockchain—its pseudo-anonymity, cross-border nature, and programmability via smart contracts—outpaces the development of corresponding supervisory technologies. Regulators often find themselves conducting forensic analyses after incidents occur, lacking the capability for proactive surveillance and intervention against complex on-chain illicit activities^[7].

4.2.2 Structural Barriers to Cross-border Enforcement

The fundamental mismatch between the borderless operation of global crypto exchanges and the territorially bound nature of national regulators creates significant enforcement gaps. Binance's infrastructure, spread across dozens of countries, complicates jurisdictional claims. As research indicates, the efficacy of cryptocurrency regulation is heavily dependent on the quality of enforcement, which is hampered by these cross-border challenges^[1]. Legal conflicts, such as those between the

U.S. CLOUD Act and EU's GDPR, can stall international investigations for extended periods, as evidenced by a reported 14-month delay in an EU probe into Binance.

The absence of globally harmonized regulatory standards and effective information-sharing protocols further exacerbates the situation. Varying definitions of crypto-assets, divergent licensing regimes, and differing enforcement priorities create a patchwork of oversight, leading to both overlap and voids. The reliance on costly and often inefficient mutual legal assistance treaties (MLATs) or unilateral "long-arm" jurisdiction is insufficient for effectively policing global platforms like Binance^[9]. The well-documented use of cryptocurrencies for money laundering underscores the critical need for enhanced international cooperation^[3].

5. Optimization Strategies for Regulatory Mechanisms

5.1 Establishing Globally Harmonized Regulatory Standards

A pivotal step is championing the development of international regulatory standards through bodies like the International Organization of Securities Commissions (IOSCO). A core objective must be creating a unified taxonomy for crypto-assets. Clear classifications—such as treating platform tokens as digital asset securities and stablecoins as regulated electronic payment instruments—would align oversight with existing financial regulatory pillars (securities regulation, payment systems) and curtail arbitrage fueled by legal ambiguity. Evidence suggests that clear regulatory frameworks contribute significantly to market stability^[2].

Secondly, establishing a coordinated global regulatory sandbox initiative among major economies (e.g., G20) is advisable. Regulatory sandboxes provide controlled environments for testing innovations^[7]. A linked network of such sandboxes could facilitate "test once, comply with many" mechanisms, easing the regulatory burden on firms operating internationally and fostering regulatory learning and standard alignment.

5.2 Deepening the Application of Supervisory Technology (SupTech)

Deploying integrated blockchain analytics platforms is crucial for modernizing oversight. These systems, functioning as "regulatory data lakes," should synthesize multi-source data (on-chain transactions, off-chain intelligence, market data) to enable advanced analytics like address clustering, transaction pattern recognition, and network analysis. Intelligent models for anti-money laundering have demonstrated considerable potential in enhancing detection capabilities^[8]. Such systems can provide real-time alerts for suspicious activities like market manipulation or large-scale money laundering attempts.

Mandating regular, independent smart contract audits for core exchange functions is essential. Game-theoretic analysis suggests that exchanges' compliance incentives are shaped by the cost-benefit calculus of adhering to rules versus violating them^[6]. Audits help identify critical vulnerabilities. Regulators should possess the authority to mandate operational pauses if severe risks, such as insufficient reserves or critical code flaws, are identified.

Implementing a robust investor risk classification and product governance framework is necessary. The novel risks associated with decentralized finance (DeFi) and high-leverage products require tailored responses^[11]. This involves imposing appropriateness tests and knowledge assessments for complex products, alongside mandatory, clear risk disclosures at the point of sale to protect less sophisticated investors.

5.3 Strengthening Transnational Regulatory Cooperation

Creating a standing international coordination group, comprising regulators from key jurisdictions, could significantly improve collaboration. The global nature of cryptocurrency risks demands a coordinated international response^[9]. This group would facilitate regular dialogue, develop minimum global standards, and coordinate joint examinations and enforcement actions, thereby mitigating the inefficiencies caused by jurisdictional conflicts.

The establishment of a global investor compensation fund, financed by levies on exchange transaction revenue, would provide a vital safety net. A comprehensive regulatory approach to crypto-assets must include robust investor protection mechanisms^[10]. This fund would offer redress for losses stemming from exchange insolvency, hackings, or fraudulent activities. A centralized, global complaint portal would streamline the process for aggrieved users. Finally, enhancing regulatory transparency by publishing clear guidance on compliance expectations helps create a predictable operating environment and reduces regulatory uncertainty.

6. Conclusion and Outlook

This research, through a detailed examination of the Binance case, elucidates the multifaceted and inherently global challenge of regulating cryptocurrency exchanges. The trajectory of the industry points towards deeper integration with traditional finance, necessitating regulatory frameworks capable of dynamically balancing financial integrity with technological innovation. The Binance saga underscores that a reactive, enforcement-centric model is insufficient; a more effective paradigm involves holistic, lifecycle governance encompassing stringent ex-ante authorization, real-time SupTech-driven monitoring, and rigorous ex-post accountability. The tripartite strategy of standard harmonization, SupTech integration, and institutionalized cooperation offers a viable pathway towards constructing a resilient regulatory ecosystem. Such an ecosystem must be designed to mitigate systemic risks without stifling the transformative potential of blockchain technology, thereby fostering the sustainable and responsible development of the cryptocurrency industry.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Cumming, D., Fuchs, J., Momtaz, P. P. (2025). Market Reactions to Cryptocurrency Regulation: Risk, Return and the Role of Enforcement Quality. *British Journal of Management*, 36(4), 1709-1745. <https://doi.org/10.1111/1467-8551.70002>
- [2] Delbianco, F., Tohmé, F. (2025). Stability and Fractality in the Behavior of Currencies: Comparing Crypto Versus National Currencies. *Journal of Quantitative Economics*, (prepublish), 1-29. <https://doi.org/10.1007/S40953-025-00483-5>
- [3] Spyra, M., Balina, R., Balina, I. M., et al. (2025). Cryptocurrencies as a Tool for Money Laundering: Risk Assessment and Perception of Threats Based on Empirical Research. *Risks*, 13(10), 189. <https://doi.org/10.3390/RISKS13100189>
- [4] Chen, J., Wang, Y. T., An, L. L., et al. (2025). Insights into the U.S. Trend of Strategic Control over Digital Currencies from the Changpeng Zhao Case of Binance. *Northern Finance Journal*, (08), 50-57. <https://doi.org/10.16459/j.cnki.15-1370/f.2025.08.009>
- [5] Cheng, X. J. (2025). Risk Regulatory System for Cryptocurrencies in the Context of Blockchain Technology. *Economic Issues*, (10), 62-72.
- [6] Han, Z. C., Tian, Y. F., Yu, B. (2025). Evolutionary Game Analysis of Exchanges' Participation in Cryptocurrency Regulation. *North China Finance*, (04), 1-12. <https://doi.org/10.3969/j.issn.1007-4392.2025.04.001>
- [7] Liu, H., Tang, Y. (2024). On the Unified Regulation of Cryptocurrencies: Based on the Principle of Regulatory Sandbox. *Digital Economy and Rule of Law*, 3(02), 88-111.
- [8] Zhang, Y. F., Yuan, Y., Yang, D., et al. (2025). Intelligent Regulatory Research for Cryptocurrency Anti-Money Laundering: Models, Methods and Applications. *Journal of Intelligent Science and Technology*, 7(02), 165-183. <https://doi.org/10.11959/j.issn.2096-6652.202522>
- [9] Zhang, M., Bao, H., Wang, Y. (2025). Challenges of Cryptocurrencies to Global Financial Governance and Corresponding Responses. *Financial Regulation Research*, (03), 73-90. <https://doi.org/10.3969/j.issn.2095-3291.2025.03.005>
- [10] Zhang, T. (2021). Risks and Regulation of Cryptocurrencies. *Securities Market Herald*, (02), 72-79. <https://doi.org/10.3969/j.issn.1007-4392.2025.04.001>
- [11] Zhang, X. M. (2025). Risk Identification and Regulatory Responses to the Decentralized Nature of Cryptocurrencies. *Financial Regulation Research*, (04), 61-78. <https://doi.org/10.3969/j.issn.2095-3291.2025.04.004>

Research on the Development of New-Quality Productive Forces Driven by the Low-Altitude Economy under the Coupling of Finance, Technology and Policy

Junquan Ding*

School of Economics, Guangzhou College of Commerce, Guangzhou, 511363, China

**Corresponding author: Junquan Ding*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: In March 2024, the low-altitude economy was included in the Government Work Report for the first time, marking that it has been elevated to an important development direction at the national strategic level and has become a key carrier for fostering new-quality productive forces. Against the dual backdrop of global industrial transformation and domestic economic restructuring, the low-altitude economy, characterized by its long industrial chain, high technological content, and strong driving force, is gradually reshaping the pattern of economic development. This paper systematically sorts out the core theoretical connotations of the low-altitude economy and new-quality productive forces, and conducts an in-depth analysis of the internal logical connection between the two. Combining with China's low-altitude economy development environment, industrial structure and current situation, it focuses on exploring the coupling mechanism of the three major factors (finance, technology and policy) and their role in promoting the development of productive forces. The research shows that the low-altitude economy takes finance as the medium for capital circulation, technology as the orientation for innovative development, and policy as the support for standardization and guarantee. The synergistic effect formed by the three effectively breaks through the bottlenecks in industrial development, accelerates the process of technological progress and industrial upgrading, and injects sustained impetus into the growth of new-quality productive forces. This paper aims to provide theoretical references and practical paths for the high-quality development of the low-altitude economy and new-quality productive forces.

Keywords: Low-Altitude Economy; New-Quality Productive Forces; Financial Support; Technological Innovation; Policy Coordination

Published: Nov 2, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.842>

1.Introduction

Against the backdrop of the accelerated evolution of the new global technological revolution and industrial transformation, the low-altitude economy, as a strategic emerging industry integrating new technologies, new business forms, and new models, is becoming a new economic frontier contested by countries worldwide. In 2024, China's Government Work Report included the low-altitude economy for the first time, explicitly proposing to "actively build new growth engines such as the low-altitude economy," highlighting its strategic position in national economic development^[1]. Meanwhile, developing new-quality productive forces has become an inherent requirement and key focus for promoting high-quality development. With

its prominent characteristics of intensive innovation factors, high technological content, and strong industrial driving force, the low-altitude economy is naturally a typical representative of new-quality productive forces.

From the perspective of industrial development trends, China's low-altitude economy is undergoing a critical transition from the concept introduction stage to the high-speed growth stage. Data shows that the market size of China's low-altitude economy reached approximately 505.95 billion yuan in 2023, is expected to jump to 970.25 billion yuan in 2024, will exceed 1.5 trillion yuan in 2025, and is projected to reach 3.5 trillion yuan by 2035. Behind this exponential growth lies the combined effect of policy support, technological breakthroughs, and market demand. At the policy level, the policy system from the central to local governments is continuously improving, removing institutional barriers for the development of the low-altitude economy; at the technological level, the integrated application of new energy, artificial intelligence, and communication technologies is driving continuous upgrades in aircraft performance; at the market level, the increasing demand from diverse scenarios such as logistics and distribution, emergency rescue, and cultural tourism consumption is providing broad space for industrial development. However, the development of China's low-altitude economy still faces many challenges: there are shortcomings in core technology fields, with some components such as high-end chips and key materials relying on imports; the financial support system is still incomplete, with prominent issues of difficult and expensive financing for asset-light enterprises; policy details such as airspace management and safety supervision need further refinement. In this context, in-depth research on the intrinsic connection between the low-altitude economy and new-quality productive forces, and exploration of the coupled development path of finance, technology, and policy, are of important practical urgency.

2.Theoretical Connotations and Relationships between the Low-Altitude Economy and New-Quality Productive Forces

2.1 Definition of Core Concepts

2.1.1 Connotation and Characteristics of the Low-Altitude Economy

The low-altitude economy refers to the general term for economic activities such as production, services, and consumption carried out through the in-depth integration of aircraft with information technology, new energy technology, etc., utilizing low-altitude airspace resources below 1,000 meters above sea level. It is an economic form with both innovativeness and comprehensiveness. Its core composition includes three dimensions: first, the spatial carrier, i.e., low-altitude airspace resources, which are characterized by scarcity and controllability^[2]; second, technical support, covering core technologies such as aircraft R&D and manufacturing, communication and navigation, and intelligent control^[3]; third, application scenarios, including logistics and transportation, emergency rescue, cultural tourism consumption, and other diverse fields.

The low-altitude economy has distinct industrial characteristics: first, it has a long industrial chain, covering a complete ecosystem of upstream raw materials and core components, midstream aircraft manufacturing, and downstream application services, which can drive the development of multiple industries such as new materials, electronic information, and high-end manufacturing; second, it has high technological content, integrating cutting-edge technologies such as new energy, artificial intelligence, Beidou navigation, and 5G-A, with a fast pace of technological iteration; third, it has strong driving capacity. It is estimated that every 1 yuan of output value generated by the low-altitude economy can drive related industries to produce 6-8 yuan of added value; fourth, it has great development potential. At present, the utilization rate of China's low-altitude airspace resources is less than 15%, and with the improvement of openness, the market space will continue to expand.

2.1.2 Connotation and Characteristics of New-Quality Productive Forces

New-quality productive forces refer to a new form of productive forces dominated by scientific and technological innovation, with the core connotation of the upgrading of laborers, means of labor, objects of labor, and their optimal combination, and with the improvement of total factor productivity as the core. Its core characteristics are reflected in three aspects: first, innovation-driven, different from the growth model of traditional productive forces relying on the input of resource factors, new-quality productive forces take technological innovation, model innovation, and institutional innovation as the core driving forces; second, quality and efficiency first, focusing on the quality and efficiency of development, pursuing the improvement of total factor productivity rather than mere scale expansion; third, green and low-carbon, conforming to the

requirements of high-quality development, and balancing economic and ecological benefits.

The cultivation of new-quality productive forces needs to rely on strategic emerging industry carriers, and the low-altitude economy is a typical representative. As General Secretary Xi Jinping emphasized, “developing new-quality productive forces is an inherent requirement and important focus for promoting high-quality development.” Through technological innovation and industrial integration, the low-altitude economy is becoming an important growth pole for cultivating new-quality productive forces.

