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Asia Pacific Economic and Management Review

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From Silence to Voice: How Ethical Leadership Influences Employees' Promotive Voice Behavior through Feedback Seeking Behavior and Role Ambiguity

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Abstract: This study focuses on two key dimensions—employees' psychological cognition and behavioral motivation—to examine the dual effects of ethical leadership on employees' promotive voice behavior. A questionnaire survey was conducted among workers from various industries in China, and data from 396 valid responses were analyzed. The findings supported our hypotheses, indicating that employees' feedback-seeking behavior and role ambiguity fully mediate the relationship between ethical leadership and promotive voice behavior. Specifically, we found that ethical leadership enhances promotive voice behavior by fostering employees' feedback-seeking behavior and by reducing their role ambiguity. These results demonstrate that ethical leadership indirectly influences promotive voice behavior by strengthening employees' behavioral motivation and alleviating their negative perceptions of roles. This study contributes significant theoretical and practical insights into the exploration of leadership and employees' voice behavior for organizational improvement and offers valuable directions for future research.

Keywords: Ethical Leadership; Promotive Voice Behavior; Feedback Seeking Behavior; Role Ambiguity; Conservation of Resources Theory

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1.Introduction

In today's fast-paced and competitive organizational environment, fostering employee proactivity and innovation is critical for sustaining long-term success (Abdul-Azeez et al., 2024). Among various forms of proactive work behaviors, promotive voice behavior has garnered significant attention in organizational behavior research. Promotive voice behavior refers to employees' voluntary and constructive expression of ideas, suggestions, or concerns aimed at improving organizational processes or performance (Memon & Ooi, 2024; Maynes & Podsakoff, 2014). This behavior not only enhances organizational adaptability and innovation but also contributes to fostering a culture of continuous improvement. Despite its importance, the factors influencing promotive voice behavior, particularly those shaped by leadership, remain an area of active investigation. Ethical leadership, characterized by fairness, integrity, and concern for the well-being of employees, has emerged as a key determinant of various positive organizational outcomes (Subedi & Bhandari, 2024). Ethical leaders serve as role models, demonstrating behaviors that align with ethical principles and creating an environment where employees feel respected,

valued, and psychologically safe (Mohi Ud Din & Zhang, 2023). Such an environment can empower employees to engage in promotive voice behavior. However, the mechanisms underlying this relationship remain insufficiently explored.

Two potential mediating factors—feedback-seeking behavior and role ambiguity—may help elucidate how ethical leadership influences promotive voice behavior (Gong et al., 2019). Feedback-seeking behavior, which refers to employees' proactive efforts to gather information about their performance and organizational expectations, can enhance their confidence and clarity about contributing meaningfully to organizational objectives. Ethical leadership, by fostering trust and openness, may encourage employees to actively seek feedback, thereby supporting their engagement in promotive voice behavior. Role ambiguity, on the other hand, refers to the lack of clarity about job responsibilities and expectations. High role ambiguity can hinder employees' willingness to express ideas or take initiative due to uncertainty or fear of misalignment with organizational goals (Alshemmari, 2023). Ethical leadership may mitigate role ambiguity by providing clear guidance and consistent communication, thereby facilitating conditions where employees feel confident to share constructive ideas.

Building on these perspectives, this study seeks to investigate the mechanisms through which ethical leadership impacts promotive voice behavior, with a particular focus on the mediating roles of feedback-seeking behavior and role ambiguity. By addressing these mediating effects, the research aims to provide a deeper understanding of how ethical leadership fosters proactive and constructive employee behavior. Additionally, it seeks to provide practical insights for organizations aiming to cultivate leadership practices that inspire innovation and improve workplace dynamics.

2. Theory and hypotheses

2.1 Conservation of Resources Theory

Conservation of Resources (COR) theory provides a valuable framework for understanding employee behavior in organizational contexts. Proposed by Hobfoll, COR theory posits that individuals are motivated to acquire, maintain, and protect valuable resources such as energy, time, psychological safety, and social support (Hobfoll et al., 2016). Resources are not only essential for coping with demands but also for enabling individuals to pursue growth and achieve goals. When individuals perceive a gain in resources, they are more likely to engage in proactive behaviors. Conversely, resource loss or the threat of resource depletion can lead to stress, reduced motivation, and withdrawal from discretionary efforts.

In the context of ethical leadership and promotive voice behavior, COR theory suggests that ethical leaders play a pivotal role in creating a resource-enriching environment. Ethical leadership fosters trust, fairness, and psychological safety, which help employees preserve existing resources and gain new ones, such as confidence, clarity, and emotional support (Bhatti et al., 2021; Khairy et al., 2023). By alleviating stressors like role ambiguity and encouraging resource-building behaviors like feedback-seeking, ethical leadership reduces the perceived costs and risks of engaging in promotive voice. Employees are thus more likely to invest their resources in voicing constructive ideas, as they feel supported and secure in their roles (Carnevale et al., 2017). This theoretical perspective highlights the dynamic interplay between leadership, resource dynamics, and employee behaviors, providing a robust basis for understanding the mechanisms underlying promotive voice behavior.

2.2 Ethical leadership and promotive voice behavior

Ethical leadership plays a significant role in influencing employees' promotive voice behavior, which refers to employees proactively expressing ideas, suggestions, or concerns that aim to improve organizational practices or performance (Cheng et al., 2014). Ethical leaders, by definition, demonstrate behaviors grounded in moral principles such as fairness, integrity, transparency, and respect. These leaders model positive conduct and set the tone for the overall organizational culture, creating an environment where employees feel safe, supported, and encouraged to share their thoughts and ideas without fear of negative consequences. The relationship between ethical leadership and promotive voice behavior is largely driven by the trust and psychological safety that ethical leaders foster within their teams. When employees perceive their leaders as ethical, they are more likely to feel confident in offering innovative ideas or raising issues that could lead to organizational improvement. This is because ethical leaders are typically seen as fair and just, treating employees with respect and valuing their input. As a result, employees are more inclined to speak up, knowing that their voices will be heard and appreciated, and that their contributions are likely to have a positive impact on the organization (Burris et al., 2013). Additionally, ethical leaders empower employees by encouraging their participation in decision-making processes and giving them the autonomy

to take ownership of their work. This sense of empowerment further motivates employees to engage in promotive voice behavior, as they feel that their ideas can genuinely influence outcomes. In this way, ethical leadership creates a culture where employees not only feel safe but are also motivated to contribute to the betterment of the organization.

Hypothesis 1. Ethical leadership has a positive impact on employees' Promotive voice behavior.

2.3 The mediating role of the feedback seeking behavior

The relationship between ethical leadership and promotive voice behavior can be partially explained through the mediating role of feedback-seeking behavior (Cheng et al., 2022; Ajmal et al., 2024). Feedback-seeking behavior, defined as employees' proactive efforts to obtain performance-related information, plays a crucial role in enhancing their understanding of job expectations, improving task performance, and fostering personal growth. Ethical leadership, characterized by fairness, integrity, and a genuine concern for employees' well-being, creates an environment conducive to feedback-seeking, which in turn facilitates promotive voice behavior.

Ethical leaders establish trust and psychological safety by demonstrating consistent, fair, and transparent behavior. Employees under ethical leadership are likely to feel valued and supported, reducing their fear of negative evaluations or repercussions when seeking feedback. This perception of psychological safety encourages employees to approach their leaders or peers to obtain constructive feedback on their performance or suggestions for improvement (Su et al., 2022). By seeking feedback, employees gain clarity about their roles, performance expectations, and areas for improvement, which increases their confidence and readiness to contribute new ideas.

Feedback-seeking behavior also allows employees to align their suggestions with organizational goals and priorities (Bălăceanu et al., 2021; Ajmal et al., 2024). This alignment is critical for promotive voice behavior, as employees are more likely to express ideas that are relevant and actionable when they have accurate and up-to-date information about organizational needs. Furthermore, feedback-seeking promotes a sense of empowerment and ownership, as employees who actively seek feedback often feel more in control of their work and more confident in their ability to influence organizational outcomes.

In the context of Conservation of Resources (COR) theory, feedback-seeking behavior serves as a resource-building mechanism. Ethical leadership reduces the emotional and psychological costs associated with feedback-seeking, enabling employees to gain valuable resources such as knowledge, confidence, and clarity. These resources not only replenish employees' energy but also encourage them to invest in promotive voice behavior, which often requires additional cognitive and emotional effort.

Overall, feedback-seeking behavior acts as a bridge linking ethical leadership to promotive voice behavior. Ethical leadership fosters an environment where employees feel encouraged to seek feedback, and the knowledge and confidence gained through this behavior empower employees to engage in constructive, proactive expressions aimed at organizational improvement (Su et al., 2021). This mediating role underscores the importance of understanding feedback-seeking as a dynamic process that amplifies the positive effects of ethical leadership on employee outcomes.

Hypothesis 2. Feedback seeking behavior mediates the relationship between ethical leadership and Promotive voice behavior.

2.4 The mediating role of the role ambiguity

Role ambiguity refers to the uncertainty or lack of clarity employees experience regarding their job responsibilities, expectations, and how their performance is evaluated (Sawyer, 1992; Lin & Ling, 2018). It can create psychological discomfort and impede employees' ability to effectively engage in various workplace behaviors, including promotive voice behavior. Promotive voice behavior, which involves employees proactively offering ideas or suggestions to improve organizational functioning, requires confidence in one's role and a clear understanding of how their contributions align with organizational goals (Rasheed et al., 2017). Role ambiguity, therefore, can hinder employees from expressing their thoughts, as they may be unsure about their position within the organization or whether their input will be valued or understood.

Ethical leadership plays a critical role in alleviating role ambiguity by providing clear communication, consistent expectations, and transparency in decision-making (Al'Ararah et al., 2024). Ethical leaders model behaviors that prioritize fairness and clarity, ensuring that employees have a well-defined understanding of their roles and the criteria by which they will be evaluated. Ethical leaders also establish an open and supportive environment, in which employees feel comfortable

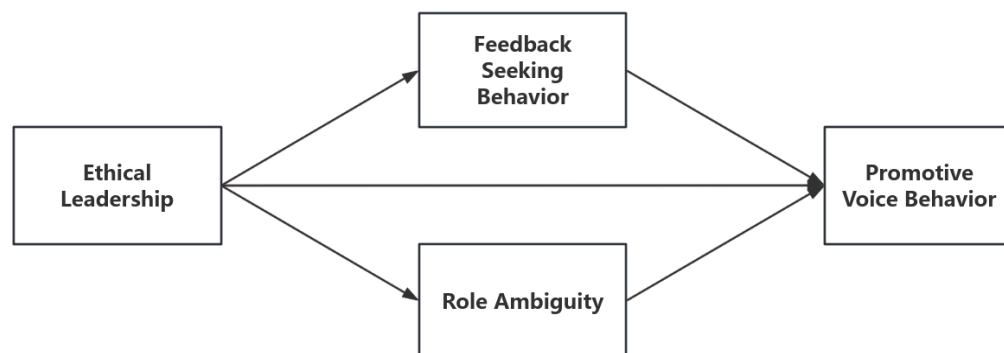
seeking clarification and voicing concerns about any uncertainties they might have regarding their roles. This clarity reduces the cognitive and emotional load associated with role ambiguity, allowing employees to focus their resources on engaging in proactive behaviors such as promotive voice.

When ethical leadership reduces role ambiguity, employees are more likely to feel confident in their job duties and organizational fit (Bouckennooghe et al., 2015). With a clearer sense of their role, employees are better equipped to assess how their suggestions align with organizational priorities, increasing the likelihood of them engaging in promotive voice. Furthermore, by reducing uncertainty about their responsibilities, employees experience a greater sense of psychological safety, which encourages them to share ideas without fear of negative evaluation or role conflict.

From the perspective of Conservation of Resources (COR) theory, role ambiguity represents a significant drain on psychological resources (De Clercq & Belausteguigoitia, 2022; Maisonneuve et al., 2024). When employees experience role ambiguity, they must expend additional cognitive and emotional resources to navigate uncertainties and make sense of their responsibilities (Sung et al., 2017). This resource depletion reduces their ability to engage in proactive behaviors such as promotive voice. However, ethical leadership, by clarifying roles and expectations, helps preserve these resources and encourages employees to use their remaining resources to contribute to organizational improvement. Role ambiguity mediates the relationship between ethical leadership and promotive voice behavior by influencing employees' perceptions of their roles and responsibilities (Li et al., 2020). Ethical leadership, by reducing role ambiguity, empowers employees to act with clarity and confidence, thereby fostering an environment where employees feel comfortable and motivated to express their ideas and suggestions. This mediation highlights the critical role of leadership in creating clear and supportive environments that enable employees to engage in behaviors that benefit both themselves and the organization.

Hypothesis 3. Role ambiguity mediates the relationship between ethical leadership and Promotive voice behavior.

Figure 1. Research model.



3. Methods

In this section, we provide a detailed account of the data collection process undertaken to test our hypotheses. First, we outline the specific steps involved in the design and administration of the survey. Additionally, we summarize the demographic characteristics of the respondents and present an overview of the survey structure, including the measurement instruments used. This comprehensive approach ensures the reliability and validity of the data, establishing a robust foundation for the subsequent analysis.

3.1 Sample and Procedures

To test the hypotheses of this study, an online survey was conducted among workplace employees from mid-April to early May 2024. The participants consisted of workers from various industries in China, including manufacturing, finance, IT, construction, service, and trade sectors. Initially, a total of 412 responses were collected. After careful screening, responses deemed unreasonable or insincere due to significant inconsistencies in selected options were excluded. Consequently, the final analysis for this study was conducted using 396 valid responses.

The demographic analysis of 396 valid respondents yielded several insights. In terms of age distribution, respondents aged 31–35 accounted for the largest proportion (32.1%), followed by those aged 26–30 and 36–40, each comprising 20.2% of the sample. Smaller proportions were observed for respondents under 25 (10.9%), aged 41–45 (9.3%), and 46 or older

(7.3%). Regarding team size, the most common group was composed of 31–40 members (25.3%), followed by teams of 21–30 members (21%), 41–50 members (21.7%), 11–20 members (16.7%), and fewer than 10 members (15.4%). In terms of employment status, the majority of respondents (83.1%) were full-time employees, with the remaining 16.9% classified as non-regular employees. Gender distribution was relatively balanced, with male respondents comprising 48.7% of the sample and female respondents accounting for 51.3%.

Educational background revealed that bachelor's degree holders represented the largest group (53.3%), followed by associate degree holders (26.8%), high school graduates (13.4%), and individuals with graduate degrees (6.6%). Concerning work experience, over half of the respondents (51%) reported 6–10 years of experience, while 33.3% had 1–5 years, 14.4% had more than 10 years, and 1.3% had less than 1 year. With respect to tenure with their current supervisor, 73.5% of respondents reported working with their current supervisor for 1–5 years, with 37.4% having 1–3 years of tenure and 36.1% having 3–5 years. Only 4.5% reported less than 1 year of tenure, while 22% indicated more than 5 years.

Finally, industry distribution showed that the trade industry accounted for the largest proportion of respondents (22.5%), followed by general enterprises (17.9%) and the service industry (15.7%). Other industries included the manufacturing industry (9.6%), the apparel industry (11.9%), the IT industry (4.5%), the financial industry (4%), and the construction industry (3.3%).

3.2 Measures

3.2.1 Ethical Leadership

To measure ethical leadership, this study utilized the 10-item scale developed by Brown et al. (2005), employing a 5-point Likert scale. Sample items from the questionnaire include: “My leader listens carefully to what employees have to say and values their ideas,” “My leader truly considers the best interests of employees when making decisions,” and “My leader is someone I can trust,” among others.

3.2.2 Feedback Seeking Behavior

To measure feedback-seeking behavior, this study employed a 5-point Likert scale based on the 5-item measure developed by VandeWalle et al. (2000). Sample items include: “I frequently ask my leader for feedback about the overall adequacy of my work performance,” and “I frequently ask my leader for feedback about the technical aspects of my performance on the job,” among others.

3.2.3 Role Ambiguity

To measure role ambiguity among employees, this study utilized a 5-point Likert scale based on the 5-item measure developed by Rizzo (1970). Sample items include: “I feel confident about how much authority I have in my job,” and “I have clear and well-planned goals and objectives for my job,” among others.

3.2.4 Promotive Voice Behavior

To measure employees' promotive voice behavior, this study employed a 5-point Likert scale based on the 5-item measure developed by Liang et al. (2012). Sample items include: “I proactively develop and make suggestions for issues that may influence my work unit,” and “I make constructive suggestions to improve the operation of my work unit,” among others.

3.2.5 statistical variable

In setting up the statistical variables, we first focus on the potential influence of age, gender, and employee status (formal vs. informal employees) on promotive voice behavior. The gender variable is coded as Male = 1, Female = 2; formal employees are coded as 1, while informal employees are coded as 2. Additionally, the educational level is encoded as follows: High school graduate = 1, Associate degree = 2, Bachelor's degree = 3, and Master's degree = 4. To further analyze the impact of leadership on promotive voice behavior, working time with supervisors and team size, including the supervisor, need to be considered. In statistical analysis, the working time of employees and their working time with supervisors are recorded and analyzed in “years.”

4. Results

In this study, statistical analysis was conducted using SPSS 27.0, AMOS 26.0, and the SPSS PROCESS v.4.2 statistical tools. Specifically, to assess the validity and reliability of the variables, SPSS 27.0 was used for basic statistical analysis,

exploratory factor analysis, reliability analysis, correlation analysis, and regression analysis to validate the hypotheses. Additionally, AMOS 26.0 was employed to perform confirmatory factor analysis to examine model fit, and SPSS PROCESS v.4.2 was further used to conduct mediation effect analysis.

4.1 Reliability and Validity Verification

To verify the validity of the variables, this study employed principal component analysis for factor extraction and utilized the Varimax rotation method to conduct exploratory factor analysis. Additionally, to assess the validity of the questionnaire, exploratory factor analysis was performed. The results indicated that the KMO value of the survey data was 0.944, exceeding the recommended threshold of 0.70. The measurement model fit indices were $\chi^2 = 5618.538$, $df = 300$, and $p = 0.000$ ($p < 0.01$). The p-value of Bartlett's test of sphericity was less than 0.05, confirming that the questionnaire data were suitable for factor analysis.

Furthermore, the validity of the entire questionnaire scale was evaluated. As shown in Table 1, the Cronbach's alpha values for each variable were as follows: ethical leadership (0.933), feedback-seeking behavior (0.888), promotive voice behavior (0.870), and role ambiguity (0.861), all exceeding the general standard of 0.7. Thus, it can be concluded that the questionnaire designed for this study demonstrates a high level of reliability.

Table 1. Exploratory factor analysis and reliability analysis.

Factor	Measure	1	2	3	4
Ethical leadership	1. My leader listens carefully to what employees have to say and values their ideas.	0.717	0.112	0.123	-0.173
	2. My leader disciplines employees who violate ethical standards in an appropriate manner.	0.764	0.220	0.149	-0.090
	3. My leader consistently maintains ethical behavior in his/her personal life.	0.746	0.132	0.149	-0.111
	4. My leader truly considers the best interests of employees when making decisions.	0.791	0.122	0.102	-0.122
	5. My leader makes decisions that are fair and take all relevant factors into account.	0.774	0.140	0.090	-0.116
	6. My leader is someone I can trust.	0.793	0.118	0.106	-0.099
	7. My leader frequently discusses business ethics or values with employees.	0.763	0.090	0.146	-0.067
	8. My leader sets an example of the correct behavior in terms of ethics for employees to follow.	0.753	0.091	0.141	-0.138
	9. My leader defines success not only by achieving results but also by ensuring that the methods used are ethical.	0.735	0.112	0.113	-0.168
	10. When making decisions, my leader asks themselves, "What is the right thing to do?"	0.776	0.107	0.037	-0.158
feedback seeking behavior	1. I frequently ask my leader for feedback about the overall adequacy of my work performance.	0.217	0.760	0.169	-0.198
	2. I frequently ask my leader for feedback about the technical aspects of my performance on the job.	0.176	0.761	0.184	-0.251
	3. I frequently ask my leader for feedback about my role expectations and how well I am meeting them.	0.137	0.773	0.224	-0.184
	4. I frequently ask my leader for feedback about my social behaviors in the workplace.	0.216	0.793	0.145	-0.091
	5. I frequently ask my leader for feedback about how well my values and attitudes align with those of the firm.	0.123	0.772	0.110	-0.223

Factor	Measure	1	2	3	4
Promotive voice behavior	1. I proactively develop and make suggestions for issues that may influence my work unit.	0.154	0.143	0.757	-0.189
	2. I proactively suggest new projects that could be beneficial to my work unit.	0.119	0.110	0.751	-0.151
	3. I raise suggestions to improve my work unit's procedures.	0.099	0.167	0.766	-0.140
	4. I proactively voice constructive suggestions that help my work unit achieve its goals.	0.209	0.166	0.783	-0.063
	5. I make constructive suggestions to improve the operation of my work unit.	0.172	0.165	0.802	-0.084
role ambiguity	1. There is a clear explanation of what I need to do at work.	-0.195	-0.172	-0.118	0.767
	2. I feel confident about how much authority I have in my job.	-0.166	-0.153	-0.174	0.747
	3. I have clear and well-planned goals and objectives for my job.	-0.164	-0.208	-0.071	0.781
	4. I know what my responsibilities are.	-0.145	-0.156	-0.064	0.763
	5. I know exactly what is expected of me in my role.	-0.164	-0.193	-0.260	0.695
	Eigenvalue	9.392	3.135	2.085	1.689
	% of variance	37.567	12.539	8.338	6.755
	% of cumulative	37.567	50.106	58.444	65.199
	Cronbach α value	0.933	0.888	0.870	0.861
	KMO = 0.944, Bartlett ($\chi^2 = 5618.538$, df = 300, p = 0.000)				

4.2 Confirmatory Factor Analysis (CFA)

This study also conducted a confirmatory factor analysis (CFA) to assess the model's goodness of fit. As shown in Table 2, the research model, which includes ethical leadership (EL), feedback-seeking behavior (FSB), role ambiguity (RA), and promotive voice behavior (PVB), demonstrated good model fit. Specifically, the absolute fit indices indicated $\chi^2 = 316.182$ ($p < .001$), $\chi^2/\text{df} = 1.175$, RMSEA = 0.021, CFI = 0.991, and IFI = 0.991.

According to Rigdon (1996), a model is considered to have a good fit when the ratio of χ^2 to degrees of freedom (χ^2/df) is less than 3, CFI exceeds 0.9, and RMSEA is below 0.08. Based on these criteria, the research model (the four-factor model of EL, FSB, RA, and PVB) demonstrated a superior fit compared to alternative models 3, 2, and 1.

Table 2. Confirmatory factor analysis.

Model	No. of Factors a	χ^2	df	χ^2/df	RMSEA	CFI	IFI
Baseline model	4 factors: EL, FSB, RA, PVB	316.182	269	1.175	0.021	0.991	0.991
Model 1	3 factors: (EL + FSB), RA, PVB	1169.471	272	4.300	0.091	0.835	0.836
Model 2	2 factors: (EL + FSB + RA), PVB	1762.840	274	6.434	0.117	0.727	0.728
Model 3	1 factors: (EL + FSB + RA + PVB)	2406.833	275	8.752	0.140	0.609	0.611

Note: EL = Ethical Leadership; FSB = Feedback Seeking Behavior; RA = Role Ambiguity; PVB = Promotive Voice Behavior; RMSEA = root mean square error of approximation; CFI = Comparative fit index, IFI = Incremental fit index.

4.3 Descriptive Statistics and Correlation Analysis

To investigate the correlations among the key variables, we conducted descriptive statistical analysis and correlation analysis. The results of the correlation analysis revealed that the Pearson correlation coefficients for the four variables used in this study were all above 0.1, with p-values meeting the significance criterion of $p < 0.05$. These findings indicate significant

correlations between the variables in the models.

Specifically, the independent variable, ethical leadership, showed significant positive correlations with the mediating variable, feedback-seeking behavior ($r = 0.413$, $p < 0.01$), and the dependent variable, promotive voice behavior ($r = 0.371$, $p < 0.01$), while showing a significant negative correlation with another mediating variable, role ambiguity ($r = -0.406$, $p < 0.01$). In addition, feedback-seeking behavior demonstrated a significant negative correlation with role ambiguity ($r = -0.495$, $p < 0.01$) and a significant positive correlation with promotive voice behavior ($r = 0.437$, $p < 0.01$). Finally, role ambiguity exhibited a significant negative correlation with promotive voice behavior ($r = -0.385$, $p < 0.01$). The relationships among all variables were consistent with our hypotheses. Subsequently, we used regression analysis to further verify these correlations. The specific results of the correlation analysis are presented in Table 3 below.

Table 3. Descriptive statistics and correlation analysis between variables

Variable	Mean	S.D.	1	2	3	4	5	6	7	8
1. Age	34.010	6.782								
2. Gender	1.510	0.500	-0.018							
3. Team Members	27.580	13.408	-0.004	-0.130**						
4. Tenure year	6.537	2.836	0.053	0.040	-0.057					
5. Education	2.530	0.806	-0.012	-0.061	-0.017	0.060				
Ethical Leadership	3.769	0.962	-0.067	0.057	0.004	0.042	-0.072			
Feedback Seeking Behavior	3.655	1.069	-0.002	-0.009	-0.074	0.075	0.028	0.413**		
Role Ambiguity	2.230	0.966	-0.046	-0.001	-0.028	-0.056	0.062	-0.406**	-0.495**	
Promotive Voice Behavior	3.700	1.020	-0.040	-0.005	-0.005	0.046	-0.046	0.371**	0.437**	-0.385**

N = 396, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

4.4 Hypothesis Testing

Prior to conducting regression analysis, a preliminary collinearity diagnostic was performed to ensure the absence of multicollinearity issues. The results indicated that the variance inflation factor (VIF) values ranged from 1 to 1.5, confirming no multicollinearity concerns. To test the mediation hypotheses of this study, we adopted the stepwise regression approach proposed by Baron and Kenny (1986).

First, based on the results from Model 2 in Table 4, the independent variable, ethical leadership, exhibited a strong and significant positive relationship with the dependent variable, promotive voice behavior ($\beta = 0.369$, $p < 0.001$). Second, the results from Model 4 indicated that ethical leadership ($\beta = 0.183$, $p < 0.001$), the mediating variable feedback-seeking behavior ($\beta = 0.277$, $p < 0.001$), and the mediating variable role ambiguity ($\beta = -0.172$, $p < 0.001$) were all significantly associated with promotive voice behavior.

Furthermore, a comparison of the results from Models 2, 3, and 4 revealed that after including the two mediating variables (feedback-seeking behavior and role ambiguity), ethical leadership maintained a significant positive effect on promotive voice behavior. This indicates that the two mediating variables partially mediate the relationship between ethical leadership and promotive voice behavior. These findings provide empirical support for hypotheses 1, hypotheses 2 and hypotheses 3 of this study.

Table 4. Results of hierarchical regression analyses

Variable	Promotive Voice Behavior			
	Model 1	Model 2	Model 3	Model 4
Age	-0.044	-0.018	-0.026	-0.037
Gender	-0.012	-0.031	-0.016	-0.016
Team Members	-0.004	-0.009	0.018	0.008

Variable	Promotive Voice Behavior			
	Model 1	Model 2	Model 3	Model 4
Tenure year	0.052	0.034	0.017	0.013
Education	-0.050	-0.023	-0.041	-0.031
Ethical Leadership		0.369***	0.224***	0.183***
Feedback Seeking Behavior			0.345***	0.277***
Role Ambiguity				-0.172***
F	0.515	10.610	17.315	16.880
R ²	0.007	0.141	0.238	0.259
ΔR^2	-0.006	0.127	0.224	0.243

N = 396, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

To further validate the mediating effects of feedback-seeking behavior and role ambiguity, this study utilized SPSS PROCESS v4.2 to conduct additional tests and analyses to determine whether significant mediating effects exist among the variables. The bootstrap method was applied with a 95% confidence interval (CI), and 5,000 resampling iterations were performed through the software to compute and verify the mediating effects. The detailed results of the analysis are presented in Table 5. The results showed that the total effect of ethical leadership on promotive voice behavior was 0.3938, with both the upper and lower bounds of the 95% CI being positive and excluding zero. This indicates that the total effect of ethical leadership on promotive voice behavior is significant. Furthermore, when feedback-seeking behavior served as the mediating variable, the direct effect of ethical leadership on promotive voice behavior was 0.2441, with the 95% CI also excluding zero, confirming the significance of the direct effect. Similarly, when role ambiguity served as the mediating variable, the direct effect of ethical leadership on promotive voice behavior was 0.2731, with the 95% CI excluding zero, further supporting the significance of the direct effect.

Finally, the indirect effect of the mediating path through feedback-seeking behavior (ethical leadership → feedback-seeking behavior → promotive voice behavior) was 0.1496, with both the upper and lower bounds of the 95% CI being positive and excluding zero, indicating the significant mediating effect of feedback-seeking behavior. Similarly, the indirect effect of the mediating path through role ambiguity (ethical leadership → role ambiguity → promotive voice behavior) was 0.1206, with the 95% CI excluding zero, demonstrating the significant mediating effect of role ambiguity. These results provide further evidence supporting the hypotheses of this study.

Table 5. Mediating Effect Bootstrapping Results

The mediation path	Effect	Standardized Estimate	BC 95% Confidence Interval	
			Lower	Upper
Total effect				
EL → PVB(M=FSB)	0.3938	0.0496	0.2963	0.4913
EL → PVB(M=RA)	0.3938	0.0496	0.2963	0.4913
Direct effect				
EL → PVB(M=FSB)	0.2441	0.0513	0.1432	0.3451
EL → PVB(M=RA)	0.2731	0.0522	0.1705	0.3758
Indirect effect				
EL → FSB → PVB	0.1496	0.0288	0.0970	0.2101
EL → RA → PVB	0.1206	0.0265	0.0739	0.1759

Note: EL = Ethical Leadership; FSB = Feedback Seeking Behavior; RA = Role Ambiguity; PVB = Promotive Voice Behavior. M=Mediator

5. Discussion

5.1 Overall Findings

This study aimed to explore the influence of ethical leadership on promotive voice behavior and identify the mediating effects of feedback seeking behavior and role ambiguity. The findings provide important insights into how ethical leadership fosters an environment that encourages employees to engage in constructive voice behaviors.

The results of this study confirm that ethical leadership plays a significant role in promoting employees' voice behavior, specifically in the context of innovative and constructive suggestions that contribute to organizational improvement. Ethical leaders, through their commitment to fairness, integrity, and transparency, create a work environment where employees feel respected and supported (Islam et al., 2024). This finding aligns with previous research that emphasizes the positive relationship between ethical leadership and employee proactivity. By demonstrating ethical principles, leaders enhance employees' trust and confidence, motivating them to share valuable insights without fear of retaliation or judgment. Ethical leadership acts as a critical catalyst for psychological safety, which is essential for promotive voice behavior. When employees perceive their leaders as ethical, they are more likely to believe that their input will be valued, leading to increased engagement in voice behavior.

Feedback seeking behavior was identified as a key mediator in the relationship between ethical leadership and promotive voice behavior (Zahoor et al., 2024). The findings suggest that ethical leadership encourages employees to seek feedback on their ideas and suggestions, which, in turn, enhances their willingness to voice opinions. This process is in line with social exchange theory, where the provision of support and guidance from ethical leaders prompts employees to engage in behaviors that foster mutual benefit. By actively seeking feedback, employees gain reassurance and validation for their contributions, further motivating them to engage in promotive voice behavior. Moreover, feedback seeking behavior provides employees with the opportunity to refine their ideas, ensuring that their contributions are relevant and well-received. This feedback loop not only reinforces the importance of voice behavior but also promotes a culture of continuous improvement within organizations.

Role ambiguity emerged as another significant factor mediating the relationship between ethical leadership and promotive voice behavior (Bai et al., 2019). When employees experience clear role expectations, they are more likely to engage in voice behaviors, as they feel secure in their understanding of what is expected of them. Ethical leadership reduces role ambiguity by clarifying goals, expectations, and organizational values, thus providing employees with the guidance necessary to express their ideas confidently (Bouckennooghe et al., 2015). This finding supports the notion that reducing role ambiguity can enhance employee motivation and engagement. Ethical leaders, by setting clear expectations and fostering transparency, help alleviate uncertainty about job responsibilities and organizational goals, which, in turn, encourages employees to engage in promotive voice behavior.

5.2 Theoretical Implications and Practical Implications

This study extends the understanding of the relationship between ethical leadership and promotive voice behavior by unveiling the mediating roles of feedback seeking behavior and role ambiguity. By doing so, it enriches the theoretical discourse on leadership behaviors that foster proactive employee actions. Specifically, the findings highlight that ethical leadership not only inspires employees through moral guidance but also reduces barriers to engagement by clarifying role expectations and fostering a culture of open feedback. This dual pathway offers a more nuanced understanding of how ethical leadership promotes a psychologically safe environment conducive to voice behaviors.

Moreover, this study contributes to the broader organizational behavior literature by integrating perspectives from COR theory, illustrating how leaders' ethical behaviors influence employees' cognitive and behavioral responses. These insights deepen our comprehension of the mechanisms that underlie the impact of leadership styles on organizational dynamics.

For practitioners, the findings underscore the critical importance of ethical leadership in fostering an organizational culture where employees feel empowered to express innovative ideas and constructive suggestions. Managers should prioritize ethical conduct and actively demonstrate fairness, integrity, and transparency to cultivate trust and psychological safety among employees (Malik, 2024). Organizations can also benefit from implementing structured feedback mechanisms and

clear role definitions to minimize role ambiguity, thereby enhancing employees' confidence and willingness to engage in promotive voice behavior. Training programs should be designed to develop ethical leadership competencies, with a focus on communication skills, active listening, and promoting an inclusive environment that values employee input.

5.3 Limitations and Future Research

Although this study empirically reveals the positive impact of ethical leadership on employees' promotive voice behavior and demonstrates the significant mediating roles of feedback-seeking behavior and role ambiguity, several limitations remain.

First, the generalizability of the research findings is constrained by the characteristics of the sample. The data were primarily drawn from industries or regions within China, potentially limiting the applicability of the conclusions. The mechanisms underlying ethical leadership may vary across cultural contexts, organizational structures, and industry types (Brown et al., 2005; Resick et al., 2006). Future research should broaden the sample scope to include cross-cultural and cross-industry data to validate the robustness of these findings in diverse settings (House et al., 2004). Second, issues related to causality warrant further attention. This study employed cross-sectional data, which cannot fully eliminate the possibility of reverse causality or common method bias (Podsakoff et al., 2003). Longitudinal research designs or experimental methods should be utilized in future studies to explore causal relationships and the dynamic interplay among variables, thereby uncovering the long-term mechanisms through which ethical leadership influences employee behavior (Schaubroeck et al., 2012). Third, this study does not thoroughly examine individual differences among employees—such as personality traits, self-efficacy, or values—that may moderate the effects of feedback-seeking behavior and role ambiguity. These individual differences could significantly influence the effectiveness of ethical leadership. Future research should consider incorporating individual-level moderating variables, such as psychological safety or constructs from self-determination theory, to explore how personal characteristics shape the pathways through which ethical leadership exerts its effects. Moreover, the study falls short in addressing contextual factors. Organizational culture, work environment, and team characteristics may play critical roles in moderating the impact of ethical leadership on employees' promotive voice behavior. Future research should include organizational-level variables, such as perceptions of organizational justice or team climate, to investigate how contextual factors shape the relationship between ethical leadership and promotive voice behavior.

Finally, the measurement of variables in this study relied heavily on survey-based self-reports, which are susceptible to social desirability bias and self-reporting inaccuracies. Future research could incorporate multi-source data, such as evaluations from supervisors and colleagues, behavioral observations, or text analysis, to enhance the objectivity and reliability of measurements. It is also worth noting that feedback-seeking behavior and role ambiguity may have an interactive or reciprocal relationship. For instance, proactive feedback-seeking could reduce role ambiguity, while lower levels of role ambiguity may, in turn, promote feedback-seeking behavior. Future studies could develop more complex models, such as cross-level mediation models or dynamic interaction models, to explore the potential reciprocal mechanisms between these two constructs.

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Conflict of Interests

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AI-Empowered Model Innovation and Adaptation in Innovation and Entrepreneurship Education: An Exploration Based on Multimodal Learning Scenarios

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Abstract: Against the backdrop of the deep integration of “AI + Education” and the strategic upgrade of “Mass Entrepreneurship and Innovation”, traditional innovation and entrepreneurship education faces challenges such as insufficient personalized training and monotonous practical scenarios. This study focuses on innovative pathways for AI-empowered education, constructing a theoretical framework based on multimodal learning scenarios and employing fuzzy-set qualitative comparative analysis (fsQCA) to uncover the key mechanisms driving educational model transformation under AI. The research finds that AI, through tools such as intelligent content generation, cross-modal interaction technology, and virtual practice simulation, enhances teachers’ and students’ AI literacy and technical adaptability while ensuring data security. This enables the construction of a trinity educational ecosystem—“data sensing, personalized adaptation, and resource sharing”—effectively addressing the disconnection between theory and practice in traditional education.

Keywords: AI-enabled; Multimodal Learning; Innovation of Educational Models

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1.Introduction

Against the backdrop of accelerating global technological revolution and industrial transformation, artificial intelligence (AI) is profoundly reshaping the educational ecosystem, driving the evolution of “AI + Education” from tool integration to model reconstruction. China’s 14th Five-Year Plan explicitly calls for “strengthening innovative talent cultivation” and “advancing industry-education integration and university-enterprise collaboration,” while the deepening implementation of the “Mass Entrepreneurship and Innovation” strategy imposes higher demands on the adaptability, practicality, and innovativeness of higher education’s innovation and entrepreneurship programs. Traditional innovation and entrepreneurship education, reliant on classroom lectures, case analyses, and limited practical experiences, suffers from structural issues such as insufficient personalized training, disconnection between virtual and real-world scenarios, and lagging competency evaluation. These limitations hinder its ability to meet the digital era’s demand for interdisciplinary innovators who must master cross-domain knowledge while possessing problem-defining, scenario-adapting, and dynamic innovation capabilities.

Addressing these challenges, this study adopts a cutting-edge “technology-enabled educational innovation” perspective to explore pathways for deep integration between AI-driven multimodal learning scenarios and innovation/entrepreneurship

education. By constructing an educational ecosystem model of “data sensing—personalized adaptation—resource sharing,” we investigate how AI technologies—through cross-modal interaction, intelligent content generation, and virtual practice simulation—can transcend the temporal, spatial, and resource constraints of traditional pedagogy. This facilitates student innovation mindset activation, practical skill advancement, and entrepreneurial literacy development. Through empirical analysis, the study focuses on two core questions: How can AI reconstruct educational models via multimodal learning scenarios? What are the mechanisms and differential effects of AI empowerment on students’ innovation and entrepreneurship competencies? The findings will catalyze a paradigm shift from experience-driven to data-intelligence-driven education, laying the foundation for universities to build more adaptive talent cultivation systems in the AI era.

2.Literature Review

The integration of artificial intelligence (AI) and multimodal technology in the field of entrepreneurship education is showing an accelerating and deepening trend, promoting the transformation of the education model from traditional knowledge transfer to ability construction^[1]. Research shows that generative AI, through intelligent content generation and cross-modal interaction technology, has significantly improved the practical efficiency of students in optimizing business plans, market analysis, and other aspects. For example, the AI virtual tutor system of Yulin University has increased the quality score of business plans by 22%, and the AI training platform of Changsha University of Science and Technology has solved the problem of a single practical scenario by simulating a business environment^[2].

Multimodal technology, through the integration of 5G, VR/AR, and holographic projection, has constructed an educational ecosystem of “data perception - intelligent adaptation - immersive scenarios”. The 5G multimodal smart classroom of Southwest University has increased the activity level of students’ innovative thinking in interdisciplinary practical courses by 37%^[3], and the “AI + Aesthetic Education” platform of Hangzhou No. 7 Middle School has increased the efficiency of artistic creation by 40% through the text-to-image function^[4].

In terms of innovation in the education model^[5], the integration of industry and education and the collaboration between universities and enterprises have become the core paths. The “AI Innovation Community in Universities” in Beijing integrates enterprise resources to support students in developing intelligent agents, increasing the implementation rate of entrepreneurial projects by 25%^[6]; the Shenzhen Futian Education Technology Industrial Park promotes the deep integration of the education chain and the industrial chain through the model of “integration of industry and education, and promoting education with industry”^[7]. At the same time, the role of teachers has shifted from knowledge transmitters to “human-machine collaborative designers”. For example, the Education Bureau of Xiangyang City proposes that teachers need to master the ability to design teaching with AI tools and use generative AI to generate personalized teaching cases^[8]. At the policy level, the initiative of “Artificial Intelligence Empowering Education Development” by the Ministry of Education has clearly defined six major directions, including ethical norms and data security, providing a top-level design framework for universities^[9].

Therefore, it is necessary to construct a “technology - scenario - ability” coupling model, reveal the generation laws of entrepreneurship abilities driven by AI, and explore the “AI + interdisciplinary” education model, such as combining AI with art and engineering to cultivate compound talents. Promote entrepreneurship education to shift from experience-driven to data intelligence-driven, and provide theoretical and practical support for cultivating innovative talents who are adaptable to the digital era.

3.Research Design

This study selects the Fundamentals and Training of Innovation and Entrepreneurship course as the specific implementation method for innovation and entrepreneurship education, focusing on undergraduate students enrolled in this course at GGS University. The fuzzy-set qualitative comparative analysis (fsQCA) method is employed to investigate the enhancement pathways of AI-empowered innovation and entrepreneurship education, analyzing the complex relationships between various educational factors and outcomes in the process of AI integration. The study aims to provide multiple explanatory pathways

for improving the quality of university-level innovation and entrepreneurship education.

3.1 Indicator Construction

3.1.1 Conditional Variable Indicators

(1) AI Literacy and Technical Adaptability of Teachers and Students (LTA)

The effective application of AI technology heavily depends on educators' and learners' understanding and operational skills. Three measurement items are selected: "Received AI technology training", "Experience in using AI tools", "Ability to efficiently integrate AI-generated content".

(2) Depth of Industry-Education Integration (DIR)

AI-empowered innovation and entrepreneurship education requires university-enterprise collaboration to construct authentic scenarios. If integration remains superficial (e.g., limited to agreements without technical or project collaboration), AI applications will struggle to impact core innovation processes. Three measurement items: "Participation in entrepreneurial activities", "Establishment of industry practice bases", "University-provided opportunities for enterprise engagement".

(3) Data Security (DS)

Misuse of AI tools may trigger academic integrity crises and data leakage risks. Three measurement items: "Received AI ethics training", "University has clear usage restrictions for AI technologies", "Awareness of risks from AI misuse in entrepreneurship".

(4) Personalization of Educational Models (PEM)

AI's strength lies in enabling tailored learning paths ("one-size-fits-one"), but requires alignment with educational objectives. Three measurement items: "Dynamic course adjustments based on AI-analyzed learning feedback", "AI-supported entrepreneurial simulations meet personalized needs", "AI tools recommend differentiated course content".

(5) Interdisciplinary Resource Sharing and Collaborative Innovation Mechanisms (IS)

Multimodal learning scenarios necessitate integrating technical, disciplinary, and industrial resources. Data silos across departments or institutions may confine AI applications to narrow domains, hindering interdisciplinary innovation. Three measurement items: "University-provided cross-disciplinary resource platforms", "AI tools enhance interdisciplinary innovation efficiency", "Collaboration with peers/faculty from other disciplines in entrepreneurial practice".

3.1.2 Outcome Variable Indicator

The study adopts "Innovation and Entrepreneurship Dynamism (HYD)" as the outcome variable, reflecting the frequency, quality, and ideational impact of student engagement in such activities. Four measurement items: "Participation in entrepreneurship/tech innovation clubs", "Involvement in university-level innovation/entrepreneurship training programs", "Perceived benefits of innovation education for personal development", "Application of entrepreneurial knowledge to real-world problem-solving".

3.2 Data Analysis

3.2.1 Reliability and Validity Analysis

This study employed a questionnaire survey method, distributing 350 online questionnaires. After excluding invalid responses, 294 valid questionnaires were collected. Reliability and validity analysis demonstrated: The overall Kaiser-Meyer-Olkin (KMO) value was 0.975, indicating excellent sampling adequacy. All factor loadings exceeded 0.6, confirming strong construct validity and high inter-item correlation. Cronbach's alpha coefficients and composite reliability (CR) for all dimensions surpassed 0.8, reflecting high internal consistency and reliability. Average variance extracted (AVE) values for all dimensions were above 0.5, establishing satisfactory convergent validity.

3.2.2 Data Calibration

Prior to fsQCA analysis, raw data were calibrated into fuzzy-set membership scores ranging continuously from 0 to 1. The calibration anchor points for each variable are presented in Table 1.

Table 1 Calibration Anchor Points for Variables

Research Variables			Anchor Points		
			Full Non-member-ship	Full Non-member-ship	Full Non-member-ship
Conditional Variable	LTA	High AI Literacy & Technical Adaptability	1	3	5
	DIR	High Industry-Education Integration	1	3	5
	DS	High Data Security	1	3	5
	PEM	High Personalization	1	3	5
	IS	High Interdisciplinary Sharing	1	3	5
Outcome Variable	HYD	High-HYD	1	3	5
		Non-High-HYD	1	3	5

3.2.3 Necessary Condition Analysis

Determining whether a precondition variable constitutes a necessary condition for the outcome variable primarily depends on the variable's consistency score relative to the outcome. The consistency score, analogous to coefficient significance in regression analysis, indicates the degree to which the outcome depends on the presence of the condition variable. When the consistency score exceeds 0.9, the variable is considered a necessary condition for the outcome. Table 2 presents the consistency test results of the precondition variables against the outcome variable in this study.

Table 4 Necessary Condition Analysis

conditional variables	High-HYD	
	Consistency	Raw Coverage
High-HYD	0.774	0.782
Low-HYD	0.568	0.592
High-LTA	0.768	0.757
Low-LTA	0.546	0.562
High-DIR	0.765	0.603
Low-DIR	0.523	0.553
High-DS	0.529	0.591
Low-DS	0.769	0.713
High-PEM	0.549	0.608
Low-PEM	0.798	0.742
High-IS	0.765	0.717
Low-IS	0.509	0.561

Table 2 demonstrates that none of the consistency coefficients for the presence or absence of variables - including AI literacy and technical adaptability of teachers and students, depth of industry-education integration, data security, personalization of

educational models, and interdisciplinary resource sharing - reached the 0.9 threshold for constituting necessary conditions of high innovation and entrepreneurship dynamism. This indicates that no single variable serves as a necessary condition for the outcome, confirming that the quality of university innovation and entrepreneurship education results from the combined effects of multiple factors.

Notably, all variables in Table 2 showed consistency scores exceeding 0.6, suggesting these conditional variables possess certain independent explanatory power regarding the outcome.

3.2.4 Configuration Analysis

The fsQCA software typically generates three types of solutions with varying complexity levels: complex solution, parsimonious solution, and intermediate solution. This study primarily references the intermediate solution while supplementing with the parsimonious solution. Through configuration analysis, we identified four effective pathways leading to high innovation and entrepreneurship dynamism, as presented in Table 3. The results reveal five distinct configuration paths of conditional variables influencing students' innovation and entrepreneurship dynamism. All paths demonstrate consistency coefficients exceeding 0.8 and coverage rates above 0.75, indicating that these four configurations effectively explain the primary drivers of high innovation and entrepreneurship activity levels.

Table 3 Configurational Paths of Conditional Variables

conditional variables	High Innovation & Entrepreneurship Dynamism			
	Path 1	Path 2	Path 3	Path 4
AI Literacy & Technical Adaptability (LTA)	●			•
Industry-Education Integration (DIR)	•			•
Data Security (DS)	•	•	•	•
Personalization (PEM)			●	•
Interdisciplinary Sharing (IS)	•	•	•	
Consistency	0.899	0.897	0.991	0.964
Raw Coverage	0.763	0.767	0.873	0.321
Unique Coverage	0.007	0.020	0.066	0.001
Solution Consistency		0.986		
Solution Coverage		0.909		

Note : ● indicates the presence of a core causal condition, ⊗ indicates the absence of a core causal condition, • indicates the presence of a peripheral causal condition, Blank space indicates the condition may be either present or absent in the configuration.

4. AI-Empowered Innovation and Entrepreneurship Education Model Pathways

Multimodal learning scenarios integrate AI technologies (generative models, cross-modal interaction, virtual simulation) with educational contexts to enhance AI literacy and technical adaptability among educators and learners while ensuring data security. This creates a three-dimensional ecosystem of „data sensing—personalized adaptation—resource sharing,“ breaking through the limitations of traditional single-modal education and achieving three core innovations:

Path1: Cross-Disciplinary Knowledge Construction Scenario – Breaking Academic Silos to Activate Innovative Thinking

Traditional education confines knowledge within „disciplinary silos,“ whereas multimodal scenarios foster integration through „knowledge visualization + cross-domain linking“: On the one hand, AI-Driven Cross-Disciplinary Knowledge Graphs. Natural language processing transforms knowledge from business models, technical principles, and user experience

into interactive graphs. Students manipulate nodes to visualize cross-domain connections (e.g., Shenzhen Polytechnic's „Innovation Canvas“ tool improves feasibility proposal efficiency by 40% by linking blockchain with agricultural traceability). On the another hand,Generative AI-Assisted Ideation. Keyword-triggered AI generates multimodal solutions, enhancing „associative innovation.“ Pilot data show student teams produce 2.3× more valid ideas, with cross-disciplinary solutions rising from 18% to 55%.

Path 2: Virtual Practice Simulation Scenario – Low-Cost Trial-and-Error for Real-World Competency

Addressing traditional practicums' „high-cost, low-fault-tolerance“ issues, digital twin technologies create lab-grade training: First,Dynamic Business Environment Simulation.AI generates interactive virtual markets using real-world data, exposing students to policy shifts and competitor challenges.Second,Embodied Interaction. VR/AR devices enable immersive experiences.

Path 3: Personalized Adaptive Learning Scenario – Precision Diagnostics for „One Learner, One Strategy“

AI-powered analytics resolve the „scalability-personalization paradox“: On the one hand,Multidimensional Competency Profiling,AI constructs 8-dimension radar maps from decision trails, discussion transcripts, and project artifacts.On the another hand,Smart Learning Paths. AI generates tailored packages (case videos, mentor matching, exercises). Pilot results: 50% faster competency growth with 23% less time investment.

Path 4: Social Collaborative Creation Scenario – Transcending Boundaries to Build Team Resilience

Multimodal technologies redefine teamwork: First,Cross-Region Virtual Teams,Metaverse platforms enable asynchronous collaboration + real-time decision-making among distributed members. Then,Human-AI Co-Creation,AI as „smart collaborator“ supplements data and identifies logic gaps while preserving human creative agency.

5.Conclusion

Multimodal learning scenarios represent not just technological augmentation but a paradigm shift in pedagogy. By solving traditional education „misaligned goals, fragmented scenarios, and lagging evaluations,“ AI transforms „standardized knowledge delivery“ into „personalized competency development.“ Future success requires universities to build ecosystems with technical depth, authentic practice, and precise assessment, cultivating talent that harnesses AI while retaining uniquely human creativity—powering sustainable advancement for China's „Mass Entrepreneurship and Innovation“ strategy.

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Conflict of Interests

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

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Research on the Risks and Strategies of ‘Trust and Safety’ in the Context of Platform Economy: Based on the Perspective of Fuzzy Analytic Hierarchy Process

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Abstract: The platform economy is centered around digital platforms, leveraging advanced capabilities in data collection, transmission, computation, processing, and algorithms to create and exchange value. It represents a new form of digital economic circulation. Compared to the traditional linear economic model, the platform economy exhibits a cyclical trend, facilitating transactions, communication, and value creation through digital platforms. Previous studies have shown that, as a space for communication across time and space, it organizes trust among individuals and determines which trust is reliable to achieve interaction and communication goals. Therefore, trustworthy security providers are crucial. Based on this, this paper constructs a risk indicator system for “Trust and Safety (T&S)”, considering the contribution value of each indicator’s evaluation. The Analytic Hierarchy Process (AHP) is used to calculate the weights of the indicators, and normalization is applied to conduct pairwise comparisons and provide quantitative descriptions of the different indicators. Based on the principle of maximum membership degree, a Fuzzy Analytic Hierarchy Process (FAHP) indicator system is applied. Through fuzzy evaluations by experts, a specific set is chosen from multiple fuzzy sets as the decision result. The analysis reveals that the model addresses the differences in the trust and safety impacts on the platform economy from different evaluation objects, with discourse and algorithmic mechanisms having the greatest influence on the platform economy.

Keywords: Platform Economy; Trust and Safety; Strategic Research; Fuzzy Analytic Hierarchy Process (FAHP)

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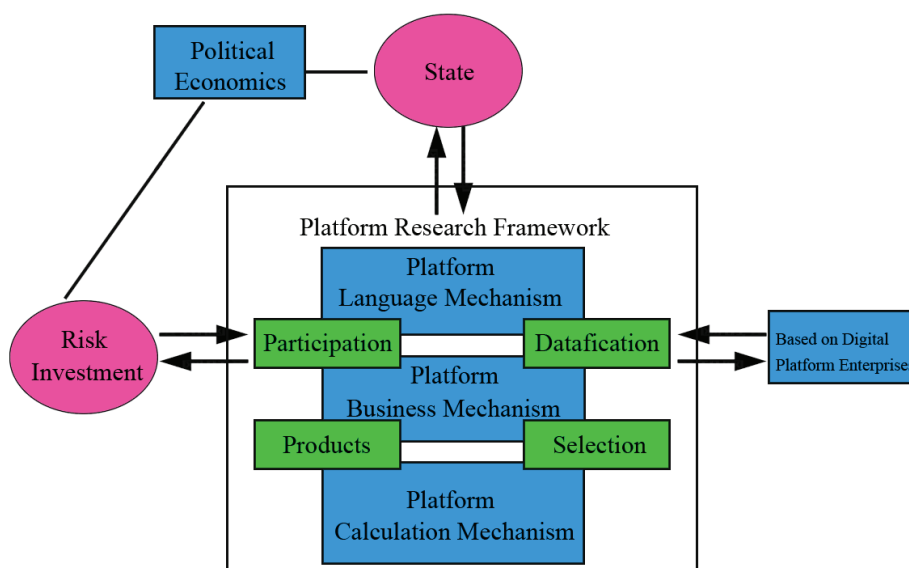
1.Introduction

The platform economy is the core of platform capitalism. It involves connecting service providers and consumers through digital platforms, using data as a resource, “digital labor” as productivity, and the value of the internet as the structure of a new interest-circulation network^[1].

The platform economy reflects the central role of digital technologies in modern market transactions and drives disruptive changes in economic models^[2]. Trust and Safety (T&S), as a barrier of digital platforms, raises the question: when individuals are required to provide personal information to use services on platforms such as apps, should they refuse outright or reluctantly accept? Digital platforms seem to have reached a consensus and are tightly interconnected, attempting to make these unequal conditions an inevitable foundation^[3]. The transformative impact of the platform economy on politics, society, and the economy is now self-evident. Today, most believe that the platform economy raises key issues regarding the ongoing

transformation of capitalism and its evolving social relations, including private governance advocating for free speech, algorithmic regulation of the internet, unrestricted control over data, general deletions, the ethics of artificial intelligence and machine learning, and the displacement of social jobs by digital automation. While each of these issues is significant, they represent only a part of a larger concern: the platform economy accumulates wealth and utilizes its value through “data governance,” which, in the context of intensifying economic conditions, prioritizes profit over democracy and is not fully democratized. Based on Western experience, platform capitalism has its own peculiarities, which are rooted in historical causes and are also related to contemporary political and economic changes. The interaction between platform companies, various levels of government, digital platform-based enterprises, and venture capital has collectively shaped the current platform-based capitalism^[4]. While there is a growing recognition of the “concentrated audience power” of the internet, under limited regulation and weak governance of the online space, individuals’ perception of the trade-off between risks and rewards has not yet resulted in an environment that is both protective and open. It is necessary to analyze a platform paradigm to explore how algorithms, business practices, and discursive mechanisms intersect with venture capital, digital platform-based enterprises, and the evolving political and economic forces, thus forming the practical relationship between state, platform, and capital, as illustrated in Figure 1^[5]. Based on this, enhancing platform trust and safety is essential to ensure that the behaviors of online audiences can have a positive impact on social and economic development.

Fig. 1 : Comprehensive Research Methodology of Platformization



2.Literature Review

Recent academic studies have extensively explored the trust and safety mechanisms of the platform economy. This study briefly outlines aspects in which it differs from previous research.

The widespread adoption and significant characteristics of the platform economy have made it an indispensable tool in contemporary life, contributing to maintaining economic and social balance. The advent of the platform economy era has enhanced people’s awareness of trust protection and provided new avenues for their participation in trust protection activities. Additionally, we have adjusted our quantification system to incorporate more comprehensive behavioral approaches covering all stages of trust and safety. Recent studies have demonstrated that implementing trust and safety mechanisms helps reduce platform system failures, enhance efficiency, and optimize the utilization of existing platform resources, thereby promoting economic consumption. However, some studies have also indicated that these mechanisms may pose risks to personal data privacy. The utilization of trust mechanisms and security technologies driven by technological advancements can enhance economic consumption and payment efficiency. Taking Chongqing Benjing Technology Co., Ltd. as a case study, this research analyzes how the company leverages platform economy policies to achieve sustainable economic growth through trust mechanisms and security systems, providing insights for other technology enterprises. The research confirms that user demands and market dynamics are crucial for sustainable economic benefits within the platform economy.

2.1 Trust Mechanisms in the Platform Economy

User demand is the lifeblood of the platform economy. In his study on users' access to information, Must's Law reveals that "an information system engine, if it does not respond to users' information requests instantly, will fail to support users." This highlights that user support is a critical aspect of trust^[6]. Trust behavior is inherently social. The subject of this behavior (the user) is social, and the objectives, targets, and methods of the behavior are all shaped by the social environment in which it occurs^[7]. With the arrival of the AI era and the widespread application of digital interaction technologies, on the one hand, they provide strong technical support for the platform economy, leading to greater economic benefits; on the other hand, they disrupt the traditional point-to-point trust-building mechanisms, prompting platform capital to establish new trust mechanisms to overcome information barriers^[8]. Platforms such as "ChatGPT," "Google," and "Amazon," as leaders in the platform economy sector, have loyal users and strong brand trust^[9]. Some scholars, in their research on platform customer loyalty, have developed the idea that brand image and trust positively influence users' brand trust in the platform, which in turn positively impacts user loyalty, thereby enhancing their willingness to participate in value co-creation on the platform^[10]. Other scholars, after studying social platforms, found that once users trust the platform's brand, it positively influences their attitude toward participating in value co-creation, thus increasing their willingness to consume^[11]. In the triangular interaction between the platform economy, media, and users, all parties influence and depend on each other. The platform, as the builder and manager, and the media, as the regulatory and promotional vehicle, are the main creators of a healthy platform ecosystem. However, the trust environment may undergo significant changes due to interference from various stakeholders, which has attracted increasing attention. The platform influences users' media exposure, allowing users to assess the platform based on its reputation, make preemptive judgments, and influence consumption behavior. Users' perception of media trust is partly derived from the platform's public opinion effects^[12]. Issues such as insufficient privacy protection and low efficiency in offline identity verification persist in user information authentication, increasing users' perceived uncertainty toward the platform. In summary, users' willingness to participate in trust-based value co-creation on the platform is influenced by four factors: platform reputation, customer support, media attention, and online identity verification.

2.2 Security Mechanisms in the Platform Economy

The primary purpose of vulnerability scanning on digital platforms is to identify and fix potential security issues, thereby enhancing system security^[13]. However, vulnerability scanning itself can introduce risks and dangers, especially if it is not properly managed or is misused. If the vulnerability scanning tools are improperly configured or poorly managed, the scanning process itself may be exploited maliciously. For example, attackers could use the data traffic generated during the scan to launch attacks or exploit flaws in the scanning tools to infiltrate the system^[14]. Platform security incidents can lead to direct financial losses for users, such as ransom payments following data theft. After a security breach is made public, user trust declines sharply, and the damage to the platform's image is often difficult to recover quickly, affecting both customer loyalty and the acquisition of new customers^[15]. Identifying potential security vulnerabilities is typically done through vulnerability scanning software, penetration testing, and user reports. Regularly conducting these checks is key to preventing security issues^[16]. When a platform is compromised by a cyber intrusion, it means that unauthorized individuals or organizations have successfully breached the platform's security defenses^[17]. Such an intrusion can lead to serious security incidents, impacting platform operations, user data security, and the company's reputation. In such cases, prompt response and isolation of affected systems to prevent further data breaches or damage is critical^[18].

2.3 Compliance in the Platform Economy

Jessica Basukie et al. selected multiple countries from Africa, Asia, and the Pacific region as samples to analyze the positive impact of compliance on the platform economy. Through qualitative content analysis, the study found that regulatory mechanisms enhance the reliability, intelligence, and security of the platform economy, thereby fostering economic growth. Regulatory fairness reduces industry monopolies and promotes market diversification^[19]. Zhang Tao et al. argue that in the era of "Internet Plus," e-commerce and digital marketing have brought revolutionary transformations to the platform economy. The researchers employed the Durbin model to analyze the relationships among digital marketing, e-commerce, and the platform economy across 30 Chinese provinces. The study indicates that the openness of business mechanisms, along with

their broad influence, immediacy, interactivity, intelligence, and information-sharing capabilities, facilitates the formation of payment-friendly practices^[20]. In a study of emerging countries, Karolina Mikołajewska-Zajac found evidence of a positive relationship between discourse mechanisms and platform reputation. However, a few studies indicate that negative news surrounding discourse mechanisms exacerbates the complexity of dispute resolution. This transformation has led to an increase in disputes and has negatively impacted platform systems^[21]. For instance, Kitae Kim et al. utilized annual report data from various regions in South Korea. Their research suggests that an inverted U-shaped relationship exists between excessive reliance on user preference algorithms and disputes. In the early stages of algorithmic mechanisms, their high intensity of use and low cost may instead lead to severe issues of excessive online data collection^[22]. Similarly, Edouard Pignot et al. examined the impact of algorithmic mechanisms on resource acquisition patterns in the platform economy. Contrary to expectations, the study found that excessive expansion of algorithms to acquire prospective user information or analyze user preference data increases the level of information resource acquisition^[23]. Likewise, Muhammad Khan et al. argue that customer information traceability is a positive outcome of improved compliance in the platform economy^[24].

2.4 Demand in the Platform Economy

We anticipate that user demand will significantly drive the growth of the platform economy. The increase in users, along with the expansion of enterprises' market shares, has introduced additional instability into the platform economy, underscoring the importance of trust and security. Researchers have conducted multiple assessments to explore the relationship between user demand and trust and security^[25]. S. Sicari et al. examined the influence of social factors, income, and information accessibility on user demand in Canada. According to their findings, an increase in social consensus and income levels is closely associated with greater use of information platforms, while enhanced information accessibility contributes to higher business transaction volumes. Their empirical study indicates that both information accessibility and economic structural adjustments contribute to the stable economic growth of enterprises. Additionally, Huai Cao et al. investigated the correlation between GMV and user demand. The study suggests that the total transaction volume of goods and services on the platform significantly influences users' willingness to engage. Moreover, their comparative analysis reveals that, compared to other regions, the eastern region demonstrates higher efficiency in product scaling and enterprise engagement with transaction platforms^[26]. Similarly, Mohd Johan et al. examined the impact of user retention rates on Malaysian users' willingness to participate in the platform economy. According to their empirical research, user retention enhances both willingness to use the platform and customer loyalty^[27].

Additionally, the authors emphasize the need for collaboration between the public and commercial sectors to replace outdated, cumbersome multi-verification technologies with an innovative trust and security system. Such collaborations are expected to facilitate the development of high-efficiency platform technologies for enterprises. Bob Feinberg and Maurizio Zanardi examined the relationship between economic cooperation, organizational trust and security, and economic growth^[28]. We recommend that service-oriented enterprises increase their investment in platform technologies to foster economic growth and enhance user loyalty, a recommendation supported by case evidence. This approach may help mitigate negative media coverage. Heejeong Jeong et al. investigated the impact of trust and security on the relationship between innovative enterprises and user registration rates. The researchers found a significant negative correlation between user preference algorithms and user retention rates, indicating that users place high importance on information protection^[29]. This finding suggests that enterprises can enhance user loyalty by strengthening technologies for user information security. Their empirical study demonstrates that trust and security play a crucial role in the long-term economic development of innovative enterprises. They suggest that innovative enterprises should drive technological advancements in trust and security to achieve long-term economic growth objectives and foster development.

3. Construction of an Indicator System Based on FAHP

The platform economy has become the primary channel for capital to collect data. Capitalists analyze data through platforms, transforming general data into economically valuable data commodities, thereby realizing the capital value of data. Use the equation editor to show each equation. In this process, platform companies become the main possessors and beneficiaries of data^[30]. The separation between digital labor, data ownership, and its profits has become increasingly apparent. Constructing

a “Trust and Security” indicator system for the platform economy is a prerequisite for ensuring platform operations and information security.

3.1 Construction of the Indicator System

Through a comprehensive analysis of the risk factors associated with “Trust and Security,” and considering the characteristics of the platform economy, it is essential to not only account for business needs but also evaluate data reliability and managerial operability to ensure that the indicator system can effectively support the development and management of the platform economy. This paper, based on the “Comprehensive Research Methodology of Platformization,” selects indicators that can comprehensively assess the risks in the platform economy. It establishes a “Trust and Security” indicator system for the platform economy, consisting of three primary indicators, nine secondary indicators, and twenty-nine tertiary indicators, as shown in (Table 1).

Table 1 Platform Economy ‘Trust and Security’ Indicator System

Primary Indicator	Secondary Indicators	Tertiary Indicators	Indicator Explanation
Platform Indicator	Security	Vulnerability Scan Reports (Number)	Regularly conduct vulnerability scans to monitor the number, types, and severity of vulnerabilities in systems and applications.
		Number of Security Incidents (Count)	Track and record the number of cybersecurity incidents, including intrusions, attacks, and data breaches.
		Time to Fix Security Vulnerabilities (Hours)	Monitor and assess the time taken to fix security vulnerabilities after their discovery, ensuring prompt response and resolution.
		Intrusion Detection Rate (%)	Monitor and evaluate the performance and effectiveness of intrusion detection systems (IDS/IPS), including intrusion detection rate and false positive rate.
	Trust	Online Identity Verification (Yes/No)	Whether the website offers multi-factor authentication, single sign-on, or other security verification mechanisms.
		Media Attention (Yes/No)	The level of attention and activity on social media platforms, including follower count and interaction frequency.
		Customer Support (Yes/No)	The types of customer support offered by the website, response time, and whether satisfactory solutions are provided.
		Platform Reputation (Excellent/Good/Fair/Poor)	The reputation index of the website, including user reviews, ratings, and comments.
Compliance Indicators	Speech Mechanism	Freedom of Expression (Yes/No)	Allow individuals and organizations to freely express opinions, views, and information on the internet.
		Information Traceability (Yes/No)	The source and dissemination path of any information can be traced back to the original publisher, ensuring transparency and authenticity.
		Dispute Resolution Mechanism (Yes/No)	Providing various dispute resolution methods, such as mediation bodies and complaint platforms, to handle disputes and conflicts.
	Business Mechanism	commerce Platform (Yes/No)	Offering features such as product display, order management, and payment settlement.
		Digital Marketing (Yes/No)	Using internet and digital channels for marketing, including search engine marketing (SEM) and social media marketing.
		User Experience Optimization (Yes/No)	Enhancing user experience and satisfaction on internet business platforms, including website interface and interaction design.

Primary Indicator	Secondary Indicators	Tertiary Indicators	Indicator Explanation
Compliance Indicators	Algorithm Mechanism	Data Analysis (Yes/No)	Using big data and data mining technologies to analyze and predict user behavior and market trends.
		Dynamic Pricing Algorithm (Yes/No)	Adjusting the pricing of goods or services dynamically based on changes in market supply and demand and user behavior.
		Ranking Algorithm (Yes/No)	Ranking goods, services, or users to provide the most relevant and valuable content or information to users, promoting transactions.
	Regulatory Mechanism	Industry Standards (Yes/No)	Promoting relevant industry standards, such as e-commerce industry standards and online payment industry standards.
		Antitrust Regulation (Yes/No)	Regulating and combating monopolistic behavior, maintaining market competition, and protecting the rights of small and medium-sized enterprises and consumers.
		User Service Regulation (Yes/No)	Regulating user service quality, providing effective complaint handling mechanisms, and ensuring customer service protection.
Demand Indicators	User	User Activity Rate (%)	Including daily active users (DAU), monthly active users (MAU), and other indicators.
		User Growth Rate (%)	Measuring the growth rate of new users, including registered and newly added users.
		User Retention Rate (%)	Measuring user loyalty and stickiness, considering 30-day retention rate.
	Enterprise	Transaction Frequency (%)	Measuring user purchase frequency and transaction activity, including average monthly transactions per user.
		Gross Merchandise Volume (Ten Thousand Yuan)	Total transaction value of goods, reflecting the overall transaction scale of goods or services on the platform.
		Market Share (%)	Measuring the platform's market share and competitive position in the relevant market.
	Transaction	Transaction Volume (Count)	Reflecting the transaction activity on the platform, including transaction amount, order quantity, and volume.
		Transaction Frequency (%)	Measures the purchase frequency and transaction activity per 100 users, including the average number of transactions per user per month.
		Platform Revenue and Profit (Ten Thousand Yuan)	Reflecting the platform's profitability and the sustainability of its business model.

3.2 Establishment of the Analytic Hierarchy Process (AHP) Model

The basic concepts of the AHP method include three analytical principles. Within the framework of the hierarchical structuring principle, a logically interconnected indicator structure is created^[31]. The priority principle involves making pairwise comparisons across all evaluation levels. Pairwise comparisons are made based on proportions, and the resulting values are used by peer experts to create a new matrix. The logical consistency principle involves measuring the strength of consistency between objectives, criteria, and variables. Pairwise comparisons are made within the matrix to obtain the weight vector for each level^[32]. The indicator weights are determined, and the overall score is calculated in conjunction with the model. This method combines the advantages of both fuzzy comprehensive evaluation and AHP, avoiding the redundant steps of the two methods. Therefore, this paper uses the fuzzy AHP method to determine the weights of the indicator system. For a complex multi-rule evaluation problem, the evaluation indicators and objects are divided into hierarchical levels. Pairwise

comparisons are made within the same level of elements, forming a fuzzy judgment matrix.

$$A = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \cdots & \cdots & \alpha_{1n} \\ \alpha_{21} & \alpha_{22} & \cdots & \cdots & \alpha_{2n} \\ \cdots & \cdots & \alpha_{ij} & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ \alpha_{n1} & \alpha_{n2} & \cdots & \cdots & \alpha_{nm} \end{bmatrix} \quad (1)$$

In the matrix, represents the relative importance of A_i compared to A_j . If A_i is more important, then > 1 ; if both are equally important, then $= 1$. To calculate the weight vector of the indicators, the first step is to normalize the matrix using the following formula.

$$\bar{a}_{ij} = \frac{a_{ij}}{\sum_{i=1}^n a_{ij}} \quad (i, j = 1, 2, \cdots, n) \quad (2)$$

Here, α_{ij} represents the data in the i -th row and j -th column of the judgment matrix A , and \bar{a}_{ij} represents the data in the i -th row and j -th column of the normalized matrix.

$$\bar{w}_i = \sum_{j=1}^n \bar{a}_{ij} \quad (i, j = 1, 2, \cdots, n) \quad (3)$$

The third step is to normalize \bar{w}_i in the above equation, where w_i represents the weight of the i -th indicator.

$$w_i = \frac{\bar{w}_i}{\sum_{i=1}^n \bar{w}_i} \quad (i = 1, 2, \cdots, n) \quad (4)$$

The fourth step is to calculate the largest eigenvalue of the judgment matrix A .

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^n \frac{(Aw)_i}{w_i} \quad (5)$$

Here, n represents the order of the matrix, A is the judgment matrix, w_i is the weight of the i -th indicator, and λ_{\max} is the largest eigenvalue of matrix A . Consistency check: The obtained vector and eigenvalue are subjected to a consistency test. If the test is passed, it means the judgment matrix is reasonable and has explanatory value. Let CI represent the consistency index, and the following is the calculation method, with results shown in (Table 2).