2.2 Intrinsic Relationship between the Low-Altitude Economy and New-Quality Productive Forces

2.2.1 The Low-Altitude Economy is an Important Industrial Carrier of New-Quality Productive Forces

The development process of the low-altitude economy is essentially the process of the formation and release of new-quality productive forces. At the level of production factors, the low-altitude economy promotes the upgrading of means of labor. New aircraft such as drones and eVTOLs replace traditional production tools, significantly improving production efficiency; at the level of production methods, the integration of digital and intelligent technologies with traditional industries has spawned new production models such as smart agricultural plant protection and intelligent logistics distribution; at the level of industrial forms, it has cultivated new business forms such as drone operations and low-altitude traffic management, promoting the upgrading of industrial structure to high-end.

For example, the application of drones in the agricultural field has increased plant protection efficiency by more than 50 times and reduced the operation cost per mu by 30%; low-altitude logistics distribution has shortened the delivery time in remote areas from several days to several hours, all of which reflect the core characteristic of new-quality productive forces of “priority to quality and efficiency.” Data shows that the total factor productivity of industries related to the low-altitude economy is more than 40% higher than that of traditional industries, becoming an important manifestation of new-quality productive forces.

2.2.2 New-Quality Productive Forces Provide Direction Guidance for the Development of the Low-Altitude Economy

The development requirements of new-quality productive forces have pointed out the upgrading path for the low-altitude economy. In terms of the direction of technological innovation, new-quality productive forces emphasize the independent controllability of core technologies, promoting the low-altitude economy to make breakthroughs in “bottleneck” fields such as high-end chips and autonomous flight control; in terms of industrial development models, new-quality productive forces advocate green and low-carbon development, guiding the transformation of low-altitude economy aircraft to electrification and hydrogenation; in terms of value realization, new-quality productive forces focus on people’s well-being, promoting the expansion of the application of the low-altitude economy in public service fields such as emergency rescue and medical care^[4]. The two form a positive cycle of mutual promotion: technological breakthroughs and industrial upgrading of the low-altitude economy drive the development of new-quality productive forces, and the development requirements of new-quality productive forces lead the low-altitude economy towards higher quality and more sustainable development.

3. Development Environment, Industrial Structure and Current Status of China’s Low-Altitude Economy

3.1 Analysis of Development Environment

3.1.1 Policy Environment: Coordinated Advancement of Top-Level Design and Local Practice

China has established a policy system featuring “central overall planning and local implementation,” providing institutional guarantees for the development of the low-altitude economy. At the central level, the National Comprehensive Multi-Dimensional Transportation Network Planning Outline (2021) incorporated the concept of the low-altitude economy for the first time; the 2024 Government Work Report listed it as a new growth engine; and the Interim Regulations on the Management of Unmanned Aerial Vehicle (UAV) Flights officially took effect in January 2024, regulating UAV flight activities. Multiple departments have collaborated to play their respective roles: the Ministry of Transport is responsible for airspace opening and infrastructure construction, the Civil Aviation Administration of China (CAAC) oversees standard-setting and safety supervision, and the Ministry of Industry and Information Technology (MIIT) promotes technological

innovation and industrial development^[5].

At the local level, various regions have issued specialized policies, forming a pattern of differentiated development. Shenzhen, known as the “UAV Capital,” took the lead in establishing a low-altitude economy legal system through local legislation; Hunan Province released the Low-Altitude Economy Development Plan (2024-2030), proposing to build a central China low-altitude economy hub; and provinces such as Anhui and Sichuan have set up pilot demonstration zones to explore application scenario models. By the end of 2024, more than 20 provinces across the country had issued policies related to the low-altitude economy, and policy dividends continued to be released.

3.1.2 Technological Environment: Multi-Field Technological Breakthroughs Lay the Foundation for Development

China has achieved multiple breakthroughs in low-altitude economy-related technological fields, providing technical support for industrial development. In terms of aircraft manufacturing, a full-range product system—from micro-UAVs to large-scale eVTOLs (electric Vertical Take-Off and Landing aircraft)—has been formed. DJI Innovations holds over 70% of the global consumer UAV market share, and EHang Intelligent’s autonomous eVTOLs have launched commercial demonstration operations. In the field of core components, the localization rate of flight control systems has exceeded 60%, and the accuracy of Beidou high-precision positioning modules has reached the centimeter level.

In terms of supporting technologies, China’s 5G-A technology leads the world and has achieved low-altitude coverage in multiple pilot areas; the production capacity of carbon fiber composite materials is growing rapidly, expected to reach over 150,000 tons by 2025, effectively reducing aircraft manufacturing costs; the application of artificial intelligence (AI) in autonomous obstacle avoidance and path planning has been continuously deepened, improving flight safety and efficiency. However, there are still shortcomings in areas such as high-end aviation-grade chips and high-energy-density batteries, which require further breakthroughs.

3.1.3 Market Environment: Joint Force of Demand Expansion and Capital Entry

China’s large market scale and diversified demand provide broad space for the development of the low-altitude economy. In the consumer sector, demand for aerial tours and film/television aerial photography continues to grow, with the 2024 consumer UAV market scale exceeding 20 billion yuan; in the production sector, industrial applications such as agricultural plant protection and power inspection have spread rapidly, with the national agricultural UAV operation area exceeding 1 billion mu (approximately 66.7 million hectares); in the public service sector, scenarios such as emergency rescue and medical transportation have been continuously expanded, with UAVs participating in over 10,000 emergency rescue operations in 2024.

At the capital level, the low-altitude economy has become an investment hotspot, forming a multi-level capital support system. By the end of 2024, China had established more than 10 provincial-level low-altitude economy industrial funds, among which the Zhejiang Airport Low-Altitude Economy Equity Investment Fund reached a scale of 3 billion yuan. The banking industry has actively deployed resources: banks such as SPD Bank and Bank of Communications have launched specialized financial products. As of 2024, the balance of technology loans of SPD Bank Shenzhen Branch exceeded 80 billion yuan, serving nearly 200 low-altitude economy-related enterprises^[6].

3.2 Analysis of Industrial Structure

China’s low-altitude economy has formed a complete industrial chain ecosystem covering the upstream, midstream, and downstream, with distinct value distribution and development characteristics in each link.

3.2.1 Upstream: Infrastructure and Core Components Support Industrial Development

The upstream link includes raw materials, core components, and infrastructure, serving as the cornerstone of industrial development, accounting for approximately 30% of the total value. In the raw materials field, the supply of metal materials such as aluminum alloy and titanium alloy is sufficient, with aluminum alloy output expected to reach 17.72 million tons by 2025; the production capacity of carbon fiber composite materials is growing rapidly, gradually realizing import substitution. In the core components field, five core segments are formed: power systems, flight control systems, navigation and communication systems, perception systems, and key chips. Among them, the flight control system has the highest

localization rate, while power systems and key chips remain weak links.

In the infrastructure field, the construction of general airports and low-altitude traffic management systems has accelerated. By the end of November 2024, the number of general airports in China had reached 470, an increase of 60% compared with 2020; the civil unmanned aerial vehicle integrated management platform was put into operation, providing integrated services such as airspace delineation and flight application. However, infrastructure still faces the problem of uneven regional distribution—the density of general airports in eastern China is more than three times that in central and western regions.

3.2.2 Midstream: Aircraft Manufacturing Becomes the Core of Value

The midstream link focuses on aircraft whole-machine manufacturing, which is the most technology-intensive and high-value-added segment, accounting for approximately 50% of the total value. This link can be divided into two categories: traditional general aviation aircraft and new-type unmanned aerial vehicles. In the traditional general aviation aircraft field, the manufacturing of helicopters and fixed-wing aircraft has developed steadily, with 3,226 registered general aviation aircraft and 1.23 million flight hours in 2024.

New-type unmanned aerial vehicles are the core of growth, forming two major segmented markets: consumer-grade and industrial-grade. In the consumer-grade UAV market, Chinese enterprises dominate globally, with companies such as DJI Innovations and Zero Tech leading in technology; in the industrial-grade UAV market, enterprises such as SF Express's Fengniao and EHang Intelligent have made breakthroughs in logistics and transportation, with the test flight success rate of eVTOL prototypes exceeding 95%. In 2024, the number of UAV operation enterprises in China was nearly 19,000, with 2.158 million registered UAVs and 25.449 million flight hours, a year-on-year increase of 15.3%.

3.2.3 Downstream: Expansion of Application Scenarios Releases Industrial Value

The downstream link covers diversified application scenarios and services, serving as the outlet for value realization. Although it accounts for only about 20% of the total value, it has the strongest radiating and driving effect. According to application fields, it can be divided into three categories: first, production services, including agricultural plant protection, power inspection, and geographic surveying and mapping, with a 2024 market scale exceeding 300 billion yuan, accounting for the largest share; second, consumer services, including aerial tours, film/television aerial photography, and competitive sports, with the fastest growth rate (a year-on-year increase of 45% in 2024); third, public services, including emergency rescue, medical transportation, and urban patrol, featuring obvious policy-driven characteristics and having been applied regularly in more than 20 provinces.

The innovative development of the downstream link has promoted the transformation of the low-altitude economy from a single business form to a comprehensive economic form. For example, "UAV + logistics" has reduced logistics costs in rural and remote areas, and "eVTOL + medical care" has shortened emergency rescue response time to less than 30 minutes. These scenario applications fully reflect the role of the low-altitude economy in improving productivity.

3.3 Current Development Status and Existing Problems

3.3.1 Current Development Status

China's low-altitude economy has entered a stage of high-speed development, showing a sound momentum of rapid scale growth, continuous structural optimization, and enhanced innovation vitality. In terms of scale, the market size reached 505.95 billion yuan in 2023 and is expected to exceed 970 billion yuan in 2024, nearly doubling in two years; in terms of structure, the proportion of high-value-added industrial applications increased from 40% in 2020 to 60% in 2024, with the industrial structure upgrading to high-end; in terms of innovation, the number of patent applications related to the low-altitude economy exceeded 100,000 in 2024, a 200% increase compared with 2020, leading the world in technological innovation activity.

Regional development has formed a characteristic pattern: eastern China focuses on technology R&D and scenario application, with Shenzhen, Shanghai, and Guangzhou becoming core industrial cities; central China relies on its manufacturing foundation to develop the aircraft manufacturing industry, with Hunan and Anhui forming industrial clusters; western China leverages its airspace resource advantages to focus on low-altitude tourism and logistics services. This pattern of differentiated regional development is in line with China's resource endowments and industrial foundation, promoting the

balanced development of the low-altitude economy.

3.3.2 Existing Problems

Despite significant progress, the development of China's low-altitude economy still faces many challenges. At the technological level, there are shortcomings in core components: the localization rate of high-end aviation-grade MCU (Microcontroller Unit) and FPGA (Field-Programmable Gate Array) chips is less than 30%, and solid-state batteries are still in the laboratory stage, restricting the improvement of aircraft performance; the reliability of autonomous flight control systems under complex weather conditions needs to be improved, affecting large-scale commercial applications.

At the financial level, the adaptability of the financing system is insufficient. Most low-altitude economy enterprises are asset-light technology-based enterprises, lacking traditional collateral and thus struggling to meet bank credit requirements; venture capital is mostly concentrated in enterprises in the growth stage, with prominent financing difficulties in the early R&D stage; financial product innovation is insufficient, and there are few exclusive products for the low-altitude economy (such as specialized insurance and supply chain finance), which cannot cover the diversified needs of industrial development.

At the policy level, airspace management still needs optimization: the delineation of low-altitude airspace is not clear enough, the cross-regional flight approval process is complicated, and some regions face the problem of "visible airspace but unallowable flights"; the standard system is not yet sound: standards in aircraft certification, flight safety, and data management are missing or inconsistent, affecting the standardized development of the industry; safety supervision capabilities need to be enhanced: the coverage of low-altitude traffic management systems is insufficient, and supervision methods for illegal activities such as "unauthorized flights" are limited.

4. Mechanism of the Low-Altitude Economy Driving the Development of New-Quality Productive Forces under the Coupling of Finance, Technology, and Policy

4.1 Financial Factor: Core Support for Capital Circulation and Risk Sharing

4.1.1 Main Paths of Financial Support for the Low-Altitude Economy

Finance provides all-round support for the development of the low-altitude economy through three core functions: capital circulation, risk sharing, and resource allocation. In terms of capital circulation, a multi-level system of "debt + equity + policy funds" has been established.

For debt financing: Banks have launched products such as intellectual property pledge loans and supply chain finance. For instance, Bank of Shanghai provides patent pledge loans for agricultural UAV enterprises, while China Minsheng Bank supports aircraft projects through park development loans.

For equity financing: Venture capital institutions and industrial funds have actively deployed resources. The first phase of the Zhejiang Airport Low-Altitude Economy Fund, with a scale of 1 billion yuan, has completed investments, focusing on supporting aircraft manufacturing enterprises.

For policy funds: The central and local governments have set up special subsidies to provide financial support for technology R&D and scenario demonstration projects.

In terms of risk sharing, insurance institutions have developed exclusive products to cover the full-chain risks of aircraft manufacturing, operation, and maintenance. For example, a combined insurance product ("aircraft hull insurance + third-party liability insurance + cargo transportation insurance") has been launched for logistics UAVs, effectively reducing the operational risks of enterprises.

In terms of resource allocation, financial institutions guide capital to concentrate on core technology and high-value-added fields through credit orientation and investment preferences. In 2024, financing for the core technology sector of the low-altitude economy accounted for 70% of the total, promoting the upgrading of the industrial structure.

4.1.2 Case Analysis of Finance Addressing Development Bottlenecks of the Low-Altitude Economy

The practice of SPD Bank (Shanghai Pudong Development Bank) serves as a typical example of financial support for the low-altitude economy. Its Shanghai Branch, in collaboration with Shanghai Low-Altitude Economy Development Co., Ltd., jointly established the "Low-Altitude Financial Service Research Institute"—China's first professional financial research institution dedicated to the low-altitude economy. To address the asset-light nature of low-altitude economy enterprises, SPD

Bank innovatively launched a “technology-driven” credit model. Instead of relying on traditional collateral, credit is granted based on indicators such as an enterprise’s R&D investment, number of patents, and technical team. By the end of 2024, the bank had provided financing support to nearly 200 low-altitude technology enterprises, with start-ups accounting for 40%, effectively resolving the financing difficulties faced by early-stage enterprises.