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (6)$$

By using the value of n , the RI value can be obtained, thus allowing the calculation of the consistency ratio, i.e., $CR = \frac{CI}{RI}$. When $CR < 0.1$, the test is considered to meet the requirements.

Table 2 Average Random Consistency Index (RI)

N	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Here, for 1st and 2nd-order judgment matrices, RI is purely formal, as these matrices always exhibit perfect consistency. When the order is greater than 2, the ratio of the consistency index CI of the judgment matrix to the corresponding average random consistency index RI is called the random consistency ratio, denoted as CR . When $CR < 0.1$, the judgment matrix is considered to have satisfactory consistency; otherwise, the matrix needs to be adjusted to achieve satisfactory consistency.

3.3 Construction of the Judgment Matrix and Calculation of Weights

After constructing the comprehensive evaluation system for platform economy based on “Trust and Security,” a weight judgment matrix is established using the fuzzy analytic hierarchy process (FAHP). Expert scoring is then applied to assess the importance of each indicator in the judgment matrix, using a 1-9 scale. Experts in the field are selected to score the importance of each indicator, followed by internal discussion and summarization of the results. The pairwise comparison matrix is shown in (Table 3).

Table 3 Discriminant Matrix

	Platform Indicator	Compliance Indicators	Demand Indicators
Platform Indicator	1.0000	1.4310	2.1689
Compliance Indicators	0.6988	1.0000	1.7826
Demand Indicators	0.4611	0.5610	1.0000

First, calculate the largest eigenvalue $\lambda_{\max} = 3.0030$ of the judgment matrix. Next, perform a consistency test, which requires calculating the consistency index CI :

$$CI = \frac{\lambda_{\max} - n}{n - 1} = \frac{3.0030 - 3}{3 - 1} = 0.0015$$

Average Random Consistency Index $RI = 0.58$. Random Consistency Ratio:

$$CR = \frac{CI}{RI} = \frac{0.0015}{0.58} = 0.0026 < 0.10$$

Since CR is less than 0.1, the construction of the judgment matrix is considered reasonable. Using this method, the consistency tests for all other judgment matrices at each level have been passed.

Table 4 Weight of Indicators at Each Level

Primary Indicator	Weight	Secondary Indicators	Weight	Tertiary Indicators	Weight	Composite Weight or Overall Weight
Platform Indicator	0.4598	Security	0.5	Vulnerability Scan Reports	0.2964	0.068142
				Number of Security Incidents	0.5084	0.116881
				Time to Fix Security Vulnerabilities	0.1157	0.026599
				Intrusion Detection Rate	0.0795	0.018277
		Trust	0.5	Online Identity Verification	0.4317	0.099248
				Media Attention	0.0947	0.021772
				Customer Support	0.1799	0.041359
				Platform Reputation	0.2937	0.067522
Compliance Indicators	0.3393	Speech Mechanism	0.2139	Freedom of Expression	0.3124	0.022673
				Information Traceability	0.5675	0.041187
				Dispute Resolution Mechanism	0.1201	0.008716
		Business Mechanism	0.1071	commerce Platform	0.2931	0.010651
				Digital Marketing	0.144	0.005233
				User Experience Optimization	0.5629	0.020455
		Algorithm Mechanism	0.4652	Data Analysis	0.4333	0.068393
				Dynamic Pricing Algorithm	0.4333	0.068393
				Ranking Algorithm	0.1335	0.021072
		Regulatory Mechanism	0.2139	Industry Standards	0.2632	0.019102
				Antitrust Regulation	0.6056	0.043952
				User Service Regulation	0.1312	0.009522

Primary Indicator	Weight	Secondary Indicators	Weight	Tertiary Indicators	Weight	Composite Weight or Overall Weight
Demand Indicators	0.201	User	0.1907	User Activity Rate	0.1544	0.005918
				User Growth Rate	0.5271	0.020204
				User Retention Rate	0.3184	0.012204
		Enterprise	0.3064	Transaction Frequency	0.1543	0.009503
				Gross Merchandise Volume	0.5302	0.032653
				Market Share	0.3155	0.019431
		Transaction	0.5029	Transaction Volume	0.2471	0.024978
				Transaction Frequency	0.1275	0.012888
				Platform Revenue and Profit	0.6255	0.063227

The results show that the total weight of the demand indicator (0.201) is significantly lower compared to the platform indicator (0.4598) and the compliance indicator (0.3393). This indicates a lack of emphasis on user and transaction demands in the overall evaluation system. In the platform economy, user demands and market dynamics are crucial for sustainable economic benefits.

4. Discussion of Results

4.1 Analysis of Platform Strategies

In August 2021, Accenture was hit by a LockBit ransomware attack, resulting in the leakage of 6TB of data. At the same time, the renowned IT solutions provider Kaseya was also attacked, impacting its services and customers. Capital One suffered a data breach affecting over 100 million customers due to a misconfiguration in its firewall. Multiple zero-day vulnerabilities in Microsoft Exchange Server were exploited. These security incidents highlight the security challenges faced by global digital platforms during their digital transformation. At the same time, they remind us that while the platform economy brings significant benefits, it also requires us to focus on platform cybersecurity to protect sensitive data, maintain user trust, and ensure the stability of the platform economy. Both security and trust are equally important. Among the security sub-indicators, the number of security incidents holds the highest weight (0.117), indicating that the frequency of security incidents is a key factor in measuring platform security. Beyond these cases, the emergence of AI-generated models such as DALL-E and ChatGPT has enabled criminals to mass-produce fake yet credible identities, facilitating scams under legitimate guises, as seen with telecom fraud rings in Southeast Asia. Banks and financial institutions need to adopt advanced authentication and verification technologies to combat such fraud, including document verification, identity graph analysis, and behavioral biometrics. Additionally, collaborative data-sharing initiatives can help uncover synthetic identity patterns across institutions. Among the trust sub-indicators, online identity verification holds the highest weight (0.093), emphasizing the core role of verifying user identity in establishing platform trust.

4.2 Analysis of Compliance Strategies

In the platform economy, big data algorithms do not always yield positive results and can sometimes have negative consequences. For example, Amazon was exposed for using an automated recruitment tool, which was found to be discriminatory against women during the resume screening process. This system disadvantaged female applicants for technical positions because it favored resumes reflecting the gender ratio in the company's technical roles, which were predominantly male. The tool even lowered the scores of resumes mentioning words like "female" (e.g., "women's rugby team") while boosting the scores of resumes using male-leaning language such as "executive" and "capture." Amazon discontinued the use of the tool after realizing that the issue was difficult to resolve, but many other companies may still be using similar flawed recruitment tools. Additionally, IBM mentioned in its discussion of AI bias that AI biases reflect existing societal prejudices, including historical and current social inequalities. For instance, if a facial recognition algorithm's training data is racially

biased, it may produce errors when attempting to recognize the faces of people of color. Furthermore, if the security data used by AI tools deployed by law enforcement contains information collected from racially biased geographical areas, it may introduce racial biases into the AI tool.

These cases indicate that big data algorithms, if not carefully designed and regulated, may replicate or even amplify existing societal biases. Therefore, to ensure the fairness of AI systems, it is necessary to rigorously examine and test the training data, the algorithms themselves, and the predictions generated by the algorithms to identify and mitigate potential biases. When utilizing big data, it is crucial for platform companies to implement effective AI governance and bias testing, which helps build a system that is fair to everyone and ensures that the true benefits of AI systems can be realized. This also highlights the importance of transparency when using big data algorithms. In the compliance indicators, the algorithmic mechanism holds the highest weight (0.465), with data analysis and dynamic pricing algorithms having equal weights (0.068 each), indicating that these technologies play a critical role in ensuring compliance.

In April 2021, China's market regulatory authorities imposed a hefty fine of 18.2 billion yuan on Alibaba Group for abusing its dominant market position and engaging in the "choose one of two" monopolistic behavior. This event sparked widespread attention and discussion across society and industry, involving the enforcement of antitrust laws, regulation of the digital economy, and competition in the internet platform market, among other aspects. Antitrust regulation holds the highest weight (0.044) within the regulatory framework, highlighting the importance of preventing market monopolies in the platform economy. even amplify existing societal biases.

4.3 Analysis of Demand Strategies

Platform revenue and profit serve as the foundation for reinvestment, which is critical for improving services, driving technological innovation, and expanding market presence. Without sufficient profit, a platform may struggle to invest in new product development or service improvements, which could impact its long-term competitiveness and market demand. Stable revenue and profit ensure that the platform can cover operational costs, including employee salaries, equipment maintenance, marketing, and other daily expenses. If a platform cannot sustain profitability, it may fail to maintain long-term operations and ultimately lose users and market share. The weight of platform revenue and profit (0.0632) reflects the significance of profitability from transactional activities for the platform. Revenue and profit provide the platform with a buffer, enabling it to survive during periods of market downturns. This is because profitable companies are more likely to remain stable during uncertain economic periods, thus continuing to meet customer demands.

Among the user and enterprise sub-indicators, user growth rate and GMV (Gross Merchandise Volume) carry relatively high weights, as they are key metrics for evaluating platform expansion and market performance. Transaction volume is a key indicator of platform economic success, as it directly impacts the platform's revenue, market share, and growth potential. As one of the world's largest e-commerce platforms, Amazon's success is largely attributed to its massive transaction volume. This not only brought significant revenue to Amazon but also attracted more sellers and buyers through its "network effect," further strengthening its leadership position in the platform economy. Taobao is renowned for its massive transaction volume and user base, with Taobao and Tmall having become the leading e-commerce platforms in China. These platforms play a central role in the platform economy, both in China and globally, by meeting the demands of a large number of consumers and businesses. As a global online auction and shopping platform, eBay leverages its large-scale transactions and extensive user base to offer a diverse marketplace. By offering a broad rental accommodation market, Airbnb rapidly grew and disrupted the traditional hospitality industry due to its large transaction volume. It created new market opportunities through a vast number of listings and bookings, impacting the development of the travel industry. These cases illustrate that transaction volume is an undeniable factor in the platform economy, with significant influence on consumers, business users, and the industry as a whole. The growth of transaction volume is often accompanied by a strengthening of network effects, where each additional user adds value to the platform and attracts more users, thereby creating a positive feedback loop.

4.4 Conclusion

The characteristics of the platform economy and the trust and security challenges it presents, including data breaches, identity theft, fraudulent activities, and algorithmic biases. These risks not only threaten the security of users' personal information

but may also damage the platform's business reputation and market competitiveness. This study examines this issue from the perspective of Fuzzy Analytic Hierarchy Process (FAHP), aiming to provide more scientific and systematic solutions to the trust and security challenges in the platform economy. Using FAHP, the study assigns weights and ranks the priority of trust and security risk factors in the platform economy. Through this approach, the study identifies the relative importance of various risk factors, providing a basis for platforms to develop targeted security strategies. For instance, data security management, user authentication, and algorithm transparency were identified as the areas requiring the most attention. Corresponding strategic recommendations include strengthening data encryption technologies, implementing multi-factor authentication, improving algorithm transparency and fairness, and enhancing collaboration with government and industry to create a secure platform economy environment. The study emphasizes that continuous monitoring and evaluation are key to ensuring trust and security in the platform economy. It is recommended that platform operators regularly conduct security audits and adjust security strategies based on audit results to ensure their effectiveness and timeliness. Through the application of FAHP, this study offers a new perspective and methodology for addressing trust and security issues in the platform economy, with the hope of providing valuable insights and references for both industry and academia.

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How Does AI Empower the Development of Cities and Enterprises? A Literature Review and Pathway Analysis

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Abstract: As a key driving force behind the new round of technological revolution, artificial intelligence (AI) is reshaping urban systems and the operational logic of enterprises at an unprecedented pace. In the urban context, it has revolutionized public governance and administrative models, driving the upgrading of smart infrastructure and the transformation of fiscal systems. In the corporate domain, AI has exerted far-reaching impacts on operational performance, corporate governance, and financing activities. However, issues such as the “algorithmic divide” and new financial risks have also become prominent. Through a comprehensive review and analysis of relevant literature, this study reveals the complex mechanism by which AI influences urban and corporate development. From the perspective of enabling pathways, the technological mechanism has altered cost structures and production models, the principal-agent mechanism has reconstructed organizational relationships, and the market allocation mechanism has reshaped market order—yet each of these mechanisms faces unique challenges. In the future, establishing a balance between AI capabilities and institutional frameworks, as well as strengthening regulatory and ethical norms, will be crucial to achieving efficient transmission across the “urban-corporate” dimension and promoting digital transformation.

Keywords: Artificial Intelligence; Urban Development; Corporate Governance; Pathway Mechanisms

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1.Introduction

Artificial intelligence (AI), as a core force in the new round of technological revolution, is empowering urban systems and enterprise operational logic at an unprecedented pace. Since 2010, breakthroughs in key foundational technologies such as big data, cloud computing, and deep learning have extended AI functional boundaries from perception and prediction to automated decision-making and institutional control, shifting its economic impacts from the technical efficiency level to the institutional structural level. This transformation has elevated AI from a mere technological variable to a critical productive factor, significantly influencing urban governance and corporate governance structures.

On one hand, concepts like the “smart institutional environment” in the urban dimension have drawn increased attention to AI role in enhancing urban system resilience (Schintler & McNeely, 2022). In urban governance, AI transcends traditional management tools, actively shaping resource allocation—from water/electricity scheduling and traffic route planning to influencing local fiscal budgeting and regulatory capacity enhancement. On the other hand, in the corporate domain, AI-

driven empowerment of corporate governance and digital transformation has substantially improved production efficiency (Wamba-Taguimdje et al., 2020). For example, AI-led risk assessment systems have revolutionized risk evaluation processes, enabling enterprises to establish intelligent end-to-end risk management.

Despite the exponential growth of AI research and its extensive exploration in urban governance and corporate management, the academic landscape remains notably fragmented. Urban governance studies predominantly focus on technical applications like “smart cities” and “digital platforms,” emphasizing efficiency improvements in traffic scheduling and public services (Yigitcanlar et al., 2020), which limits insights to isolated “governance function modules.” Corporate research largely concentrates on AI optimization of “overt economic indicators” such as productivity and management performance (Wamba-Taguimdje et al., 2020), with preliminary discussions on its role in reorganizing corporate structures and driving digital transformation. More critically, the urban and corporate research dimensions have long operated in parallel, lacking systematic linkages—making the exploration of how AI empowerment transmits across the “urban-corporate” continuum a pivotal research gap (Liu et al., 2024).

Consequently, systematically understanding the impacts of AI empowerment on urban and corporate development has become a key concern for both academia and policymakers. While existing studies address application outcomes in specific domains, a comprehensive synthesis of literature is lacking, and a unified explanatory framework for transmission pathways and action mechanisms across urban and corporate levels remains underdeveloped. This paper therefore systematically reviews AI empowerment application scenarios and economic performances within multi-level institutional logics of cities and enterprises, aiming to fill theoretical gaps in the “AI-institution-performance” relationship and provide insights for policymakers and corporate managers during digital transformation.

2. Economic Impacts of AI on Urban Systems

2.1 AI Empowerment of Urban Public Governance and Digital Government

AI most direct transformation of cities lies in its reshaping of the technical foundations and organizational logic for public governance and administrative capabilities. In a systematic review of smart city practices, Yigitcanlar et al. (2020) argue that AI is evolving from a technical support layer to an “institutional hub,” assuming multiple roles in data-driven governance—including prediction, scheduling, early warning, and feedback. Notable examples include real-time urban traffic signal scheduling, rapid emergency response systems, and automated governance performance feedback mechanisms. Take Singapore’s “Virtual Singapore”—a digital twin city project that uses AI to integrate geospatial, traffic, and demographic data, enabling policy simulation and risk assessment to provide scenario models for urban planning and emergency response. This governance paradigm marks a shift from “reactive decision-making” to “predictive governance.”

Das (2025) studying cities in the Global South, found that after introducing an AI data platform in São Paulo, Brazil, urban work order processing time decreased by over 40%, yet the system feedback accuracy was significantly lower in impoverished areas. This reveals the “algorithmic divide” issue: without institutional foundations and data equity mechanisms, the governance optimization effects of AI platforms (AI administrative platforms) will exhibit pronounced spatial disparities, potentially even reinforcing existing governance inequalities. Deng et al. (2021) further note that AI systems under the “digital twin city” concept not only enhance response speed but also embed decision preferences and governance process standards. For instance, Shenzhen’s deployment of AI risk identification algorithms in urban safety has enabled “full-domain sensing-adaptive response” across subway stations, communities, and buildings. This governance model, emphasizing a closed-loop of pre-judgment-scheduling-feedback, is termed the “governance-nested AI model”. Additionally, Schintler and McNeely (2022) characterize AI’s role in urban governance as an “institutional resilience reinforcement mechanism”: AI not only provides real-time information but also helps government agencies construct “multi-scenario adaptive strategies” through algorithmic simulation, enhancing cities’ institutional flexibility and emergency response capabilities amid risks like pandemics and climate disasters.

2.2 AI Empowerment of Urban Smart Infrastructure and Fiscal Efficiency

With the integration of AI technologies, urban infrastructure has evolved from “passive maintenance assets” to “active learning systems”. Traditional urban foundational systems—including transportation, energy, water, and environmental

monitoring—are being reconstructed by AI-driven intelligent systems, whose impacts extend beyond operational efficiency to fundamentally empower urban fiscal logic. AI has reshaped fiscal expenditure patterns, budget allocation principles, and performance evaluation systems, driving urban fiscal institutions toward a more dynamic, data-driven, and outcome-oriented framework.

Korada (2021) notes that in AI-dominated infrastructure systems, urban fiscal resources are shifting from passive repair and periodic maintenance to upfront investments in intelligent systems and algorithmic updates, forming a fiscal transformation mechanism that transitions “from asset maintenance to smart scheduling.” This signifies a fundamental of budget structures and drives fiscal resources from “stock control” to “incremental optimization”. In transportation systems, AI scheduling platforms analyze real-time traffic flow data to accurately identify congestion points, predict peak traffic, and dynamically adjust signal systems, thereby reducing congestion costs and energy waste. In urban budget management, AI plays a crucial role in optimizing government budget allocation: Valle-Cruz et al. (2022) developed a hybrid algorithm model using multi-layer perceptrons and multi-objective genetic algorithms, analyzing open data from 217 countries (1960-2019) to construct a “budget input-policy output” framework. The results show that AI can identify complex nonlinear relationships through massive data processing, uncovering expenditure allocation patterns imperceptible to traditional methods. Its decision-support systems demonstrate significant potential in optimizing resource allocation, promoting economic stability, and enhancing income equity. The study validates the consistency between AI methods and traditional public budget theory, providing a technical pathway for dynamic and precise budget formulation in smart government initiatives, while also offering data-driven policy tools for addressing dynamic challenges such as economic crises and inflationary pressures. AI is driving urban fiscal institutions from “ex-ante static planning” to “in-process dynamic scheduling” and “ex-post outcome orientation.” Fiscal behaviors have become more transparent, real-time, and responsive due to AI’s deep integration, significantly enhancing governance efficiency. However, this technological governance also poses new demands for regulatory capabilities, ethical standards, and algorithmic governance structures. The future development of urban fiscal systems will largely depend on building a balance mechanism between AI capabilities and institutional adaptation.

3.Economic Impacts of AI on Enterprises

3.1 AI Empowerment of Enterprise Operational Performance

From productivity gains to transformations in capital returns, AI, as a general-purpose technology, is to enterprise value creation systems. Brynjolfsson (2021) posits in his “complementary mechanism of intangible capital” hypothesis that AI’s true value does not stem from its computational capabilities alone but relies on deep integration with a firm’s unique intangible capital—including organizational process reengineering, employee skill upgrades, and cross-departmental data-sharing mechanisms. Without these “complementary institutions,” AI not only fails to drive performance leaps but may even exacerbate resource allocation inefficiencies. This “institutional complementarity dependence” has gained empirical support from numerous studies. Wang et al. (2023) utilized panel data from 938 Chinese manufacturing listed firms (2011-2020) and employed fixed-effects models, mediating effect models, and difference-in-differences (DID) models to scientifically examine the impact of artificial intelligence (AI) on TFP. The results show that AI significantly enhances the TFP of Chinese manufacturing enterprises, with the most pronounced improvements observed in firms featuring strong knowledge-sharing institutions and flat organizational structures. Conversely, enterprises with rigid hierarchies and fragmented management information flows often experience minimal performance gains due to the “digital silo effect,” even after AI system investments.

Kuang and Zhou (2025) identifies an inverted U-shaped relationship between enterprise digital transformation—especially the adoption of advanced technologies like AI and cloud computing—and ESG performance. At the profitability level, the study notes that digital technologies initially reduce operational costs and boost profits through automated process optimization, intelligent forecasting, and improved resource allocation. However, in the deepening phase of transformation, firms that fail to align organizational structures, management mechanisms, or business models with technological upgrades may face increased technical path dependence, sunk costs, and organizational inertia, which can suppress profitability and weaken overall ESG performance. This finding underscores that AI’s effectiveness is not automatic; its performance benefits are heavily contingent

on institutional environments, managerial responsiveness, and cultural adaptability. Sokolowska and Zargartalebi (2024) further argue that some enterprises, under financing constraints and labor informality, treat AI as a “cost-cutting tool” focused solely on labor substitution rather than systematic upgrades or organizational restructuring. Such “myopic deployments,” while effective in the short term, fail to deliver long-term improvements in capital return rates.

The impact of AI on enterprise performance operates through a “structural nonlinear mechanism”: its multiplicative effects are realized only when AI deployment is embedded with institutional, organizational, and cultural elements. Otherwise, it may lead not to performance enhancements but to capital misallocation, resource stagnation, and exacerbated institutional frictions. Therefore, in future policy-making and corporate strategies, AI should be treated as an institutional variable rather than a mere tool, requiring holistic transformation to address its challenges to production and organizational models.

3.2 AI Empowerment of Corporate Governance

As artificial intelligence deepens its integration into enterprise management, the logic of corporate governance is undergoing a profound shift from “human governance” to “algorithmic rule-based governance.” This transformation not only redefines the roles and responsibilities of managers but also poses new challenges to internal power structures, organizational forms, and employee behavioral norms. AI’s core roles in corporate governance can be categorized into three dimensions: algorithmic decision substitution, strengthened internal controls, and facilitated organizational restructuring.

AI is reshaping corporate decision-making logic and power distribution. Agrawal et al. (2022) argue that AI economic value stems from a substantial reduction in “prediction costs,” enabling automated probabilistic reasoning and scenario screening in domains where mid-to-top managers historically held information judgment monopolies. This erodes the “monopoly of judgment” in traditional management hierarchies, driving power structures toward flattening and fostering “decentralized” governance models rooted in data-driven algorithms. Shao et al. (2022) in an empirical study of Chinese fintech platforms, found that non-state-owned enterprises experienced significantly improved financing transparency and efficiency after adopting AI credit mechanisms. This change arises from algorithmic models conducting dynamic credit evaluations based on transaction data and operational performance, reducing the role of “relationship capital” and indirectly promoting a shift in governance structures from “power-dependence” to “rule-transparency”.

AI also plays an increasingly pivotal role in internal control mechanisms. Traditional financial control, performance evaluation, and compliance processes rely heavily on post-hoc audits and supervisory oversight, whereas AI integration enables “process control.” Enterprises deploy AI and IoT to establish automated compliance tracking, real-time risk alert systems, and abnormal data detection mechanisms (Mahmood et al., 2022), achieving preemptive “digital governance” even before formal institutionalization. This “digital incubation model” has become a common pathway for emerging corporate governance under AI influence.

However, AI governance mechanisms are not without controversy. Yu and Li (2022) identify a complex mechanism through which AI decision transparency affects employee trust: while higher transparency enhances perceived effectiveness and fosters trust, it also triggers employee discomfort, potentially inhibiting trust. Mishandling this parallel multiple-mediation effect may lead to algorithmic distrust and “technological domination” anxiety, weakening organizational cohesion and institutional identification. Thus, enterprises must deeply understand the relationship between AI decision transparency and trust, balancing effectiveness with comfort to enhance employee acceptance and promote human-AI collaboration.

3.3 AI Empowerment of Corporate Financing Behavior

As artificial intelligence deeply penetrates financial systems, corporate financial behaviors, especially financing mechanisms, are undergoing a structural transformation. AI applications in credit allocation, risk management, and credit assessment are dismantling the structural discrimination and information asymmetry in traditional finance, which historically relied on human-defined labels such as identity, firm size, and property rights. Particularly for small and medium-sized enterprises (SMEs), AI empowerment is opening new channels for capital acquisition while presenting novel institutional challenges and opportunities for financial governance.

The mitigating effect of AI on financing constraints has been widely validated. Shao et al. (2022), in an empirical study of non-state-owned enterprises in China emerging markets, show that AI financial platforms leverage machine learning models

to collect real-time operational data—including transaction frequency, cash flow volatility, and supply chain transactions—to construct dynamic credit scoring systems. This data-driven approach breaks through the long-standing “scale-ownership bias” of traditional financial institutions, enabling previously marginalized small and medium non-state enterprises to access credit systems more equitably, significantly improving their financing availability and reducing costs. Alao (2024) highlights that AI technologies are reshaping the matching mechanisms of financing markets through fintech platforms. Unlike traditional banks that rely on historical credit records and external rating agencies, AI platforms extract real-time information from diverse “digital footprints”, user behavior data, invoice records, social media feedback, via API interfaces to build dynamic credit evaluation models. This mechanism allows marginalized enterprises lacking traditional credit histories, such as female-led startups and new-energy microenterprises to gain recognition and support from financial institutions through behavioral profiling, thereby enhancing structural inclusivity and equality of opportunity in financing.

AI has also exerted profound impacts on capital structure. Xu and Zhao (2023) notes that AI-driven enterprises are altering how capital structures are constructed. These firms typically feature light asset structures, long R&D cycles, and scarcity of fixed assets, making it difficult for traditional credit institutions to conduct effective valuations. As a result, they tend to favor equity financing over debt financing. Concurrently, AI platforms analyze corporate behavioral data to more accurately predict growth potential, enhancing their financing ratings in capital markets. This shift not only strengthens venture capitalists’ willingness to invest in AI enterprises but also reduces their reliance on high-leverage debt, facilitating more robust capital structure optimization. Chang et al. (2024) through a cross-sectional empirical analysis of digital transformation in China A-share market, shows that the widespread adoption of AI platforms in banking systems is transitioning traditional credit models—based on historical scores and fixed credit limits—toward dynamic credit granting systems rooted in real-time behavioral data and risk early-warning mechanisms. This transformation enhances banks’ responsiveness to corporate credit status and significantly improves the flexibility of enterprise liquidity allocation, thereby shortening capital turnover cycles and boosting overall operational efficiency.

4. Mechanisms of AI Empowerment for Urban and Corporate Development

4.1 Technological Enablement Mechanism

The technological mechanism represents the most direct and foundational layer of AI’s empowerment pathways for cities and enterprises. Core AI technologies—particularly machine learning and deep neural network models, excel at processing unstructured big data, enabling real-time prediction and automated response, thereby drastically reducing marginal decision-making and coordination costs in traditional economic activities. Unlike traditional information technologies, however, the cost structure changes induced by AI are not merely linear optimizations but institutional transformations of production factor boundary conditions.

From a cost structure perspective, AI models require substantial data resources and engineering costs during training and system integration phases, constituting their high fixed costs. Once deployed, however, their inference and application processes demand negligible marginal labor or additional computational resources. This “high initial cost + near-zero marginal cost” structural feature grants AI technologies powerful multiplicative effects across multi-scenario and large-scale expansions, rapidly releasing economic and efficiency dividends (Chang et al., 2025). Nayak and Walton (2024) further argues that the “fixed capital-data training” model structure underpinning AI systems is evolving into a new form of institutional market entry barrier. Unlike traditional economic models where marginal costs decrease with production scale, cost reductions in the AI economy depend on continuous model iteration and synergistic expansion of computational infrastructure. This mechanism inherently favors large AI enterprises, as small and medium-sized enterprises (SMEs) lacking data resources and training capabilities face marginalization risks, being excluded from core technologies and markets. At the industrial level, AI-driven automation is reshaping production models. Liang et al. (2025) made an empirical analysis of AI applications across Chinese industries reveals significant disparities in inter-industry adaptability, exhibiting a typical “asymmetric technological penetration” pattern. Data-intensive, highly standardized industries such as finance, e-commerce, and manufacturing more easily integrate AI systems, achieving substantial marginal efficiency gains. In contrast, labor-intensive or service-oriented sectors, characterized by high automation substitutability and technical integration challenges,

are more prone to structural employment shocks and job reconfiguration risks. This divergence is driving dynamic evolutions in China industrial structure.

The production process reconfiguration enabled by AI has also spurred investment waves in new digital infrastructure. Christou and Piller (2024) in their research on organizational transformation, posit that the core of the AI economy has shifted from “labor-for-output” to “algorithm-for-feedback,” with its fundamental economic units evolving from “capital + labor” to a new paradigm of “computational power + data”. This technological logic has triggered a new round of digital infrastructure construction, making AI an institutional variable that redefines the production function itself rather than merely a technical tool. Platform enterprises like Amazon, Google, and Alibaba have embedded AI into their logistics, finance, marketing, and customer relationship management systems, creating closed-loop ecosystems of production-prediction-feedback. These intra-platform AI coordination mechanisms further reduce marginal transaction costs, enabling enterprises to transcend traditional market specialization and adopt full-process automated management models.

Notably, however, the cost structure changes brought by AI are not inherently benign. In the absence of institutional regulation, AI deployment may induce “scale monopoly” and “algorithmic path dependence” issues. Narechania (2025) highlights that the high fixed costs and extremely low marginal costs of AI systems, once a first-mover advantage is established in a market, enable path dependence and market exclusivity through algorithmic optimization and data feedback mechanisms. As model dominance solidifies, AI not only narrows technological competition but also embeds itself into market rules via its cost structure and learning mechanisms, becoming an institutional variable that reshapes resource allocation and production functions. This structural shift promotes a new infrastructure logic centered on “computational power + data,” systematically influencing the evolution of enterprise behavior patterns and urban economic structures.

4.2 Principal-Agent Mechanism

The principal-agent problem, rooted in information asymmetry and misaligned objectives, is a core driver of organizational governance failures. The deep integration of artificial intelligence fundamentally restructures this relational system, giving rise to a new “algorithmic agency structure” that reshapes not only within enterprises but also the interaction logic among government agencies, urban platforms, and the public.

Möhlmann et al. (2021) argue that AI technologies are profoundly transforming agency relationships in traditional corporate governance. By real-time collecting and integrating dynamic data from both inside and outside organizations, AI effectively mitigates information asymmetry in the traditional principal-agent chain, reducing reliance on cumbersome monitoring and incentive mechanisms. Their data-driven governance model, centered on algorithms, enables top managers to conduct continuous, automated behavioral monitoring of frontline and middle-level operations, significantly enhancing organizational responsiveness and operational transparency. In urban governance, this trend is also emerging: many city governments deploy AI for budget allocation, performance monitoring, and public affairs management, transforming traditional hierarchical authorization mechanisms into algorithm-dominated “real-time response systems.” This breaks down information silos between government departments and establishes a “data-logic-based agency monitoring structure.”

AI-empowered principal-agent mechanisms exhibit unique characteristics and advantages: First, efficiency. AI systems outperform human agents in real-time monitoring and behavioral memory, better identifying deviant behaviors and opportunism; second, transparency, AI-recorded processes provide quantifiable governance data for post-hoc accountability and institutional feedback; third, boundary redefinition, the traditional control system based on hierarchical structures is increasingly replaced by algorithmic data chains.

However, these mechanisms are not without risks. Delacroix and Wagner (2021) caution that as AI becomes a key information processing and decision-making hub, traditional responsibility structures are eroding. When AI systems substantially influence decision-making but lack ethical awareness, legal personality, or institutional ownership, a “non-accountable agency” structure emerges. This can be exploited by top managers to evade accountability, shifting risks to “technical systems” and masking the absence of human judgment, potentially inducing “algorithmic authoritarianism” at the institutional level.

4.3 Market Allocation Mechanism

While AI technological enablement mechanisms reshape production functions and governance mechanisms redefine organizational boundaries, its ultimate impact at the market level is the formation of a new round of institutional market restructuring through platform-dominated network effects and data monopoly structures.

Narechania (2021) dubs AI platforms “natural algorithmic monopolists,” distinguishing their monopoly from traditional fixed-asset-based natural monopolies by attributing it to “increasing returns to data learning”. Larger platforms optimize algorithms more effectively, improving marginal decision precision in a non-linear manner that makes market entry extremely difficult for smaller players, leading to competitive path lock-in. AI platforms construct “intelligent lock-in mechanisms”: on one hand, they make user migration difficult through interface binding, data sedimentation, and habitual behavior guidance; on the other, they deeply entangle enterprise resources via intra-platform ecosystems (e.g., supply chain finance, logistics algorithms, precision advertising), creating institutional dependence. This evolves into “semantic path dependence” and “knowledge monopoly”, platforms control not only traffic and transactions but also semantic categorization, trust mechanisms, and consumer choices.

AI platforms fundamentally construct a new co-creation relationship through data synergy: users serve as both consumers and algorithm trainers, with their behavioral data fueling model optimization. The end result is a shift in market control from price mechanisms to algorithmic mechanisms. Platforms shape user choice spaces through recommendation paths, information ranking, and traffic allocation, establishing new market order. Neumann et al. (2022) highlight that AI platforms implement differentiated pricing via user profiling and behavioral data, so-called “algorithmic discriminatory pricing models”, controlling access and prices to reshape transaction pathways, thereby exacerbating information asymmetry and institutional power concentration. Corresponding regulatory measures must keep pace to ensure the equitable and effective use of AI tools.

5. Conclusion

Artificial intelligence as a critical productive factor, plays a pivotal role in urban and corporate development, exerting far-reaching impacts while presenting substantial challenges.

In urban contexts, AI empowers public governance and digital administration, driving a shift from “reactive decision-making” to “predictive governance.” However, this transformation also exposes issues such as the “algorithmic divide,” highlighting risks of spatial disparities in governance efficiency. Regarding smart infrastructure and fiscal efficiency, AI accelerates the intelligentization of urban infrastructure and fosters fiscal institutional reforms, yet it imposes new demands for regulatory frameworks and ethical standards to address potential governance inequalities.

In the corporate domain, AI’s effects on operational performance exhibit structural nonlinearity, with multiplicative benefits realized only through synergy with institutional, organizational, and cultural elements. In corporate governance, AI reshapes decision-making logic and power structures while strengthening internal controls; however, the absence of complementary mechanisms can erode employee trust due to opaque algorithmic processes and “non-accountable agency” risks. Concerning financing behaviors, AI mitigates financing constraints and optimizes capital structures for enterprises, especially SMEs by reducing information asymmetry, though it also introduces new financial risks tied to data-driven credit models and potential market exclusivity.

From the perspective of enabling mechanisms, the technological pathway alters cost structures and production models, but its “high fixed cost + near-zero marginal cost” feature may lead to “scale monopoly” and market entry barriers for smaller players. The principal-agent mechanism enhances organizational transparency and responsiveness through algorithmic monitoring, yet it risks enabling managerial accountability evasion via “non-accountable agency” structures. The market allocation mechanism restructures market order through platform-driven network effects and data monopolies, but this process raises concerns about “algorithmic discriminatory pricing” and concentrated institutional power, necessitating adaptive regulatory interventions.

AI presents both opportunities and challenges in urban and corporate development. Moving forward, fostering a balance between AI capabilities and institutional adaptation, through enhanced regulatory frameworks, ethical guidelines, and cross-dimensional transmission mechanisms between “urban-corporate” systems, will be crucial. This requires interdisciplinary research to address structural mismatches, ensure equitable technology diffusion, and maximize AI’s potential to drive

sustainable, inclusive digital transformation. By embedding AI within robust institutional ecosystems, societies can harness its transformative power while mitigating risks, laying a solid foundation for the future of urban and corporate development in the digital era.

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Mapping New Quality Productive Forces A Grounded Theory Approach Enhanced by DeepSeek

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Abstract: New quality productive forces have become a central driver of China's transition toward high-quality economic development. This study employs a grounded theory approach and integrates DeepSeek, a large language model, to construct an evaluation framework based on five dimensions: technological innovation, industrial restructuring, institutional coordination, green transformation, and social support. The analysis reveals that these productive forces operate as a co-evolutionary system that combines technology, institutions, and society. It emphasizes the dynamic interaction among foundational technological breakthroughs, policy innovation, and the alignment of human capital. The proposed framework provides both theoretical insights and practical guidance to support innovation-driven development while addressing ecological sustainability.