The Zhejiang Airport Low-Altitude Economy Fund exerts its role through a “fund + scenario + infrastructure” model. In addition to providing capital support to enterprises, the fund leverages the resource advantages of Zhejiang Airport Group to offer invested enterprises resources such as apron space, flight test sites, and scenario demonstration opportunities. For example, an eVTOL enterprise invested by the fund obtained test site support from Hangzhou Xiaoshan Airport through the fund platform, accelerating the commercialization of its technology and shortening the cycle from R&D to demonstration operation by 18 months.

4.2 Technological Factor: Core Driver of Innovation and Efficiency Improvement

4.2.1 Path of Core Technological Breakthroughs Promoting Industrial Upgrading

Technological innovation is the core driver of the low-altitude economy’s development. It fosters and advances new-quality productive forces by upgrading production tools, transforming production methods, and innovating industrial forms.

In upgrading production tools: New aircraft such as UAVs and eVTOLs have replaced traditional tools, achieving a leap in production efficiency. For example, power inspection UAVs have replaced manual inspection, increasing efficiency by more than 10 times and raising the fault detection rate from 60% to 95%.

In transforming production methods: Digital and intelligent technologies have driven the in-depth integration of the low-altitude economy with traditional industries. In smart agriculture, UAVs combined with AI technology enable precise sowing, fertilization, and plant protection, increasing per-mu yield by 10% and reducing pesticide usage by 30%. In intelligent logistics, UAVs integrated with big data realize path optimization and intelligent scheduling, improving distribution efficiency by 50%.

In innovating industrial forms: Technological breakthroughs have spawned new business formats such as urban air mobility, low-altitude tourism, and UAV logistics, expanding the space for economic development.

4.2.2 Typical Case of Technological Innovation Fostering New-Quality Productive Forces

EHang Intelligent’s autonomous eVTOL technology is a typical representative of technological innovation fostering new-quality productive forces. The company’s independently developed EH216-S autonomous eVTOL integrates multiple core technologies, including flight control systems, navigation and communication, and artificial intelligence, enabling fully autonomous flight, intelligent obstacle avoidance, and cluster scheduling. In the demonstration operation in Nansha, Guangzhou, this aircraft has completed over 10,000 manned flights, with an on-time rate of 99%, shortening the 30-kilometer ground travel time from 1 hour to 15 minutes.

This technology has not only driven the innovation of low-altitude transportation formats but also promoted the development of upstream and downstream industries. Upstream: It has advanced the upgrading of material and component industries such as carbon fiber composites and high-energy-density batteries. Midstream: It has formed large-scale manufacturing capabilities for autonomous eVTOLs. Downstream: It has spawned new business formats such as air taxis and sightseeing tours.

It is estimated that the industrial chain related to this technology has created an output value of over 10 billion yuan, with total factor productivity 60% higher than that of the traditional aviation industry—fully demonstrating the role of technological innovation in fostering new-quality productive forces.

4.3 Policy Factor: Core Guarantee for Standardized Guidance and Support

4.3.1 Main Dimensions of Policy Support for the Low-Altitude Economy

Policies provide guarantees for the development of the low-altitude economy through three key dimensions: institutional supply, planning guidance, and regulatory standardization.

In institutional supply: A sound legal and regulatory system defines the institutional framework for industrial development. The Interim Regulations on the Management of Unmanned Aerial Vehicle Flights clarifies the classified management standards and flight rules for UAVs, resolving the issue of “lack of legal basis.” At the local level, legislation on the low-

altitude economy refines policy measures based on regional realities, providing specific guidance for industrial development. In planning guidance: Development plans at the central and local levels clarify the direction and key tasks of industrial development. National-level plans focus on core technological breakthroughs, infrastructure construction, and airspace opening. Local plans, based on regional advantages, define differentiated development paths—for example, Shenzhen focuses on technology R&D and scenario application, while Hunan focuses on aircraft manufacturing.

In regulatory standardization: A supervision system featuring “government supervision + industry self-regulation + technical support” has been established. Intelligent supervision is realized through the Civil Unmanned Aerial Vehicle Integrated Management Platform, ensuring the safe development of the industry^[7].

4.3.2 Practical Case of Policies Guiding the Healthy Development of the Industry

Shenzhen’s policy practice on the low-altitude economy serves as a model for policies guiding the healthy development of the industry. As a pioneer city in China’s low-altitude economy development, Shenzhen has promoted the rapid development of the low-altitude economy through a policy path of “legislation first, planning guidance, and pilot breakthroughs.”

In legislation: The Regulations on Promoting the Low-Altitude Economy of the Shenzhen Special Economic Zone, issued in 2024, is China’s first local regulation on the low-altitude economy, clarifying key systems such as airspace management, infrastructure construction, and safety supervision^[8].

In planning: Shenzhen has formulated the Low-Altitude Economy Development Plan (2024-2030), proposing an industrial layout of “one core, two zones, and three belts” and setting a target of achieving a low-altitude economy scale of over 100 billion yuan by 2025.

In pilots: Low-altitude economy demonstration zones have been established in districts such as Bao’an and Longhua to carry out scenario pilots in UAV logistics and air transportation, forming a policy implementation mechanism of “pilot - summary - promotion.”

By the end of 2024, Shenzhen had over 3,000 low-altitude economy enterprises, accounting for 25% of the national total, demonstrating the remarkable effectiveness of policy guidance.

4.4 Coupling Mechanism of the Three Factors and Their Role in Driving New-Quality Productive Forces

4.4.1 Formation Path of the Finance-Technology-Policy Coupling Mechanism

The three factors—finance, technology, and policy—do not function in isolation but form a mutually promoting and supporting coupling mechanism:

Policy provides institutional guarantees for the development of finance and technology. It guides financial capital to flow into core technology fields by establishing special funds and introducing subsidy policies.

Finance provides capital support for technological innovation. It drives technology from the laboratory to the market through R&D loans and venture capital.

Technological breakthroughs provide support for financial innovation and policy optimization. The application of new technologies generates new financial demands and promotes the continuous improvement of policies.

Specifically, the formation of the coupling mechanism includes three stages:

Policy Guidance Stage: The government guides financial capital to focus on the low-altitude economy’s technology sector by issuing development plans and support policies.

Financial Empowerment Stage: Financial institutions innovate products and services to provide capital support for technology R&D and industrialization.

Collaborative Upgrading Stage: Technological breakthroughs drive industrial development, which in turn triggers new policy demands and financial innovations, forming a positive cycle.

4.4.2 Internal Logic of the Coupling Effect Driving New-Quality Productive Forces

The coupling effect of the three factors drives the development of new-quality productive forces by improving total factor productivity^[9], which is specifically reflected in three aspects. Efficiency Improvement Effect: Policies optimize airspace resource allocation, finance supports infrastructure construction, and technology enhances aircraft performance. The three

factors work together to improve the operational efficiency of the low-altitude economy, thereby driving efficiency upgrades in related industries. **Innovation-Driven Effect:** Policies provide innovation incentives, finance shares innovation risks, and technology achieves innovation breakthroughs. This forms an innovation ecosystem, promoting technological progress and model innovation.

Structure Optimization Effect: By guiding capital and technology to concentrate in high-end fields, it drives the industrial structure toward high-end, intelligent, and green upgrading, fostering new industrial growth points.

Take the UAV logistics industry as an example: At the policy level: The Civil Aviation Administration of China (CAAC) has approved pilot projects for the construction of low-altitude UAV logistics systems, simplifying flight approval procedures. At the financial level: Industrial funds invest in logistics UAV enterprises, and banks provide supply chain financial services. At the technical level: Breakthroughs have been made in autonomous flight control and navigation communication technologies. The coupling of these three factors has promoted the large-scale application of UAV logistics. In 2024, the national UAV logistics delivery volume exceeded 100 million items, a 300% increase compared with 2022. Logistics efficiency has more than doubled, and logistics costs have decreased by 30%—fully demonstrating the role of the coupling effect in driving new-quality productive forces.

5. Conclusions and Path Recommendations

5.1 Research Conclusions

Through theoretical and practical research on the low-altitude economy and new-quality productive forces, this paper draws the following conclusions: First, there is a close intrinsic connection between the low-altitude economy and new-quality productive forces. As a strategic emerging industry intensive in innovation factors, the low-altitude economy serves as an important industrial carrier for new-quality productive forces; meanwhile, the development requirements of new-quality productive forces provide directional guidance for the low-altitude economy, and the two form a positive cycle of mutual promotion. Second, major countries around the world have formed differentiated development models for the low-altitude economy. The market-led model of the United States, the collaborative linkage model of Europe, and the policy-driven model of Japan all reflect the synergy of financial, technological, and policy factors. Their experiences in airspace management, technological innovation, and policy coordination hold important reference value for China. Third, China's low-altitude economy has formed a complete industrial ecosystem, with a continuously optimized policy environment, continuous breakthroughs in technological innovation, and growing market demand. However, it still faces problems such as shortcomings in core technologies, insufficient financial support, and incomplete policy details, which restrict the high-quality development of the industry. Fourth, the coupling mechanism of the three major factors—finance, technology, and policy—is the core driving force for the development of the low-altitude economy. Policies provide institutional guarantees, finance provides capital support, and technology provides innovation momentum. The synergistic effect formed by the three effectively breaks through the bottlenecks in industrial development, and promotes the sustained growth of new-quality productive forces through efficiency improvement, innovation-driven development, and structural optimization.

5.2 Path Recommendations

5.2.1 Build a Multi-Level Financial Support System and Strengthen Capital Guarantee Capabilities

First, innovate financial products and services. In response to the asset-light characteristics of low-altitude economy enterprises, promote financing models such as intellectual property pledge and equity pledge; develop combined “loan + insurance + guarantee” products to reduce financing risks. Draw on SPD Bank's “technology-focused” credit model to establish a credit evaluation system suitable for technology-based enterprises.

Second, improve capital market support. Encourage qualified low-altitude economy enterprises to go public for financing and set up a dedicated low-altitude economy section on the Science and Technology Innovation Board (STAR Market); expand the scale of industrial funds, guide the participation of social capital, and form a multi-level investment system consisting of “government-guided funds + industrial funds + venture capital funds”. Refer to the model of Zhejiang Airport Fund to realize comprehensive empowerment of “capital + scenarios + resources”.

Third, improve the risk-sharing mechanism. Promote insurance institutions to develop exclusive products such as aircraft

manufacturing insurance, operation insurance, and liability insurance; establish a government risk compensation fund to provide appropriate compensation for low-altitude economy loan losses of financial institutions; explore a “regulatory sandbox” mechanism to provide a fault-tolerance space for financial innovation.

5.2.2 Break Through Core Technology Bottlenecks and Enhance Independent Innovation Capabilities

First, focus on key technology research. Establish a list of “bottleneck” technologies and prioritize breakthroughs in core fields such as high-end aviation-grade chips, solid-state batteries, and autonomous flight control systems. Build an industry-university-research collaborative innovation platform, encourage enterprises to set up joint laboratories with universities and research institutes, and accelerate technology transformation.

Second, improve the technological innovation ecosystem. Strengthen intellectual property protection, establish a low-altitude economy patent pool to promote technology sharing; set up a technological innovation reward fund to offer heavy rewards for original breakthroughs; promote the formulation of technical standards, participate in the construction of international standard systems, and enhance international discourse power.

Third, promote the integrated application of technologies. Facilitate the in-depth integration of low-altitude economy technologies with new energy, artificial intelligence, 5G-A, and other technologies; accelerate scenario-based demonstration applications, create a number of benchmark technology application projects in logistics, emergency response, cultural tourism, and other fields, and form a transformation path of “technology - scenarios - industry”.

5.2.3 Optimize the Policy System and Strengthen Institutional Guarantee Capabilities

First, improve the airspace management mechanism. Accelerate the delineation of low-altitude airspace and clarify the boundaries between controlled airspace and usable airspace; establish a national unified low-altitude flight service platform, simplify the flight approval process, and realize “one-stop online handling”; expand the scope of low-altitude opening pilot projects to accumulate regional management experience.

Second, improve the standardization system. Formulate national standards in fields such as aircraft design and manufacturing, safe operation, and data management; establish an aircraft certification system to achieve alignment with international standards; improve the qualification certification system for practitioners and enhance the professionalization level of the industry.

Third, strengthen policy coordination and linkage. Establish an inter-departmental coordination mechanism to coordinate policies of civil aviation, industry and information technology, transportation, finance, and other departments; strengthen regional policy coordination to break down local protectionism and regional barriers; promote coordination between policies and the market, giving play to the guiding role of the government while fully stimulating market vitality.

5.2.4 Promote the Coupling and Coordination of Factors to Release Synergistic Development Momentum

First, build a factor coordination platform. Establish a national-level low-altitude economy collaborative development center to coordinate financial, technological, and policy resources; set up a factor matching mechanism and regularly hold low-altitude economy investment and financing matching meetings and technical exchange conferences.

Second, build industrial ecological clusters. Construct low-altitude economy industrial parks in regions with solid industrial foundations to gather enterprises engaged in R&D, manufacturing, operation, services, and other links; promote coordination between the upper, middle, and lower reaches of the industrial chain, and cultivate a number of industrially leading enterprises with international competitiveness.

Third, strengthen international cooperation and exchanges. Draw on advanced international experience and participate in global low-altitude economy governance; attract international high-end technologies and capital to enter China’s market, while supporting domestic enterprises to “go global” and participate in international competition and cooperation.

With the in-depth coupling of financial, technological, and policy factors, the low-altitude economy will usher in explosive growth, become a core growth pole of new-quality productive forces, and provide solid support for China’s high-quality economic development and the construction of a modern industrial system.

Funding

No

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Wen, N. (2024). Constructing a low-altitude economy development system to build an internationally influential “city of the stars”. *Policy Outlook*, (04), 33-38.
- [2] Liao, X. H., Huang, Y. H., & Xu, C. C. (2021). Research on low-altitude airspace resources for unmanned aerial vehicle applications. *Acta Geographica Sinica*, 76(11), 2607-2620.
- [3] Li, S. J. (2024). Practical paths for new-quality productive forces to empower the development of the low-altitude economy in Hainan Free Trade Port. *People’s Tribune · Academic Frontier*, (15), 76-83.
- [4] Hong, Q. L. (2024). Conceptual characteristics, development conditions and promotion countermeasures of the low-altitude service industry. *Economic Review*, (08), 45-52.
- [5] Chen, G. X., Zhao, Y. N., Zhong, B. L., et al. (2022). Research on the impact of laws and regulations such as the Civil Code on the aviation industry. *China Storage & Transport*, (09), 96-99.
- [6] Gong, S. (2019). Study on the improvement of marketing strategies for personal financial products of SPD Bank Shenzhen Branch. Lanzhou University.
- [7] Ma, Z. F., & Hu, L. (2020). International law on financial security in the construction of a community with a shared future in cyberspace. *Shanghai Finance*, (10), 69-79.
- [8] Li, C. (2024). The low-altitude economy gathers momentum for “take-off”. *East China Science & Technology*, (08), 18-21.
- [9] Shen, J. B. (2024). Thoughts on the path selection of rural revitalization from the perspective of new-quality productive forces. *Journal of Smart Agriculture*, 4(19), 172-175.