Keywords: DeepSeek; Grounded Theory; New Quality Productive Forces; Evaluation Framework

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1.Introduction

In recent years, the global economy has been undergoing profound transformations, driven by accelerated technological innovation and continuous industrial restructuring. Within this evolving context, China's economic development is transitioning from a phase of high-speed growth to one that emphasizes high-quality development. The traditional model based on factor-driven expansion is gradually being replaced by a new development paradigm, characterized by innovation-led growth, low-carbon initiatives, and the rise of the digital economy. The concept of "new quality productive forces" has emerged under these conditions as a central engine for economic transformation and industrial upgrading.

Concurrently, the rapid development of artificial intelligence (AI), particularly large-scale language models such as DeepSeek, has opened new frontiers for both theoretical research and practical applications in the field of productivity studies. DeepSeek is capable of efficiently processing and analyzing complex data from the domains of economics, science, and industry. This capability provides more accurate support for constructing evaluation systems. With strengths in natural language processing, automated knowledge generation, and decision assistance, tools like DeepSeek enable policymakers, enterprises, and researchers to develop more responsive strategies, predict economic trends, and promote collaborative innovation (Wang & Kantarcioglu, 2025; Allen, 2025). Incorporating such AI technologies into academic inquiry helps to overcome conventional methodological limitations, encouraging interdisciplinary integration and enhancing the systematic

study of new quality productive forces.

Guided by these developments, this study investigates the conceptual foundations, structural features, and evolutionary logic of new quality productive forces. It further aims to build a scientifically robust evaluation framework by integrating AI-assisted analysis, offering novel insights and methodological pathways to better understand and assess this emerging economic paradigm.

2. Literature Review

The concept of “new quality productive forces” represents a theoretical breakthrough from traditional paradigms of productivity. It responds to the need to restructure productive forces under the dual imperatives of the digital technology revolution and sustainable development. From a historical perspective, productivity theory has gradually moved beyond a linear factor-based model centered on capital and labor since Schumpeter’s pioneering theory of innovation-driven growth (Evangelista, 2018). Later, Freeman expanded the analytical scope by incorporating institutional environments into the framework of national innovation systems (Huang et al., 2024). More recently, studies such as Li et al. (2021) have shown that in the context of the digital economy, technological change has a significant nonlinear impact on total factor productivity. These theoretical advances reflect a growing recognition that traditional productivity theories are insufficient to explain the driving forces behind high-quality development in an era of rapid technological advancement, institutional diversity, and social restructuring.

In this context, the notion of new quality productive forces has gradually gained prominence in both academic and policy circles. In China, the term was formally introduced by President Xi Jinping in 2023, who emphasized the central role of scientific and technological innovation while calling for coordinated development across technological revolutions such as artificial intelligence, institutional restructuring such as data ownership reforms, and broader societal transformations such as the dual carbon strategy (Xie et al., 2024). This marked a new phase in the evolution of China’s productivity theory. In contrast to Porter’s theory of competitive advantage, which focuses on factor endowments and industrial structure, the framework of new quality productive forces places greater emphasis on disruptive technological innovations, such as quantum computing, and their critical role in enabling transformative upgrades of traditional industries. As such, it presents a more complex and systemic perspective (Rubio-Andrés et al., 2024).

Despite increasing scholarly interest, the evaluation of new quality productive forces remains an area marked by disagreement and fragmentation (Yao et al., 2025). The technology-oriented school argues that the essential features of new quality productive forces arise from the emergence of original and disruptive technologies (Zheng, 2024). These innovations have redefined the functions and configurations of traditional production elements—such as labor, tools, and materials—and have introduced new elements like data and information. This has enabled a qualitative leap in productivity. However, while such frameworks are operationally feasible, they often fall short in addressing regional disparities in technological capabilities and variations in local innovation ecosystems (Xue & Chen, 2025). In parallel, the institution-oriented school centers its analysis on changes in production relations and institutional innovations. It often uses policy text analysis to quantify institutional effectiveness, for instance through policy quality indexes or incentive strength metrics (Huang & Li, 2025). Yet these methods face empirical challenges such as semantic complexity in policy language and time-lagged policy effects.

In sum, new quality productive forces represent a vital engine for China’s high-quality economic development. Developing a scientific evaluation framework for this concept is therefore not only a theoretical priority but also a practical necessity for policymaking and resource allocation. At the same time, AI-powered tools such as DeepSeek introduce new possibilities for overcoming traditional methodological bottlenecks. Accordingly, this study adopts an integrated framework that combines grounded theory with large-scale AI models. This approach enhances the consistency and efficiency of text coding, better captures the semantic depth of policy discourse, and facilitates a transition from manual interpretation to AI-enhanced theoretical modeling. Ultimately, it aims to offer both conceptual clarity and technical support for constructing an effective evaluation framework for new quality productive forces.

3. Research Design

3.1 Research Methodology

This study adopts grounded theory as the primary research method and integrates DeepSeek, a large-scale language model, to assist with data processing, coding, and theory development. Grounded theory emphasizes deriving conceptual categories and theoretical frameworks directly from empirical data through systematic coding procedures. It is particularly well-suited for exploratory research, especially in fields such as new quality productive forces, which remain in the early stages of theoretical development. By incorporating DeepSeek, the study enhances the efficiency of data processing and improves the scientific rigor and structural consistency of theory construction.

Data Collection

This study employed big data techniques to collect and filter policy documents and news articles issued by Chinese government and official media sources. Texts were selected based on their relevance to the concept of new quality productive forces, with particular attention to policy authority, thematic clarity, and representativeness across different time periods and administrative levels. The final dataset consists of 127 documents, including 18 policy documents, 18 government reports, and 91 news articles.

Table 1 Statistics of Data Types and Quantities

Category	Number of Documents
Policy Documents	18
Government Reports	18
News Articles	91

4. Coding Process

4.1 Open Coding

During the open coding stage, over 480 distinct codes were generated using DeepSeek through the analysis of 127 policy-related texts published between September 18, 2023, and March 10, 2025. These texts, issued by official government sources, reflect the evolving discourse on the development of new quality productive forces.

The results of the coding process reveal a clear shift in thematic focus over time. In the early stages, discussions primarily concentrated on initial exploration, often approached from a user-centric perspective. As policy efforts progressed, the discourse gradually expanded to emphasize broader stakeholder engagement, cross-sector coordination, and the simultaneous pursuit of technological advancement and systemic security. These trends are reflected in the codes, which capture both direct policy directives such as “prioritizing science and technology-driven development” and “accelerating the formation of new quality productive forces” as well as practical strategies including “digital empowerment,” “industrial chain collaboration,” and “green and low-carbon transformation.” The emergence of these codes corresponds closely with the phased evolution of policy priorities during the 2023 to 2025 period. Table 2 provides selected examples of initial codes, and Table 3 further illustrates how the model effectively extracted meaningful thematic patterns from the overall dataset.

Table 2. Examples of Initial Conceptualization (Selected)

Date	Document Title	Initial Concepts	Quoted Example
2023/9/18	Xinhua Commentary: Leading Development with Scientific and Technological Innovation – First in the Series on Accelerating the Formation of New Quality Productive Forces	Science and technology as the driving force	“Prioritizing scientific and technological innovation in development”
		New quality productive forces	“Accelerating the formation of new quality productive forces”
		Self-reliance and overcoming bottlenecks	“Working urgently to achieve self-reliance in science and technology and overcome key bottlenecks”
		Commercialization of research outcomes	“If going from zero to one represents original breakthroughs, then market application is the path from one to infinity”

Date	Document Title	Initial Concepts	Quoted Example
2023/9/18	Xinhua Commentary: Leading Development with Scientific and Technological Innovation – First in the Series on Accelerating the Formation of New Quality Productive Forces	Increased R&D investment	“In recent years, China’s basic research funding has increased from 49.9 billion yuan in 2012 to 202.35 billion yuan in 2022”
		Innovative policy instruments	Improving the competitive leader selection mechanism by releasing 28 major task lists.
		Strategic emerging industries	“Vigorously developing strategic emerging industries such as new energy, new materials, advanced manufacturing, and electronic information”
		Integration of innovation and industry	“Accelerating the integration of scientific innovation and industrial development”
		Industrial modernization and upgrading	“Promoting qualitative, efficiency, and power shifts in economic development”

Table 3. Initial Category Coding

Initial Category	Conceptual Elements	Source Examples
Technological innovation capacity	Strength in science and education, increased R&D investment, key core technology breakthroughs, original disruptive innovations, policy instruments, institutional reforms, innovation-driven strategy, international cooperation	Central and local government reports, policy briefings, national innovation directives
Industrial restructuring pathways	Deep integration of innovation and industry, strategic emerging industries, future industry planning, commercialization of research, industrial upgrading, national science projects, modernization of the industrial system	Commentaries on industrial upgrading, work reports, statements on innovation-industry integration
Digital empowerment mechanisms	Industrial automation, development of data markets, intelligent manufacturing, metaverse industries, AI applications, digital transformation, computing infrastructure, enterprise digitalization, intelligent operations, autonomous driving	National plans on smart manufacturing, digital economy policies, local pilot projects
Institutional innovation and policy tools	Capital market reforms, competitive leader selection mechanisms, data governance innovations, regional coordination strategies, innovation-friendly policies, factor market reform, science and technology system reform, IP protection, major project investment tools	National policy speeches, five-year plans, ministerial regulations
Green development paradigm	Green productivity, expansion of the NEV industry, low-carbon technologies, circular economy, biomedical innovation, carbon neutrality goals, environmentally friendly technologies, hydrogen energy pilot programs	Policy series on ecological civilization, government work reports, sustainability-focused white papers
Human capital support system	Cultivation of new labor forces, integration of education–research–industry, training of top talent, vocational education reform, promotion of craftsmanship spirit, talent development systems, youth scientist support, international academic cooperation	Speeches by central leadership, Ministry of Education guidelines, provincial education reform documents
Enterprise-driven innovation ecosystem	Role of enterprises as innovation actors, transformation of research outcomes, joint innovation mechanisms, industrialization of R&D, innovation platforms, SME innovation support, research–market matchmaking, restructuring of research institutes	Reports from SOEs and private enterprises, industrial policy updates, commentary on commercialization of innovation
Global competition and cooperation strategies	Regional integration (e.g., Yangtze River Delta), global competitiveness, industrial chain restructuring, international technology exports, innovation clusters, cross-border data flows, international phenomics projects	International cooperation strategies, regional development reports, Belt and Road policy documents
Frontier technology sources	Increase in basic research funding, deployment of large science facilities, quantum R&D, brain–computer interface research, controlled nuclear fusion, general-purpose AI, mesoporous materials, humanoid robotics, third-generation superconducting quantum computers	Reports on major technology projects, expert briefings, science and technology white papers
Modernization of social governance	Public service improvements, data-driven governance, smart cities, health technologies, elderly care solutions, educational equity, autonomous logistics, intelligent emergency response systems	Smart city blueprints, digital governance frameworks, social service innovation reports

4.2 Axial Coding

The purpose of axial coding is to refine and organize the initial codes generated during open coding by identifying their internal relationships and grouping them into higher-level conceptual categories. With the support of DeepSeek's topic modeling capabilities, this stage enabled the identification of recurring themes and the construction of a more abstract and structured coding framework.

Based on a thorough analysis of policy texts and empirical examples, the study extracted five core categories: technological innovation, industrial ecosystem restructuring, green development, institutional and market coordination, and social and human capital support. These categories reflect the key dimensions through which new quality productive forces are conceptualized in both policy narratives and practical implementation.

Table 4. Results of Axial Coding

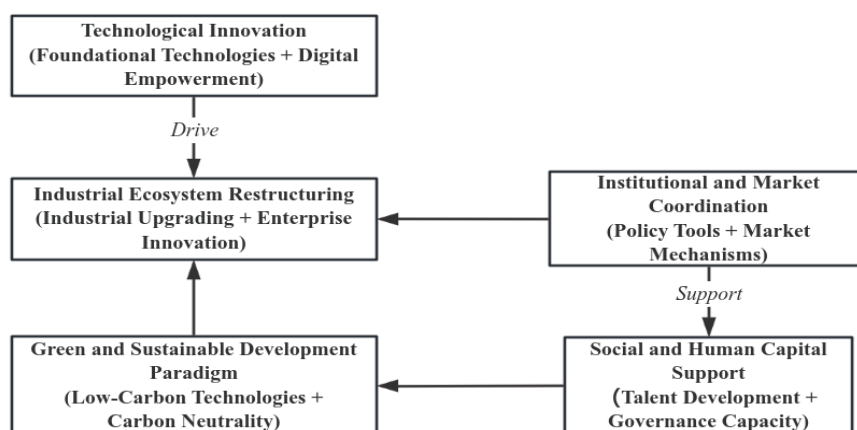
Core Category	Initial Categories	Category Description
Technological Innovation	Technological innovation capacity, Frontier technology sources, Digital empowerment mechanisms	The core driving force of new quality productive forces stems from breakthroughs in foundational research and the widespread application of digital technologies such as the industrial internet.
Industrial Ecosystem Restructuring	Industrial restructuring pathways, Enterprise-driven innovation ecosystem	Focuses on integrating strategic emerging industries with scientific innovation and upgrading traditional industries to build a closed loop from technology to application to market outcomes.
Green and Sustainable Development	Green development paradigm	Green productivity is a defining feature of new quality productive forces. Through carbon neutrality goals, hydrogen energy programs, and circular economy initiatives, it ensures the alignment of economic growth with ecological sustainability.
Institutional and Market Coordination	Institutional innovation and policy tools, Global competition and cooperation strategies	Relies on institutional design and global strategies to break administrative barriers, stimulate market activity, and coordinate innovation policies with industrial transformation.
Social and Human Capital Support	Human capital support system, Modernization of social governance	Emphasizes talent cultivation and governance reform, forming a support network that strengthens institutional performance and enhances long-term innovation capacity.

4.3 Selective Coding

4.3.1 Model Construction

Selective coding represents the final phase of grounded theory analysis. In this stage, the five core categories—technological innovation, industrial restructuring, institutional coordination, green development, and social support—were integrated to form a unified conceptual model. The model reveals the core logic underlying the emergence of new quality productive forces. Specifically, it illustrates how technological breakthroughs drive industrial upgrading, how institutional policies provide structural support, and how social and human capital offer foundational guarantees. The green development paradigm functions as an external constraint that shapes the direction and boundaries of this transformation. Together, these elements constitute a dynamic cycle of innovation, upgrading, support, and sustainability.

Figure 1. Development Model of New Quality Productive Forces



By linking the five core categories, the study conceptualizes new quality productive forces as a co-evolutionary system involving technology, institutions, and society. DeepSeek was employed to assist in generating the visual representation of the model and to validate its internal logic. The result is a five-dimensional framework that illustrates the complex interdependencies among various forces contributing to high-quality economic development.

4.4.2 Model Interpretation

The proposed model reveals the structural logic and dynamic mechanism underlying the formation of new quality productive forces. At its core, technological innovation functions as the initiating mechanism that sets the system in motion. Through foundational research breakthroughs and the deployment of digital technologies, this dimension reshapes traditional production factors and introduces new ones such as data, algorithms, and computing power. It does not operate in isolation, but rather triggers downstream restructuring throughout the industrial ecosystem.

Industrial ecosystem restructuring serves as the primary channel for translating technological potential into economic value. This transformation is not limited to isolated upgrading of specific sectors but entails a systemic reorganization of industrial chains, value networks, and innovation platforms. Strategic emerging industries are embedded into existing structures through processes of coupling and substitution, while traditional sectors are revitalized through technological retrofitting and cross-sectoral integration.

Institutional and market coordination plays a critical enabling and stabilizing role. It creates the necessary institutional infrastructure to reduce transaction costs, allocate innovation resources efficiently, and align market incentives with long-term technological development. This dimension also mitigates the risks associated with uncertainty in innovation by providing regulatory clarity, financial support, and platform governance. The coordination of administrative regulation with market flexibility ensures adaptive policy feedback, which is essential in complex innovation systems.

The dimension of social and human capital support represents the underlying capacity condition of the system. Talent formation, knowledge transfer, and governance capabilities constitute the soft infrastructure that sustains long-term innovation. These human and institutional resources not only absorb and diffuse technological change, but also ensure its contextual adaptation and social acceptability. In this sense, social support is not a passive backdrop but an active participant in shaping the trajectory and effectiveness of new quality productive forces.

Green and sustainable development functions as an external constraint as well as a normative orientation. It sets ecological boundaries within which technological and industrial transformation must take place. This dimension introduces a teleological logic to the model by defining what constitutes “quality” in productive forces. Sustainability is not only an outcome but also a guiding principle that influences decision-making across all other dimensions.

The interaction among these five core dimensions forms a recursive and co-evolutionary system, driven by feedback loops, mutual reinforcement, and functional complementarity. Technological breakthroughs stimulate institutional adaptation; institutional arrangements, in turn, shape innovation pathways; social foundations absorb and sustain systemic change; and green constraints redirect innovation toward long-term equilibrium. The model thus conceptualizes new quality productive forces as an integrated and adaptive system characterized by innovation-driven transformation, institutionally conditioned evolution, and ecologically bounded development.

5. Validation with LDA Topic Modeling

To further verify the robustness and explanatory power of the grounded theory model, this study applies Latent Dirichlet Allocation (LDA) to conduct topic modeling on the full corpus. LDA is a probabilistic generative model that identifies latent semantic structures within a large volume of unstructured text (Liao, 2025). It is particularly useful for uncovering implicit themes in policy discourse and provides empirical support for the conceptual categories established during the qualitative coding process.

The analysis was conducted using Python, and the optimal number of topics was determined through a coherence score test. As shown in Figure 2, coherence scores peaked when the number of topics was set to 5, indicating that a five-topic solution achieves the best semantic interpretability and thematic consistency. Each topic generated by the model was manually labeled based on the top 20 keywords and representative texts associated with it. The resulting topics correspond closely to

the five core categories identified in the grounded theory analysis: technological innovation, industrial restructuring, green development, institutional coordination, and social support. This high degree of alignment between the LDA results and the conceptual model reinforces the validity of the theoretical framework constructed in this study.

Table 5. LDA Topic Extraction Results and Corresponding Manual Labels

No.	Top Keywords	Manual Label
1	industrial upgrading, intelligent manufacturing, integration, enterprise, scenario, application, industry, transformation, platform, chain	Industrial Restructuring
2	talent, training, education, youth, innovation, development, support, mechanism, governance, employment	Social and Human Capital Support
3	green, carbon, low-carbon, hydrogen energy, emission reduction, neutrality, ecology, resources, environment, recycling	Green and Sustainable Development
4	technology, innovation, science, digital, breakthrough, core technologies, internet, platform, research, data	Technological Innovation
5	reform, system, coordination, market, investment, globalization, policy, mechanism, capital, regulation	Institutional and Market Coordination

6. Discussion

This study applies grounded theory, supported by large language model tools, to extract latent logic from policy discourse. Based on a corpus of policy documents, government reports, and media texts, it constructs a five-dimensional framework consisting of technological innovation, industrial ecosystem restructuring, green development paradigm, institutional and market coordination, and social and human capital support. This model reflects the multi-level structure and systemic logic of new quality productive forces.

The model shows that new quality productive forces are not composed of a single factor, but are the result of the co-evolution and interaction among multiple dimensions. Technological breakthroughs initiate the transformation of the industrial ecosystem. Institutional and market systems provide external structural support and incentive guidance. Social and human capital act as the foundation for sustaining innovation. Meanwhile, green development defines the boundary and direction of transformation. These five dimensions form an internally consistent system, reflecting the comprehensive requirements of high-quality development in the new era.

At the methodological level, this study attempts to incorporate large language models into the grounded theory process. Compared with traditional manual coding, AI assistance enhances efficiency, improves coverage, and provides semantic consistency in open coding. At the axial coding stage, the topic modeling capability of the large language model effectively identifies internal semantic links and conceptual clusters, reducing the subjectivity of human aggregation. During selective coding, model-generated visual tools assist in structural inference and help validate theoretical saturation. This approach compensates for the limitations of traditional grounded theory in handling large-scale and complex policy texts.

However, the use of large language models also presents certain risks. First, as a language generation tool, the model's understanding of social context is limited, and it may produce structurally coherent but semantically hollow interpretations. Second, the interpretability of the model remains opaque, making it difficult to fully explain how specific conceptual associations are generated. Therefore, in the application of grounded theory, large models should not replace human interpretation but rather serve as an auxiliary mechanism to enhance inductive analysis.

In sum, this study provides a preliminary demonstration of combining grounded theory with AI tools in policy research. It shows that under conditions of strict human oversight, AI-assisted coding can enhance analytical transparency and efficiency while retaining the theoretical depth and flexibility of grounded theory.

7. Conclusion

This study takes new quality productive forces as its core research object and, through grounded theory methods supported

by large language model tools, constructs a five-dimensional analytical framework consisting of technological innovation, industrial ecosystem restructuring, green development paradigm, institutional and market coordination, and social and human capital support. This framework reveals the internal structure and operating logic of new quality productive forces, and provides a conceptual basis for subsequent measurement and evaluation.

Methodologically, this study explores the feasibility of combining grounded theory with AI-based text analysis, offering a scalable and transparent approach to theory development from large-scale unstructured policy texts. The model demonstrates that artificial intelligence can play a supportive role in the qualitative research process without undermining its inductive logic.

Overall, this study provides a theoretical foundation for understanding new quality productive forces and offers a potential reference framework for future policy design and empirical evaluation.

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Conflict of Interests

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

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Appendix: Instructional Protocol for AI-Assisted Grounded Theory Research

This study adopts grounded theory as the core qualitative research strategy to systematically analyze the conceptual structure

and categorical composition of China's policy discourse on "new quality productive forces." To enhance efficiency, reduce subjectivity, and improve semantic depth and breadth, a large language model (DeepSeek R1) was introduced as a coding support tool. The following records the instructions issued to the AI system at each stage of the research process, enhancing reproducibility and procedural transparency.

Step 1: Open Coding: Instruction Design and Execution

During the open coding stage, the researcher uploaded and annotated representative raw policy documents, including media commentaries, government work reports, and departmental policy drafts. The instruction to the AI was as follows:

"Please analyze each policy text provided, identify core semantic units with theoretical relevance, and extract potential concepts. Each concept should be accompanied by its original citation sentence. The output structure should include document date, title, initial conceptual item, and quoted text."

Based on this instruction, the AI system performed automated text parsing and preliminary coding, with researcher review to confirm meanings, standardize terminology, and add interpretive notes. The results focused on high-frequency policy terms and governance intentions such as "technological innovation leadership," "industrial chain coordination," and "green and low-carbon transformation."

Step 2: Initial Category Formation: Instruction for Semantic Grouping

Upon completion of open coding, the study proceeded to group concepts into initial categories. The instruction was:

"Please group all previously generated initial concepts based on semantic similarity. Each category should include: a category name, a set of included concepts, a brief definition, and examples of source documents."

This stage facilitated the transition from concept-level to category-level abstraction, laying the foundation for mid-level analysis. It resulted in eight initial categories, such as "basic capacity for technological innovation," "institutional incentive mechanisms," and "green transformation practices."

Step 3: Axial Coding: Instruction for Core Category Construction

To raise the level of theoretical abstraction, the researcher guided the AI through axial coding. The instruction was:

"Based on the existing initial categories, extract and integrate 5 to 7 higher-level core categories that serve as the first-tier structure of theoretical analysis. Each core category should clearly indicate its included initial categories, structural characteristics, and analytical function."

Through identifying dynamic relationships among policy objects, instruments, and goals, the study identified five core categories: "technological innovation," "industrial ecosystem restructuring," "green and sustainable development paradigm," "institutional and market coordination," and "social and human capital support." This five-dimensional structure provided a coherent framework for theorizing the formation and evolution of new quality productive forces.

Step 4: Selective Coding: Instruction for Model Integration

After establishing axial categories, the researcher instructed the AI to perform selective coding and assist in theoretical model construction. The instruction was:

"Based on the established core categories, identify causal pathways and feedback mechanisms, and construct a theoretical model describing the formation of 'new quality productive forces.' The model should include: core dimensions, structural logic (e.g., spiral, hierarchical, or cyclical), and interaction mechanisms."

The AI generated a dynamic path model of "innovation → upgrading → support → ecological constraint." After interpretive refinement by the researcher, this was finalized into a five-dimensional spiral co-evolution model centered on the "technology–institution–society" triadic interaction.

Step 5: Theoretical Saturation Test

To ensure theoretical saturation, additional policy documents were input, and the AI received the following instruction:

"Please apply the same open coding and category matching process to the new texts. Determine whether any novel concepts or categories emerge. If none, confirm that the theoretical model is saturated."

The results showed that while new examples enriched existing categories, no new conceptual dimensions emerged, supporting the model's explanatory sufficiency and structural stability.

Note: AI Tools and Roles

The AI platform employed was DeepSeek-R1, which supported the following functions:

- Semantic recognition and concept extraction
- High-dimensional text clustering and topic modeling
- Categorical inference and structural simulation
- Stability testing of researcher-refined models

AI was used solely as a recommendation engine for coding. Final concept formation and model structuring remained under the researcher's control to ensure theoretical validity and semantic rigor.

Research on the Construction of a Big Data-Based Real Estate Marketing Model Based on the Customer Life Cycle

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Abstract: As the real estate market becomes more competitive and consumer demands continue to evolve, traditional marketing models are increasingly inadequate in meeting the market's need for precise and personalized services. The emergence of big data technology has brought new development opportunities to the real estate industry, particularly in customer lifecycle management, where big data can provide deep customer profiling and behavioral analysis to help businesses develop more accurate marketing strategies. By integrating different stages of the customer lifecycle, this paper constructs a big data-based real estate marketing model. The model implements full-cycle management from potential customers to loyal customers through data collection, analysis, and modeling techniques.

Keywords: Customer Lifecycle; Big Data; Real Estate Marketing; Data Analysis; Marketing Strategy

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The real estate industry has always faced intense market competition and increasingly diverse consumer demands. With technological advancements, traditional marketing methods can no longer meet the modern consumer's need for personalized and precise services. The application of big data technology offers new opportunities for the real estate industry, especially in customer management and marketing decision-making. By analyzing the customer lifecycle in depth, real estate companies can more accurately grasp customer needs at different stages and develop more targeted marketing strategies. Customer lifecycle management not only helps improve conversion rates but also enhances customer loyalty, creating long-term value for businesses.

1. Big Data Applications in Real Estate Marketing

1.1 Current Status of Big Data Application in the Real Estate Industry

The application of big data in the real estate industry has gradually expanded from traditional market research and customer analysis to more complex intelligent applications. Currently, real estate companies mainly utilize big data to innovate in customer management, market forecasting, and marketing planning.

In customer management, businesses form precise customer profiles by analyzing multidimensional data such as purchasing history, browsing behavior, and social interactions. This data-driven personalized marketing significantly improves customer conversion rates and satisfaction. In market forecasting, businesses use big data technologies to analyze information such as market supply-demand changes and price fluctuations, enabling accurate predictions of future market trends, which serve as

references for project development and investment decisions^[1]. In marketing planning, businesses use data-driven advertising placements and precise push strategies to improve marketing resource efficiency and reduce unnecessary costs.

1.2 The Value of Big Data in Real Estate Marketing

Big data enables real estate companies to extract deep insights from customer data, thereby offering personalized services to each client. By conducting detailed analysis of customer behavior, businesses can precisely identify potential customers and increase conversion rates through customized recommendations, targeted advertising, and other means. Furthermore, big data technology also helps businesses provide personalized property recommendations based on customer preferences, ensuring precise matching. This not only enhances the customer buying experience but also increases sales opportunities for the company.

Big data technology can also assist companies in optimizing resource allocation based on real-time data and market changes. In traditional marketing models, businesses often rely on experience and fixed budget allocation plans, which can lead to significant resource wastage and inefficiency^[2]. Through big data analysis, companies can dynamically adjust marketing resources in response to changes in customer demand, precisely target advertising, and choose the most effective marketing channels, thereby reducing marketing costs and improving resource utilization efficiency.

The speed at which the market changes is increasing, and real estate companies risk losing market share if they cannot respond promptly to these changes. Big data technology helps businesses monitor market dynamics in real time and promptly access information about customer demand changes and competitors. By quickly analyzing this data, businesses can adjust their marketing strategies in a short period, optimize ad placements, promotional plans, and more, ensuring they maintain a competitive edge in the market. The real-time nature of big data enables businesses to respond immediately to market changes, enhancing their ability to adapt^[3].

2. Customer Lifecycle and Marketing Strategy

2.1 Definition and Stages of the Customer Lifecycle

The customer lifecycle refers to the entire process from a customer's first contact with a brand or product to becoming a loyal customer who may continue to purchase and recommend it. Lifecycle management helps understand customer needs and behavioral characteristics at different stages and allows businesses to design marketing strategies accordingly. By segmenting customers in different stages, businesses can more accurately formulate marketing measures to improve customer satisfaction and conversion rates^[4]. The customer lifecycle is typically divided into four stages: Initial Stage (Potential Customers), Growth Stage (Purchase Intent Customers), Maturity Stage (Purchase Customers), and Loyalty Stage (Repeat Customers). Each stage has distinct customer characteristics, needs, and behaviors, allowing businesses to design more fitting marketing strategies through deep lifecycle analysis, maximizing customer value.

2.2 Lifecycle-Based Marketing Strategies

Real estate businesses should develop different marketing strategies for each stage of the customer lifecycle to maximize conversion rates and loyalty. The stages of the customer lifecycle and corresponding marketing strategies are shown in Table 1 :

Table 1 Customer Lifecycle Stages and Corresponding Marketing Strategies

Lifecycle Stage	Customer Needs	Recommended Strategy	Marketing Tools
Potential Customers	Information seeking	Brand promotion	Advertising
Purchase Intent	Clear demand	Personalized recommendation	Custom solutions
Purchase Customers	Completed transaction	Experience enhancement	Customer follow-up
Loyal Customers	Long-term maintenance	Membership services	Social media

In the Initial Stage (Potential Customers), customers have limited awareness of the brand and product, and businesses should focus on brand promotion and attracting attention. Through multi-channel advertising, social media marketing, and content marketing, businesses can effectively increase brand exposure and enhance customer awareness and interest through educational content and interactive activities. In the Growth Stage (Purchase Intent Customers), customer needs gradually become clearer, and businesses should implement precise marketing strategies. Through data analysis, businesses

can identify customers' potential demands and further stimulate their desire to purchase with personalized recommendations and promotional activities. At this stage, increasing interaction with customers, providing special offers or events through email marketing or SMS push, helps improve conversion rates. In the Maturity Stage (Purchase Customers), customers have completed their purchase, and the focus should be on enhancing the customer experience. By providing high-quality after-sales service, customer satisfaction surveys, and product usage tutorials, businesses ensure positive brand recognition. At this stage, value-added services such as extended warranties, regular follow-ups, and membership cards can effectively increase customer loyalty, prompting repeat purchases. In the Loyalty Stage (Repeat Customers), businesses should solidify relationships through membership programs, reward points, and exclusive offers^[5]. Loyal customers also have higher potential for word-of-mouth promotion, and businesses can encourage them to share on social media and refer new customers, further expanding the customer base.

2.3 Key Points of Customer Lifecycle Management

The key to customer lifecycle management lies in accurately identifying customer needs and implementing differentiated marketing strategies at different stages of the lifecycle. Big data technology provides strong support, helping businesses conduct in-depth analysis of customer behavior, preferences, purchase history, and other dimensions. Through data mining, companies can precisely identify the characteristics of different customer groups and their evolving needs, and formulate more personalized and accurate marketing strategies. Since customer needs and market environments are continuously dynamic, real-time monitoring and flexible adjustment of marketing strategies are key to ensuring marketing success. Big data technology enables businesses to monitor changes in customer behavior and market trends through real-time data analysis. By analyzing real-time feedback and purchasing dynamics, businesses can identify potential shifts in demand or market fluctuations and quickly adjust marketing strategies to ensure that marketing activities remain aligned with market trends. Customer lifecycle management goes beyond just product sales and involves long-term interaction and relationship maintenance with customers. By maintaining ongoing communication through multiple channels, businesses can better understand customer needs and expectations, enhance customer engagement, and improve loyalty. Whether through social media platforms, official websites, or offline activities, businesses can interact continuously with customers through these channels, enhancing customer brand recognition and deepening customer stickiness through regular communication.

3. Building a Big Data-Based Real Estate Marketing Model

3.1 Model Design Concept

The design concept of a big data-based marketing model is to integrate customer lifecycle management with big data analysis techniques to create a marketing framework that can dynamically adjust and precisely identify customer needs. The model framework includes three key components: data collection and analysis, strategy formulation, and performance evaluation. Data collection is the foundation of the big data marketing model, primarily involving obtaining raw data from customer behavior, market changes, social media, and other channels. Common data analysis methods include cluster analysis, association rule mining, and predictive modeling, which help businesses segment customers, identify potential customers, and predict future behaviors^[6]. Based on the data analysis, businesses can develop marketing strategies targeted at different lifecycle stages. To ensure the effectiveness of marketing strategies, businesses need to evaluate the performance of marketing activities. This process requires comparative analysis of pre- and post-implementation data to evaluate the changes in key indicators such as customer conversion rates and customer satisfaction. Evaluation criteria include customer acquisition cost (CAC), customer lifetime value (CLV), and customer loyalty, which help businesses assess the effectiveness of their marketing activities.

3.2 Model Implementation and Key Technologies

In a big data marketing model, due to the diversity of data sources and the varying quality of data, it is essential to use data cleaning techniques to filter and process raw data, removing noise and redundancy. By using ETL (Extract, Transform, Load) technology, businesses can standardize data from various channels into a unified format, creating a complete dataset for analysis.

Customer lifecycle analysis is at the core of the big data marketing model. Through customer behavior prediction and customer value assessment algorithms, businesses can predict future behavior based on customers' historical actions and evaluate their future value. Commonly used customer behavior prediction algorithms include regression analysis, time series analysis, and machine learning algorithms (such as decision trees and random forests). These algorithms can predict customers' future purchasing intentions and timing based on their purchasing records, browsing history, and social behaviors^[7].

Customer value assessment is primarily based on the RFM (Recency, Frequency, Monetary) model. By analyzing customers' recent purchase timing, purchase frequency, and spending amount, businesses assign a value score to each customer. Based on this score, businesses can better identify high-value customers and optimize the allocation of marketing resources.

Personalized recommendation systems leverage big data techniques to recommend the most relevant products or services to customers based on their historical behavior, preferences, and similar users' behavior data. By using collaborative filtering and content-based recommendation algorithms, the system can accurately push real estate information that matches customer needs, improving conversion rates.

3.3 Marketing Model Performance

To verify the effectiveness of the big data marketing model in the real estate industry, businesses need to use historical data for model validation. This process primarily depends on customer behavior data, market trend data, sales data, etc., which are typically sourced from CRM systems, website analytics tools, social media platforms, and other sources. The model validation process includes data splitting (such as dividing the data into training and testing sets) and cross-validation methods. To further demonstrate the actual effectiveness of the big data marketing model, a study was conducted on a real estate company. This company faced the issue of fragmented and insufficient customer data in their daily marketing efforts, and the lack of in-depth analysis of customer behavior led to ineffective marketing outreach to potential customer groups. Additionally, the low advertising return on investment (ROI) meant that marketing resources were not being efficiently allocated. The company urgently needed to integrate data to enhance precise marketing capabilities and increase customer conversion rates.

To address these issues, the company decided to implement a big data-based marketing model. Initially, the company performed customer lifecycle analysis to segment customers and offer personalized marketing solutions for each customer group. By utilizing behavior prediction models, the company could predict future customer needs based on historical behavior, further enhancing the precision of marketing strategies. Additionally, by using personalized recommendation systems, the company could recommend real estate listings aligned with customers' interests, thereby improving conversion rates.