Digital Infrastructure Development Driving the Intelligent Transformation of Manufacturing: Technological Application Scenarios and Policy Optimization Strategies

Liyu Ge*, Keke Ning, Mengyi Zheng

School of Public Finance and Taxation, Guangdong University of Finance & Economics, Guang'zhou, 510320, China

*Corresponding author: Liyu Ge, 1246523179@qq.com

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: The analysis begins by deconstructing the conceptual architecture of digital infrastructure, articulating how its core components—ubiquitous connectivity, pervasive sensing, distributed computation, and integrative platforms—logically necessitate the emergence of key manufacturing capabilities such as real-time perception, data-driven cognition, adaptive response, and systemic integration. These capabilities are then logically synthesized into three representative technological application scenarios: holistic visibility and optimization, predictive intervention and autonomous quality assurance, mass customization through flexible reconfiguration. The paper further deduces the inherent socio-technical challenges that arise from this infrastructural transformation, including economic barriers, structural complexities, and skill obsolescence. Finally, through logical extension, the paper proposes a holistic set of policy optimization strategies designed not to subsidize technology adoption per se, but to cultivate a fertile ecosystem that addresses these inherent challenges, fosters innovation, and ensures the equitable and sustainable evolution of the manufacturing sector.

Keywords: Digital Infrastructure; Intelligent Manufacturing; Technological Scenarios; Policy Strategy; Logical Framework; Socio-Technical Systems; Ecosystem

Published: Nov 3, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.796>

1.Introduction

1.1 The Paradigmatic Imperative of Intelligent Manufacturing

The global manufacturing sector is undergoing a transformation that is not merely incremental but paradigmatic in nature. This shift, often termed the Fourth Industrial Revolution or Industry 4.0, represents a fundamental departure from the logic of automated but isolated production systems. The driving forces behind this shift are multifaceted and self-reinforcing. Intensifying global competition compels a relentless pursuit of operational excellence beyond what traditional models can offer. Concurrently, the maturation of consumer markets fosters a demand for personalization that mass production cannot economically satisfy. Furthermore, the increasing volatility of supply chains and resource markets necessitates a level of agility and resilience that rigid, centralized systems are incapable of achieving. In this context, intelligent manufacturing emerges not as a discretionary strategic option, but as a logical and necessary response to these systemic pressures. It posits a future where manufacturing systems are not only automated but are characterized by connectivity, intelligence, adaptability, and a degree of autonomy, enabling them to self-optimize in response to a dynamic internal and external environment.

1.2 The Centrality of Digital Infrastructure

While the vision of intelligent manufacturing is widely acknowledged, a critical conceptual clarification is required: this new paradigm is fundamentally predicated upon a new layer of societal and industrial capability—digital infrastructure. To conceptualize this transformation as primarily about the adoption of advanced robotics or specific software applications is to mistake the symptoms for the cause. Traditional infrastructure—the physical networks of transport, energy, and utilities—remains indispensable, but it is no longer sufficient. In the age of information, the critical resource that flows through the economic system is data. Digital infrastructure, therefore, constitutes the essential pathways, processing hubs, and governance frameworks for this new resource. It forms the central nervous system of the intelligent manufacturing ecosystem, without which the advanced functions of perception, cognition, and coordinated action remain unrealizable. The development of this infrastructure, therefore, is not a parallel activity to manufacturing transformation; it is the foundational activity upon which transformation depends.

1.3 Literature Review

This study builds upon existing theoretical research concerning the relationship between digital infrastructure and the transformation towards intelligent manufacturing. Current academic inquiry primarily explores this relationship across three dimensions: technological architecture, capability evolution, and system integration.

At the level of technological architecture, scholars generally recognize the layered characteristics of digital infrastructure. Zhou et al. (2015) proposed a five-layer architecture for cyber-physical systems within the context of Industry 4.0, providing a systematic framework for understanding the technological foundations of intelligent manufacturing^[1]. Xu et al. (2018) further elaborated on the core role of the Industrial Internet Platform (IIP) as the “operating system” for intelligent manufacturing, emphasizing its key value in resource integration and optimal allocation^[2].

Regarding capability evolution, researchers focus on how digital infrastructure enables the intellectualization of manufacturing systems. Kagermann et al. (2013) early on indicated that Industry 4.0 would realize a shift from automation to autonomy, a process highly dependent on data-driven decision-making capabilities^[3]. The industrial big data analytics framework proposed by Lee et al. (2015) systematically delineated the pathways and methods for transforming data into manufacturing intelligence^[4]. Liao et al. (2017), through case studies, validated the specific roles of technologies like cloud computing and the Internet of Things (IoT) in enhancing the perception and cognitive capabilities of manufacturing systems^[5].

In the dimension of system integration, existing research emphasizes the importance of digital infrastructure in breaking down information silos and enabling value chain collaboration. Porter and Heppelmann (2015) discussed how smart, connected products reshape the structure of the value chain, highlighting the fundamental impact of data integration on value creation^[6]. Frank et al. (2019), through comparative multiple case studies, revealed the mechanisms and effects of digital platforms in facilitating collaborative innovation within manufacturing ecosystems^[7].

However, existing research often focuses on technological implementation or case analyses at the single-firm level, lacking a systematic theoretical explanation of the intrinsic logical connection between digital infrastructure and the intelligent transformation of manufacturing. Particularly concerning how infrastructure necessarily engenders specific manufacturing capabilities, and how these capabilities logically synthesize into representative application scenarios, a coherent theoretical framework is still absent. This study aims to fill this theoretical gap by constructing a logical deduction framework to systematically expound the theoretical basis for digital infrastructure as the fundamental substrate of intelligent manufacturing.

1.4 Research Positioning and Logical Methodology

This paper aims to provide a rigorous theoretical elucidation of the relationship between digital infrastructure and manufacturing intelligence, deliberately eschewing empirical case studies and quantitative data. Its purpose is to construct a logically sound and internally consistent argument that traces the causal links from infrastructural foundations to functional capabilities, and from there to tangible application scenarios and consequent policy implications. The research questions guiding this inquiry are:

- How does the intrinsic nature of advanced digital infrastructure logically generate the core capabilities that define an

intelligent manufacturing system?

- What are the archetypal application scenarios that emerge from the synthesis of these capabilities, and what is their transformative significance?
- What inherent socio-technical challenges and barriers does this infrastructural transition inevitably engender?
- What principles should guide the formulation of policy strategies to proactively manage this transition, mitigate its dislocations, and maximize its societal benefits?

By addressing these questions through deductive reasoning, this paper seeks to contribute a foundational theoretical model that can inform both scholarly discourse and the strategic deliberations of industry leaders and policymakers.

2. Archetypal Technological Application Scenarios: A Logical Synthesis

The core capabilities enabled by digital infrastructure do not exist in isolation; they combine and interact to form coherent and transformative application scenarios. These scenarios are not exhaustive but are representative of the fundamental shifts in manufacturing logic.

2.1 Scenario1: Holistic System Visibility and Continuous Optimization

Holistic System Visibility and Continuous Optimization represents one of the most fundamental yet revolutionary application scenarios enabled by digital infrastructure for intelligent manufacturing. It is not merely the application of a single technology, but a complex, system-level engineering feat comprising underlying infrastructure-driven data foundation, a middle-layer of data interpretation, and a top-layer of decision-making and intervention. This scenario signifies a fundamental paradigm shift in manufacturing management, moving from “experience-driven, lagging response” to “data-driven, real-time foresight.”

2.1.1 Technological Foundation: Constructing the Digital Mirror from Physical Entities

The realization of this scenario depends primarily on a “sensing-transmission-mapping” system built by digital infrastructure, covering the entire manufacturing process.

First, is the ubiquity and refinement of the sensing layer. This requires moving beyond traditional data collection points on critical equipment to achieve deep digitization of all production factors. Specifically:

At the Material Level: Through RFID, QR codes, or more advanced UWB (Ultra-Wideband) tags, every raw material, work-in-progress (WIP), and finished good is endowed with a unique digital identity. Its location, status (e.g., temperature, humidity, vibration history), process parameters, and associated order information are recorded and tracked in real-time. This means materials are no longer static, passive objects but intelligent entities that “speak,” carrying information throughout their entire lifecycle.

At the Equipment Level: Beyond the traditional operational data (running, stopped, fault) from PLCs, a multi-dimensional sensor network is deployed. This includes vibration sensors monitoring spindle health, acoustic sensors identifying abnormal noises, thermal imaging cameras monitoring equipment temperature fields, and power quality analyzers tracking energy consumption and power factors in real-time. This data collectively forms a panoramic picture of the equipment’s “physiological state.”

At the Environment and Process Level: Data is collected on environmental parameters (temperature, humidity, cleanliness), the status of jigs and fixtures, and key steps of manual operations (via visual recognition or IoT tools), ensuring every variable of the production micro-environment is monitored.

Second, is the reliability and massive connectivity of the network layer. The vast, heterogeneous data generated by the sensors requires a network infrastructure capable of simultaneously delivering high bandwidth, low latency, massive connection density, and extreme reliability. The characteristics of 5G, namely uRLLC (Ultra-Reliable Low-Latency Communication) and mMTC (massive Machine-Type Communication), coupled with TSN (Time-Sensitive Networking) technology, form the “information highway” for this scenario. They guarantee the instantaneous delivery of critical control commands and the unblocked upload of massive sensor data, providing the physical assurance for real-time operation.

Finally, is the integration and mirror construction at the platform layer. All incoming data converges within an Industrial Internet Platform (IIP) or Manufacturing Execution System (MES), where it is cleaned, contextualized, and correlated.

Through data modeling and fusion, the platform constructs a “Digital Twin”—a dynamic, data-driven, living mirror of the physical factory that operates in sync and reflects every subtle change in real-time. At this point, the manufacturing system gains, for the first time, a complete and real-time “self-awareness” of its own state.

2.1.2 Core Value: The Progression from “Visible” to “Understandable” and “Optimizable”

Achieving holistic visibility is not an end in itself; its immense value lies in providing an unprecedented data foundation for subsequent cognition and optimization.

First Level: The Management Efficiency Revolution Driven by Transparency.

Information asymmetry is a core source of inefficiency in traditional manufacturing management. Management relied on daily or weekly reports, which were filtered, processed, and lagging, often leading to distorted information. Holistic visibility overturns this model entirely. Managers can use a panoramic dashboard to gain insight into any level of detail, from enterprise-level KPIs to the torque of a single screw, anytime and anywhere. This transparent, penetrating management drastically compresses the decision-making loop, allowing problems to be detected and located at their inception, avoiding batch quality incidents or production stoppages caused by information delays. Furthermore, it enables precise, data-based accountability and performance evaluation, driving a change in organizational culture.

Second Level: Deep Insights Driven by Data Mining.

Building on transparency, big data analytics techniques can unearth deep-seated patterns and correlations from the massive volumes of real-time and historical data that are difficult for the human brain to discern. For example:

Correlation Analysis: Can reveal a statistically significant correlation between minor fluctuations in a workshop’s environment and the yield rate of a specific critical process in the final product.

Root Cause Analysis (RCA): When a quality defect occurs, it is possible to trace back all the process parameters, equipment status, operators, and material batches that the specific product experienced, quickly pinpointing the root cause of the problem rather than just addressing the symptoms.

Trend Prediction: By analyzing trends in equipment performance degradation data, one can forecast when a machine will exceed process tolerance limits, providing a precise time window for predictive maintenance.

Third Level: Continuous Optimization Driven by Closed-Loop Autonomy.

This represents the highest value manifestation of this scenario. When the system not only “sees” but also “understands” the dynamics of the production process, it can perform real-time or near-real-time decision-making based on predefined optimization objectives (e.g., highest OEE, lowest unit energy consumption, shortest delivery cycle) using algorithmic models (e.g., linear programming, machine learning, reinforcement learning) and automatically execute adjustments. This forms a closed-loop autonomous system of “Sense-Analyze-Decide-Act.” Specific manifestations include:

Dynamic Scheduling and Dispatching: If the system detects that a critical piece of equipment is about to go down for predictive maintenance or a material delivery is delayed, it can automatically reschedule subsequent production orders, reassign tasks to other available resources, and notify relevant stakeholders, thereby achieving “dynamic rolling optimization” of the production plan and maximizing overall equipment utilization.

Adaptive Parameter Optimization: During machining, the system can compare actual processing data in real-time with the ideal model simulated in the digital twin and automatically fine-tune the equipment’s process parameters (e.g., feed rate, spindle speed) to compensate for the effects of tool wear or material property variations, ensuring machining quality remains consistently within the optimal range.

Lean Energy Management: Through real-time monitoring and load analysis of all energy-consuming equipment in the plant, the system can intelligently implement “peak shaving and valley filling.” It can automatically adjust the operating schedules of non-critical processes during peak electricity price periods or briefly cycle auxiliary equipment on and off, significantly reducing comprehensive energy costs while ensuring production continuity.

2.2 Scenario 2: Predictive Intervention and Autonomous Quality Assurance

Predictive intervention and autonomous quality assurance represent the maturation of data-driven cognitive capabilities within intelligent manufacturing systems. The realization of this scenario marks a fundamental shift in manufacturing from

traditional experience-based decision-making models to foresight-based operational models rooted in data intelligence. The core logic lies in leveraging enhanced data cognition to transform uncertain factors within manufacturing systems into predictable and manageable deterministic problems, thereby achieving leapfrog improvements in operational efficiency and quality.

2.2.1 Fundamental Shift in Cognitive Paradigm

Decision-making logic in traditional manufacturing environments is based on historical experience and statistical patterns, essentially representing inductive summaries of past events. This cognitive model has inherent limitations: its basis for decisions relies on lagging, partial, and probabilistic information, incapable of accurately predicting the degradation trajectory of specific equipment or the quality status of individual products. The realization of the predictive intervention scenario signifies a fundamental paradigm shift from “empirical induction” to “data deduction.”