After implementing the big data marketing model, the company's key indicators showed significant improvements. The performance metrics after six months of model implementation are shown in Table 2 :

Table 2 Performance Analysis of the Marketing Model

Metric	Pre-Implementation	Post-Implementation	Improvement Percentage
Customer Conversion Rate	3.5%	6.2%	+77.14%
Customer Acquisition Cost (CAC)	500 yuan	450 yuan	-10%
Return on Investment (ROI)	1.5	2.8	+86.67%

By implementing a big data marketing model, the company achieved significant improvements in customer conversion rate, customer acquisition cost, and return on investment. The increase in customer conversion rate indicates that the company can more effectively turn potential customers into actual buyers; the reduction in customer acquisition cost demonstrates that precise marketing has helped control the cost of acquiring customers; and the improvement in return on investment reflects a more efficient use of marketing resources. Through personalized recommendation systems and targeted customer segmentation strategies, the company is better able to meet customer needs and drive purchasing decisions, thereby significantly enhancing marketing effectiveness.

Conclusion: By applying big data technology, the real estate marketing model not only improved customer conversion rates and satisfaction but also significantly optimized resource allocation and marketing efficiency. As customer demands diversify

and market competition intensifies, big data-based marketing strategies provide businesses with stronger market adaptability and precision. This model, by fully integrating customer behavior, market trends, and real-time data feedback, allows companies to implement personalized marketing strategies at each stage of the lifecycle, effectively increasing customer loyalty and brand value. As technology continues to advance, future big data marketing will increasingly focus on real-time and automated systems, achieving more efficient decision support and strategy execution, thus further driving the digital transformation of the real estate industry.

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Industrial Upgrading and Structural Transformation under the Context of Globalization: Theoretical Pathways and Policy Implications

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Abstract: With the continuous advancement of globalization, economies around the world are facing significant challenges and opportunities in industrial upgrading and structural transformation. This paper aims to explore the theoretical pathways and driving factors of industrial upgrading and structural transformation under the context of globalization, and provide corresponding policy implications. The study shows that technological innovation, deep integration into global value chains, and regional economic coordination are key factors driving industrial upgrading and structural transformation. The transformation of traditional industries relies on technological upgrades and the expansion of industrial chains into higher value-added sectors, while emerging industries promote economic growth through cluster development and cross-sector integration. At the same time, globalization brings a dynamic balance of cooperation and competition, requiring countries to achieve coordinated development in this process. Finally, this paper suggests that by increasing R&D investment, optimizing global value chain layout, and strengthening policy coordination, countries can effectively promote industrial upgrading and structural transformation, supporting high-quality economic development.

Keywords: Globalization; Industrial Upgrading; Structural Transformation; Global Value Chain; Regional Economic Coordination

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1.Introduction

1.1 Research Background

Globalization is a defining characteristic of contemporary world economic development, and its process has had a profound impact on the economies of various countries. By promoting the global allocation of resources, expanding market sizes, and facilitating technological diffusion, globalization has not only enhanced the overall efficiency of national economies but has also accelerated the integration of international economies. However, with the deepening of globalization, traditional industries face intense international competition and the pressure of technological iteration, making it difficult for many labor-intensive and low value-added industries to maintain their competitive advantages. At the same time, emerging industries, particularly those represented by digital technology, green energy, and high-end manufacturing, have rapidly risen to become new engines of global economic growth.

In this context, countries have increasingly emphasized the importance of industrial structural transformation, aiming to enhance their global competitiveness by optimizing industrial layouts and promoting industrial upgrading. Therefore,

exploring the theoretical pathways for industrial upgrading and structural transformation under the context of globalization is of significant practical importance and academic value.

1.2 Significance of the Research

1.2.1 Theoretical Significance

This research aims to systematically review and analyze the theories related to industrial upgrading and structural transformation under globalization, constructing a comprehensive theoretical framework to deepen the understanding of economic structural adjustment mechanisms. The study seeks to reveal the internal mechanisms of globalization in the upgrading of traditional industries, the development of emerging industries, and the overall optimization of economic structures, thus enriching the theoretical system in the field of industrial economics. Furthermore, by analyzing the driving factors and pathways of industrial upgrading, this research provides a foundation for further expanding theoretical studies on globalization and industrial structural transformation.

1.2.2 Practical Significance

From a practical perspective, this research aims to provide specific guidance for governments and enterprises in driving industrial upgrading and structural optimization. The findings of this study can offer valuable reference for policymakers in formulating effective industrial policies during the economic transformation process, with the goal of improving economic efficiency and global competitiveness. Moreover, by summarizing the interactive relationship between globalization and industrial transformation, this paper provides theoretical foundations and strategic recommendations for enterprises to seize opportunities and achieve sustainable development amidst the waves of globalization.

2. Theoretical Foundations

2.1 Theoretical Overview of Globalization and Industrial Development

2.1.1 Definition and Core Features of Economic Globalization

Economic globalization refers to the flow and integration of goods, capital, technology, information, and labor on a global scale. Its core features include the internationalization of markets, the globalization of resource allocation, and the transnational cooperation of economic activities. Globalization has accelerated international trade and investment, breaking down national borders and strengthening the economic ties and interdependence between countries.

In addition, economic globalization is not only characterized by the growth of cross-border trade and investment but also by the widespread application of information technology and the deep integration of financial systems. While this process has brought unprecedented opportunities for economic development, it is also accompanied by challenges such as regional economic imbalances, cultural conflicts, and environmental issues.

2.1.2 Impact of Globalization on Resource Allocation

Globalization has achieved global resource optimization through market mechanisms. Resources include natural resources, human capital, and financial capital. Developed countries, with their advantages in technology and capital, occupy the high-end segments of the global value chain, while developing countries attract low-end manufacturing industries by offering cheap labor and natural resources. This resource allocation has contributed to the improvement of global economic efficiency but has also exacerbated global economic imbalances.

2.1.3 Impact of Globalization on Industrial Division of Labor

Globalization has deepened and refined global industrial division of labor, with countries embedding themselves in different segments of the industrial chain based on their comparative advantages. For example, East Asian countries occupy an important position in the global industrial division due to their efficient manufacturing and supply chain management. Meanwhile, developed countries have gradually shifted their industrial focus from manufacturing to knowledge-intensive services. However, this division of labor may lead to some developing countries remaining stuck in low-value-added segments for extended periods, making it difficult to achieve industrial upgrading.

2.2 Theoretical Pathways of Industrial Upgrading

2.2.1 Product Gradient Transfer Theory

The product gradient transfer theory describes the evolutionary process of industries moving from low-end manufacturing

to high-end manufacturing during globalization. In this process, technology and capital-intensive industries gradually concentrate in developed economies, while labor-intensive and low-tech industries shift to developing countries and regions. This gradient transfer provides developing countries with opportunities for technological learning and capacity building, but it also requires recipient countries to have the ability to absorb and adapt to these transferred industries.

2.2.2 Value Chain Theory

Value chain theory emphasizes that the key to industrial upgrading lies in advancing to the high-value-added segments of the value chain. From simple product assembly to more complex R&D, design, and branding, countries have enhanced their industrial competitiveness by deeply participating in the global value chain. For example, Chinese companies have gradually moved beyond low-end manufacturing by building their own brands and engaging in technological innovation. Upgrading in the value chain not only requires support from technological innovation but also requires cooperation from policies, financial systems, and market environments.

2.2.3 Technological Innovation and Industrial Transformation Theory

Technological innovation is the core driving force for industrial upgrading. Whether it is the technological renovation of traditional industries or the birth of emerging industries, technological progress provides crucial support for industrial structural adjustment. For example, technologies such as artificial intelligence and big data are reshaping both manufacturing and service industries. Moreover, technological innovation not only changes production modes within enterprises but also fosters cross-industry integration, laying the foundation for new business models.

2.3 Theoretical Framework for Structural Transformation

2.3.1 Theory of Evolution of Three-Stage Industrial Structure

The theory of the evolution of industrial structure suggests that economic development generally progresses from agriculture-dominated primary industries to industry-dominated secondary industries, and finally to service-dominated tertiary industries. This process is accompanied by increases in labor productivity and optimization of economic efficiency. For example, in developed countries, the service sector typically accounts for more than 70% of GDP, while in developing countries, manufacturing and agriculture still dominate. Industrial structural transformation is an inevitable trend of economic development but requires corresponding policy support and institutional guarantees.

2.3.2 Mechanism of Coordinated Development between Emerging and Traditional Industries

The rise of emerging industries provides an opportunity for the modernization of traditional industries. Through technological spillover effects, emerging industries can inject vitality into traditional industries, such as the transformation of agriculture and manufacturing by digital technologies. At the same time, the development of traditional industries provides raw materials, capital, and market foundations for emerging industries. The mechanism of coordinated development not only improves resource utilization efficiency but also enhances the resilience of industries to risks.

2.3.3 Theoretical Basis for Industrial Structure Optimization and Regional Economic Coordination

Coordinated regional economic development is an important prerequisite for achieving industrial structure optimization. By promoting industrial cooperation between developed and underdeveloped regions, it is possible to achieve the rational allocation of resources and reduce regional disparities. For example, China's "gradient development strategy" has facilitated the transfer of industries from the eastern region to the central and western regions, thereby forming a new pattern of coordinated regional development. This theory emphasizes that industrial structure optimization needs to be closely integrated with regional economic development policies to achieve coordinated progress in both industries and regional economies.

3. Drivers of Industrial Upgrading and Structural Transformation in the Context of Globalization

3.1 Technological Progress and Innovation-Driven Factors

3.1.1 The Role of New Technologies like Digitalization and AI in Driving Industrial Upgrading

With the rapid development of new technologies such as digitalization, artificial intelligence (AI), big data, and the Internet of Things (IoT), global industrial patterns are undergoing profound changes. These technologies not only enhance production efficiency but also drive the transformation and upgrading of traditional industries. For instance, in manufacturing, the

implementation of Industry 4.0 technologies has enabled smart manufacturing, reducing costs and increasing production flexibility. At the same time, digital technologies have fueled innovation in the service sector, giving rise to emerging industries such as fintech and e-commerce platforms, injecting new energy into economic growth. The widespread use of AI has also enabled companies to achieve high levels of automation and personalized services in design, production, logistics, and other processes, further promoting industrial advancement and intelligence.

3.1.2 Formation and Expansion of Innovation Ecosystems in Globalization

Globalization has not only facilitated the spread of technologies but also contributed to the formation of cross-national innovation ecosystems. These ecosystems, by gathering top-tier research institutions, innovative enterprises, and venture capital firms from around the world, have accelerated the conversion of technology into practical applications. For example, Silicon Valley, as a typical representative of a global innovation ecosystem, has formed a powerful innovation-driven force by clustering numerous high-tech companies and innovative talents, driving technological innovation in the U.S. and globally. In the context of globalization, many countries have also established regional innovation centers and innovation parks to strengthen their innovation capabilities and international competitiveness. Collaboration among multinational companies and regions, knowledge sharing, and technology transfer have facilitated the global dissemination of innovative results.

3.2 International Division of Labor and Integration into Global Value Chains

3.2.1 The Role of Industrial and Supply Chains in Globalization

Globalization has accelerated the transnational division of labor within industrial and supply chains, allowing different countries and regions to play distinct roles in the global economic system. Developed countries typically control high-value-added segments such as research and development (R&D), design, and brand marketing, while developing countries primarily handle low-value-added production and assembly tasks. This division of labor has promoted the optimization of global resource allocation and the improvement of productivity, while also strengthening economic ties between different regions. The internationalization of industrial and supply chains allows enterprises to reduce costs, enhance production efficiency, and maximize market opportunities by sourcing materials globally.

3.2.2 Paths and Challenges for Emerging Economies in Integrating into Global Value Chains

Emerging economies have gained access to global markets by embedding themselves into global value chains, which has facilitated their rapid economic growth. Emerging economies typically start by taking on low-end manufacturing jobs transferred by foreign investments and multinational corporations, gradually extending into higher-value-added, technology-intensive, and capital-intensive sectors. This process not only promotes industrialization in emerging economies but also leads to technological progress and accumulation of human capital. However, during their integration into global value chains, emerging economies face challenges such as inadequate innovation capacity, heavy pressure for industrial upgrading, and relatively low environmental protection standards. Therefore, enhancing industrial competitiveness and optimizing industrial structures have become urgent issues for these countries in the context of globalization.

3.3 Support from Policies and Institutional Environments

3.3.1 Optimizing Trade and Investment Policies

Trade and investment policies are key factors in driving industrial upgrading and structural transformation. Globalization has gradually reduced trade barriers between countries, allowing for the freer flow of multinational enterprises and capital. Optimized trade policies, such as the establishment of free trade zones and the reduction of tariff barriers, have provided important support for global economic integration. At the same time, governments in various countries have optimized their investment environments by attracting foreign investment, offering tax incentives, and providing subsidies to encourage technological innovation and industrial upgrading. For instance, China has attracted significant foreign investment in high-end manufacturing and technology R&D in recent years through deepening reforms and improving the business environment. The optimization of trade and investment policies provides enterprises with more development space and creates necessary conditions for the adjustment and upgrading of global industrial structures.

3.3.2 Balancing Environmental Protection Policies and Sustainable Development

In the context of globalization, environmental issues and sustainable development have become critical topics for industrial

transformation. The rapid expansion of traditional industries often comes at the cost of excessive resource consumption and environmental pollution, particularly in high-pollution, energy-intensive industries such as coal and steel. This situation has prompted governments to strengthen the formulation of environmental protection policies by promoting green technological innovation, enhancing environmental regulations, and encouraging the transition to a low-carbon economy. At the same time, balancing environmental protection policies with industrial structural transformation is crucial for driving efficient and green economic growth. For developing countries, how to achieve environmental protection and sustainable development while pursuing economic growth is both an opportunity and a challenge.

4.Theoretical Pathways for Industrial Upgrading and Structural Transformation

4.1 Transformation Paths for Traditional Industries

4.1.1 Enhancing Efficiency through Technological Upgrading and Digital Transformation

Under the pressures of globalization and technological innovation, traditional industries are facing immense transformation challenges. Technological upgrading, especially digital transformation, has become a vital pathway for enhancing the competitiveness of traditional industries. The application of digital technologies, automation equipment, IoT, and big data enables businesses to manage resources more precisely, optimize processes, and improve production efficiency. For example, in manufacturing, the introduction of smart manufacturing and robotics has allowed traditional mechanical processing and assembly lines to become automated, flexible, and customizable, significantly reducing labor costs while improving product quality and production flexibility. This not only helps improve the production efficiency of traditional industries but also injects innovation into these sectors, driving their upgrading and modernization.

4.1.2 Advancing the Industry Chain towards Higher-Value-Added Segments

The transformation of traditional industries depends not only on technological innovation but also on extending the industry chain into higher value-added segments. Within the global value chain, low-value-added production and assembly segments have become less competitive, especially with rising labor costs and resource constraints. To enhance the comprehensive competitiveness of industries, traditional sectors must expand beyond basic production processes into higher value-added areas such as R&D, design, branding, and marketing. For instance, some automotive manufacturers have successfully transitioned from simple producers to comprehensive automotive groups by strengthening independent R&D and launching high-end smart vehicles. This transformation not only increases product value but also enhances the company's innovation capabilities and market influence.

4.2 Development Pathways for Emerging Industries

4.2.1 Formation of Emerging Industry Clusters and Enhancement of Innovation Capabilities

The rapid development of emerging industries provides new momentum for economic transformation, especially in fields like high technology, green energy, and life sciences. Emerging industries often promote innovation through the clustering model. Industrial clusters facilitate rapid technology flow, effective resource sharing, and synergetic innovation through the collaboration of enterprises, research institutions, and governments within a region. Silicon Valley, as a typical global innovation cluster, has formed a powerful innovation ecosystem by gathering numerous start-ups and technology R&D institutions, making significant contributions to global technological advancement. By adopting cluster-based development models, emerging industries can stand out through technology spillover effects, talent flow, and capital support.

4.2.2 Cross-Sector Integration and the Construction of Industry Ecosystems

The further development of emerging industries requires cross-sector integration and the construction of industry ecosystems. With the widespread adoption of emerging technologies like information technology, AI, and IoT, the boundaries between industries are becoming increasingly blurred, and cross-sector integration has become a key driver of innovation. For example, the integration of the automotive industry with information technology and electronics has led to the creation of smart vehicles, while the fusion of finance with information technology has driven the rapid growth of financial technology (FinTech). By collaborating across sectors, industries can not only enhance their innovation capabilities but also promote resource sharing and technological synergy, forming more competitive industry ecosystems. The construction of such ecosystems includes not just technological integration but also the coordination of markets, policies, and capital.

4.3 Pathways for Regional Economic Coordinated Development

4.3.1 Industrial Gradient Transfer and Collaboration Between Eastern Coastal and Central/Western Regions

China's regional economic structure illustrates a typical industrial gradient transfer phenomenon. As industrial costs rise and the labor market in the eastern coastal regions becomes saturated, some low-value-added, labor-intensive industries have started shifting to the central and western regions. This transfer not only helps ease overcapacity and resource constraints in the eastern coastal areas but also injects new vitality into the economic development of central and western regions. During this process, government policy support, infrastructure development, and talent cultivation have played key roles. Additionally, the industrial collaboration model between eastern coastal and central/western regions, through complementary advantages, resource sharing, and market expansion, has promoted coordinated development and enhanced competitiveness within these regions.

4.3.2 Regional Integration and Industrial Cluster Development Strategies

Regional integration development strategies are important pathways to driving industrial upgrading and structural transformation. By promoting economic integration within regions, facilitating collaboration across industries, technology, markets, and capital, resources can be allocated more efficiently, and industrial structures optimized. Regional integration can strengthen infrastructure construction and logistics networks, while fostering the formation of industrial clusters that bring together various resources and drive innovation. For example, the "Yangtze River Delta Integration" strategy has created multiple industrial clusters covering high-end manufacturing, finance, and technological innovation, thereby enhancing the economic competitiveness of the entire region. Furthermore, regional integration promotes the free flow of talent and cooperation among enterprises, helping form an advantageous complementary industrial development structure.

5. Policy Implications

5.1 Enhancing Technological Innovation Capacity

5.1.1 Increasing R&D Investment and Improving Innovation Support Systems

Technological innovation is the core driver of industrial upgrading. Governments should increase investment in R&D through various channels such as financial subsidies, tax incentives, and venture capital to encourage enterprises and research institutions to tackle technological challenges. At the same time, improving the innovation support system is crucial. Governments should support the establishment of industry-academia-research cooperation platforms to facilitate close collaboration between universities, research institutes, and businesses, fostering the translation and application of scientific achievements. For example, establishing science and technology innovation funds and certification systems for high-tech enterprises can encourage businesses to engage in frontier technology research. Only by continuously advancing technological innovation can industries enhance their core competitiveness and drive sustainable economic growth.

5.1.2 Encouraging Technology Transfer and Knowledge Sharing

As globalization deepens, technology transfer and knowledge sharing have become increasingly important. Promoting international technology cooperation and transfer can help rapidly absorb advanced technological outcomes, shortening the cycle of technological innovation. For example, governments can establish technology transfer platforms to help domestic enterprises effectively connect with foreign technology providers, facilitating the introduction, digestion, and reinvention of technologies. Additionally, building knowledge-sharing platforms helps spread and apply technological outcomes, raising the overall innovation capacity of society. Encouraging multinational companies to establish R&D centers locally can leverage technology spillover effects, fostering the development of domestic industries.

5.2 Optimizing Global Value Chain Layout

5.2.1 Promoting the Deep Integration of Domestic Enterprises into Global Value Chains

To maintain competitiveness in the context of globalization, domestic enterprises should actively integrate into global value chains and move toward higher value-added segments. Governments can implement policies to encourage businesses to upgrade their technological capabilities, improve management practices, and strengthen brand-building efforts, facilitating their transition from basic production processes to high-value-added areas like R&D, design, and branding^[1]. Specific policy measures might include strengthening international cooperation, aligning technical standards, and encouraging partnerships

between foreign and domestic companies. Simultaneously, governments should enhance infrastructure development, optimize logistics, and improve information flow to create a more conducive environment for enterprises to integrate into global value chains.

5.2.2 Cultivating Internationally Competitive Leading Enterprises

To improve global competitiveness, governments should support domestic enterprises, particularly SMEs, in becoming industry leaders through technological innovation and internationalization strategies. Governments can assist businesses in gaining a significant market position both domestically and internationally through tax reductions, financial support, and brand promotion policies^[2]. For high-tech enterprises with potential, promoting mergers, investments, and cross-border acquisitions can help them secure strategic positions within the global industrial chain. Furthermore, encouraging enterprises to internationalize, particularly into higher value-added fields, will enhance the overall competitiveness of the country's industries.

5.3 Strengthening Policy Coordination and Institutional Innovation

5.3.1 Improving the Business Environment to Attract High-Quality Foreign Investment

Improving the business environment is fundamental to driving industrial upgrading and structural transformation. Governments should simplify administrative approval processes, optimize tax policies, and strengthen intellectual property protection to reduce operating costs for businesses and increase market transparency, encouraging high-quality foreign investment. For example, the establishment of free trade zones, science and technology parks, and other innovative regions can attract international investors and multinational companies, promoting the flow of technology, capital, and talent^[3]. Foreign investment not only provides funding support to the domestic economy but also brings advanced management practices and technologies, helping enhance the technological level and management capacity of domestic enterprises.

5.3.2 Developing Targeted Regional Development Policies to Reduce Regional Disparities

Regional economic imbalance is a key issue in the process of globalization. Developing policies to reduce regional disparities is essential for achieving balanced and coordinated development. Governments should tailor regional development policies according to the resource endowments, industrial structures, and stages of development of different regions. For example, in the central and western regions, funds can be directed toward infrastructure construction, tax incentives can be provided, and local specialty industries can be supported to promote regional economic growth^[4]. In the developed eastern regions, the focus can be on supporting the innovation and upgrading of high-end manufacturing and service industries, pushing the regional economy towards higher value-added, knowledge-intensive industries. By promoting regional coordinated development, the national industrial layout can be optimized, enhancing the overall economic coordination and sustainability.

6. Conclusion and Outlook

6.1 Main Conclusions

In the context of globalization, industrial upgrading and structural transformation are key to enhancing national competitiveness and achieving high-quality economic development. Through in-depth exploration of the driving forces, theoretical paths, and policy implications of industrial upgrading and structural transformation, the following main conclusions have been drawn:

First, globalization has driven deep integration of technological innovation, international division of labor, and global value chains, becoming the core driving force for industrial upgrading^[5]. Technological progress, particularly digital transformation and intelligent manufacturing, is crucial for improving the efficiency of traditional industries and moving towards higher value-added segments. The rapid rise of emerging industries, fueled by cluster development and cross-field integration, has created new economic growth points. Regional economic collaboration has become an important support for industrial transformation, with the industrial gradient transfer and cooperation between eastern and central/western regions promoting the optimization of industrial structures and balanced regional development.

Second, globalization has not only increased economic cooperation between countries but also intensified international competition. Under the framework of global value chains, countries participate in the division of labor based on their advantages and disadvantages^[6]. This allows for collective industrial development through technology cooperation and capital

flow, but it also creates competitive pressures such as market share battles and technological bottlenecks. Therefore, how to achieve a dynamic balance between cooperation and competition in the process of globalization has become a key issue for the formulation of economic policies by various countries.

6.2 Future Research Directions

6.2.1 Examining the Far-reaching Impact of Technological Change on Employment and Society

While technological innovation and industrial upgrading can improve productivity and drive economic growth, they may also lead to changes in employment structures and exacerbate social inequalities. Specifically, the widespread application of new technologies such as artificial intelligence and robotics may lead to the disappearance of certain low-skilled jobs. Future research should delve into the impact of technological change on the labor market, exploring how educational training, social security systems, and other measures can alleviate the social challenges brought by technological advancements, ensuring social stability and fairness.

6.2.2 Exploring the Experiences and Lessons from Different Countries in Industrial Transformation

In the context of globalization, different countries face different opportunities and challenges in promoting industrial transformation. Developed countries often rely on technological innovation and high-value-added industries, while developing countries leverage industrial gradient transfer and low labor costs to drive transformation^[7]. Therefore, future research could involve comparing the success stories and failures of various countries in their industrial transformation processes, offering more targeted policy recommendations. Furthermore, research should focus on how to cope with uncertainties and risks in the globalization process, particularly under the influence of geopolitical and global economic changes, ensuring the sustainability of industrial transformation.

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Study on the Mechanisms through which Macroeconomic Policies Affect Real Estate Market Price Volatility

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Abstract: This study analyzes how macroeconomic policy tools such as monetary policy, fiscal policy, and tax policy affect the real estate market through various channels. The study finds that monetary policy influences real estate demand and, consequently, price fluctuations by adjusting interest rates and credit supply. Fiscal policy, through government spending, tax incentives, and housing subsidies, adjusts market demand and supply, thereby impacting price volatility. Tax policies, particularly property taxes and land taxes, exert a profound influence on the real estate market by altering market expectations and investor behavior. By constructing a theoretical framework and analyzing policy mechanisms, this research uncovers the complex relationship between macroeconomic policies and real estate market price fluctuations and provides relevant policy recommendations. The study concludes that the effectiveness of these policies depends on their timeliness, coordination, and the execution capacity of local governments. Finally, the paper looks forward to future research directions, particularly in the areas of diversified policy combinations, market expectation management, and the application of digital technologies.

Keywords: Macroeconomic Policy; Real Estate Market; Price Fluctuations; Transmission Mechanisms

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1.Introduction

1.1 Research Background and Significance

Macroeconomic policies, as crucial tools for national economic regulation, can directly or indirectly influence the functioning of various markets, including the real estate market. As an important component of the national economy, the real estate market not only drives economic growth but also has a profound impact on wealth accumulation and social stability. In recent years, with the intensification of price fluctuations in the Chinese real estate market, the impact of real estate prices on the economy has gradually attracted significant attention from both academia and policymakers.

The price fluctuations in the real estate market have had a substantial effect on economic stability and people's livelihoods. On one hand, excessive price increases can lead to a real estate bubble, triggering financial risks and suppressing consumption and investment. On the other hand, price declines may negatively affect household wealth, leading to reduced consumption and harming overall economic vitality. Therefore, real estate price fluctuations are not merely the result of market behavior, but are closely related to national economic policy interventions.

Macroeconomic policies, particularly monetary and fiscal policies, play a crucial role in regulating the real estate market. By adjusting interest rates, credit policies, and tax policies, macroeconomic policies influence the supply-demand relationship,

investor expectations, and financial market conditions in the real estate sector, thereby causing price fluctuations. As such, an in-depth study of the transmission mechanisms of macroeconomic policies on real estate market price fluctuations can provide a theoretical foundation for policy formulation and assist decision-makers in better managing regulatory timing and policy tool combinations.

1.2 Research Issues and Objectives

1.2.1 Research Questions

The central question of this study is: How do macroeconomic policies influence real estate market price fluctuations through various channels and mechanisms? Under this framework, this paper will focus on exploring how monetary policy, fiscal policy, and other macroeconomic policies impact the real estate market through channels such as the credit market, interest rate transmission, and government spending. Additionally, the study will analyze the manifestation and mechanisms of these effects in different economic cycles.

1.2.2 Research Objectives

The aim of this study is to uncover the transmission mechanisms between macroeconomic policies and real estate market price fluctuations, and to construct a theoretical framework to systematically understand how these policies influence the real estate market^[1]. The specific objectives include:

Identifying the main channels and transmission paths through which different macroeconomic policies (monetary, fiscal, tax, etc.) affect real estate market price fluctuations.

Analyzing the time-lag effects of policy transmission and its variations under different market conditions.

Proposing corresponding policy recommendations to help policymakers effectively respond to price fluctuations in the real estate market, maintaining a balance between economic stability and social well-being.

2. Literature Review

2.1 The Impact of Macroeconomic Policies on the Real Estate Market

2.1.1 The Impact of Monetary Policy

Monetary policy influences the liquidity and financing costs of the real estate market through channels such as interest rate adjustments and money supply changes. According to Keynesian economic theory, central banks impact market investment and consumption decisions by adjusting interest rates. In the real estate market, lower interest rates typically stimulate demand, driving up housing prices. Fisher (2001) suggests that loose monetary policy reduces financing costs, boosts demand in the real estate market, and increases investors' risk tolerance, thereby intensifying price fluctuations. Conversely, tight monetary policy, by raising interest rates and restricting credit supply, can reduce demand, leading to price stabilization or decline^[2].

2.1.2 The Impact of Fiscal Policy

Fiscal policy primarily regulates the economy through government spending and tax policies, which in turn affects the demand side of the real estate market. Fiscal measures such as increased infrastructure construction and housing subsidies directly boost demand in the real estate market. Additionally, government tax policies, especially real estate-related taxes (e.g., property tax, land appreciation tax), can alter market expectations and affect the supply-demand dynamics by increasing holding costs or changing buyers' expectations (Brunnermeier & Sannikov, 2014)^[3]. For example, tax cuts may encourage more consumers to enter the market, pushing prices higher, while higher tax burdens could dampen market demand and curb price increases.

2.1.3 Economic Theories Explaining the Role of Macroeconomic Policies

Keynesian theory emphasizes the role of government intervention in balancing market supply and demand, arguing that macroeconomic policies can effectively prevent economic overheating or cooling. Supply-demand theory, rooted in basic economic principles, explores how demand and supply fluctuate under the influence of monetary and fiscal policies, which subsequently affects price levels^[4]. Financial market theory focuses more on asset pricing and market sentiment, suggesting that changes in interest rates and money supply not only directly affect real estate markets through capital flows but also indirectly influence price fluctuations by affecting investor risk preferences and market confidence (Shiller, 2000).

2.2 Research on Real Estate Market Price Fluctuations

2.2.1 Causes and Characteristics of Price Fluctuations

The causes of real estate price fluctuations are often attributed to supply-demand factors, policy regulation, financial market volatility, and speculative behavior. Imbalances between supply and demand are direct causes of price fluctuations, but market irrationality, such as excessive speculation, often exacerbates these fluctuations. Himmelberg et al. (2005) note that speculative behavior in the real estate market, particularly speculative home purchases, can cause sharp changes in demand in the short term, leading to significant price volatility^[5].

Additionally, real estate price fluctuations exhibit cyclical patterns. Traditional market cycle theory suggests that real estate market fluctuations are closely tied to economic cycles (Case & Shiller, 2003). During periods of economic expansion, demand for real estate is strong, driving up prices; during economic downturns, credit tightening and reduced demand lead to price declines.

2.2.2 Patterns and Factors of Price Fluctuations

Existing studies show that real estate price fluctuations are influenced by multiple factors. Firstly, the macroeconomic cycle is a significant driver of real estate price fluctuations. During periods of economic growth, strong demand drives up prices, whereas during economic recessions, reduced demand causes prices to fall. Secondly, policy regulation plays a crucial role in moderating price fluctuations^[6]. Governments can stabilize the market through measures like purchase restrictions, credit controls, and tax policies. Furthermore, market expectations are also a key driver of price fluctuations. Real estate prices are often influenced not only by current market conditions but also by future expectations (Saiz, 2010).

2.3 Research on the Transmission Mechanism of Macroeconomic Policies

2.3.1 Interest Rates and Credit Channels

Interest rates are one of the core factors in the transmission of macroeconomic policies. By adjusting interest rates, central banks can influence loan rates and the financing costs in the market, thereby altering demand in the real estate market. For example, lower interest rates typically reduce borrowing costs, stimulating demand for real estate and driving up prices (Mian & Sufi, 2011). The credit market serves as an essential bridge between macroeconomic policies and the real estate market. A relaxed credit policy increases the supply of funds to the real estate market, driving up prices, while a tightening of credit may suppress demand, causing prices to fall.

2.3.2 Government Spending and Tax Policies

Government spending, particularly on infrastructure and housing policies, influences real estate markets by altering market expectations and actual demand. Government spending stimulates economic growth, which in turn boosts demand for real estate, particularly during economic downturns. Tax policies also play an important role in influencing the real estate market. Government adjustments to real estate taxes can directly affect supply and demand in the market. For instance, the introduction or increase of property taxes may reduce investors' willingness to purchase homes, thus limiting price increases.

2.3.3 Differences in Macro Policy Transmission Mechanisms

The transmission mechanisms of macroeconomic policies differ across countries and regions. Schularick & Taylor (2012) found that in developed economies, monetary policy is transmitted through well-developed financial markets, while in developing countries, where financial markets are less mature, policy transmission tends to be weaker. Furthermore, different economies react to macroeconomic policies in different ways. In China, for example, the real estate market's price fluctuations are more heavily influenced by direct government intervention, whereas in the U.S., with its more market-driven financial system, price fluctuations are largely determined by market supply and demand forces.

3. Theoretical Framework

3.1 Classification and Mechanism of Macroeconomic Policies

Macroeconomic policies, as important tools for government economic regulation, influence the operation of various markets, including the real estate market, through different instruments and channels. This section explores the impact of monetary policy, fiscal policy, and tax and regulatory policies on the real estate market and their transmission mechanisms.

3.1.1 The Mechanism of Monetary Policy

Monetary policy regulates economic activity mainly through adjusting interest rates, money supply, and credit conditions. The mechanism of its influence can be summarized as follows:

Interest Rate Channel: The central bank adjusts the benchmark interest rate, which affects commercial bank lending and deposit rates, thus influencing the financing costs of consumers and businesses. In the real estate market, lower interest rates stimulate housing demand and real estate investment, driving up housing prices, while higher interest rates may suppress demand, leading to price declines (Mian & Sufi, 2011).

Money Supply Channel: By altering the money supply in the market, the central bank influences the liquidity of funds. An increase in the money supply enriches the capital available in the real estate market, which can lead to higher housing prices. Conversely, when the money supply is tightened, market liquidity is constrained, which may cause housing prices to fall.

Credit Channel: Monetary policy directly affects the financing costs and credit supply of the real estate market by adjusting credit conditions in banks. A relaxed credit policy enables more consumers to access home loans, boosting demand and potentially driving up prices; whereas a tight credit policy restricts loan access, reducing demand in the real estate market and suppressing price growth.

3.1.2 The Mechanism of Fiscal Policy

Fiscal policy adjusts economic activity through government spending and taxation, thereby impacting the demand and supply sides of the real estate market:

Government Spending: The government directly influences the real estate market supply through investments in infrastructure and public housing projects. During economic downturns, increased government spending on infrastructure not only stimulates overall economic demand but also affects the supply-demand relationship in the real estate market by increasing housing supply. Improvements in infrastructure (e.g., transportation, education) can also increase the real estate value in specific areas, thereby influencing housing price fluctuations.

Tax Policies: Real estate-related tax policies (such as property tax, land appreciation tax) affect the supply-demand structure by changing the costs of purchasing and holding property. For example, an increase in property taxes may reduce the attractiveness of real estate investments and decrease speculative demand, thus curbing price increases. On the other hand, tax reductions may stimulate consumer demand for housing and push prices higher.

3.1.3 The Mechanism of Tax and Regulatory Policies

Tax and regulatory policies play an essential role in regulating the real estate market by adjusting market cost structures and expectations, thus influencing price fluctuations:

Property Taxes and Land Taxes: Policies such as property and land taxes raise the cost of purchasing and holding property, which suppresses both investor and consumer demand, thus controlling excessive demand and reducing price volatility.

Purchase and Loan Restrictions: Governments use purchase and loan restrictions to limit excessive demand in the real estate market. These policies effectively curb speculative behavior by limiting the eligibility of homebuyers (e.g., policies on first- and second-home purchases) and controlling loan amounts, thus preventing irrational price hikes.

3.2 Price Fluctuation Mechanism in the Real Estate Market

3.2.1 Supply-Demand Relationship

The primary factor influencing price fluctuations in the real estate market is the supply-demand relationship. When market demand is strong and supply is insufficient, housing prices tend to rise; conversely, when demand weakens and supply exceeds demand, prices are likely to fall (Case & Shiller, 2003). Under the influence of macroeconomic policies, changes in both demand and supply sides magnify price fluctuations. For instance, loose monetary policies stimulate housing demand, while supply-side reforms from the government may alter the supply structure in the real estate market.

3.2.2 Speculative Behavior

The real estate market is highly speculative, especially under uncertain market expectations, where speculative behavior intensifies price fluctuations. Real estate, as a high-leverage investment tool, often leads investors to make speculative purchases based on future price predictions. This speculative behavior can drive prices up sharply in the short term, but may result in significant price drops when policies tighten or market confidence collapses.

3.2.3 The Role of Financial Markets

Financial markets also play an important role in real estate price fluctuations, particularly in regions with a high degree of real estate financialization. The financing costs, capital liquidity, and other financial factors in the real estate market are often closely tied to macroeconomic policies. When monetary policies are loose, financing costs in the real estate market tend to decrease, encouraging investors to increase investments in real estate, thereby pushing prices higher. In contrast, under monetary tightening, liquidity in the real estate market may be restricted, leading to rapid price declines.