The philosophical foundation of this shift is that any functional degradation of equipment or quality variation in products is not a randomly occurring isolated event, but rather a continuous process following specific physical laws with clear causal relationships. From microscopic bearing wear to macroscopic loss of precision, from changes in the microstructure of materials to functional failure of products, there exists an inevitable chain of causality and quantifiable patterns of evolution. The core logic of predictive intervention is to reveal these inherent causal laws through data perception and modeling analysis, thereby achieving accurate predictions of the future.

2.2.2 Cognitive Logic of Predictive Maintenance

The realization of predictive maintenance is built upon three levels of cognitive capability. The first is the most basic perceptual cognition, which involves constructing a “digital vital signs” monitoring system for equipment through a multi-dimensional sensor network. This goes beyond simple collection of traditional operational parameters to build a three-dimensional indicator system that reflects equipment health status. From vibration spectrum characteristics to temperature field distribution, from acoustic patterns to energy consumption curves, each data dimension carries specific information about the equipment’s health status.

The second level is pattern recognition and correlation analysis capability. Functional degradation of equipment often manifests as coordinated changes in multiple parameter indicators, rather than abnormal fluctuations in a single parameter. Through deep mining of historical operational data and failure cases using machine learning algorithms, the system can establish mapping relationships between different parameter combinations and specific failure modes. These mappings are not simple linear correlations but involve multi-dimensional nonlinear associations including temporal features and operational context.

The highest level is trend extrapolation and remaining useful life prediction capability. Based on the equipment’s current operational status and historical degradation trajectory, and through the integration of physical and data models, the system can extrapolate the future state evolution path of the equipment. This extrapolation considers not only the equipment’s own aging but also the influence of external factors such as operating environment, load conditions, and maintenance history, thereby achieving probabilistic prediction of remaining useful life.

2.2.3 Cognitive Revolution in Quality Assurance

The cognitive limitation of traditional quality control lies in the statistical nature of its sampling inspections. This method, based on probability and statistics, inherently acknowledges a certain degree of uncertainty; its quality control is a compromise based on an acceptable level of quality loss. The realization of the autonomous quality assurance scenario, however, marks a revolutionary shift in quality control from “statistical inference” to “complete population cognition.”

The technical foundation of this shift is the comprehensive perceptual capability built by machine vision and multi-sensor fusion technologies. Through perceptual devices such as high-resolution industrial cameras, spectral analyzers, and 3D scanners, the system can acquire complete information about product quality, achieving comprehensive inspection from macroscopic dimensions to microscopic structures, from surface features to internal defects. This inspection is no longer based on statistical inference from samples, but on deterministic cognition derived from complete population data.

A deeper cognitive breakthrough lies in the reverse deduction of quality formation mechanisms. By analyzing the correlation

between process parameters, equipment status, environmental conditions, and other data accumulated during the production process and the final product quality, the system can establish a causal model of quality formation. This model not only explains the root causes of quality variation but, more importantly, can predict the impact of process parameter adjustments on quality outcomes, thereby enabling proactive quality control.

2.3 Scenario 3: Mass Customization through Dynamic Reconfiguration

The core logic of achieving mass customization through dynamic reconfiguration lies in dismantling the inherent “scale-variety” dichotomy traditional to manufacturing. This contradiction essentially represents the concentrated manifestation of the structural conflict between industrialized production models and personalized demand. The traditional manufacturing paradigm is built upon the theory of economies of scale in economics, based on the fundamental assumption that the more specialized the production system and the longer its stable operation, the lower the unit cost. However, this paradigm reveals fundamental limitations when facing the modern business environment characterized by fragmented market demand and shortened product life cycles.

2.3.1 Theoretical Foundation of the Paradigm Shift

The realization of the dynamic reconfiguration scenario first requires a fundamental logical shift from “economies of scale” to “economies of scope.” The core of economies of scale lies in cost optimization through standardization and specialization, while the essence of economies of scope lies in value creation through flexibility and adaptability. This shift is not a simple negation of economies of scale, but rather a reinterpretation of the basic theorems of manufacturing economics under new technological conditions. The refinement of digital infrastructure enables manufacturing systems to simultaneously balance the cost advantages of scale effects and the value advantages of scope effects, thereby resolving the “scale-variety” dichotomy.

From a systems theory perspective, traditional manufacturing systems can be viewed as highly structured closed systems, whose operational efficiency relies on stable relationships and deterministic interactions among internal elements. In contrast, intelligent manufacturing systems with dynamic reconfiguration capabilities exhibit characteristics of dissipative structures. They maintain a state of dynamic order far from equilibrium through continuous exchange of material, energy, and information with the environment. Such systems no longer pursue static efficiency maximization but emphasize maintaining adaptability and evolutionary capacity amidst dynamic changes.

2.3.2 Logical Architecture of the Technological Enabling Mechanism

Digital twin technology plays a key enabling role in this scenario. Its value lies not only in the digital mapping of physical entities but also in constructing a virtual manufacturing environment that is computable, simulatable, and verifiable. This environment is essentially a mathematical space containing all elements and constraints of the manufacturing system, where the feasibility of any product design and process plan can undergo rigorous mathematical deduction and optimization calculation. When a new customization demand arises, the system first conducts collaborative simulation of all elements in the digital space, verifying the compatibility of all links from equipment capability and material flow to quality control, ensuring the theoretical feasibility of the physical system’s reconfiguration plan.

High-reliability networks constitute the neural system for dynamic reconfiguration, with their value reflected in three dimensions: timeliness ensures the instantaneous delivery of control commands, reliability guarantees the deterministic and error-free transmission of commands, and synchrony achieves the precise consistency of multi-equipment coordination. These network characteristics enable the manufacturing system to achieve rapid and precise linkage from the “brain” (control center) to the “limbs” (execution equipment), much like a biological nervous system.

The software-defined nature of robots and automated equipment forms the material basis for physical reconfiguration. The functions of traditional dedicated equipment are hardwired into the hardware structure, whereas software-defined intelligent devices decouple functional implementation from the physical entity, enabling rapid function switching through program reloading. This design philosophy of “hardware platformization and software definition” enables a single physical device to handle multiple manufacturing tasks, significantly expanding the equipment’s application scope and value density.

2.3.3 Intrinsic Logic of Value Creation

The value creation logic of the dynamic reconfiguration scenario is reflected at three levels. At the operational level, the system directly reduces costs by minimizing equipment changeover time and improving equipment utilization. Unlike the production stoppages caused by equipment changeovers in traditional manufacturing, dynamic reconfiguration compresses the physical system's reconfiguration time to the extreme through pre-simulation via digital twins and instant network control, potentially achieving the ideal state of "zero changeover time."

At the tactical level, the system's value lies in its rapid response capability to changes in market demand. When personalized demand emerges, the system bypasses the lengthy processes of traditional manufacturing, such as process preparation, equipment debugging, and trial production. Instead, through pre-verification in the digital space and rapid reconfiguration of the physical system, it achieves direct conversion from order to product. This capability significantly shortens product delivery cycles, enhances customer satisfaction, and reduces inventory risks and capital occupation.

At the strategic level, dynamic reconfiguration capability enables enterprises to break the value creation boundaries of traditional manufacturing. The manufacturing system is no longer merely a production tool for products but transforms into a solution platform for meeting customers' personalized needs. Enterprises can establish differentiated competitive advantages by offering personalized customization services, maintain market sensitivity through rapid product design iteration, and build sustainable business ecosystems through flexible production capacity.

3. Inherent Challenges and Socio-Technical Barriers

The transition to an infrastructure-driven manufacturing paradigm, while logically compelling, is not a frictionless process. It inherently generates a set of profound challenges that are as much economic and social as they are technical.

3.1 Economic and Strategic Dislocations

The development and deployment of comprehensive digital infrastructure requires massive upfront capital investment. This creates a significant barrier to entry, particularly for small and medium-sized enterprises, potentially leading to a bifurcated market where only large corporations can afford to become "intelligent." Furthermore, the business case for such investments often extends beyond simple cost savings into more nebulous areas like strategic agility and future-proofing, which are difficult to capture with traditional return-on-investment calculations. This can lead to strategic paralysis. Another economic challenge is the risk of new forms of vendor lock-in; reliance on a specific technology stack or platform ecosystem can create dependencies that reduce future flexibility and bargaining power.

3.2 Structural and Operational Complexities

The integration of historically separate operational technology (OT) and information technology (IT) domains creates profound structural complexity. These domains have different cultures, lifecycles, and priorities, and their convergence demands new governance models and architectural standards. A critical barrier is the lack of universal interoperability standards, which can result in "islands of automation" even within a digitally equipped factory, defeating the purpose of systemic integration. Moreover, the increased connectivity and software-dependence of industrial systems dramatically expand the cybersecurity attack surface. A breach could lead not just to data theft, but to physical damage, production stoppages, or safety incidents, making robust, security-by-design principles a non-negotiable requirement.

3.3 Human Capital and Organizational Inertia

Perhaps the most profound challenges are human and organizational. The new manufacturing environment demands a workforce with a hybrid of skills that combine deep domain knowledge in manufacturing processes with expertise in data science, software engineering, and cybersecurity. Such talent is scarce, and the existing workforce faces the threat of skill obsolescence, necessitating large-scale reskilling and upskilling initiatives. Beyond individual skills, organizations themselves often exhibit deep-seated inertia. Hierarchical structures, functional silos, and risk-averse cultures can actively resist the flatter, more agile, and data-driven decision-making models that intelligent manufacturing requires. Overcoming this internal resistance is frequently more difficult than overcoming the technical hurdles.

4. A Framework for Policy Optimization Strategies

Given the scale and nature of these challenges, the role of public policy is not to direct the transformation but to strategically

enable and shape it. Effective policy must evolve from subsidizing specific technologies to cultivating a fertile ecosystem that encourages innovation, manages risk, and ensures broad-based participation.

4.1 Fostering Strategic Investment and Ecosystem Development

Policy should focus on de-risking private investment and catalyzing collaborative ecosystems. This can involve public-private partnerships to co-invest in foundational, shared infrastructure like 5G industrial networks or testing and demonstration facilities that are accessible to smaller firms. Fiscal incentives should be designed to encourage not just capital expenditure but also investments in intangible assets like software, data architecture, and workforce training. Furthermore, policy can play a convening role, fostering the creation of innovation clusters that physically and virtually bring together large manufacturers, technology startups, academic institutions, and SMEs to collaborate on solving common industrial problems.

4.2 Establishing Trust through Governance and Security

A primary function of policy in the digital age is to establish the rules of the road that build trust. This involves creating clear and predictable data governance frameworks that define rights and responsibilities regarding data ownership, access, portability, and usage. Such frameworks are essential to encourage data sharing while protecting proprietary and security interests. Concurrently, governments must establish and enforce robust cybersecurity standards and certification regimes for critical industrial equipment and systems. This does not mean picking technological winners but setting performance-based requirements that ensure a baseline of security and resilience across the manufacturing base.

4.3 Catalyzing Human Capital and Capability Development

Policy must address the human dimension of the transition proactively. This requires a fundamental reform of educational and vocational training curricula to produce graduates with the necessary hybrid skills. More urgently, it demands the creation of large-scale, lifelong learning systems that can rapidly reskill the existing workforce. Policy can incentivize this through individual learning accounts, tax credits for employer-provided training, and support for industry-led certification programs. The goal is to manage the transition of the workforce not as a passive cost, but as an active investment in human capital.

4.4 Championing Interoperability and Open Platforms

To prevent market fragmentation and monopolistic stagnation, public policy should actively champion the development and adoption of open, international technical standards. Government agencies can participate in standard-setting bodies and use public procurement to preference solutions that demonstrate adherence to interoperability standards. The policy objective should be to create a “level playing field” where innovation can thrive, competition is based on the value of services rather than proprietary lock-in, and manufacturers retain sovereignty over their own data and processes.

Conclusion

This paper has argued, through a process of logical deduction, that the intelligent transformation of manufacturing is an infrastructural inevitability. The development of advanced digital infrastructure—comprising connectivity, sensing, computation, and platforms—logically creates the necessary conditions for the emergence of manufacturing systems characterized by real-time perception, cognitive decision-making, dynamic flexibility, and systemic integration. These capabilities, in turn, synthesize into transformative application scenarios that redefine efficiency, quality, customization, and collaboration. Therefore, the ultimate shape and success of the intelligent manufacturing future will be determined less by the pace of technological invention and more by the wisdom of our governance and policy responses. The required policy shift is from a focus on direct intervention to one of strategic ecosystem cultivation. By fostering investment in shared foundations, establishing trusted governance frameworks, catalyzing human capability development, and championing open competition, policymakers can steer this infrastructural transformation towards outcomes that are not only productive but also inclusive, resilient, and sustainable. The interplay between the logic of technology and the vision of policy will write the next chapter in the history of manufacturing.

Funding

General Program of the National Social Science Fund of China: “Research on the Mechanism, Pathways, and Policies of Digital Infrastructure Driving the Intelligent Development of China’s Manufacturing Industry” (Project No.: 23BJY126)

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Zhou, K., Liu, T., & Zhou, L. (2015). Industry 4.0: Towards future industrial opportunities and challenges. In 2015 12th International Conference on Fuzzy Systems and Knowledge Discovery (FSKD) (pp. 2147-2152). IEEE.
- [2] Xu, L. D., Xu, E. L., & Li, L. (2018). Industry 4.0: state of the art and future trends. *International Journal of Production Research*, 56(8), 2941-2962.
- [3] Kagermann, H., Wahlster, W., & Helbig, J. (2013). Recommendations for implementing the strategic initiative INDUSTRIE 4.0: Final report of the Industrie 4.0 Working Group. Forschungsunion. <https://www.din.de/resource/blob/76902/e8cac883f42bf28536e7e8165993f1fd/recommendations-for-implementing-industry-4-0-data.pdf>
- [4] Lee, J., Bagheri, B., & Kao, H. A. (2015). A cyber-physical systems architecture for industry 4.0-based manufacturing systems. *Manufacturing Letters*, 3, 18-23.
- [5] Liao, Y., Deschamps, F., Loures, E. D. F. R., & Ramos, L. F. P. (2017). Past, present and future of Industry 4.0-a systematic literature review and research agenda proposal. *International Journal of Production Research*, 55(12), 3609-3629.
- [6] Porter, M. E., & Heppelmann, J. E. (2015). How smart, connected products are transforming companies. *Harvard Business Review*, 93(10), 96-114.
- [7] Frank, A. G., Mendes, G. H., Ayala, N. F., & Ghezzi, A. (2019). Servitization and Industry 4.0 convergence in the digital transformation of product firms: A business model innovation perspective. *Technological Forecasting and Social Change*, 141, 341-351.

Research on the Narrative Characteristics and Aesthetic Evolution of Micro-Series in Short-Video Platforms

Haitao Cheng*

Guangzhou Huashang College, School of Digital Communication, Guangzhou, Guangdong 511300, China

*Corresponding author: Haitao Cheng

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: With the development of digital media technology, short-video platforms such as Douyin and Kuaishou have, driven by algorithms and user co-creation mechanisms, given rise to micro-series characterized by short duration, high density, and intense plots. These micro-series not only promote the structural renewal of the film and television industry but also reflect the profound evolution of narrative and aesthetic logic in the context of digital media. By analyzing the media context, this study reveals the narrative characteristics of micro-series, including plot density, character labeling, subjective perspective, and temporal-spatial reconstruction. By exploring the aesthetic evolution, it identifies the crises faced by micro-series and calls for emphasizing innovation in narrative depth and cultural connotation while adapting to algorithmic logic. This research enriches the study of digital narrative aesthetics, provides a basis for creators, and contributes to the healthy development of the micro-series industry. In the future, it is necessary to balance commercial demands and cultural value.

Keywords: Short-Video; Narrative Features; Aesthetic Evolution

Published: Nov 5, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.856>

Introduction

With the rapid development of digital media technology today, short-video platforms have become one of the most influential cultural communication carriers worldwide. Short-video platforms such as Douyin, Kuaishou, and Bilibili have built a brand-new video narrative and consumption system under the dual influence of algorithm-driven mechanisms and user co-creation. As the content forms of short videos diversify and the platform ecosystem expands, micro-series, a new type of cultural product, has emerged. Featuring short duration, high density, intense plots, and concentrated emotions, it has quickly become a key category in online audio-visual culture and shown explosive growth in terms of audience scale, content production, and dissemination speed. It is estimated that the market size of China's micro-series will reach 67.79 billion yuan in 2025, with the user scale exceeding 660 million, accounting for 68.4% of the total number of Internet users—this market size has surpassed that of the traditional film industry ^[1].

The emergence of micro-series has not only brought structural updates to the form of the film and television industry but also reflected the profound evolution of narrative methods and aesthetic logic in the context of digital media. Traditional film and television works rely on complete temporal and spatial narrative structures, and promote the development of plots and emotions through the presentation of camera language and character relationships ^[2]; micro-series, however, reconstruct narrative rhythm and audience experience under the constraints of fragmented time and algorithmic logic ^[3]. Its production

mechanism, dissemination path, and aesthetic orientation have all changed against the background of media transformation: the narrative mode of micro-series presents the characteristics of high concentration and labeling, and the cultural logic and media logic it reflects indicate new social psychology and aesthetic changes.

This study aims to systematically analyze the narrative structure and aesthetic mechanism of micro-series on short-video platforms from a theoretical perspective, and reveal their generation logic and cultural implications. By examining the narrative characteristics of micro-series, we can understand how media technology and audience psychology jointly shape new story-telling methods; by deeply exploring the internal driving forces of aesthetic evolution, we can gain insight into the transformation process of contemporary culture from artistic logic to algorithmic logic. Theoretically, this research hopes to enrich the studies of narratology and aesthetics in the context of digital media, explore the variation and reorganization of traditional narrative paradigms in the new media environment, and provide a new analytical perspective for understanding “digital narrative”. Practically, this study can provide theoretical basis for micro-series creators regarding narrative innovation and aesthetic direction, promote the healthy development of the short-video cultural industry, and enhance the aesthetics of online audio-visual art.

1. Media Context of Short-Video Platforms and Micro-Serie

1.1 Media Logic and Algorithmic Mechanism of Short-Video Platforms

As a new form of media, the core driving force of short-video platforms is algorithm recommendation, and their internal communication logic is essentially different from that of traditional mass media. Platforms continuously analyze data such as users' interest tendencies, duration of stay, and interactive behaviors through algorithm systems, and based on this, build a highly personalized information flow push mechanism. This algorithm operation mode not only improves the accuracy and efficiency of content distribution but also deeply reconstructs the basic logic of narrative generation. Under the discipline and guidance of algorithms, narrative activities are under strong time pressure and need to quickly arouse users' viewing interest within a very short time to serve the core indicators of the platform, such as retention rate and click-through rate. As a result, “high-density narrative” and “instant stimulation” have gradually become indispensable creative strategies in the content production process, and studies have pointed out that micro-series are essentially the practical product of “algorithmic narrative”^[4].

In-depth analysis shows that the communication structure of short-video platforms continuously strengthens the characteristics of time fragmentation and the pleasure orientation of content. Users' viewing behaviors mostly occur in scattered time periods such as commuting, waiting, and intermittent breaks. Narrative texts need to actively adapt to this fragmented and fluid temporal-spatial situation, and rely on highly condensed plot progression, intensive conflict settings, and rapid emotional turns to achieve efficient capture and continuous maintenance of the audience's attention. In this process, algorithms are no longer just technical tools but have evolved into a new type of narrative intermediary. They deeply participate in every link of content from production to distribution, leading to the gradual replacement of narrative logic by communication logic, and artistic expression has to submit to the maximization of communication efficiency to a certain extent. In this way, the compactness of narrative rhythm and the intensity of emotional mobilization have increasingly become key dimensions for evaluating the value of works, and they have also invisibly reshaped the expression paradigm and acceptance habits of contemporary visual culture.

1.2 Definition and Development Stages of Micro-Series

Micro-series is a narrative form emerging in the short-video ecosystem, with both media and artistic attributes^[5]. It inherits the communication logic and aesthetic genes of short videos and has gradually formed its own unique content system and expression methods. Initially, micro-series were mainly user-created plot-based short videos, and later developed into content products with in-depth participation and systematic promotion by platforms. Their evolution path shows a clear trajectory from a folk original ecosystem to an industrialized production system. This transformation has not only promoted the development of content forms towards professionalism and scale but also reflected the maturity and further segmentation of the entire short-video industry in terms of content creation, distribution mechanisms, and commercial operations.

In terms of type construction, micro-series have gradually broken away from a single content model and formed a rich and

diverse theme pattern^[6]. Whether it is urban themes focusing on emotional expression and realistic observation, or genre creations relying on suspense structures and ancient-style images, they all reflect the continuous expansion of micro-series in the content dimension. Typification is not only a strategic choice made by producers in response to market segmentation and algorithm recommendation mechanisms but also an inevitable development stage of micro-series as a mature content form. Micro-series have also gradually formed a relatively stable paradigm in terms of narrative: short duration carries high-concentration plots, strong conflicts drive the narrative rhythm, and fast pace maintains audience stickiness—these common characteristics have shaped the unique aesthetic identity of micro-series and imperceptibly cultivated the audience's viewing habits and aesthetic expectations, forming a continuous positive feedback cycle between content production and audience feedback.

1.3 Changes in Audience and Viewing Psychology

The continuous evolution of the media environment has not only profoundly transformed the basic logic of content production but also reconstructed the audience's viewing habits and psychological expectations. In the new communication field of short videos, the audience has gradually transformed from relatively passive receivers in the traditional film and television era to active participants with a high degree of choice. They continuously feed back their preference information to the content end through interactive behaviors such as swiping, staying, liking, and commenting; the algorithm system adjusts the content distribution strategy based on this information, forming a “two-way adjustment” collusive relationship. In such a mechanism, the audience is no longer just the receiver of the narrative but also becomes an invisible participant in narrative communication and form shaping. The subjective boundary of the narrative has become increasingly blurred, and a high degree of dynamic adaptation has been presented between content and consumption.

In terms of audience psychology, micro-series usually rely on high-intensity emotional output and highly condensed conflict settings to quickly arouse the audience's emotional resonance, meeting their psychological needs for rapid release and instant satisfaction in fragmented time. Against the macro background of an accelerated society, the “short, flat, and fast” characteristics of micro-series enable them to efficiently “create” instant emotional release and psychological compensation for users^[7]. Based on this, an instant aesthetics centered on “pleasure first” has gradually been established, which is not only reflected in the external characteristics of content forms but also reflects the changes in the audience's attention structure and the acceleration of emotional rhythm in the digital context. The formation of this psychological mechanism is not only the result of the development of media technology but also a specific manifestation of the contemporary social and cultural mentality in the field of content consumption.

2. Analysis of Narrative Characteristics of Micro-Series

2.1 “High-Density” and “Minimalist Narrative” of Plot Structure

The primary narrative characteristics of micro-series are the high density of plots and the minimalism of narrative. Within a limited duration, the narrative needs to quickly enter plot conflicts and achieve the transition of emotions through the shortest path. The narrative methods of traditional films and television, such as slow presentation and focus on detail description, are compressed here, and instead, a structural design with a tight rhythm and frequent turns is adopted. This minimalist narrative is not only a requirement in terms of duration but also the result of the joint action of algorithmic logic and the audience's attention economy. Micro-series build a “sense of continuity” in a fragmented time structure. Through unitized and serialized narrative strategies, creators shape each episode into an independent but interrelated plot unit, enabling the audience to form a stable narrative experience in the process of repeated viewing and full expectation. In this way, fragmentation is not a complete separation but a strategy to reorganize narrative coherence within a limited duration.

2.2 “Typification” and “Labeling” of Character Shaping

The typification of character shaping is a key feature of micro-series narrative. Due to the limitations of duration and the needs of communication, character images mostly present distinct labeling characteristics, so that the audience can complete the identification of characters in a very short time. Character types have become a convenient entry point for the narrative. Through the standardization of personality, identity, and emotional patterns, a highly recognizable symbolic system is built. This labeled shaping has dual meanings in terms of narrative function: on the one hand, it improves the efficiency of

information transmission and enables the audience to quickly enter the context; on the other hand, it invisibly reduces the complexity and multidimensionality of characters, forming a tendency of aesthetic flatness. However, from the perspective of cultural psychology, character labeling exactly reflects the resonance mechanism in popular culture. The audience projects their own emotions and desires into familiar character types, forming “symbolic identity”, which constitutes the social psychological basis for the popularity of micro-series.

2.3 Narrative Perspective and Participation Mechanism

Micro-series usually adopt the narrative methods of first-person perspective and short lens switching to enhance the audience’s sense of immersion and involvement during viewing. Such “subjective lenses” and “close-range narrative” can not only maintain an intimate relationship between the audience and the story space visually but also build an on-site experience psychologically. The audience seems to become part of the narrative, experiencing the occurrence of the story and the flow of emotions. The unique bullet screen, comment, and secondary creation mechanisms of short-video platforms make the narrative process of micro-series present the characteristic of “co-narration”: the audience is no longer just passive viewers but continuously affects the reception and dissemination of the story through comments and interactions. Narrative thus becomes a multi-directional flow process, and the meaning of the text is constantly generated between production and reproduction.

2.4 Reconstruction of Time and Space

In a fragmented media environment, the narrative of micro-series in terms of time and space shows a very prominent reconstruction phenomenon. The originally linear time is interrupted and reorganized, and the narrative rhythm unfolds in an instantaneous form. The short-duration and fast-switching narrative mode of micro-series causes the story to build plot logic not through the continuous extension of time but through strong visual impact and emotional impact to achieve a sense of time compression. From the perspective of space, the boundary between reality and virtuality has become blurred. Multiple scenes on short-video platforms overlap with each other, making the virtual space a key part of the narrative. Space is no longer just the background of the story but has become a medium involved in the construction of narrative meaning. In this way, micro-series present the reconstruction characteristics of digital narrative in the dimensions of time and space.

3. Aesthetic Evolution of Micro-Series

3.1 From Traditional Narrative Aesthetics to “Algorithmic Aesthetics”

The aesthetic evolution of micro-series is first reflected in the direction of the transformation of aesthetic logic. Traditional narrative aesthetics emphasizes the integrity and expressive depth of artistic creation and attaches great importance to the balance between emotion and form; however, in short-video platforms dominated by algorithms, aesthetic standards are gradually replaced by data logic. Indicators such as click-through rate, completion rate, and interaction volume have become the basis for evaluating the value of works, and artistic logic is surrounded by traffic logic. This algorithmic aesthetics is oriented to user preferences and adjusts the creative direction through data feedback, forming a cycle of “data-content-feedback”. Aesthetic taste has become digitizable and quantifiable, and artistic evaluation has given way to algorithmic regulation. In this sense, the aesthetics of micro-series no longer belongs solely to creators but has become the result of the joint shaping of algorithms and the audience.

3.2 Strengthening of Emotional Logic and Sensory Pleasure

The aesthetic strategy of micro-series takes the strengthening of emotional logic and sensory stimulation as the core. Due to the short duration, the narrative mostly achieves aesthetic impact through emotional concentration and emotional outbursts. Strong emotional contrasts and rhythm changes form the source of the audience’s pleasure experience. Narrative no longer pursues complex psychological portrayal but stimulates emotional responses through direct and intense sensory effects. This “pleasure-oriented aesthetics” presents the characteristics of emotional consumption in the digital media era. The audience’s aesthetic needs tend to be instant satisfaction, and sensory experience has become a key basis for judging content value. Micro-series rely on simple forms and strong rhythms to build emotional templates adapted to the attention economy, such as touching, counterattack, and a sense of satisfaction. The standardization of these emotional templates has gradually made aesthetics stylized, but at the same time, it has also revealed the psychological structure of contemporary media culture.

3.3 Daily Aesthetics and Grassroots Creation

Another aesthetic turn presented by micro-series is reflected in the rise of daily aesthetics and the extensive participation of grassroots creation. The openness and low-threshold characteristics of short-video platforms have made ordinary individuals a group with creative potential. Scenes and experiences in daily life are transformed into narrative materials, forming the realistic basis of micro-series. The life-oriented expression and ordinary perspective together build a new aesthetic value, that is, the presentation of “the beauty of the ordinary” in the media. This decentralized production model has broken the elite structure of traditional film and television production and achieved the democratization of aesthetics. The boundary between creators and the audience has become blurred, and the aesthetic discourse has shifted from the professional system to popular culture. The popularity of micro-series reflects the diversification of cultural production on the one hand and shows the artistic possibilities of daily experience in digital media on the other hand.