3.2.4 Irrational Factors

Price fluctuations in the real estate market are not only driven by rational economic behavior but also influenced by irrational factors, such as consumer psychology and investor sentiment. When macroeconomic policies trigger certain expectations, consumers and investors often make purchasing decisions based on predictions of future price trends. For example, expectations of policy loosening can spark a buying frenzy, while expectations of policy tightening may cause panic selling, exacerbating price fluctuations.

3.3 Transmission Pathways of Macroeconomic Policies to the Real Estate Market

3.3.1 Policy Transmission Pathway Model

According to the theoretical model, macroeconomic policies influence real estate price fluctuations mainly through the following transmission channels:

Interest Rate Transmission Channel: Adjustments in monetary policy directly affect market interest rates, which in turn influence the cost of home loans and financing for investors. Lower interest rates reduce housing purchase costs, stimulating real estate demand and driving up housing prices. In contrast, higher interest rates suppress demand and lead to price declines.

Credit Transmission Channel: Credit policies adjust the availability of loans and loan conditions, directly affecting the capital supply to the real estate market. When banks loosen lending conditions, more consumers can obtain home loans, which boosts demand and raises prices.

Government Spending and Tax Transmission Channel: Government spending, tax policies, and other measures directly affect the supply and demand relationships in the market, thus influencing price fluctuations. For instance, infrastructure investments increase market demand for real estate, while property taxes and similar policies raise purchase and holding costs, suppressing demand.

3.3.2 Time Lags in Policy Changes

The effects of macroeconomic policies on the real estate market typically exhibit time lags. Policy adjustments usually take time to manifest in the market. For instance, changes in monetary policy may take months or even years to affect the real estate market through the credit market. Furthermore, the effects of these policies may be constrained by factors such as economic cycles and market expectations, thereby influencing the final impact on price fluctuations.

4. Analysis of the Relationship Between Macroeconomic Policies and Real Estate Market Price Fluctuations

4.1 The Relationship Between Monetary Policy and Real Estate Market Price Fluctuations

4.1.1 The Impact of Interest Rate Adjustments on the Real Estate Market

Interest rates are one of the most direct tools of monetary policy. When the central bank adjusts the benchmark interest rate, it affects both lending and deposit rates, influencing the cost of capital in the market. In the real estate market, changes in interest rates have a significant impact on the demand side. A low interest rate environment typically reduces borrowing costs, stimulates consumer demand for housing, and drives up real estate prices. Conversely, a high interest rate environment increases the burden on homebuyers, suppressing housing demand and leading to price declines (Mian & Sufi, 2011). Additionally, interest rate fluctuations affect investor capital costs, which in turn influence the investment decisions of real estate developers and market supply.

4.1.2 The Impact of Money Supply on the Real Estate Market

Changes in money supply significantly influence the liquidity and capital supply in the real estate market. An increase in the money supply raises market liquidity, lowers borrowing costs, and stimulates activity in the real estate market, leading to

price increases. During periods of monetary easing, the real estate market may become overheated, resulting in significant price hikes (Glaeser et al., 2010). In contrast, tightening the money supply restricts the flow of capital, increases financing difficulties, and may cause housing prices to fall or experience reduced fluctuations.

4.1.3 The Relationship Between Bank Credit Policies and the Real Estate Market

Bank credit policies are another important transmission mechanism of monetary policy. Bank credit supply is influenced not only by the central bank's monetary policies but also by banks' own risk management practices and capital costs. In the context of an accommodative monetary policy, banks often ease loan conditions, increase credit support to the real estate market, and further drive up demand, which leads to price increases. On the other hand, when monetary policy tightens, banks raise loan rates and reduce loan amounts, which restricts liquidity in the real estate market and decreases demand, putting downward pressure on prices. Moreover, the balance sheet effect of banks may also affect the real estate market, especially when banks face capital pressures, as credit supply may contract, which impacts the real estate market performance.

4.2 The Impact of Fiscal Policy on the Real Estate Market

4.2.1 The Impact of Government Spending on the Real Estate Market

Government spending on infrastructure and real estate development projects directly impacts both supply and demand in the real estate market. An increase in government spending, especially in infrastructure and public services, usually stimulates local economic development, increases regional housing demand, and pushes up housing prices. For instance, in large-scale urban construction or transportation network projects, surrounding real estate prices tend to rise. Moreover, the government's direct participation in real estate development can also change the market supply structure, thus affecting market prices.

4.2.2 The Impact of Tax Policies on the Real Estate Market

Tax policies, particularly those related to real estate, such as property tax and land appreciation tax, have a direct impact on the supply and demand dynamics in the real estate market. High property taxes or land appreciation taxes increase the holding costs of real estate, potentially reducing investors' incentives to purchase property, thus suppressing demand and exerting downward pressure on prices (Brunnermeier & Sannikov, 2014). Conversely, tax reductions or tax incentives, such as tax exemptions for first-time homebuyers, can boost consumers' willingness to purchase property, thereby driving up housing prices.

4.2.3 Housing Subsidies and Fiscal Stimulus Policies

Housing subsidies and other fiscal stimulus measures, especially during economic downturns or crises, can significantly increase demand in the real estate market. For example, under government-sponsored home purchase subsidy policies, low-income groups can more easily enter the housing market, thus stimulating demand and driving up housing prices. Additionally, fiscal stimulus policies can indirectly influence market expectations and, in turn, affect price fluctuations.

4.3 The Transmission Mechanism of Tax Policies on Real Estate Market Price Fluctuations

4.3.1 The Impact of Property Tax and Land Tax

Policies such as property tax and land tax affect investors' and consumers' purchasing behavior by altering the holding costs in the real estate market. Higher property taxes increase holding costs, reducing investors' motivation to purchase properties, potentially leading to a decrease in housing prices. Land taxes, which increase developers' landholding costs, can restrict real estate development and supply, thus exacerbating upward pressure on prices (Glaeser et al., 2008). In certain cases, high tax burdens may compel some investors to shift their funds to other asset classes, thus reducing real estate investment demand and slowing down price fluctuations.

4.3.2 The Impact of Tax Policies on Market Expectations

Tax policies also influence housing prices by altering market participants' expectations. When the government announces plans to increase property taxes or implement new tax policies, market participants may expect reduced returns from the real estate market, leading to a decline in investment willingness and price drops. On the other hand, tax reduction policies can boost consumer expectations, stimulate demand for housing, and push prices higher.

4.3.3 The Impact of Tax Policies on Purchase Costs

Tax policies directly affect the purchase costs for homebuyers, especially transaction taxes involved in real estate transactions

(e.g., deed tax, value-added tax). For example, under tax relief policies, the actual purchase cost for homebuyers is reduced, which may encourage them to purchase homes more quickly, boosting demand and driving up prices. On the other hand, if taxes increase, the cost of purchasing property rises, which may weaken demand and lead to a decline in prices.

4.4 The Impact of Other Policy Factors

4.4.1 The Impact of Foreign Exchange Policies

Foreign exchange policies affect the real estate market indirectly by influencing currency exchange rates, capital flows, and cross-border investments. For example, the relaxation of foreign exchange policies may attract foreign investors into the real estate market, increasing demand and raising prices. In contrast, tightening foreign exchange policies may restrict foreign capital inflows, reduce market purchasing power, and put downward pressure on prices.

4.4.2 The Impact of Import Tariffs and Trade Policies

Import tariffs and trade policies typically affect the cost structure of real estate developers by influencing the cost of imported construction materials. When import tariffs rise, the cost of building materials increases, which raises developers' costs and may eventually lead to higher housing prices as these costs are passed on to consumers. Similarly, changes in trade policies may influence the overall economic situation, which can indirectly affect demand in the real estate market.

5. Policy Implications and Recommendations

5.1 Effectiveness Analysis of Policy Regulation

5.1.1 Current Effectiveness of Macroeconomic Policies

Currently, macroeconomic policies, including monetary, fiscal, and tax policies, have achieved some success in regulating the real estate market. For instance, monetary policy has been effective in curbing excessive expansion in certain economic cycles by adjusting interest rates and credit supply. Fiscal policy, through infrastructure investment and housing subsidies, has helped stabilize the real estate market's development. However, the effects of these policies are not always consistent, and issues such as high housing prices and market instability persist in some regions.

Monetary Policy: While monetary policy can effectively limit market expansion in some cases, its tightening often has significant negative impacts on other economic sectors (such as consumption and investment), potentially leading to broader economic instability. In some cities, especially those with high population inflows, monetary policy has had limited impact on curbing high housing prices.

Fiscal Policy: Government spending on infrastructure and housing subsidies has stimulated market demand and driven short-term prosperity. However, long-term reliance on fiscal spending may lead to overdependence on government funds, making the market more sensitive to changes in fiscal conditions, which could lead to drastic fluctuations.

Tax Policy: Although property and land taxes have to some extent restricted speculative behavior in the real estate market, their impact on market expectations has been delayed. In some cities, the market has not fully responded to the regulatory effects of tax policies.

5.1.2 Shortcomings and Room for Improvement

Lag in Regulation: Current macroeconomic policies exhibit certain lags, particularly in monetary and tax policies, which are often slow to adjust to market changes, resulting in delayed responses to price fluctuations. A more flexible policy response mechanism is needed to minimize delays and enhance the timeliness and effectiveness of policies.

Lack of Policy Coordination: Although monetary and fiscal policies play roles in real estate market regulation, they often suffer from a lack of coordination due to differing objectives and implementation bodies. For example, while monetary policy may tighten, fiscal policy may focus on increasing infrastructure investment, leading to conflicting effects that weaken the overall regulatory impact.

Execution Issues at Local Government Level: Local governments may fail to implement central government policies effectively, especially when they prioritize local economic growth. Some local governments may adopt lenient real estate policies, leading to rapid price increases in the housing market.

5.2 Policy Optimization Suggestions

5.2.1 Optimization of Macroeconomic Policies

Enhance Policy Proactiveness and Flexibility: Governments should closely monitor market trends and adjust policies promptly. For example, flexible interest rate bands and credit policies should be introduced to respond quickly to market changes, preventing both excessive expansion and sharp price declines in the real estate market. Furthermore, the government should invest more in managing market expectations through transparent information dissemination and policy forecasting mechanisms, reducing market uncertainty.

Strengthen Policy Coordination and Synergy: Greater coordination between monetary, fiscal, and tax policies is crucial to avoid conflicting objectives. For instance, tightening monetary policy can be complemented by fiscal investment stimulus, controlling demand while ensuring stable economic growth.

Improve Local Government Regulation Capability: To address execution problems at the local level, a robust policy evaluation mechanism should be established. The central government should strengthen its supervision of local policy implementation to ensure that local governments strictly adhere to national real estate regulatory policies, preventing overheating of the market.

5.2.2 Adaptive Regulation Recommendations

Addressing Overheating in the Real Estate Market: When the real estate market shows signs of overheating, it is recommended to intensify policy regulation by raising property taxes, increasing down payment requirements, and raising loan interest rates. Additionally, stronger financial market supervision is needed to prevent excessive financialization of the real estate market and avoid accumulating financial risks.

Addressing a Cooling Real Estate Market: When the market shows signs of stagnation, the government can relax housing loan conditions, lower interest rates, and increase infrastructure investment to stimulate demand and boost market activity. Tax reduction policies aimed at first-time homebuyers and low-income groups can encourage broader market participation, promoting healthy market development.

Balancing Economic Growth with Market Stability: In regulating the real estate market, the government should focus on balancing economic growth and market stability. Over-regulation could cause demand to fall sharply, negatively affecting overall economic growth. Therefore, flexible policy adjustments are crucial to avoid market volatility caused by overly aggressive regulatory measures.

5.3 International Experience and Insights

5.3.1 U.S. Macroeconomic Policy Experience

The United States has extensive experience in real estate market regulation, particularly following the 2008 financial crisis. Through a combination of accommodative monetary policies (such as interest rate cuts and quantitative easing) and fiscal stimulus measures (such as government home purchase subsidies and mortgage interest rate reductions), the U.S. successfully alleviated the downturn in the real estate market. The U.S. experience shows that a well-coordinated mix of monetary and fiscal policies can effectively address market crises and balance supply and demand.

5.3.2 U.K. Real Estate Regulatory Policies

In the U.K., real estate regulation focuses on using tax policies to intervene in the market, particularly by increasing property taxes and capital gains taxes to reduce speculative behavior. These strict tax policies have helped lower speculative trading and stabilize price fluctuations in the real estate market.

5.3.3 Applicability to China

Drawing on the experiences of the U.S. and the U.K., China can place greater emphasis on the coordination between monetary and fiscal policies in future real estate market regulation. Adjusting interest rates, credit policies, and tax policies should be done carefully to manage market fluctuations. Furthermore, introducing property taxes and related tax policies at the right time can help suppress excessive speculation and reduce the risk of a real estate bubble. Additionally, market expectations should be better managed through transparent communication and policy forecasting to enhance market trust and responsiveness to government regulations.

6. Conclusion

6.1 Summary of Research

This study explored how macroeconomic policies influence real estate market price fluctuations through various channels, revealing the complex transmission mechanisms at play. By analyzing monetary, fiscal, and tax policies, the study concludes: Monetary policy impacts real estate market demand and supply by adjusting interest rates, credit supply, and money liquidity. In low interest rate and easy credit conditions, price bubbles can form, while tightening monetary policy suppresses demand and reduces prices.

Fiscal policy, through government spending, tax incentives, and housing subsidies, not only stimulates demand but also regulates market supply. Infrastructure and public housing projects significantly influence short-term price fluctuations, but long-term effects may increase the market's dependence on government support.

Tax policy, especially property and land taxes, directly affects holding costs and market expectations, influencing both consumer behavior and investor incentives, which in turn affects price volatility.

Additionally, the study highlights that the transmission mechanisms of macroeconomic policies are not linear but interact through financial markets, consumer behavior, and investor psychology. As such, the impact of macro policies on the real estate market is inherently uncertain, making timeliness and coordination critical for effective regulation.

6.2 Research Limitations and Future Outlook

Despite exploring the transmission mechanisms of macroeconomic policies on real estate market price fluctuations and offering relevant policy suggestions, the study has limitations. First, the research focuses mainly on monetary, fiscal, and tax policies, excluding other policy tools such as foreign exchange or land use policies. Thus, a more comprehensive evaluation of policy impacts is needed. Secondly, the study relies on theoretical analysis based on literature and secondary data, without empirical research to accurately reflect the policy transmission effects. Additionally, the international comparisons are limited, mainly drawing on the U.S. and U.K. experiences, and do not deeply explore practices in emerging market economies.

Future research can address several areas: optimizing policy combinations, particularly how to effectively regulate the real estate market in different economic cycles and market conditions through flexible combinations of monetary, fiscal, and tax policies. Further studies can also investigate how macroeconomic policies influence market expectations and how transparency and expectation management strategies can help stabilize the market. Cross-country comparison studies will also be valuable in understanding the policy applicability differences across economies and offering tailored frameworks for real estate regulation. Lastly, with the advancement of digital technologies, future research could explore how big data and artificial intelligence can optimize policy implementation, particularly in analyzing market expectations and consumer behavior.

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Analysis of the Financial Performance Management Path of Enterprises under Green Tax Policy

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Abstract: Under the backdrop of green tax policies, companies face new challenges and opportunities in financial performance management. This paper explores the direct and indirect impacts of green tax policies on corporate financial performance management, highlighting the main issues companies encounter during their green transformation from three aspects: performance evaluation systems, information disclosure supervision, and green investment. In response to these issues, the paper further proposes optimization paths for corporate financial performance management. The aim is to provide guidance for companies to promote green transformation through economic means and to offer decision-making support for governments in formulating relevant green development policies.

Keywords: Green Tax Policy; Financial Performance Management; Environmental Information Disclosure

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1.Introduction

Industrialization and urbanization are accelerating, leading to increasingly severe environmental pollution, which poses a significant threat to human survival and development. Driven by global environmental protection trends, environmental conservation has become an urgent social issue in China today. Environmental protection is not only the responsibility of the government and environmental organizations but also an inescapable social duty for enterprises. To achieve sustainable development goals, companies need to transform their strategies towards greener practices. As consumer awareness of environmental issues grows, the demand for green products and services is increasing. By adopting green transformation strategies, companies can meet market demands, gain policy support and incentives, and enhance their economic benefits and social impact. Among these measures, the introduction of green tax policies, which impose higher taxes on high-polluting and high-energy-consuming enterprises, encourages companies to reduce pollutant emissions and improve resource efficiency, guiding and incentivizing them to focus more on environmental protection during operations. Financial performance management is a crucial aspect of corporate strategy implementation. Under green tax policies, financial performance management must pay greater attention to the relationship between the company and the environment, incorporating environmental costs and benefits into the evaluation criteria. This helps companies adapt to the requirements of green tax policies, enabling them to achieve economic benefits while also considering social and environmental impacts. In this context, exploring the management paths of corporate financial performance under green tax policies becomes particularly important.

2.The necessity of financial performance management under green tax policy

2.1 Direct impact

Companies should attach importance to the direct impact of green tax policies on their development. On one hand, the implementation of green tax policies is a means for government to regulate environmental protection actions, aiming to encourage companies to reduce pollutant emissions and adopt more environmentally friendly production technologies^[1] through economic incentives. It also presents an opportunity for companies to enhance their environmental awareness and sense of social responsibility. For companies, improving environmental awareness and social responsibility is a necessary choice to adapt to green tax policies. Under the backdrop of green tax policies, companies face additional financial pressures from environmental taxes and carbon taxes. If internal management lacks environmental awareness and fails to timely adjust its operational model according to green tax policies, it will face high tax burdens and other fines, negatively impacting its financial performance. On the other hand, enhancing social responsibility can boost a company's market competitiveness and brand value^[2]. As consumers and investors increasingly focus on environmental and social responsibilities, a company's performance in these areas becomes a concrete manifestation of its market competitiveness. Companies with a strong sense of social responsibility are more likely to win consumer trust and loyalty, attracting more green investments. At the same time, actively participating in environmental protection and public welfare not only secures more market opportunities but also wins the favor of investors in the capital market, directly reflected in increased sales growth and reduced financing costs, thereby improving the company's financial condition. Moreover, in the modern economic environment, short-term financial performance is no longer the sole pursuit of companies; long-term sustainable development has become a new strategic focus. By enhancing environmental awareness and social responsibility, companies can more effectively manage their environmental costs, continuously optimize resource allocation, improve production efficiency, and reduce long-term operational risks. At the same time, a strategic mindset for sustainable development can influence the company's development costs and revenue in a highly competitive market environment, directly impacting the management and continuous improvement of financial performance.

2.2 Indirect effects

Currently, green tax policies are being gradually promoted globally. In line with these policies, the government has implemented mandatory regulations for corporate environmental behavior. Companies should pay more attention to the indirect impact of green tax policies on their internal development and financial performance management. On one hand, as green tax policies are rolled out nationwide, a well-established green tax system can provide clearer guidance and support to companies, helping them better understand and respond to changes in the market environment, thereby optimizing financial management^[3]. Optimizing financial performance management not only reduces environmental risks but also enhances overall financial performance, achieving a win-win situation for economic and environmental benefits^[4]. On the other hand, green tax policies not only require companies to comply with environmental laws but also encourage them to take proactive environmental measures to reduce environmental risks. By establishing an environmental cost accounting system, companies can accurately calculate and manage environmental costs, reduce environmental tax burdens, and improve financial transparency and management efficiency. Further strengthening environmental risk assessment and management can minimize fines and compensation due to environmental violations, thus ensuring financial health^[5]. Moreover, an innovation-driven development model aligns with the requirements of green tax policies, promoting long-term sustainable development for companies. Through research and application of green technologies, companies continuously innovate and upgrade green technologies, reducing pollutant emissions and energy consumption during production processes, achieving clean production and recycling. This not only lowers environmental costs but also optimizes resource allocation, impacting financial performance management^[6].

3. Problems existing in financial performance management of enterprises under green tax policy

3.1 The performance evaluation system is not perfect

The compensation of business operators is linked to corporate financial indicators, leading them to prioritize short-term benefits and downplay the importance of non-financial metrics such as energy conservation and emissions reduction. To

break this deadlock, “Chinese-style performance management” must shift from an excessive focus on outcomes to greater emphasis on processes, and from short-term to long-term considerations. The imperfections in China’s green financial performance evaluation system are mainly reflected in three aspects: First, the setup of non-financial indicators in the corporate performance evaluation system is inadequate; these indicators account for too little or are difficult to quantify, causing ambiguity in performance evaluations. When assessing overall performance levels, most companies prioritize financial indicators, but an evaluation system heavily weighted towards financial metrics can foster short-term profit motives, which not only contradicts China’s green development philosophy but also leads to one-sided evaluation results, hindering sustainable corporate growth. Second, performance evaluation indicators fail to fully reflect the principles of green development and social responsibility. The lack of standardized non-financial indicators makes it difficult for companies to promptly identify shortcomings in environmental and social performance, thus making it hard to adjust their development paths in a timely manner. An evaluation system dominated by financial performance also discourages employees from practicing green development concepts, neglecting the company’s long-term goals and social responsibilities, ultimately preventing the company from achieving sustained positive development. Third, differences across industries pose another challenge in corporate performance evaluation. Significant variations exist between different industries and even among companies within the same industry, making a generalized evaluation system unsuitable for all enterprises. When performing performance evaluation, enterprises must combine their own business characteristics and comprehensively consider the norms of green tax policies to construct an applicable green financial performance evaluation index system.

3.2 Insufficient disclosure and external supervision

Information disclosure serves as a vital bridge for communication between companies and the external environment. However, incomplete and inaccurate information disclosure hinders external oversight. On one hand, information asymmetry makes it difficult for outsiders to assess a company’s environmental performance. Many companies focus on traditional financial data such as revenue, profit, and costs when disclosing financial information, while neglecting crucial environmental protection-related details. The lack of detailed green financial information, including pollutant emissions, resource consumption, environmental investments, and emission reduction effects, prevents investors, regulatory bodies, and the public from fully understanding a company’s performance in environmental protection. Even if companies disclose some green financial information, the authenticity and accuracy of this information cannot be guaranteed. If companies exaggerate their environmental achievements or conceal shortcomings and violations in environmental protection, the true state of their environmental performance can be obscured, making it difficult for outsiders to evaluate their environmental performance and further complicating external oversight. In such cases, external supervision loses its effectiveness and fails to effectively monitor and assess a company’s environmental performance. On the other hand, there is no uniform standard for green financial information disclosure at the global and national levels. There are significant differences among companies in terms of content, format, and frequency of disclosure. The absence of a standardized mechanism makes it challenging for companies to ensure the completeness and consistency of their information, leading external stakeholders to struggle in comparing different companies’ green financial information and thus failing to form a comprehensive understanding of the industry’s overall environmental performance. In addition, due to the incompleteness and opacity of green financial information, it is difficult for enterprises to form a scientific decision support system internally. Business operators may pay more attention to short-term financial indicators, which may encourage short-term speculative behavior to gain short-term benefits, neglecting long-term environmental protection and sustainable development goals. This could lead to environmental pollution and resource waste, contradicting the original intentions of green development and social responsibility.

3.3 Green investment expenditure is too heavy

The implementation of green tax policies requires companies to strictly adhere to environmental standards; otherwise, they will face hefty fines, making their pollution emissions more costly. On one hand, to comply with the relevant provisions of green tax policies, companies need to invest substantial funds in environmental facilities and pollution control, as well as regular maintenance to ensure proper functionality. The high initial capital expenditure and subsequent maintenance costs directly increase operational expenses. Moreover, cost shifts force companies to pay more taxes, reducing funds available

for other areas, which limits corporate development space and negatively impacts long-term growth. On the other hand, when facing increased environmental costs, companies often find themselves in a dilemma. They need to invest heavily in environmental equipment and technology upgrades while also maintaining sufficient funds for daily operations and market expansion. If companies fail to balance environmental protection and economic benefits, short-term financial pressure will severely affect their profitability. Additionally, although green investment is a necessary means for companies to meet environmental standards, purchasing more environmentally friendly equipment, implementing more energy-efficient manufacturing processes, or upgrading or rebuilding production lines does not always bring immediate economic returns. Green technological changes and equipment modernization often require significant capital investment, but the operating costs of green technologies and equipment are high, and companies need a considerable amount of time to recoup their investment. At the same time, the market prices of green products may not be higher than those of traditional products in the short term, making it difficult for companies to quickly cover their investment costs through product sales, further increasing their financial pressure. If the enterprise can not effectively manage these financial risks, it may lead to the enterprise into financial difficulties, or even face the risk of bankruptcy.

4. Analysis of the management path of enterprise financial performance under green tax policy

4.1 Formulate diversified development strategies

Companies should attach importance to the direct and indirect impacts of green tax policies on their development. Whether in the growth stage or mature, companies should seize this opportunity to adjust their development strategies, tackle key technologies, ensure stability in development, and adopt long-term strategic planning to form a foundation for diversified development, thereby exploring the space for corporate green transformation. First, when managing financial performance, companies need to integrate green concepts into their development strategies and enhance performance management levels by establishing a green performance indicator system and developing green financial management tools. They must also fully consider the impact of green tax policies on operating costs, investment decisions, and market positioning, incorporating environmental factors into their considerations to formulate strategic plans that align with policy guidance and the company's long-term development. Second, companies should strengthen green technology innovation and R&D investment to achieve diversified technological innovation. They should continuously improve their environmental standards in areas such as energy conservation, emission reduction, global and green energy production, pollution reduction, and production environment technology improvements. Emphasis should be placed on cultivating and attracting high-quality talent and establishing industry-university-research cooperation mechanisms with schools to continuously enhance employees' professional skills and innovative capabilities. Third, companies should actively explore diversified financing channels in the green financial market. Under green tax policies, the environmental costs faced by companies increase, leading to greater financial pressure. Companies should actively seek support from green bonds and green credit products to reduce financing costs and provide financial security for their green transformation. Fourth, companies should focus on expanding into diversified markets. With the increasing demand of consumers for green products, enterprises should actively adjust the product structure, develop green products in line with market demand, and expand the international market to improve the competitiveness of enterprises in the global market.

4.2 Improve the quality of information disclosure

Environmental information disclosure is not only a social responsibility but also an internal management task for companies. As the public and corporate stakeholders increasingly focus on environmental protection, companies must not only disclose their environmental information internally but also seek a balance between public environmental awareness and economic interests. On one hand, companies should proactively disclose environmental information, enhancing the transparency of non-financial data, especially regarding their social responsibility and green practices, to send positive environmental signals to the public, thereby improving their social image and market value. Moreover, during the process of environmental information disclosure, companies can better align with green tax policies by organizing green financial information, enriching their green financial databases, and addressing any gaps in financial data. On the other hand, companies should

strengthen communication with stakeholders on environmental information, improve the information disclosure system, and ensure the reliability and timeliness of environmental information. Currently, the third-party service market has developed quite maturely, and leveraging the power of third-party institutions can enhance the quality of corporate environmental information disclosure. By utilizing these institutions, companies can promote the provision of specialized information disclosure services, indirectly improving the standardization and professionalism of their disclosures. Additionally, the role of the government is to regulate corporate behavior through the formulation and enforcement of environmental laws. Government environmental supervision not only encourages companies to pay attention to environmental issues but also requires them to assume environmental responsibilities, thus driving companies to improve their environmental governance and information disclosure. These measures will not harm the fundamental interests of enterprises, but force them to better manage and reduce environmental emissions, so as to meet the social demand for sustainable development.

4.3 Optimize financial management process

Under the backdrop of green tax policies, companies need to integrate green concepts into their financial decision-making and budget management. First, adjust financial planning. Companies should conduct in-depth study and analysis of green tax policies to understand their impact on financial performance metrics such as cost, profit, and cash flow. To meet the requirements of green tax policies, companies should consider environmental factors at the initial stage of financial planning, develop a dedicated green budget to support projects that reduce environmental pollution, and seek and utilize diversified financing channels during the mid-term. By collaborating with banks and other financial institutions, they can leverage green credit and other financial products to provide necessary funding for their environmental projects. Second, establish a green investment evaluation system. For investments and risk management in green projects, companies should adopt more systematic and scientific methods. By establishing a comprehensive green investment evaluation system, companies can accurately analyze the potential environmental benefits and economic returns of each investment project, and comprehensively assess the environmental impact, potential environmental tax incentives, and long-term economic benefits of the projects. Third, improve the financial risk management system. Companies should strengthen risk management for green projects, identify and evaluate potential environmental risks, and pay greater attention to uncertain factors such as the failure of green technology implementation or changes in market demand, ensuring the robustness of investment decisions. Fourth, introduce advanced financial management technologies. By leveraging advanced information technology, using automated accounting systems and intelligent financial analysis software, companies can better integrate green financial information and manage finances more efficiently.

Conclusion

The original intention of implementing green tax policies is to protect the ecological environment and thereby achieve sustainable development. If companies can actively respond to these policies by innovating in green technology and optimizing management, they can not only reduce environmental costs but also enhance market competitiveness and brand value. However, due to the lack of non-financial indicators in corporate green performance evaluation systems, insufficient environmental information disclosure, and high capital expenditures resulting from green investments, the associated green tax costs and management costs pose challenges for corporate development. To address these challenges, a strategic green transformation is needed. By formulating diversified development strategies, improving the quality of information disclosure, and optimizing financial management processes, companies can not only lower environmental risks and meet environmental protection goals but also better manage their financial performance to improve overall financial outcomes. In the future, companies should continue to explore green development paths to achieve a win-win situation for economic and environmental benefits, driving continuous progress on the path of sustainable development.

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Research on the Application of Blockchain Technology in Supply Chain Finance

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Abstract: At present, blockchain, with its distributed structure, trust mechanism, openness and transparency, and tamperability, has significantly optimized the information flow in supply chain finance, constructed a multi-body cooperation and coordination mechanism, and effectively solved the risk control problems. This paper analyzes the practice of Ant Gold's "Double Chain" platform, which demonstrates the role of blockchain technology in simplifying the financing link, aggregating multi-value chain, and promoting the innovation of supply chain finance. Finally, policy recommendations are put forward, including the development of supply chain finance, alleviating financing constraints and strengthening blockchain applications to promote the technology and the healthy development of supply chain finance. The study shows that the application of blockchain technology not only improves the efficiency and security of supply chain finance, but also brings innovative solutions for supply chain management

Keywords: Supply Chain Finance; Blockchain Technology; Dual-Chain Pass; Trust in Institution

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1. Research background

1.1 Blockchain Overview and Characteristics

The essence of blockchain technology is to jointly maintain a continuously growing distributed database by multiple parties, also known as distributed shared ledger (distributed shared ledger), the core of which lies in the establishment of a trust relationship between each other through a distributed network, time-ordered tamper-proof cryptographic ledger and distributed consensus mechanism, and the use of automated script code composed of smart contracts to program and manipulate data, ultimately realizing the evolution from information interconnection to value interconnection. to program and manipulate data, and ultimately realize the evolution from information interconnection to value interconnection^[1].

Blockchain technology, as a trust-creating machine, has the following main characteristics

1.1.1 Distributed Architecture

Blockchain technology is built on a decentralized network architecture, its ledger information is not stored in a single server or data center, and is not subject to the control and record of any single authority, but is dispersed in the network of each node, each node has a copy of the ledger, and all copies are synchronously updated.

1.1.2 The Confidence Mechanism

Blockchain technology utilizes mathematical foundations and algorithmic procedures to ensure the openness and transparency of its operating rules, enabling both parties to a transaction to build trust through a consensus mechanism without the need for

a third-party authority to provide proof of credit.

1.1.3 Openness and Transparency

Characterized by its openness and transparency, it allows anyone to join and query its block records. In this system, all participants have access to the same shared ledger and can view the history of all transactions recorded therein. This design ensures consistency and traceability of transactions, allowing each user to witness every transaction that occurs on the ledger.

1.1.4 Time-series and Tamper-evident

Blockchain stores data by using a chained block structure with timestamps, which gives blockchain a high degree of traceability and verifiability^[2]. Since each block contains a timestamp, this not only ensures the authenticity of the transaction record, but also allows each transaction to be traced and verified through the chain structure. Cryptographic algorithms ensure the security of the data, while the consensus mechanism ensures consistent recognition of the data by all nodes in the network.

1.2 The Current State of Blockchain Technology Development

As of 2024, blockchain technology continues to develop rapidly globally, especially in China, with rapid growth in market size, continuous optimization of the policy environment, continuous breakthroughs in technological innovation, consolidation of the application foundation, and remarkable results in ecological structure and standardization. China's blockchain market scale will grow at a CAGR of 73% between 2019 and 2023, showing strong growth momentum. Meanwhile, blockchain standardization is active both at home and abroad, with fruitful results in the development of domestic blockchain technology and application standards, and a large number of group standards covering various fields such as terminology specifications, technical specifications, security, and performance indicators. In addition, the in-depth integration of blockchain technology with various economic and social fields has continued unabated, and the application and industrial development of blockchain technology has continued to make breakthroughs, and its key role in serving the efficient collaboration of multi-party business and establishing a trustworthy value network has further gained recognition in the industry^[3].

1.3 Overview and Characteristics of Supply Chain Finance

Relying on core users, with real trade backgrounds, applying self-reimbursable trade finance in a manner that is closed by specialized means, such as registration of pledges of accounts receivable and third-party supervision financial flows or control of property rights, for upstream and downstream enterprises, integrated financial products and services^[4].

1.3.1 Based on Supply Chain Management

Taking the core enterprise in the supply chain as the hub, it provides financial services around its upstream and downstream enterprises, covering the full range of processes from research and development, purchasing to logistics, information management and sales, as well as the status of coordination between these links and activities.

1.3.2 Integration of the three streams

In the real transaction background, through the integration of capital flow, logistics, information flow and other information, it builds a comprehensive financial supply and risk assessment system centered on core enterprises and connecting upstream and downstream enterprises in the supply chain, provides systematic financial solutions, and improves the transparency and efficiency of the supply chain.

1.3.3 Serving small and medium-sized enterprises

The main service targets are growing small and medium-sized enterprises (SMEs), solving the problem of financing difficulties by filling the gap of SMEs' capital, making the transactions between upstream and downstream enterprises in the supply chain smoother, and enhancing the overall competitiveness of the supply chain network^[5].

1.3.4 Relying on information technology

Utilizing big data, blockchain and other technologies to improve the accuracy and security of financial services. Thanks to the progress of modern information technology, especially the application of big data and blockchain technology. Enabling financial institutions to more accurately assess the risks of each link in the supply chain and improve the efficiency and security of financing.

1.4 The Status of Supply Chain Development

1.4.1 The environment for the development of supply chain finance has gradually become better

Despite the impact of the epidemic, compared with the international situation, under the government's control, the domestic economy is less affected by the epidemic and recovers faster, and the situation is rising steadily. The General Office of the Central Committee of the Communist Party of China (CPC) has put forward specific measures to address the problems of difficult and expensive financing for small and medium-sized enterprises (SMEs) in China, and local governments have successively introduced and implemented relevant policies to create a favorable environment for the healthy development of supply chain finance.

1.4.2 There have been significant upgrades in the infrastructure, technology related to supply chain finance

Human society is currently experiencing a hundred years of unprecedented changes, a new round of industrial revolution has promoted the transformation and upgrading of enterprise network, intelligence, digitalization, enterprise digital transformation and upgrading is conducive to the development of supply chain finance, the technology is gradually popularized and slowly matured to improve the overall operational efficiency.

2. Blockchain technology to optimize the effects of supply chain finance

2.1 Significantly optimizing the information flow problem in supply chain finance.

With the globalization of division of labour and the deepening of international trade, the structure of supply chains has become more complex, and the number of links involved is also increasing. Systematic differences among enterprises have led to interruptions in information transmission and the phenomenon of silos, especially in transnational supply chains, where real-time information sharing is difficult. Different data standards and quality of supply chain enterprises make it difficult for small and medium-sized enterprises (SMEs) to meet the credit standards of financial institutions, which affects the effective operation of supply chain finance. Blockchain technology promotes the informatization of the whole chain of supply chain and realizes the transparency, smoothness and security of information through appropriate structure and guarantee mechanism. It can open up the underlying data of the supply chain, promote the integration of logistics, information flow and capital flow, and is especially suitable for complex supply chain finance scenarios involving multiple trading entities^[4] Blockchain technology. By centralizing the processing of financing-related data, blockchain technology creates transparent and complete transaction records and allows participants to share a unified data source. At the same time, its encryption and distributed ledger features guarantee the security and non-tampering of data, meeting the needs of financial security and effectively preventing document forgery and data loss.

2.2 Blockchain builds a multi-body cooperation and coordination mechanism for supply chain finance

Blockchain technology plays a crucial role in supply chain finance, especially in the construction of cooperation and coordination mechanisms involving multiple parties. Private chains lack openness and transparency, centralized control models, which can easily lead to trust issues and do not conform to the basic trend of diversified technological development[6]. Under this model, with the increase of transaction nodes, the financing chain is lengthened, and the difficulty and cost for financial institutions to process the transactions increase and the efficiency decreases. Blockchain technology utilizes a distributed ledger structure to facilitate the establishment of trust and the transfer of credit between the two parties in the supply chain. It eliminates the single maintenance role of a centralized institution, ensures data inerrancy, and establishes a direct peer-to-peer connection between supply chain participants. This structure simplifies complex business processes and provides a solid foundation of trust for supply chain finance. Regardless of which level of the supply chain a supplier is located in, holding a pass means obtaining credit support from the core enterprise, thus solving the problem of multi-level supplier credit transfer^[5].

2.3 Blockchain technology to solve supply chain finance risk control challenges

At present, China's supply chain finance lacks a unified enterprise credit evaluation system, especially in factoring business, there is a lack of perfect legal framework, blockchain reduces the potential fraud under the traditional model by promoting cooperation and supervision between institutions. Under the blockchain mechanism, there is a common recognition of the credit status of the institutions, which reduces repeated audits of the authenticity of documents. This kind of transaction behavior of mutual verification enhances the self-proof and value-added of credit, thus improving the credit level of supply chain finance. Blockchain promotes the fairness and credibility of the transaction environment. Take the bill market as an

example, the risk events of “one vote selling more than one” and false bills of exchange occur frequently, and the application of blockchain technology in this field is particularly important. Blockchain technology-supported digital bills make use of distributed storage to enhance data security, reduce dependence on centralized institutions, automate bill exchange activities through smart contracts, control risks from various restrictions, provide intelligent technical support for credit management, and provide credit guarantee for bill transactions.

3. Innovation and Practice of Blockchain Technology in supply chain finance

3.1 Innovative applications

3.1.1 Multi-party data sharing and transparency mechanisms

Blockchain technology achieves instant recording and sharing of information in the supply chain through a decentralized node verification system, which improves transparency. This enables participants to quickly adjust production and distribution strategies and reduce resource wastage. At the same time, blockchain provides a shared real data environment, which facilitates the establishment of trust relationships, and this data-based transparent trust mechanism effectively reduces the uncertainty of transactions, enabling the supply chain to operate more closely and efficiently.

3.1.2 Agreeing to self-executing supply chain financing agreements

Blockchain technology in supply chain finance provides the basis for automatically enforcing protocols through its decentralized ledger system. Transaction records, once verified and added to the blockchain, are immutable, ensuring tamper-proof evidence of the flow of funds. This simplifies, automates, and improves the timeliness of the use of funds by streamlining and automating the traditional cumbersome financing process that relies on financial institutions and intermediaries. Blockchain enhances transaction transparency, allowing all authorized parties to access transaction details in real time, identify supply chain bottlenecks and risk points, and optimize strategies.

3.1.3 Blockchain solutions for cross-border payments

Traditional cross-border payments involve multiple intermediaries, resulting in high costs and delays. Blockchain technology supports peer-to-peer payments, reducing costs and time and enabling funds to arrive quickly, which is critical for fast money flows. Distributed authentication mechanisms and encrypted storage of transaction records enhance security while ensuring transparency and privacy, with only authorized users having access to detailed information. This technology enhances the efficiency and security of payments and represents a major innovation in the financial sector.

3.2 Ant Gold’s supply chain finance practice based on blockchain technology

The “double chain” launched by ant gold service is a supply chain collaboration network system based on blockchain technology, double chain is blockchain and supply chain finance. Through the blockchain technology to realize the whole chain coverage of supply chain finance, the traditional supply chain financial model, the first level supplier is the main object of Ant Financial Services to provide financing, while the double chain mode will be the financing of the second, third, fourth and fifth level suppliers into the scope of the bank’s financing object, which is conducive to alleviating the financing difficulties and financing problems of small and micro enterprises, and continue to promote the cost of the real economy, and to reduce cost^[7].

3.2.1 Autonomous and innovative blockchain technologies

The “Double Chain” supply chain finance platform adopts the blockchain technology independently developed by Ant Group, which covers the underlying technologies such as hardware, network, storage, computing, cryptography, consensus, block formation, etc., as well as the business links such as the confirmation, circulation, financing, and clearing of accounts receivable, which ensures that the information and business of each segment of the supply chain can be securely controlled, effectively protecting the privacy of each enterprise and financial institution. It ensures that the information and business data of each business link in the supply chain are safe and controllable, and effectively protects the privacy of enterprises and financial institutions^[8].

3.2.2 Simplification of financing

Ant Financial Services’ “Double Chain Link” platform integrates blockchain technology and online banking credit loan services, effectively simplifying manual processes in supply chain finance, facilitating automated system operations and

enhancing the speed of information exchange between different systems. The application of this technology not only shortens the financing cycle of small and microenterprises, but also effectively reduces their cost of capital.

3.2.3 Multi-value chain aggregation

‘Dual Chain Connect’ is the integration of blockchain technology into the supply chain, including alliance networks, enterprise operation services, and financial infrastructure services^[9]. Together with multiple partners, Ant Financial Services has launched a comprehensive open platform, which realizes a high degree of integration and deep integration of logistics, business flow, capital flow and information flow with the help of its powerful Internet payment and e-commerce system, thus stimulating the cluster effect of the value chain. This integrated supply chain financial service not only enhances Ant Financial’s financial business, but also attracts more high-quality value chains to join, further promoting the continuous progress of Ant Financial’s supply chain finance and blockchain financing model.

4. Policy Recommendations for Promoting Blockchain Technology in Supply Chain Finance

4.1 Vigorously developing supply chain finance

The government and financial institutions should jointly formulate policies to encourage financial institutions to innovate supply and marketing financial products to support the financial needs of business and trade circulation enterprises, especially small and medium-sized business and trade circulation enterprises, and effectively alleviate the financial pressure on business and trade circulation enterprises by providing more flexible and convenient financing channels, so as to enable them to focus on the development of their core business and innovation. Promote the construction of supply chain financial platform. The development of modern information technology provides a solid technical foundation for the construction of supply chain finance platform. The government should actively promote the construction of supply chain finance platform based on blockchain, big data and other technologies, create an open, transparent and efficient supply chain finance ecosystem, realize automated financing approval and settlement processes through smart contracts, reduce financing costs and enhance the efficiency of capital utilization. The government should establish a sound risk management system for supply chain finance, and utilize big data analysis and artificial intelligence technology for risk monitoring and early warning to ensure the healthy development of supply chain finance; improve laws and regulations, clarify the responsibilities of all parties, and safeguard the legitimate rights and interests of the main parties involved^[10].

4.2 Sustained alleviation of financing constraints

It is necessary for relevant departments to strengthen policy support measures to promote the healthy development of small and medium-sized enterprises. By establishing a special guarantee fund and implementing loan interest subsidies, we can effectively reduce the operational burden on enterprises. Banks and other financial institutions need to adjust their lending strategies, increase the scale of funding supply for the real economy, and develop more diversified financial service products. Solving the funding problem requires innovative financial tools, and regulatory authorities should support banks and other institutions in developing financing solutions that meet market demand. Focus on promoting the application of financial technology, using intelligent risk control systems and data mining technology to optimize loan review processes, reduce information barriers, and improve the efficiency of fund utilization. A sound credit system is an important support for improving the financing environment. Suggest promoting the construction of cross departmental enterprise credit databases, standardizing the collection, processing, and application standards of credit data^[11]. By constructing a scientific credit evaluation model and establishing a system of credit incentives and punishment for dishonesty, market entities are guided to enhance their credit awareness, thereby improving their opportunities and capabilities to access financial services.

4.3 Focusing on strengthening blockchain applications

Strengthen the promotion of blockchain technology, enhance enterprises’ understanding and enthusiasm for using this technology. We can organize a series of activities such as special lectures and practical training to help related industries improve their technical application capabilities. Enterprises should actively explore the applicable scenarios of blockchain in the supply chain field, and promote its in-depth application in logistics monitoring, product traceability, supply chain collaboration, and other aspects. Specifically, by utilizing the tamper proof nature of blockchain, it is possible to achieve

open and traceable data throughout the entire supply chain process, thereby enhancing credibility and operational efficiency. While promoting the implementation of technology, it is necessary to simultaneously improve risk management mechanisms. Relevant departments should accelerate the formulation of normative requirements and regulatory frameworks for blockchain applications, guide the healthy and orderly development of technology, and ensure its stable operation and data security.

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no

Conflict of Interests

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

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Do Investors Care About Green Bonds? Evidence From China

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Abstract: This study provides an empirical examination of green bond issuance within the Chinese capital market and its differential effects on short-term and long-term corporate stock performance. Employing both event studies and DID analysis, I investigate the impact of green bonds, compared to conventional bonds. The findings reveal that green bond issuance elicits positive short-term market reactions, reflected by positive CAR before and after the issuance announcement, which is separated by an insignificant negative CAR on and days after the announcement. However, the long-term analysis indicates no significant effect on stock price or firm valuation, suggesting the market's limited recognition of long-term ESG improvements. The research highlights sector-specific responses, with public utilities and state-owned enterprises exhibiting more pronounced reactions to green bond announcements. These outcomes underscore the complexity of the green bond impact in the context of the evolving standards and investor perceptions shaping the Chinese market.

Keywords: ESG; Green Bond; Abnormal Return

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1.Introduction

The integration of environmental, social, and governance (ESG) considerations into corporate strategies has become an essential facet of contemporary business practices, reflecting a paradigm shift toward the recognition and incorporation of broader stakeholder interests within corporate decision-making frameworks. Existing papers explore the emergent and rapidly expanding domain of the green bond market—a financial instrument innately crafted to bolster environmental and social welfare. Pioneered in corporate finance, green bonds represent an innovative mechanism through which firms can acquire capital to fund investments, inextricably linked to the promulgation of environmental goodness, such as amelioration of carbon footprint and pollution mitigation. These bonds are distinguished not only by their explicit commitment to environmental projects but also by the requirement of certification from third-party entities, a validation process that can impose additional administrative and compliance burdens, particularly on first-time issuers.

Scholars have approached the study of green bond issuance and its effect on corporate stock returns from various angles, yielding a spectrum of conclusions. This divergence can be attributed to multiple factors, including the temporal context of analysis, the heterogeneity of data drawn from disparate capital markets, and the selection of distinct research timeframes, which have fundamental implications on the resultant insights. Post-2016, a notable surge in the green bond market has influenced sample selections, altering the landscape of empirical evidence, and consequently, skewing the interpretations of green bonds' impacts. Additionally, national disparities in the recognition standards for green bonds, levels of regulatory

oversight, and societal acceptance of sustainable investments have resulted in heterogeneous findings across different countries.

China, as one of the key participants in the green bond market and the country with the largest issuance volume, necessitates a focused study on its latest green bond samples. The unique features of Chinese capital market and green bonds, in turn, influences the mechanism by which green bonds impact corporate stock prices. Therefore, the uniqueness and the imperative for a dedicated study of green bonds in the Chinese context are further emphasized by these factors. More than the event study that is used by existing studies, I have further employed the Difference-in-Differences (DID) analytical technique to differentiate between the impacts of green bond and conventional bond issuances for both the short-term and long-term effects of green bonds.

The results of the event study and DID analysis regarding the short-term impact of green bond issuance on stock prices indicate the occurrence of positive CAR in the window period around 10 days before and after the event. Upon further segmentation, positive CAR is significant in the range from 1 day before the announcement to 5 days before and from 5 days after to 9 days after, while CAR is slightly negative but not significant in the range from the announcement day to 4 days after. However, the DID analysis shows that green bond issuance does not lead to a significant increase in stock price or company value in the long term.

This lack of enhancement is attributed to the absence of an improvement in the company's ESG governance level in the long term, rendering it unrecognized by investors—a potential consequence of the lack of clarity in “greenwashing” and green bond standards and regulations. In contrast, green bond issuance in the short term generates abnormal returns and is associated with increased stock trading volumes, consistent with the limited attention theory, where the issuance of green bonds as positive news attracts more attention to the company. The DID analysis also reveals a more significant effect on public utility companies and central state-owned enterprises.

The conclusions drawn from this study on Chinese green bonds harmonize with the existing research on green bonds in other countries and feature detailed short-term influence and underlying mechanisms. Moreover, this study conducts a comparative analysis of the short-term and long-term effects of green bonds and delves into the underlying mechanisms. These research findings are consistent with the characteristics of the Chinese capital market. In synthesizing these findings, the study contributes to a nuanced appreciation of the intricate dynamics between green bond issuance and corporate stock performance, as embedded in the idiosyncrasies of the Chinese green bond market.

2.Literature review and motivation

2.1 Related theories

Efficient Market Hypothesis (EMH): The Efficient Market Hypothesis, introduced by Fama^[1] asserts that financial markets efficiently incorporate all available information, rendering attempts to consistently outperform the market through analysis of publicly available information futile. It suggests that asset prices reflect all available information, making it challenging for investors to gain exceptional returns on their investments. EMH is categorized into three forms: weak, semi-strong, and strong, each reflecting the extent to which information is already factored into stock prices.

Limited Attention Theory: Limited Attention Theory, introduced by Egeth and Kahneman^[2] explores the cognitive constraints and selective information processing capabilities of individuals. It posits that individuals have limited attention spans and are more likely to focus on readily accessible and simplified information, potentially overlooking more complex and comprehensive data. This theory has broad implications for consumer behavior, financial decision-making, and market dynamics, offering insights into the interplay between information availability and individual decision processes.

Stakeholder Theory: The Stakeholder Theory, conceived by Freeman^[3], emphasizes the intricate relationships between a company and its stakeholders, advocating for the consideration of the diverse interests and expectations of stakeholders beyond shareholders. This theory asserts that businesses should manage their operations regarding the welfare of multiple stakeholders, including customers, suppliers, employees, and the wider community, to achieve sustainable and equitable corporate governance and social responsibility outcomes.

Theory of Asymmetric Information: The Theory of Asymmetric Information, spearheaded by Akerlof^[4], investigates the dynamics of transactions when one party holds more information than the other. It highlights the potential for market inefficiencies and adverse outcomes due to information imbalance. The theory addresses issues such as moral hazard and adverse selection, shedding light on how the unequal distribution of information can impact markets, contracts, and economic decision-making processes.

Signaling Theory: Signaling Theory, pioneered by Spence^[5], elucidates how individuals or entities with superior information can transmit credible signals to parties with limited or asymmetric information. This theory is paramount in understanding how signaling actions, such as educational qualifications, dividend announcements, and corporate disclosures, can serve as credible indicators of unobservable attributes, mitigating information asymmetry and influencing market behaviors and outcomes.

2.2 Recent related literatures

Before the rise of ESG, much literature study the impacts of CSR events on corporate financial performance (CFP). Klassen and McLaughlin^[6] and Flammer^[7] reveal positive investor reactions to CSR events, but the margin impact is decreasing. Byun and Oh^[8] provide evidence that publicized CSR activities significantly and positively impact shareholder value as measured by Tobin's q. But Krüger^[9] finds that investors respond weakly negatively to positive events, suggesting that investors do not appreciate the implementation of CSR policies. Krüger^[9] also finds that investors react strongly negatively to negative CSR events, especially those about communities and the environment.

With the rise of ESG, the impact of ESG events on stock market is also studied. Capelle-Blancard and Petit^[10] use the news from Covalence EthicalQuote and find that firms get a drop in market value of 0.1% from negative ESG news but nothing on average from positive. Serafeim and Yoon^[11] and Yoon^[12] investigate the relation between ESG news, ESG rating and stock price. They find that firm with higher ESG rating is likely to have more positive ESG news. They also suggest little price reaction for companies with high ESG ratings for positive news, as the prices already incorporate the news. However, the reaction is significant for negative news regardless of the rating.

Green bonds, as a typical positive practice of ESG, have garnered increasing attention from scholars in recent years. The academic discourse on corporate green bonds, financial instruments designated for funding environmentally beneficial projects, has intensified, offering nuanced insights into their market impacts and investor perceptions. This literature review synthesizes key findings from several seminal studies in this field.

Tang and Zhang^[13] present the empirical investigation into green bond issuance's announcement returns and real effects across 28 countries from 2007 to 2017. Their comprehensive dataset reveals a positive stock price response to green bond issuance. However, they note the absence of a consistent significant premium for green bonds, implying that the positive stock returns are not wholly attributable to a lower cost of debt. Intriguingly, post-issuance, an increase in institutional ownership, particularly domestic institutions, and a significant improvement in stock liquidity are reported. These findings suggest benefits to existing shareholders following green bond issuance, albeit with nuances regarding the bonds' pricing.

Similarly, Flammer^[14] provides a pivotal analysis of corporate green bonds, underscoring their growing prevalence, particularly in sectors where environmental issues significantly affect firm operations. This study reveals that the announcement of green bond issuance generally elicits a positive investor response, more pronounced for first-time issuers and bonds with third-party certification. Notably, post-issuance, these firms tend to demonstrate enhanced environmental performance, evidenced by improved environmental ratings and reduced CO2 emissions. Furthermore, a surge in ownership by long-term and green investors is observed. Flammer's findings align with the signaling theory, suggesting that by issuing green bonds, firms credibly demonstrate their commitment to environmental stewardship.

While Tang and Zhang^[13] and Flammer^[14] highlight positive market reactions and potential benefits for issuers, Baulkaran^[15] and Lebel et al.^[16] provide a more nuanced view, indicating that investor responses can vary based on bond characteristics and issuer profiles.

Baulkaran^[15] examines the stock market reaction to green bond announcements, observing positive and significant cumulative abnormal returns. This outcome suggests that shareholders perceive green bond financing as value-enhancing, with the funds

likely directed towards profitable green initiatives or risk mitigation. An interesting aspect of Baulkaran's analysis is the impact of bond and firm characteristics on investor response. Higher coupon rates on green bonds correlate with negative investor reactions, while firm size, Tobin's Q, and growth exhibit positive relations to the cumulative abnormal return. This complex interplay underscores the multifaceted nature of green bond issuance and its perception in the market.

Lebelle, Lajili Jarjir, and Sassi^[16] provide a contrasting perspective, noting a negative market reaction to green bond announcements. Analyzing a sample of 475 corporate green bonds from 2009 to 2018, they find that the stock market reacts negatively on the announcement date and the day after, with cumulative abnormal returns ranging between -0.5% and -0.2%, depending on the pricing model used. This negative reaction is particularly pronounced during the first issuance and in developed markets. The authors suggest that this investor behavior towards green bonds is akin to that towards conventional or convertible bonds, indicating that green bond offerings might convey unfavorable information about the issuer. However, they also note that this negative reaction is less pronounced in firms with fewer financial constraints and more growth opportunities.

The extant research on the impact of green bond issuance on corporate stock returns yields divergent conclusions. This variation largely stems from scholars conducting their analyses at different points in time, leveraging data from disparate capital markets, and selecting distinct research timeframes. The rapid expansion of the green bond market post-2016 has notably influenced the sample selection and, consequently, the research outcomes pertaining to green bonds. Additionally, variations in the national standards for green bond recognition, regulatory oversight, and levels of acceptance have contributed to differences in research findings across countries.

Furthermore, as the concept of ESG becomes increasingly ingrained in the collective consciousness, investors' perceptions, and degrees of endorsement of green bonds are also evolving. This shift may further account for the dynamic landscape of research conclusions pertaining to the relationship between green bond issuance and stock performance.

2.3 Research motivation

As previously noted, the selection of research period and capital market is critical in studies examining the impact of green bonds, potentially leading to contrasting conclusions. China, as one of the key participants in the green bond market and the country with the largest issuance volume^[14], which has been rapidly increasing in recent years, necessitates a focused study on its latest green bond samples. Moreover, scholars have highlighted the prevalence of "greenwashing" among Chinese corporations^{[17][18][19]}, a factor that significantly affects investors' perception and acceptance of green bonds. This, in turn, influences the mechanism by which green bonds impact corporate stock prices. Therefore, the uniqueness and the imperative for a dedicated study of green bonds in the Chinese context are further emphasized by these factors.

In terms of research methodology, scholars like Baulkaran^[15], Tang and Zhang^[13], and Flammer^[14] have utilized the event study approach to analyze the abnormal returns of issuing companies' stock prices during the green bond issuance window. However, this method may not sufficiently disentangle the "green" attributes of green bonds from the effects solely attributable to the bond issuance itself on the abnormal returns. Consequently, building upon an event study of green bond issuances in China, I have further employed the Difference-in-Differences (DID) analytical technique to differentiate between the impacts of green bond and conventional bond issuances. Additionally, considering the presence of "greenwashing," the short-term and long-term effects of green bonds may differ.

Following the aforementioned rationale, I concentrate my investigation on green bonds issued in China from 2016 through October 2023, and hereby propose two testable hypotheses:

Hypothesis 1: The issuance of green bonds in China does indeed exert a positive impact on the company's stock price in the short term.

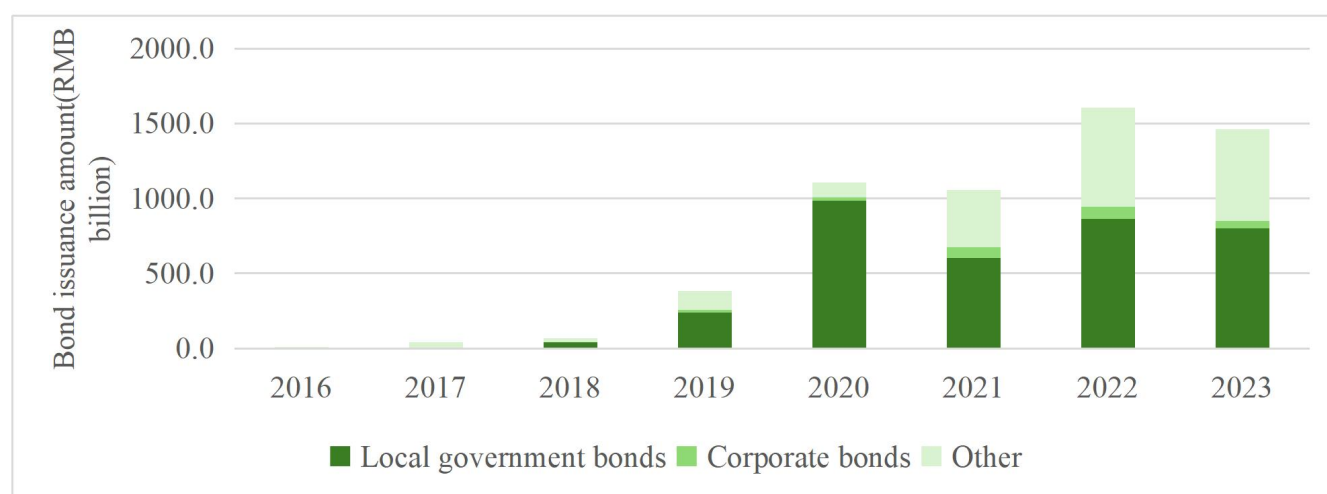
Hypothesis 2: In the long term, the issuance of green bonds in China does not enhance corporate value.

3.Data and descriptive

I primarily utilized the Wind database as the source of my data. The Wind database is a robust repository encompassing comprehensive economic and company data pertinent to China. From its bond segment, I procured the bond data as the

focus of my study revolves around the impact of green bond issuance on companies. Consequently, I selected the corporate bond data of Chinese firms from this database. Through the utilization of Wind, I obtained the pertinent data associated with these corporate bonds, including the bond codes, issuance announcement dates, issuance amounts, coupon rates, green bond classification, as well as the names of the bond-issuing companies, their public listing status, and the corresponding stock codes. These green bonds are labeled by Wind primarily based on the alignment of their fundraising proceeds with green industries or projects. The delineation of green industries or projects primarily refers to guidelines or project directories issued by various relevant regulatory authorities. The announcement dates for the issuance of these green bonds span from 2016, with the first domestic bond issued by the China Three Gorges Corporation being a corporate bond, up to October 31, 2023. These green bonds have been categorized by Wind as local government bonds, corporate bonds, and others, which includes commercial paper, medium-term notes, financial bonds, and asset-backed securities. It is evident that the overall issuance amount of Chinese green bonds has exhibited an increasing trend, experiencing a significant surge in 2020, primarily dominated by local government bonds, which have accounted for over 50% of the total issuance amount each year. (Figure 1).

Figure1: Chinese green bond issuance over time



This figure depicts the annual issuance amounts of green bonds from 2016 to October 31st, 2023, categorized by Wind. Within the classification, corporate bonds strictly pertain to a narrow definition of corporate bonds, while the other category encompasses instruments such as commercial paper, medium-term notes, financial bonds, and asset-backed securities.

I only consider issuers which are financials and industrial corporations. Due to the limited availability and infrequent updating of public data for non-publicly listed companies, this study focuses on examining the impacts of green bond issuance on publicly listed companies, particularly those in China, encompassing both the companies and bonds within the Chinese financial market. Given these considerations, the study has selected green bonds issued by companies listed on the stock exchanges of mainland China, including the Shanghai Stock Exchange and the Shenzhen Stock Exchange. Wind provides robust stock data, and I have cleaned and organized the stock codes of companies issuing green bonds. In cases where companies are listed on both mainland Chinese exchanges and other exchanges such as the Hong Kong Stock Exchange, only the codes for companies listed on mainland Chinese exchanges are retained.

Table 1 shows summary statistics for sample of public issuers' green bonds' characteristics. The average issuance amount of the 204 green bonds issued by mainland Chinese listed companies is 3140 million RMB, with the highest amount reaching 30,000 million RMB and the lowest being only 300 million RMB. The median amount and the mode is both 1000 million RMB, indicating that the majority of green bonds have a issue amount around 1000 million RMB. The average maturity is 4.2 years, with the minimum being 0.3 years and the maximum extending up to 18 years. Both the median and the mode are 3.0 years, indicating that the majority of green bonds have a maturity period around 3 years. The average coupon rate is 3.2%, with the minimum at 2.1% and the maximum at 6.5%. The median rate is 3.1%, and the mode is only 2.8%.

Table1: Summary statistics for public issuers' green bonds

	Amount (100 million)	Maturity (year)	Coupon rate (percent %)
Mean	31.4	4.2	3.2
Median	10.0	3.0	3.1
Mode	10.0	3.0	2.8
Std.	59.2	3.5	0.8
Minimum	0.3	0.3	2.1
Maximum	300.0	18.0	6.5
N	204	204	204

This table shows summary statistics for sample of public issuers' green bonds' characteristics.

I also collect data for ESG (Environmental, Social, and Governance) bonds for comparative study. Table 2 shows summary statistics for sample of public issuers' ESG bonds' characteristics. These ESG bonds are also categorized by Wind based on the definitions of ESG projects provided by regulatory authorities. In the context of sustainable finance, (ESG bonds represent a broader concept than green bonds. ESG bonds encompass not only green bonds but also include social bonds and sustainability-linked bonds, among others. Specifically, in the Chinese market, green bonds constitute the predominant category within the ESG bond spectrum, accounting for approximately 80% of ESG bonds. Generally, both industry and academic circles exhibit a heightened focus on green bonds, given their significant proportion and pivotal role in advancing environmental objectives within the broader framework of ESG financing.

Table2: Summary statistics for public issuers' ESG bonds

	Amount (100 million)	Maturity (year)	Coupon rate (percent %)
Mean	27.4	4.3	3.4
Median	10.0	3.0	3.1
Mode	10.0	3.0	2.8
Std.	53.9	3.8	1.0
Minimum	0.3	0.3	2.1
Maximum	300.0	24.0	7.5
N	253	253	253

This table shows summary statistics for sample of public issuers' ESG bonds' characteristics.

Using Excel VBA, the codes are formatted into standard stock codes recognizable by the Wind stock database. This facilitated the retrieval of daily closing price data, daily return data and monthly return data for companies issuing green bonds, with the stock price and return being adjusted for prior rights issues, bonus issues, stock splits, and reverse stock splits, to enable a more accurate calculation of the true stock returns. The corporate fundamental database of Wind is also utilized to obtain the fundamental information of the companies.

4.Short-term event study for green bonds

4.1 Event study methodologies

To study the short-term impact of green bond, I use the event study methodology to examine the short-term stock price change due to the announcement of green bond. Following Tang and Zhang^[13], I selected the announcement of bond issuance, rather than the actual issuance, as the event for the event study because the issuance announcement represents the formal dissemination of issuance information to the market and investors. In contrast, the actual issuance merely signifies the completion of the issuance process procedurally, without providing additional information to the market and investors.

As the issuance of green bonds is the event for this event study, the issuance date of the green bonds is considered as the event date, also referred to as day 0. I set the event window for the event study from 10 trading days before the issuance announcement date of the green bonds to 19 trading days after the issuance announcement date, also referred to as day [-10,19]. The reason for starting the event window before the issuance announcement date is following Krüger^[20]'s research, considering that some information may have already been disseminated to certain investors through various means before the announcement date, especially in light of the widely held view that China's capital market governance is not yet mature, and insider trading is not uncommon. The reason why I choose day 19 rather than a more rounded figure, such as day 20, as the end of the event window, is because I aim for a more detailed observation. I divide the event window into shorter sub-windows of 5 days each to closely monitor the event effects, resulting in a total of 30 days or 6 sub-event windows for day [-10,19].

After setting the event window, I estimate the abnormal return, which is used to measure the impact of green bond issuance on stock price. For bond i , the coefficients α_i and β_i of the market model are estimated by ordinary least squares (OLS) based on pre-event estimation window, which is day [-220, -15]. Formally, I estimate:

$$R_{i,t} = \alpha_i + \beta_i \times R_{m,t} + \varepsilon_{i,t}$$

Where $R_{i,t}$ is the return on the stock of the issuer company of bond i on day t , $R_{m,t}$ is the daily market return, and $\varepsilon_{i,t}$ is the residual. I use the total return of CSI 300 Index which is obtained from Wind for $R_{m,t}$.

The estimated return stock of firm i is calculated using estimated coefficient $\hat{\alpha}_i$ and $\hat{\beta}_i$. The daily abnormal return $AR_{i,t}$ of the issuer company of bond i is the difference between real return $R_{i,t}$ and the estimated return $\hat{R}_{i,t}$. The cumulative abnormal return CAR_i for each sub-event window is the sum of $AR_{i,t}$ of every day in that sub-event window. All in all, I calculate the daily abnormal return $AR_{i,t}$ of firm i on day t and cumulative abnormal return for the sub-event windows as follows:

$$\hat{R}_{i,t} = \hat{\alpha}_i + \hat{\beta}_i \times R_{m,t}$$

$$AR_t = R_t - \hat{R}_t$$

$$CAR_i = \sum_{t=\text{begin date}}^{\text{end date}} AR_{i,t}$$

For the robustness checks, I also estimate $\hat{R}_{i,t}$ using market model based on pre-event estimation window of day [-120, -15] and day [-420, -15]. Following Flammer^[14], to mitigate the abnormal return driven by industry trend, I also estimate $\hat{R}_{i,t}$ using industry adjusted return, where the $R_{m,t}$ is represented by the total return of industry index, based on Wind First-Level Industry Classification. And the corresponding CARs are called industry-adjusted CARs. Table 3 shows the methods for abnormal returns estimation.

Table3: Abnormal returns estimation methodologies

Cumulative abnormal return	Pre-event estimation window	Index for market return
CAR1	[-220, 15]	CSI 300 Index
CAR2	[-120, 15]	CSI 300 Index
CAR2	[-420, 15]	CSI 300 Index
CAR4	[-220, 15]	Wind Industry Index
CAR5	[-120, 15]	Wind Industry Index
CAR6	[-420, 15]	Wind Industry Index

This table shows summary of abnormal returns estimation methodologies.

4.2 Event study results for green bond announcement

In accordance with the described event study methodology, I conducted the event study on the sample of green bonds and their corresponding stocks. Some companies, having been listed relatively recently, lacked complete stock price and return

data during the pre-event estimation window and the event window. These green bonds and stocks are excluded from the sample in the event study. Additionally, to facilitate a subsequent comparison with the impact of conventional bond issuances, I also excluded a small number of samples from companies that had only issued green bonds. Table 4 shows the result for the event study.

Table4: Event study result for the green bonds announcement

	$R_{m,t}$ = CSI 300 Index			$R_{m,t}$ = Wind Industry Index		
	CAR1	CAR2	CAR3	CAR4	CAR5	CAR6
Day [-10, -6]	-0.1258 (0.3014)	0.0257 (0.3060)	-0.0387 (0.3016)	-0.1058 (0.2555)	-0.0628 (0.2630)	-0.1193 (0.2559)
Day [-5, -1]	0.7506* (0.4240)	1.0742** (0.4312)	0.7918* (0.4231)	0.6112* (0.3162)	0.7952** (0.3259)	0.5689* (0.3114)
Day [0, 4]	-0.2939 (0.3192)	-0.1384 (0.3317)	-0.1311 (0.3345)	-0.0708 (0.2800)	-0.0288 (0.2903)	0.0585 (0.2840)
Day [5, 9]	0.9486** (0.3966)	1.0065** (0.4001)	1.0676*** (0.4010)	0.7673** (0.3261)	0.7135** (0.3342)	0.8384*** (0.3202)
Day [10, 14]	0.2351 (0.3319)	0.3992 (0.3352)	0.3990 (0.4265)	-0.0368 (0.2471)	-0.0227 (0.2504)	0.1325 (0.3204)
Day [14, 19]	-0.5150 (0.3539)	-0.3583 (0.3600)	-0.4574 (0.3434)	-0.5763* (0.3102)	-0.4984 (0.3097)	-0.5308* (0.3049)
N	152	156	146	152	156	146

N is the number of observations, the upper number in each cell is the mean of CAR and the number in the bracket is the corresponding standard error. All cumulative abnormal returns (CAR) are expressed in units of percentage (%). *, **, *** denote statistical significance at 10%, 5%, 1% respectively

Figure2: CAR trends over time in this event study

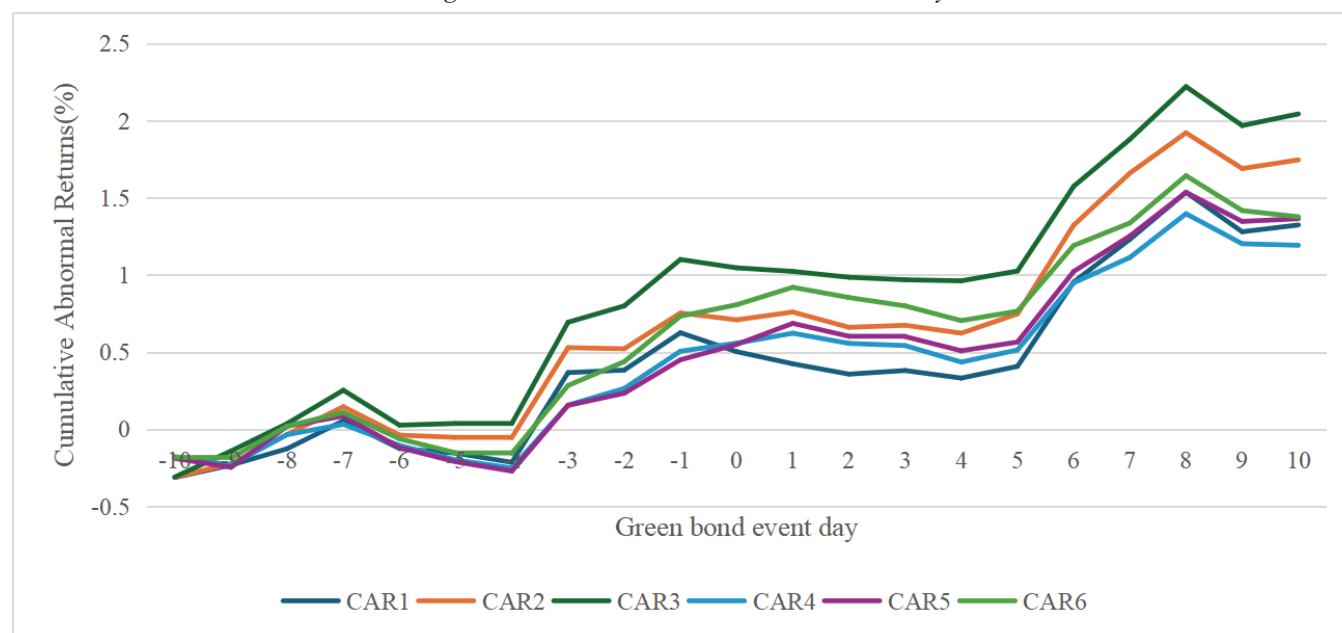
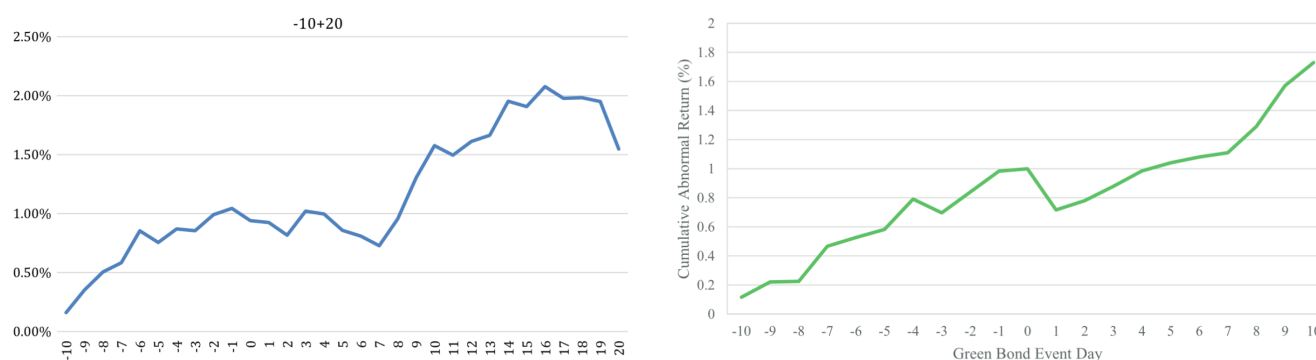


Figure 2 delineates the overarching trajectory of the CARs during the event study window, depicting an ascending CAR trend prior to the issuance announcement date. This is followed by a slight downtrend for approximately five days subsequent to

the announcement, after which the CARs experience a continued upward movement for a subsequent five-day period. The empirical results from my event study corroborate the trends demonstrated in the CAR over time as depicted in the Figure 3 from Baulkaran (2019) and Tang and Zhang (2020). Specifically, the CAR trajectory exhibits a slight initial decline during the period spanning from the announcement date to several days thereafter, which is statistically insignificant for the window day [0, 4] in my event study result. The periods preceding and succeeding this period by approximately six days display a significant upswing in the CAR series, which is in alignment with my findings of statistical significance for the windows day [-5, -1] and day [5, 9]. While Baulkaran (2019) and Tang and Zhang (2020) report a positive and significant CAR throughout the entire event window, my analysis extends these findings by detailing the 5-day-window CAR movements within said event window in the following part.