3.4 Aesthetic Crisis and Innovation Space

With the rapid increase in the number of micro-series and the gradual solidification of models, they are also facing a crisis in terms of aesthetics. On the one hand, the existing tendency of homogenization and fast-food culture has led to aesthetic fatigue. Works tend to be repetitive in structure and emotion, lacking depth and innovation; on the other hand, the algorithm-oriented creative logic has increased the dependence on traffic, weakening the ideological and artistic nature of the content. Against this background, the innovation space of micro-series lies in breaking through the constraints of algorithms and reconstructing narrative depth and cultural connotation. By strengthening the theme implication, expanding the expression form, and reconstructing the aesthetic rhythm, the transition from “sensory pleasure” to “cultural thinking” can be achieved. Platforms should also transcend the single logic of “traffic first” and actively inject diversity into the content ecosystem through technical means^[8]. Only when creation returns to the exploration of human nature, emotions, and social reality can micro-series gain new vitality in the process of aesthetic evolution.

4. Conclusions and Recommendations

The rise of micro-series reflects the dual impact of media evolution and cultural turn. Its narrative structure presents the characteristics of fragmentation, labeling, and interaction: fragmentation reconstructs the expression of time and space, labeling simplifies the setting of characters and plots, and interaction makes the audience’s participation a part of narrative construction. In terms of aesthetics, the aesthetic logic of micro-series has gradually transformed from traditional artistic aesthetics to pleasure-oriented aesthetics driven by algorithms and emotions. Aesthetic evaluation is no longer limited to artistic value itself but is closely linked to traffic dissemination and emotional resonance.

Theoretically, micro-series point out the reconstruction process of narrative mechanisms in the digital context and provide a new perspective for understanding the interactive relationship between algorithms, emotions, and aesthetics. It is not only an extension of the film and television form but also the result of the mutual shaping of media logic and the aesthetic system. Practically, micro-series creation should actively explore the depth and diversity of artistic expression while adapting to algorithms and user preferences. Creators should pursue the condensation of meaning within a limited duration and balance commercial demands and cultural value. The future development of micro-series requires continuous innovation in narrative structure, character portrayal, and emotional expression to form a digital narrative form with both artistic quality and ideological connotation.

Funding

Ministry of Education's Industry-University Cooperation and Collaborative Education Project "Research on Digital Application in Film and Television Production" (Project Number: 230905242075056)

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] Chen, Y. J., & Cui, N. W. (2025). Micro-Series: How Does “Visual Fast Food” Reshape the Digital Audio-Visual Cultural Ecosystem? China Social Sciences Network. https://www.thepaper.cn/newsDetail_forward_31594086

- [2] Xie, J. F. (2025). Chinese narrative tradition and the reconstruction of video ethics: Also on the possibility of “Chineseness as a method”. *Jiangxi Social Sciences*, 45(09), 129-138.
- [3] Zhang, X. L., Zhang, X., & Xu, M. Y. (2025, November 4). How is “instant gratification” generated: A study on the attention-triggering effect of algorithmic narrative in micro-series. *New Media and Society*, 1-17. <https://link.cnki.net/urlid/CN.20251016.1315.002>
- [4] Dong, C. Y., & Xiong, F. (2025). Narrative of micro-series: Platform vision, content evolution and style shaping. *Editors' Friend*, (05), 22-28. <https://doi.org/10.13786/j.cnki.cn14-1066/g2.2025.5.003>
- [5] Yang, H., & Ling, Y. (2023). Online micro-series: An exploration of the “post”-drama characteristics in the context of integrated culture. *China Television*, (03), 48-55.
- [6] Shen, X., & Cao, D. (2025, November 4). Towards reality: Ethical risks and governance strategies of AI micro-series in the pseudo-environment. *New Media and Society*, 1-14. <https://link.cnki.net/urlid/CN.20251023.1450.008>
- [7] Pang, H., Zhu, Y. T., & Xue, Y. J. (2025, November 4). From virtual coexistence to emotional energy: A study on the community interaction and emotional communication dynamic mechanism of ReelShort micro-series' cultural overseas expansion from the perspective of interaction ritual chain. *New Media and Society*, 1-18. <https://link.cnki.net/urlid/cn.20250917.1133.002>
- [8] Zhang, X. L., & Nie, Y. Z. (2025). Using digital games as a medium: Practical approaches to enhancing the international communication effectiveness of excellent traditional Chinese culture. *China Editor*, (03), 70-76.

Research on the Integration Path of Smart Wearable Technology in Jewelry Design

Xianfa Zhang*

Jewelry College, Guangzhou Huashang College, Guangzhou, Guangdong, 511300, China

**Corresponding author: Xianfa Zhang*

Copyright: 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY-NC 4.0), permitting distribution and reproduction in any medium, provided the original author and source are credited, and explicitly prohibiting its use for commercial purposes.

Abstract: Against the backdrop of the in-depth integration of technology and art, the traditional jewelry industry is facing a demand to transform from a single decorative attribute to a composite functional attribute. At the same time, the functions of smart wearable devices are expanding. The integration of the two is not only an inevitable direction for the development of tech aesthetics but also accurately meets users' core needs. This study analyzes the feasibility of integration from the technical and market perspectives, emphasizing that technologies such as micro-sensors, flexible electronics, and new materials provide support for the functionalization of jewelry, while consumers' diverse needs for health management, emotional connection, and personalized expression drive market development. On this basis, three paths of functional integration, material and process innovation, and design concept reconstruction are proposed, and the current challenges such as technical bottlenecks, cost control, and cognitive biases as well as their countermeasures are discussed. The study holds that smart jewelry is not only an upgrade of product form but also an overall reshaping of design thinking and industrial ecology. In the future, it will continue to deepen in terms of interaction methods and emotional connection, and become an intelligent medium among humans, technology, and culture.

Keywords: Integration of Technology and Art; Smart Jewelry; Functional and Design Innovation

Published: Nov 5, 2025

DOI: <https://doi.org/10.62177/apemr.v2i5.857>

Introduction

With the continuous innovation of information technology and its in-depth integration into social life, a series of cutting-edge technologies such as artificial intelligence, the Internet of Things, big data, and flexible electronics have developed jointly. This has not only greatly expanded the functional boundaries of smart wearable devices but also accelerated their popularization in different application scenarios. Smart wearable devices are innovative achievements of the in-depth interdisciplinary integration of materials science, electronic technology, communication technology, computer science, and other disciplines ^[1]. They have shown unprecedented great application potential and broad development prospects in many fields such as health monitoring, sports assistance, military applications, medical rehabilitation, emergency rescue, and smart home, and have increasingly become a hot topic of common concern in the academic and industrial circles ^[2].

The jewelry industry is a field with profound humanistic traditions and aesthetic accumulation. Up to now, significant changes have taken place in terms of shape, material, and wearing method, and people's demand for jewelry is also quietly changing ^[3]. Driven by the wave of digitalization and intellectualization, the jewelry industry urgently needs to transform

from a single decorative attribute to a composite functional attribute to meet the composite needs of contemporary consumers for personalized expression, emotional connection, and technological experience. Traditional jewelry design focuses on the preciousness of the material itself, the aesthetic expression of the shape, and the exquisite craftsmanship, while smart wearable technology emphasizes the practicality of functions, the interactivity of the system, and the real-time nature of data. The integration of the two is not a simple superposition but an in-depth reconstruction at the levels of design thinking, technical path, and user experience. It is a concrete practice of cross-field integration of technology and art, and also a key opportunity to promote the value reshaping and structural upgrading of the jewelry industry.

The systematic integration of smart wearable technology into jewelry design can effectively expand the functional scope of jewelry as a wearable item, transforming it from a static decorative symbol into an intelligent carrier with perception, feedback, and interaction capabilities. It can also realize dynamic response to the wearer's physiological state, behavioral habits, and emotional changes with the help of technologies such as data perception and emotional computing. This transformation from "object" to "entity" and from static to dynamic enriches the connotation of the relationship between jewelry and humans and redefines its role and significance in daily life. This cross-border integration conforms to the development trend of tech aesthetics in the contemporary era and also accurately responds to the new demands put forward by the increasingly emerging personalized, healthy, and intelligent lifestyle for product form and function.

Theoretically, in-depth analysis of the integration mechanism between smart wearable technology and jewelry design can deepen the understanding of machines, humans, and contemporary art in design science, expand the connotation and extension of design innovation theory in an intelligent environment, and provide a new theoretical framework and analysis approach for relevant interdisciplinary research. Practically, comprehensively exploring the technical approaches and design strategies for the integration of the two can provide operable transformation plans and innovation directions for jewelry enterprises, helping the industry make breakthroughs in technology integration, aesthetic improvement, and market expansion, and promoting the construction of a healthy and sustainable industrial ecology in the field of smart jewelry.

1. Relevant Theoretical Foundations of Smart Wearable Technology and Jewelry Design

1.1 Overview of Smart Wearable Technology

Smart wearable devices take microelectronic systems as the core part, integrate sensors, processors, and communication modules, and build wearable devices with perception, analysis, and interaction capabilities. This technical system includes hardware, algorithms, and user interfaces. Its essence is to break through the form of traditional devices and achieve the coordination of physiological monitoring, behavior recognition, and situational services. According to functions, it can be divided into health monitoring, communication interaction, sports management, emotional interaction, and other categories. Its core value is to integrate multi-modal data and establish a real-time two-way channel between humans and the environment.

The system adopts a hierarchical architecture, in which the perception layer collects the user's physiological indicators and movement parameters in real-time through a variety of built-in sensors^[4], the transmission layer realizes low-power data communication, and the application layer completes data analysis and decision-making by means of edge and cloud computing. In terms of energy, new batteries and energy harvesting technologies have improved battery life; in the field of materials, the development of flexible circuits and biocompatible materials has optimized the wearing experience, laying a foundation for intelligent devices in the form of jewelry. Since the concept was put forward, this technology has gone through a development stage from single function to multi-functional integration. The future trends include hardware flexibility, algorithm personalization, and interaction naturalization. With the continuous advancement of interdisciplinary integration, smart wearable products will gradually enhance their emotional and artistic attributes and build a new user-centered innovation ecology.

1.2 Connotation and Characteristics of Jewelry Design

Jewelry design is a creative practice that integrates aesthetics, craftsmanship, and cultural narration. Its core elements cover the coordination and unity of materials, shapes, craftsmanship, and colors. Materials have physical properties and symbolic meanings; shapes need to take into account both formal aesthetics and structural logic; craftsmanship runs through traditional

and modern technologies; colors emphasize harmonious configuration. These elements together construct the material form and spiritual connotation of the work.

The evolution of jewelry styles reflects the spirit of the times and cultural changes. From the complex decorations in history to the geometric expressions in modern times, each stage reflects specific aesthetic pursuits. Contemporary design integrates digital technology on the basis of inheriting traditional craftsmanship, forming a creative ecology of cross-border integration. At present, the industry is at the intersection of tradition and innovation. The high-end market continues to pursue materials and craftsmanship, while technology promotes functional expansion and sustainable practices. The tension between traditional aesthetics and technical functions also provides innovative possibilities for smart wearable technology, that is, relying on the integration of aesthetics and technology to reshape the value dimension of jewelry.

2. Feasibility Analysis of the Integration of Smart Wearable Technology and Jewelry Design

2.1 Feasibility at the Technical Level

Jewelry manufacturing processes and smart wearable technology have a natural adaptability at the structural level. Although the internal space of jewelry is relatively limited, its precise structure just creates ideal conditions for the embedding of microelectronic components. Technologies such as flexible circuits, micro-sensors, and wireless energy transmission^[5] can realize functional integration without affecting the appearance, breaking through the limitation that traditional jewelry is only a static decoration. Through material light transmission design and structural optimization, electronic components can be organically integrated with precious metal or gemstone substrates; at present, electronic components are constantly developing towards miniaturization, and the volume of radio frequency chips and multi-modal sensors has been significantly reduced^[6], enabling jewelry carriers to have the potential of functionalization; with the help of three-dimensional stacking and system-level packaging technologies, sensing, computing, and communication units can be integrated in a limited space; the combination of ultra-thin solid-state batteries and energy harvesting devices improves the battery life of the device, and low-power edge algorithms improve the stability and security of the system operation.

2.2 Feasibility at the Market Demand Level

At present, jewelry consumption is shifting from pure aesthetic demand to experience value. The new generation of consumers is increasingly valuing emotional connection and functional innovation. By integrating functions such as health monitoring, social interaction, and personalized expression, smart jewelry accurately meets the diverse needs of modern people for health management, identity recognition, and self-presentation. In the field of products with medical-grade certification, the market acceptance is constantly improving. Against the background of the parallel development of digital and experience economy, smart jewelry, as a representative of fashion technology, is reshaping the value chain of the jewelry industry. This market exists in the high-end field and is gradually expanding to the mass consumer end through models such as modular design and subscription services, forming a differentiated development path. Smart jewelry and traditional jewelry complement each other in terms of consumer groups and usage scenarios. The former expands practical functions, while the latter continues the emotional and collection significance. In practice, the two penetrate each other, giving birth to a new product form that combines traditional aesthetics and intelligent technology, and promoting market integration and value innovation.

3. Integration Paths of Smart Wearable Technology in Jewelry Design

3.1 Functional Integration Path

The health monitoring function of some smart jewelry relies on the breakthrough of micro-sensors and their hidden integration. In the design of smart jewelry, it is necessary to optimize the structure to balance the functional modules and the wearing experience. For example, embedding a flexible substrate into the jewelry allows the sensor array to be naturally integrated with the main structure. This design not only achieves the purpose of physiological parameter monitoring but also takes into account the wearing comfort and visual aesthetics through the coordinated processing of materials and structures. As a carrier of information, smart jewelry needs to coordinate the contradiction between interface information density and

aesthetic expression. With the help of multi-modal interaction methods such as touch, light signals, and voice, a natural human-computer communication channel is built. In the design process, the “minimum interference principle” is followed to maintain static aesthetics in the non-interactive state, and functions are only activated when necessary, so that jewelry can achieve flexible conversion between decorative attributes and interactive media.

In terms of personalized customization, smart jewelry integrates multi-source data through a deep learning system, constructs user portraits, and generates shape and function schemes that meet individual aesthetic and behavioral preferences. The system also considers the adaptation of cultural context and integrates regional aesthetic characteristics into global design. The development of flexible electronics and nanomaterials provides key technical support for smart jewelry. New materials such as graphene circuits, piezoelectric materials, and phase change media endow jewelry with characteristics such as light weight, extensibility, and dynamic response, breaking through the dual structure of traditional metals and gemstones and realizing multi-dimensional expression of optical, electrical, and thermal properties. Modern manufacturing processes are also reshaping the boundaries of jewelry production. The combination of 3D printing technology and traditional processes improves the manufacturing accuracy and shape freedom of complex structures, and digital full-process simulation optimizes manufacturing quality. Process innovation also promotes the transformation of design paradigms from static shapes to dynamic systems. Modular strategies and interdisciplinary collaboration continue to expand the functional and aesthetic boundaries of smart jewelry.

3.2 Material and Process Integration Path

Advances in flexible electronics and nanomaterials have provided key technical support for smart jewelry. Flexible circuit materials such as graphene have good electrical conductivity, and their high light transmittance can also hide the circuit in transparent materials ^[7]. Nano-piezoelectric materials can promote dynamic deformation on the surface of jewelry, and temperature-sensitive phase change materials can enable jewelry to have interactive visual changes. These innovative materials break through the dual structure of traditional metals and gemstones, enabling jewelry to achieve multi-dimensional expression in terms of optics, electricity, and touch.

Modern manufacturing technologies are reshaping the boundaries of jewelry craftsmanship. The in-depth combination of 3D printing and traditional processes improves the manufacturing accuracy and shape freedom of complex structures. Micro-nano processing technology can construct functional textures on the surface of precious metals to achieve a balance between visual aesthetics and technical performance. Multi-material composite printing breaks through material barriers, and digital twin technology effectively ensures manufacturing quality through full-process simulation. Process innovation promotes the development of smart jewelry design from static shapes to dynamic systems. Flexible electronic packaging technology provides a new way for mass production of circuits and promotes the development of modular design strategies. With the help of standardized interfaces, functional components can be replaced flexibly, extending the product life cycle. Technologies such as microstructured surfaces generated by interdisciplinary collaboration not only meet mechanical needs but also create unique visual effects, continuously expanding the aesthetic boundaries of smart jewelry.

3.3 Design Concept Integration Path

The reason why jewelry is loved by people is not only due to the preciousness of its own materials and its gorgeous appearance but also related to its exquisite design ^[8]. Smart jewelry design needs to build a systematic user experience framework. With the help of multi-dimensional user research methods, it accurately identifies functional and emotional needs in different scenarios, uses design methods such as the double diamond model to capture potential needs, and continuously optimizes schemes through prototype iteration, ultimately achieving the organic integration of functional configuration and emotional value.

In the field of smart jewelry, technology is gradually evolving from a tool for realizing functions to a design language for expressing aesthetics. Parametric design can generate forms with both structural rationality and visual aesthetics; smart materials enable jewelry to have dynamic response capabilities; the in-depth integration of interaction logic is to transform data into a unique aesthetic experience. This in-depth combination of technology and art makes smart jewelry a new type of artistic medium in the digital age. Emotional design establishes a deep emotional connection between users and jewelry by

constructing multi-sensory interactions at the cognitive, behavioral, and reflective levels. Smart jewelry can not only transmit information and provide feedback but also carry memories and emotions, surpassing the simple functional attribute and becoming a digital carrier with humanistic warmth and artistic beauty.

4.Challenges and Countermeasures for the Integration of Smart Wearable Technology and Jewelry Design

4.1 Challenges Faced

Smart jewelry still faces some key challenges in its development process. From the technical level, the battery life and wearing comfort of the device are the main bottlenecks for its popularization^[9]. The heat dissipation management and the power balance of the edge computing unit also restrict the stability and reliability of the device. High manufacturing costs have become another obstacle. The cost of materials such as medical-grade sensors and flexible substrates is higher than that of general devices, and precision manufacturing processes such as micro-nano processing increase the production cost. Although cross-field R&D cooperation is necessary, it also increases the investment of time and funds. In terms of market cognition, consumers generally regard smart jewelry as “decorations with sensors” and have a shallow understanding of its cultural value and technical aesthetics. This cognitive bias is affected by the traditional industry positioning on the one hand and stems from the fact that smart functions and jewelry aesthetics have not yet achieved organic integration on the other hand. The industry standard system has not been established yet, and there is a lack of unified standards in the fields of product quality, data security, and medical-grade function certification, which not only increases the compliance cost of enterprises but also affects consumers’ trust in products.

4.2 Countermeasures

To promote the development of the smart jewelry field, it is necessary to build an interdisciplinary collaboration mechanism and focus on overcoming key technologies such as energy management, heat dissipation optimization, and low-power computing architecture. With the help of in-depth integration of industry, university, and research, the R&D efficiency and algorithm reliability can be improved. In terms of cost control, vertical integration of the supply chain and innovation of manufacturing processes should be promoted. The overall cost optimization can be achieved by using modular design, digital twin technology, and sustainable materials, and combining regionalized production networks and automated quality inspection. For market promotion, a hierarchical communication system should be established, and the spiritual connotation and technical cognition of products should be strengthened through cultural narration and experiential marketing. Step-by-step user education can gradually establish value recognition. In terms of industry standards, a three-level standard system covering material safety, technical performance, and product certification should be established, third-party testing and credible data traceability should be introduced, and the orderly development of the industry should be guided by policy coordination.

5.Conclusions and Prospects

The in-depth integration of smart wearable technology and jewelry design is gradually becoming a key direction for the coordinated development of technology and art. Starting from three key dimensions of technical feasibility, market acceptance, and aesthetic expression, this paper systematically analyzes the internal logic and practical basis of the integration of the two, proposes three integration paths of functional integration, material innovation, and design thinking reconstruction, and puts forward countermeasures for the current challenges such as technical bottlenecks, industrial collaboration, and user cognition. The study shows that smart jewelry not only represents the iterative upgrade of product form but also reflects the transformation of design thinking paradigm and the overall reshaping of industrial value network.

Driven by the continuous development of artificial intelligence and the continuous breakthrough of new functional materials, smart jewelry will achieve deeper integration in three aspects: interaction methods, personalized expression, and emotional connection. The role of jewelry will gradually transform from a traditional static decoration to an “intelligent entity” with environmental perception, cognitive judgment, and emotional interaction capabilities, and finally form a multi-dimensional and dynamic design ecosystem centered on user needs and experience. In this process, jewelry design

empowered by technology inherits the aesthetic essence of traditional craftsmanship and expands its functional boundaries as a communication medium among humans, technology, and culture. This not only injects new innovation momentum into the jewelry industry but also opens up new possibilities for integrating aesthetic value and technological functions in the entire smart wearable field, marking the beginning of a new chapter of design innovation in the context of human-machine coexistence.

Funding

Ministry of Education's Industry-University Cooperation and Synergistic Education Project "Training of Teachers for Game Cultural and Creative Product Design" (Project Number: 230905242264052)

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

- [1] He, J., Zhang, H. Q., Chen, J., et al. (2025). Smart Wearable Devices: Technology Integration and Application Development. *Journal of Tianjin Polytechnic University*, 44(04), 95-102.
- [2] Shen, L., & Sun, T. (2023). Research Status and Development Trend of Smart Wearable Field. *Journal of Clothing Research*, 8(02), 125-133.
- [3] Liu, Q. D. (2022). Artistic Design and Ultimate Craftsmanship of Eastern and Western Jewelry Aesthetics. *Journal of Synthetic Crystals*, 51(07), 1320-1321. <https://doi.org/10.16553/j.cnki.issn1000-985x.2022.07.003>
- [4] Liu, F., Han, J. L., Qi, J., et al. (2021). Research and Application Progress of Smart Wearable Devices. *Chinese Journal of Analytical Chemistry*, 49(02), 159-171. <https://doi.org/10.19756/j.issn.0253-3820.201410>
- [5] Peng, Z. K., Cui, X. R., Zhang, Z. B., et al. (2023). Wearable Devices: Prospect of Evaluating and Monitoring Human Physiological State. *Journal of Biomedical Engineering*, 40(06), 1045-1052.
- [6] Ji, Y., Cai, X. B., & Peng, X. (2024). Research and Design of a Highly Integrated Wide and Narrow Band Integrated Radio Frequency. *Journal of Air and Space Early Warning Research*, 38(06), 401-405.
- [7] Chen, H., Zhuo, F., Zhou, J., et al. (2023). Advances in graphene-based flexible and wearable strain sensors. *Chemical Engineering Journal*, 464, 142576. <https://doi.org/10.1016/j.cej.2023.142576>
- [8] Liu, W. T. (2017). Exploration of Jewelry Design Concepts Based on the Combination of Miao Nationality Costume Characteristics and Tea Culture. *Journal of Fujian Tea*, 39(08), 84-85.
- [9] Qiao, Y. C. (2025). Key Technologies and Application Frontier Progress of Sports Smart Wearable Devices. *Journal of Capital University of Physical Education and Sports*, 37(04), 364-374. <https://doi.org/10.14036/j.cnki.cn11-4513.2025.04.002>

Dear Researchers and Scholars :

Greetings from Asia Pacific Science Press, a beacon of academic and scientific publishing, located in the vibrant city of Hong Kong.

We extend our heartfelt gratitude for your relentless pursuit of knowledge, and your significant contributions to the advancement of science and society. It is researchers and scholars like you who propel humanity forward, and we at the Asia Pacific Science Press are devoted to ensuring that your groundbreaking works receive the global recognition they rightfully deserve.

In light of our commitment to disseminating pioneering research across various disciplines, such as medicine, architecture, education, and electronics, we are reaching out with two pivotal opportunities to augment our collaboration with the global academic community:

Call for Paper Submissions:

We cordially invite you to submit your original research articles to our fast-growing, peer-reviewed, and open-access journals. Our platform guarantees an extensive, global reach, enabling your work to garner maximum visibility and citation in the academic sphere. Rest assured, your work will be meticulously assessed by experts in the field, ensuring it receives the acknowledgment and exposure it merits.

Join Our Esteemed Team:

We are fervently searching for passionate researchers and scholars interested in joining our burgeoning team at Asia Pacific Science Press. We offer numerous roles, such as peer reviewers, editors, and advisory board members, where your expertise will significantly shape the content and quality of our publications. In return, you will gain invaluable experience, network with preeminent scholars, and play a pivotal role in molding the future of global academic publishing.

Why Choose Asia Pacific Science Press?

Global Reach: Your work will be accessible to a worldwide audience, free from any access barriers.

Collaboration with Renowned Universities: We have established extensive publishing systems in cooperation with world-renowned universities, such as Wuhan University, Hong Kong University, and the University of Malaya.

Diverse Disciplines: Your research will be housed among numerous journals across a multitude of academic projects and disciplines.

As we stride forward in the academic landscape, we envision a future where our collective efforts shape a more enlightened, innovative, and interconnected global society. We sincerely hope that you consider this invitation to join us on this auspicious journey towards knowledge, discovery, and global impact.

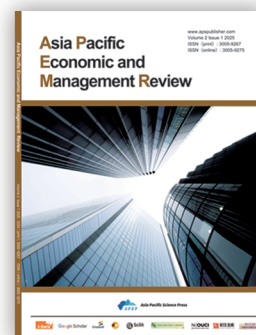
Should you wish to submit your work or express interest in joining our team, please do not hesitate to contact us. You can submit your manuscript or personal profile to info@apspublisher.com or visit our website at www.apspublisher.com for more information.

Thank you for considering this opportunity, and we eagerly anticipate the possibility of welcoming you to the Asia Pacific Science Press family. Together, let's forge a future of unparalleled scientific advancement and discovery.

Warm regards
Asia Pacific Science Press

OUR JOURNALS

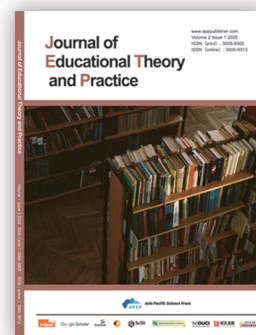
Asia Pacific Economic and Management Review is an international, peer-reviewed and open access journal which focuses on theoretical and applied studies of corporate and financial behavior. Aiming to promote the research in fields of business economics and management, it covers mainly but not limits to the following areas: accounting and financial management, economics, human resource management and organizational behavior, information management, international business, strategy and innovation, management science and operations management, marketing and retailing, finance.



Critical Humanistic Social Theory is an journal that publishes papers specifically using quantitative or qualitative research methods for social science research. The journal encourages scholars to conduct social science theory research from the perspective of social critical theory and emphasizes research concerned with issues or methods that cut across traditional disciplinary lines.



Journal of Educational Theory and Practice is an international, peer-reviewed and open access journal which is to promote the evaluative, integrative, theoretical and methodological research on contemporary education; shape a novel, broader view of issues in contemporary education; enhance the caliber of humanities research through active use of best domestic and foreign practices; and integrate the achievements of various sciences and knowledge areas with unconventional approaches.



Journal of Advances in Engineering and Technology is an international, peer-reviewed and open access journal which publishes original articles, reviews, short communications, case studies and letters in the field of electronic research and application.



Advances in Management and Intelligent Technologies is an international, peer-reviewed, open-access academic journal, hosted by the Fujian Strait Institute of Intelligent Equipment and managed and published by Asia-Pacific Science Press. It focuses on the latest research in the fields of management and intelligent technologies, and aims to advance both theoretical and applied research in management, technological innovation, and intelligent development.



Asia Pacific Journal of Clinical Medical Research is an international, peer-reviewed, open access journal dedicated to advancing clinical medical research across multiple disciplines. The journal serves as a platform for publishing high-quality original research, reviews, and clinical studies that enhance the understanding of medical practices, treatment innovations, and healthcare outcomes, thereby supporting patient care and medical advancements in the Asia Pacific region and beyond.



Asia Pacific Journal of Educational Research is an international, peer-reviewed, open-access academic journal focusing on educational theory and practice. It publishes high-quality research on educational reform, teaching methods, educational equity, and policy studies. The journal addresses practical needs and institutional changes in the education systems of the Asia-Pacific region, advocating a balance between theoretical inquiry and practical experience. It encourages original studies from multicultural, comparative, and interdisciplinary perspectives, aiming to support educational innovation and policy development across the region.



Asia Pacific Economic and Social Development is an international, peer-reviewed, open-access academic journal openly distributed to the global academic community. The journal is committed to publishing original research with theoretical depth and practical value in the fields of economic and social development. It focuses on issues such as economic behavior, social structure transformation, policy innovation, and regional coordinated development in the Asia-Pacific region. The journal encourages interdisciplinary perspectives and promotes the integration of economics, sociology, management, and related disciplines.