Figure3: CAR trends over time in comparable studies [13], [15]



The empirical results from my event study corroborate the trends demonstrated in the CAR over time as depicted in the left figure from Baulkaran (2019) and the right figure from Tang and Zhang (2020). The CAR trajectory exhibits a slight initial decline during the period spanning from the announcement date to several days thereafter, which is statistically insignificant for the window day [0, 4] in my event study result. The periods preceding and succeeding this period by approximately six days display a significant upswing in the CAR series, which is in alignment with my findings of statistical significance for the windows day [-5, -1] and day [5, 9].

The observation of positive CARs preceding the issuance announcement of green bonds could plausibly be attributed to the leakage of issuance information. This aligns with the Efficient Market Hypothesis (EMH), suggesting that in weak-form and semi-strong form efficient markets, insider information can still yield abnormal returns. Several studies also confirm the stock return predictability by insider trading in China's stock market^{[21][22]}. The retail investor-dominated market structure in China's stock market significantly increases insiders' incentives to trade with significant informational advantage over general market participants^[23]. In the practice of bond issuance in China, particularly for credit bonds, institutional investors typically constitute the primary investors. During the pre-issuance phase, intermediary institutions engage in preliminary communications with potential institutional investors to ensure sufficient buying interest at the time of issuance, thereby fulfilling their underwriting responsibilities. Consequently, institutional investors are indeed likely to be privy to information about upcoming bond issuance announcement. Although regulatory requirements stipulate information barriers between different departments within financial institutions – thereby theoretically preventing bond investment and equity investment departments from exploiting insider information – in practice, it is challenging to completely prevent the leakage of issuance information.

The CARs for the period day [5, 9] are also positive and statistically significant. This can likely be attributed to retail investors purchasing the company's stock upon learning of the green bond issuance, leading to excess returns. This aligns with the general paradigm of event studies, where the occurrence of a company-beneficial event leads to excess stock returns. The robust positive CARs in both the day [5, 9] and day [-5, 1] windows suggest that the issuance of green bonds indeed has a short-term positive impact on the company's stock price, indicating that investors perceive the issuance of green bonds as a positive event for the company. Flammer^[14] explicates this phenomenon by integrating theories of information asymmetry and signaling, suggesting that the observed positive CAR around the bond issuance announcement are indicative of the market's

response to signals emitted by the firm. These signals, underpinned by the issuance of green bonds, are interpreted by market participants as informative cues about the firm's commitment to sustainability and its potential future performance, thereby reducing information asymmetry between the firm and its investors.

Counterintuitively, during the issuance announcement window of green bonds, specifically day [0, 4], the stocks of companies that announce issuing green bonds do not exhibit significant positive CARs, despite the surrounding periods of day [-5, 1] and day [5, 9] manifesting significant positive CARs for these stocks. This consists with the finding of Baulkaran^[15], that the mean abnormal returns in the green bond issuing announcement day is negative and not statistically significant. This anomaly can be plausibly explained by two credible scenarios. One possibility is that investors privy to insider information prior to the issuance announcement may have commenced selling their shares post the formal announcement of the green bond issuance, leading to the absence of significant positive returns in the period of day [0, 4]. This consist with the Overreaction Theory of Bondt and Thaler^[24], which suggests that markets can exhibit overreactions to new information, leading to excessive buying or selling of securities based on psychological factors rather than fundamental analysis. This behavior can result in stock prices moving beyond what is justified by their intrinsic value. Since the prices move beyond the intrinsic value, some investors may take advantage of the temporary price increase to sell and lock in profits, which contributes to the stock price exhibiting downward pressure after the positive news. Another possibility suggests that some investors, following the announcement of the issuance, might have anticipated additional costs for the company to comply with the various requirements associated with green bonds, which they deem to be disadvantageous for the company. This is similar to the announcement effect of convertible bonds^[25], and may suggests that green bond offerings convey unfavorable information about the issuing firms^[16]. Furthermore, for the period of day [14, 19], CARs estimated by two methodologies exhibit significance at the 10% level, yet the CARs estimated by other methodologies during this period do not show significance, thus mitigating their interpretative value.

The empirical results from above illustrate that investors hold a generally positive view towards green bonds. However, this sentiment may not be consistent across the board; it appears to be mixed, interspersed with diverging opinions, potentially reflecting the complex attitudes and cognitive dissonance among Chinese investors towards green bonds.

4.3 Comparative event study

Furthermore, to validate that the positive CARs are attributable to the announcement of green bond issuance announcement rather than ordinary bond issuance announcement, and to affirm that the "green" value of green bonds is what investors value, I also selected conventional bonds as a control group for the event study to substantiate the aforementioned perspective. As previously discussed, when elaborating on the event study methodology, I have excluded companies that have only issued green bonds. This exclusion allows me to select conventional bonds issued by the same companies that issued green bonds for the control group, thereby minimizing the influence of issuer-specific characteristics. Additionally, to prevent potential interference between the announcements of green and conventional bond issuances, the announcement dates of the bonds in the control group are deliberately spaced at least 15 trading days apart from those in the experimental group. On this basis, the conventional bond with the closest issuance announcement date was chosen for the control group. As shown in Table 5, in the case of conventional bond issuance announcements, the CARs estimated for various periods using different methodologies are not statistically significant. This finding consist with the study of Myers and Majluf^[26] that the stock market shows no significant reaction to bond issues, substantiates the earlier assertion that the positive CARs associated with the announcements of green bond issuances are indeed attributable to the "green" aspect of these bonds.

Table5: Event study result for the conventional bonds announcement

	$R_{m,t}$ = CSI 300 Index			$R_{m,t}$ = Wind Industry Index		
	CAR1	CAR2	CAR3	CAR4	CAR5	CAR6
Day [-10, -6]	-0.1502 (0.6158)	0.1407 (0.6097)	-0.1051 (0.6150)	-0.0660 (0.4095)	0.0424 (0.4275)	0.0450 (0.4156)

	$R_{m,t} = \text{CSI 300 Index}$			$R_{m,t} = \text{Wind Industry Index}$		
	CAR1	CAR2	CAR3	CAR4	CAR5	CAR6
Day [-5, -1]	0.2130 (0.5354)	0.4757 (0.5125)	0.2550 (0.5371)	0.1366 (0.3962)	0.3125 (0.3594)	0.1249 (0.4014)
Day [0, 4]	-0.0283 (0.6714)	0.1166 (0.6967)	0.0890 (0.6758)	0.5917 (0.5519)	0.6826 (0.6015)	0.5864 (0.5579)
Day [5, 9]	-0.1260 (0.7153)	0.2157 (0.7066)	0.0475 (0.7158)	-0.1237 (0.5429)	0.0030 (0.5328)	-0.1469 (0.5474)
Day [10, 14]	-1.0815 (0.6963)	-0.7045 (0.6603)	-1.0279 (0.7179)	-0.9200 (0.5654)	-0.7149 (0.5349)	-0.9916 (0.6124)
Day [14, 19]	0.3337 (0.7099)	0.5232 (0.6621)	0.5097 (0.7112)	0.1458 (0.5810)	0.2539 (0.5254)	0.1147 (0.5931)
N	152	156	146	152	156	146

N is the number of observations, the upper number in each cell is the mean of CAR and the number in the bracket is the corresponding standard error. All cumulative abnormal returns (CAR) are expressed in units of percentage (%). *, **, *** denote statistical significance at 10%, 5%, 1% respectively

I also applied the same event study methodology to ESG bonds. ESG bonds, encompassing a broader spectrum than the common green bonds, include sustainable development bonds and social responsibility bonds, among others, that allocate funds towards ESG (Environmental, Social, and Governance) related projects. These ESG bonds are also categorized by Wind based on the definitions of ESG projects provided by regulatory authorities. The event study results shown in Table 6 for ESG bonds indicate that their issuance announcements also generate positive CARs for the corresponding companies' stocks. However, the range of significant CARs is narrower compared to green bonds, suggesting a relatively lower degree of investor recognition for ESG bonds compared to green bonds. This could be attributed to the less clear-cut criteria for defining sustainable development and social responsibility bonds as opposed to green bonds.

Table6: Event study result for the ESG bonds announcement

	$R_{m,t} = \text{CSI 300 Index}$			$R_{m,t} = \text{Wind Industry Index}$		
	CAR1	CAR2	CAR3	CAR4	CAR5	CAR6
Day [-10, -6]	-0.1756 (0.2986)	-0.1117 (0.3041)	-0.0047 (0.3034)	-0.0582 (0.2460)	-0.0933 (0.2479)	0.0264 (0.2523)
Day [-5, -1]	0.2507 (0.4078)	0.2956 (0.4075)	0.5365 (0.4111)	0.2646 (0.2837)	0.2297 (0.2803)	0.4320 (0.2895)
Day [0, 4]	-0.4659 (0.3257)	-0.3402 (0.3271)	-0.2538 (0.3362)	-0.2245 (0.2751)	-0.1729 (0.2823)	-0.1309 (0.2804)
Day [5, 9]	1.0133** (0.3988)	1.1274*** (0.3938)	1.0795*** (0.4029)	0.6697** (0.3189)	0.7502** (0.3079)	0.6343* (0.3266)
Day [10, 14]	0.2987 (0.3324)	0.4427 (0.3949)	0.4394 (0.3377)	0.0778 (0.2568)	0.2104 (0.3035)	0.1279 (0.2616)
Day [14, 19]	-0.0624 (0.3367)	0.0074 (0.3272)	0.1586 (0.3382)	-0.3862 (0.2701)	-0.3444 (0.2676)	-0.2518 (0.2694)
N	179	184	173	179	184	173

N is the number of observations, the upper number in each cell is the mean of CAR and the number in the bracket is the corresponding standard error. All cumulative abnormal returns (CAR) are expressed in units of percentage (%). *, **, *** denote statistical significance at 10%, 5%, 1% respectively

To mitigate the impact of outliers, I performed a 1% two-tailed winsorization on the CARs prior to conducting the event study. Table 7 displays the results post-winsorization. It can be noted that the significance of CARs for the pre-announcement period of day [-5, -1] is no longer robust, with only two methods estimating significant positive CARs. This suggests that the previously significant results may have been influenced by extreme values. This is a reasonable observation, given that, unlike widely circulated public information, the extent of dissemination of insider information before each green bond announcement varies, consisting with the study that stock returns are affected by the accuracy of insiders' private information, and the number of days that insiders have obtained the information in advance^[27]. Consequently, certain stocks exhibited more pronounced CARs than others. After the application of winsorization, the significance of CARs for the day [-5, -1] period became less robust.

Table7: Event study result for the green bonds announcement (winsorized)

	$R_{m,t}$ = CSI 300 Index			$R_{m,t}$ = Wind Industry Index		
	CAR1	CAR2	CAR3	CAR4	CAR5	CAR6
Day [-10, -6]	-0.1413 (0.2899)	-0.1275 (0.2435)	-0.0513 (0.2931)	-0.1324 (0.2468)	0.0112 (0.2948)	-0.0779 (0.2501)
Day [-5, -1]	0.5741 (0.3874)	0.4321 (0.2774)	0.6330 (0.3906)	0.4149 (0.2768)	0.9050** (0.3947)	0.6084** (0.2851)
Day [0, 4]	-0.3123 (0.2882)	-0.1238 (0.2386)	-0.1819 (0.3050)	-0.0031 (0.2447)	-0.1534 (0.2998)	-0.0771 (0.2435)
Day [5, 9]	0.8846** (0.3736)	0.7264** (0.3101)	1.0009*** (0.3795)	0.8033*** (0.3061)	0.9372** (0.3775)	0.6875** (0.3181)
Day [10, 14]	0.3372 (0.3128)	-0.0331 (0.2347)	0.3806 (0.3508)	0.0485 (0.2667)	0.4953 (0.3184)	0.0014 (0.2378)
Day [14, 19]	-0.4033 (0.3174)	-0.4798* (0.2807)	-0.3569 (0.3145)	-0.3916 (0.2813)	-0.2644 (0.3247)	-0.3890 (0.2780)
N	152	156	146	152	156	146

N is the number of observations, the upper number in each cell is the mean of CAR and the number in the bracket is the corresponding standard error. All cumulative abnormal returns (CAR) are expressed in units of percentage (%). *, **, *** denote statistical significance at 10%, 5%, 1% respectively

5.Short-term difference in difference study for green bonds

5.1 Difference in difference study methodologies

To further ascertain that the CARs observed around the issuance announcement of green bonds are attributable to the "green" attributes of the bonds, rather than the mere act of bond issuance announcement, I employed a Difference-in-Differences (DID) approach to analyze the experimental group of green bonds and the control group of conventional bonds, as previously constructed. Considering the internal information and the observed CARs prior to the announcement date of green bond issuances, pinpointing the exact effective date of the event posed a challenge. Therefore, I adopted a dynamic DID methodology, examining whether the differences between the control and experimental groups in each sub-event window are statistically significant. Formally, I estimate:

$$CAR_{i,t} = \beta \times Green_i \times Period_t + \alpha_i + \alpha_t + \epsilon_{i,t}$$

Where CAR_{it} is the cumulative abnormal return of the issuer company of bond i in period t . $Green_i$ is the dummy variable (treatment dummy) that equals one if the bond i is green bond and equals zero if the bond i is not green bond. $Period_t$ is the categorical variable for the sub-event windows or periods. $\alpha_i, \alpha_t, \epsilon_{it}$ are the individual (bond) fixed effects, time fixed effects and error term. The coefficient of interest is β , which measures the difference-in-differences in outcome variable CAR_{it} between treated and control bonds. In deviation from the basic DID model setup, the current model does not include separate terms for $Green_i$ and $Period_t$. This is because, in the dynamic Difference-in-Differences approach, the individual fixed effects and time fixed effects are already capable of capturing the effects of these two variables. I also excluded control variables at the bond level or the firm level. This exclusion is justified because, within the event study window, the attributes of each bond and the fundamental data of the corresponding companies remain constant. Consequently, the effects of these control variables are already encompassed by individual fixed effects. Incorporating them into the model would result in their impact being absorbed by the individual fixed effects.

5.2 Difference in difference study result

Table 8 presents the results from the DID analysis, which are in line with the earlier event study results, exhibiting a similar pattern and confirming that the announcements of green bond issuance indeed result in positive CARs for the issuing companies' stocks before and after the announcement date. However, there are several distinctions. The coefficient of interest for Day [-5, -1]*Green is not robustly significant. When the CSI 300 index is used as the market return, the DID results for the estimated CARs are not significant, whereas using the Wind industry index, the DID results are significant. This is logical for a couple of reasons. On one hand, the use of the Wind industry index accounts for industry-specific trends, which may otherwise cause anomalous changes in stock prices [14], allowing the industry-adjusted CARs to capture the effects of the green bond issuance announcements more accurately. Hence, the results are more significant compared to those obtained using the CSI 300 index. On the other hand, as previously mentioned, the dissemination of insider information prior to the announcement date is unstable. Therefore, it is reasonable that the CARs induced by the insider information before the green bond issuance announcements are not robust.

Moreover, the coefficient of interest for Day [10, 14]*Green following Day [5, 9] is also significant, which is not evident in the earlier event study, suggests that DID indeed more precisely captures the differential impacts of the announcements of green bond and conventional bond issuances.

Table8: DID result for the green bonds announcement

	$R_{m,t} = \text{CSI 300 Index}$			$R_{m,t} = \text{Wind Industry Index}$		
	CAR1	CAR2	CAR3	CAR4	CAR5	CAR6
Day [-10, -6] *Green	0.9294 (0.9700)	0.9556 (0.9742)	0.9028 (0.9825)	1.2044 (0.7643)	1.2725 (0.7757)	1.2048 (0.7747)
Day [-5, -1] *Green	1.4426 (0.9700)	1.4260 (0.9742)	1.6162 (0.9825)	1.7987** (0.7643)	1.8808** (0.7757)	1.7927** (0.7747)
Day [0, 4] *Green	0.6394 (0.9700)	0.6692 (0.9742)	0.7628 (0.9825)	0.6616 (0.7643)	0.9090 (0.7757)	0.5987 (0.7747)
Day [5, 9] *Green	1.9796** (0.9700)	1.9093* (0.9742)	1.8086* (0.9825)	2.2152*** (0.7643)	2.4221*** (0.7757)	2.0206*** (0.7747)
Day [10, 14] *Green	2.2216** (0.9700)	2.3162** (0.9742)	2.1214** (0.9825)	2.2074*** (0.7643)	2.5609*** (0.7757)	2.0024*** (0.7747)
Day [14, 19] *Green	0.0563 (0.9700)	-0.0778 (0.9742)	0.1363 (0.9825)	0.6021 (0.7643)	0.7913 (0.7757)	0.5578 (0.7747)
N	152	156	146	152	156	146
Individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

N is the number of observations, the upper number in each cell is the estimated coefficient of interest β in each period for each CAR and the number in the bracket is the corresponding standard error. All cumulative abnormal returns (CAR) are expressed in units of percentage (%). *, **, *** denote statistical significance at 10%, 5%, 1% respectively

5.3 Comparative difference in difference study result

In a manner akin to previously conducted event studies, Table 9 presents the findings from the DID analysis regarding the impact of ESG bond issuance announcements on CAR. Table 10 further elucidates the relationship between 1% two-tailed winsorized CAR and green bond issuance announcements via a DID analysis. The outcomes of the DID analyses are in concordance with those observed in the aforementioned event studies. Moreover, the discrepancy in significance and robustness between the control DID results and the original DID outcomes is markedly less than that observed between the control event studies and the initial event study findings. This suggests that the DID analysis more precisely captures the effect of green or ESG bond issuance announcements on the firm's stock price as measured by CAR.

Table9: DID result for the ESG bonds announcement

	$R_{m,t}$ = CSI 300 Index			$R_{m,t}$ = Wind Industry Index		
	CAR1	CAR2	CAR3	CAR4	CAR5	CAR6
Day [-10, -6] *ESG	0.4267 (0.9332)	0.4629 (0.9336)	0.3821 (0.9505)	0.6845 (0.7284)	0.6118 (0.7378)	0.6434 (0.7395)
Day [-5, -1] *ESG	1.3154 (0.9332)	1.3287 (0.9336)	1.3429 (0.9505)	1.3758* (0.7284)	1.4240* (0.7378)	1.2999* (0.7395)
Day [0, 4] *ESG	0.5918 (0.9332)	0.6068 (0.9336)	0.6879 (0.9505)	0.3949 (0.7284)	0.5676 (0.7378)	0.3587 (0.7395)
Day [5, 9] *ESG	1.8647** (0.9332)	1.8827** (0.9336)	1.5251 (0.9505)	1.6789** (0.7284)	1.8810** (0.7378)	1.4043* (0.7395)
Day [10, 14] *ESG	2.3278** (0.9332)	2.3948** (0.9336)	2.2276** (0.9505)	1.8400** (0.7284)	2.1886*** (0.7378)	1.7008** (0.7395)
Day [14, 19] *ESG	1.1069 (0.9332)	1.0264 (0.9336)	1.1295 (0.9505)	0.7675 (0.7284)	0.9159 (0.7378)	0.7233 (0.7395)
N	179	184	173	179	184	173
Individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

N is the number of observations, the upper number in each cell is the estimated coefficient of interest β in each period for each CAR and the number in the bracket is the corresponding standard error. All cumulative abnormal returns (CAR) are expressed in units of percentage (%). *, **, *** denote statistical significance at 10%, 5%, 1% respectively

Table10: DID result for the green bonds announcement (winsorized)

	$R_{m,t}$ = CSI 300 Index			$R_{m,t}$ = Wind Industry Index		
	CAR1	CAR2	CAR3	CAR4	CAR5	CAR6
Day [-10, -6] *Green	0.8798 (0.8957)	0.9276 (0.8989)	0.8562 (0.9093)	1.1031 (0.6930)	1.1003 (0.7005)	1.1050 (0.7010)

	$R_{m,t}$ = CSI 300 Index			$R_{m,t}$ = Wind Industry Index		
	CAR1	CAR2	CAR3	CAR4	CAR5	CAR6
Day [-5, -1] *Green	1.0078 (0.8957)	1.0376 (0.8989)	1.1955 (0.9093)	1.3519* (0.6930)	1.4677** (0.7005)	1.3341* (0.7010)
Day [0, 4] *Green	0.4005 (0.8957)	0.4206 (0.8989)	0.5452 (0.9093)	0.4624 (0.6930)	0.7372 (0.7005)	0.3919 (0.7010)
Day [5, 9] *Green	1.6724* (0.8957)	1.6425* (0.8989)	1.5047* (0.9093)	1.8213*** (0.6930)	2.0460*** (0.7005)	1.6565** (0.7010)
Day [10, 14] *Green	2.0502** (0.8957)	2.0831** (0.8989)	1.9833** (0.9093)	1.9470*** (0.6930)	2.1847*** (0.7005)	1.7774** (0.7010)
Day [14, 19] *Green	0.0693 (0.8957)	-0.0549 (0.8989)	0.1520 (0.9093)	0.5517 (0.6930)	0.7919 (0.7005)	0.5316 (0.7010)
N	152	156	146	152	156	146
Individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

N is the number of observations, the upper number in each cell is the estimated coefficient of interest β in each period for each CAR and the number in the bracket is the corresponding standard error. All cumulative abnormal returns (CAR) are expressed in units of percentage (%). *, **, *** denote statistical significance at 10%, 5%, 1% respectively

5.4 Homogeneity and heterogeneity

Subsequent to the initial findings, I have utilized the DID methodology to conduct an analysis of both homogeneity and heterogeneity, aiming to further elucidate the characteristics and mechanisms driving the impact of green bond issuance announcements on the issuing firms' CAR. Considering the comparison involving diverse industries, to enhance the precision of the results, this analysis is confined to the examination of industry-adjusted CAR (CAR4, CAR5, CAR6), for the DID result comparison. It should also be acknowledged that the relatively small sample size may introduce some bias into these findings of following homogeneity and heterogeneity analysis.

First, in terms of industry, given that utilities constitute the most prolific issuers of green bonds, I segmented the issuing firms into two categories: utilities and non-utilities. I then applied the aforementioned DID analysis to the green bond issuance events for these two cohorts separately. The results presented in Table 11 reveal that for utility companies, the DID analysis of CAR shows stronger significance compared to the overall DID analysis, with the majority of positive CARs being significant at the 1% level. Moreover, the duration of significant positive CAR following green bond announcements extends further, from the initial day [5, 14] to day [5, 19]. This finding aligns with intuitive reasoning, as utilities typically comprise companies engaged in electricity, energy, and water resources, which have a strong correlation with "green" initiatives and are industries where the environment is financially material to the companies' operations according to the materiality classifications of SASB (Sustainability Accounting Standards Board). On one hand, these entities usually undergo more stringent environmental regulations and thus have a higher likelihood of allocating the proceeds from green bond issuances to genuine green projects. On the other hand, many of these green projects not only have environmental significance but also present opportunities for utilities to reduce costs and enhance operational efficiency. Consequently, green bond issuances by utility companies are met with greater recognition compared to those by general corporates, reflecting an acknowledgment of the close alignment between their core operations and the concept of sustainability. This also consists with previous

studies. The study of Flammer^[14] shows that abnormal returns are only significant in industries where the natural environment is financially material to the firms' operations, which is explained by Signaling Theory that shareholders are sensitive to companies' eco-friendly behavior and would expect a stronger stock market response in industries where the natural environment is material to the companies' financial performance (CFP). Similarly, Khan, Serafeim, and Yoon^[28] demonstrate financially material ESG issues have a greater impact on CFP according to the materiality classifications of SASB.

Furthermore, the presence of significantly negative CAR during the day[0, 4] can potentially be attributed to reasons analogous to those posited in the previous event study analysis. This finding is congruent with the research outcomes of Baulkaran^[15] and Lebellet et al.^[16], indicating that on the day of the green bond issuance announcement and the ensuing 3-5 days, the company's stock price exhibits a significantly negative abnormal return. Despite that the outcome might be attributed to the limited sample size, it is suggested that insider investors, who had access to information regarding the green bond issuance prior to the announcement, may have engaged in selling the company's stock following the public release of the announcement, consisting with the mentioned Overreaction Theory of Bondt and Thaler^[24]. The prevailing sentiment among investors, who are more receptive to positive news, creates an irrational exuberance, leading to disproportionate reactions such that the stock price appreciation exceeds the intrinsic value. Consequently, this results in excessive upward pressure on prices, which then gives rise to greater downward correction forces subsequently. In the case for green bonds of utilities, as the positive CAR preceding the disclosure of green bond issuing is more pronounced, resulting in a larger uptick in stock price, the subsequent selling led to a greater extent of mean reversion. This overreaction could explain the negative CAR observed during the day [0, 4], which is more statistically significant to the overall DID analysis findings.

As mentioned earlier, another possibility suggests that some investors, following the announcement of the issuance, might have anticipated additional costs for the company to comply with the various requirements associated with green bonds. Lebellet, Lajili Jarjir, and Sassi^[16] suggests that the announcement of a new green bond issuance, which may offer the information about upcoming evolution of operational and capital expenditures to make them more sustainable, might be interpreted by investors as providing uncertainty regarding whether this potential new business model would remain as profitable as it has been so far, broadly leading to negative market reactions.

Additionally, the DID analysis of non-utility firms also indicated that investors are less receptive to green bond issuances from these companies, evidenced by the notably weaker significance of the results compared to the overall DID analysis. On the one hand, post-announcement CAR for non-utilities was only significantly positive during the day [10, 14], which is a shorter and less significant period compared to the overall DID analysis. This suggests that the general investor sentiment towards green bond issuances by non-utility companies is not as favorable, possibly due to skepticism such as concerns over potential "greenwashing". Since environment is not financially material to most of these non-utility companies, green bonds are not necessary and essential, and may become a tool of "greenwashing"—the practice of making unsubstantiated or misleading claims about the company's environmental commitment, which is a widespread phenomenon^{[29][30][31]}.

On the other hand, the positive CAR generated by pre-announcement insider information for non-utility firms commenced five days earlier than what was observed in the overall DID analysis. This could be attributed to underwriting intermediaries perceiving a higher degree of difficulty in placing these bonds, thereby initiating communications with potential buyers ahead of schedule, leading to earlier information leakage and insider trading, as reflected in the advanced positive CAR. This temporal shift underlines the complexities and challenges faced by non-utility firms in aligning their green bond issuances with investor expectations and highlights the role of intermediaries in shaping market dynamics prior to public announcements. The analytical comparison between utilities and non-utilities in the context of green bond issuances highlights the industry as a critical determinant in the impact of such issuances on stock prices. It is evident from the findings that the market perceives green bond issuances by utility companies more positive than those by non-utility companies. Furthermore, the analysis indicates that the overall significant positive CARs observed before are predominantly driven by the contributions from the utility sector. This distinction underscores the importance of industry-specific dynamics in shaping investor responses to green finance initiatives and suggests a differential valuation mechanism in the market depending on the issuer's industry alignment with environmental objectives.

Table11: DID result for the green bonds issued by utilities and non-utilities

	Utility companies			Non-utility companies		
	CAR4	CAR5	CAR6	CAR4	CAR5	CAR6
Day [-10, -6] *Green	0.9751 (2.1412)	1.3572 (2.1098)	1.9379 (2.1264)	1.8419** (0.8316)	1.9077** (0.8425)	1.4632* (0.8485)
Day [-5, -1] *Green	6.0428*** (2.1412)	6.6371*** (2.1098)	5.8614*** (2.1264)	1.5583* (0.8316)	1.6976** (0.8425)	1.4061* (0.8485)
Day [0, 4] *Green	-5.1636** (2.1412)	-4.5755** (2.1098)	-4.7906** (2.1264)	0.6448 (0.8316)	0.8336 (0.8425)	0.5173 (0.8485)
Day [5, 9] *Green	9.2212*** (2.1412)	9.6132*** (2.1098)	10.1438*** (2.1264)	0.5980 (0.8316)	0.8974 (0.8425)	0.0018 (0.8485)
Day [10, 14] *Green	5.2881** (2.1412)	6.6869*** (2.1098)	4.6822** (2.1264)	1.9328** (0.8316)	2.1289** (0.8425)	1.4018* (0.8485)
Day [14, 19] *Green	8.6736*** (2.1412)	9.0994*** (2.1098)	8.8947*** (2.1264)	0.1642 (0.8316)	0.3115 (0.8425)	0.0818 (0.8485)
N	50	54	50	102	102	96
Individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Considering the comparison involving diverse industries, to enhance the precision of the results, this analysis is confined to the examination of industry-adjusted CAR (CAR4, CAR5, CAR6), for the DID result comparison. N is the number of observations, the upper number in each cell is the estimated coefficient of interest β in each period for each CAR and the number in the bracket is the corresponding standard error. All cumulative abnormal returns (CAR) are expressed in units of percentage (%). *, **, *** denote statistical significance at 10%, 5%, 1% respectively

Table 12 displays the results of the DID analysis, categorizing green bonds based on whether they are issued by central state-owned enterprises. Approximately half of these green bonds are issued by central state-owned enterprises, which may be due to their social responsibility mandates and the heightened requirements for green development, or it could be a reflection of the regulatory authorities' greater support for green bond issuance by these entities. Indeed, on December 8, 2023, the China Securities Regulatory Commission and the State-owned Assets Supervision and Administration Commission jointly issued a notice in support of green bond issuance by central state-owned enterprises. Although the date of this notice postdates the data cut-off for this study, it does manifest the attitude and orientation of Chinese regulatory bodies. Green bonds issued by central state-owned enterprises exhibit significant positive CARs around the announcement date. However, for green bonds not issued by central state-owned enterprises, significant positive CARs are observed only within a short period after the announcement. This heterogeneous analysis in DID suggests a higher degree of investor confidence in green bonds issued by central state-owned enterprises. This could be attributed to the stricter governance and more rigorous regulatory oversight of these enterprises, which likely assures investors of more standardized management and utilization of funds raised for green projects. Additionally, the close DID results between central state-owned enterprises and utilities could be related to their high degree of overlap. For instance, out of the 50 green bonds issued by utility companies and the 71 issued by centrally state-owned enterprises in the CAR4 samples, there is an overlap of 37 bonds, meaning these are issued by entities that are both utilities and central state-owned enterprises.

Table12: DID result for the green bonds issued by central state-owned enterprises and others

	Central state-owned enterprises			Others		
	CAR4	CAR5	CAR6	CAR4	CAR5	CAR6
Day [-10, -6] *Green	2.1118 (1.7019)	1.8153 (1.6734)	2.4213 (1.6895)	1.0753 (0.8800)	1.6196* (0.9217)	0.9102 (0.9062)
Day [-5, -1] *Green	5.3416*** (1.7019)	5.3358*** (1.6734)	4.9285*** (1.6895)	1.0695 (0.8800)	1.6002* (0.9217)	1.1106 (0.9062)
Day [0, 4] *Green	-3.176* (1.7019)	-3.0246* (1.6734)	-3.2148* (1.6895)	0.3271 (0.8800)	0.8029 (0.9217)	0.4225 (0.9062)
Day [5, 9] *Green	6.6732*** (1.7019)	6.6189*** (1.6734)	6.8392*** (1.6895)	0.6841 (0.8800)	1.3726 (0.9217)	0.3795 (0.9062)
Day [10, 14] *Green	3.8460** (1.7019)	4.0762** (1.6734)	2.9706* (1.6895)	2.3677*** (0.8800)	3.2953*** (0.9217)	2.1156** (0.9062)
Day [14, 19] *Green	6.1997*** (1.7019)	6.5322*** (1.6734)	6.3191*** (1.6895)	0.2309 (0.8800)	0.3874 (0.9217)	0.1635 (0.9062)
N	71	74	71	81	82	75
Individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Considering the comparison involving diverse industries, to enhance the precision of the results, this analysis is confined to the examination of industry-adjusted CAR (CAR4, CAR5, CAR6), for the DID result comparison. N is the number of observations, the upper number in each cell is the estimated coefficient of interest β in each period for each CAR and the number in the bracket is the corresponding standard error. All cumulative abnormal returns (CAR) are expressed in units of percentage (%). *, **, *** denote statistical significance at 10%, 5%, 1% respectively

Table 13 presents the results of the DID analysis of green bonds categorized by coupon rates. Specifically, the median coupon rate among the sampled green bonds was identified, and bonds are divided into two groups accordingly: those with coupon rates equal to or higher than the median, and those with rates below the median. Each group underwent separate DID analysis. The results for bonds with coupon rates equal to or higher than the median are similar to those previously observed for central state-owned enterprises and utilities. However, for the group with rates below the median, there are significant positive CARs observed during the day [-5, 9] period. This suggests that investors perceive green bonds with lower coupon rates as more favorable for the issuing company, as lower rates imply reduced financing costs, which aligns with fundamental theories in corporate finance. This consists with the study of Baulkaran [15], which shows that higher coupon rates on green bonds correlate with negative investor reactions.

Table13: DID result for the green bonds categorized by coupon rate

	Coupon rate \geq Median			Coupon rate $<$ Median		
	CAR4	CAR5	CAR6	CAR4	CAR5	CAR6
Day [-10, -6] *Green	1.7363 (1.5430)	1.9399 (1.5513)	1.6870 (1.5390)	1.0314 (0.9470)	1.0803 (0.9471)	1.1593 (0.9465)
Day [-5, -1] *Green	3.5564** (1.5430)	3.9408** (1.5513)	3.0155* (1.5390)	1.8770** (0.9470)	2.0141** (0.9471)	2.1546** (0.9465)

	Coupon rate \geq Median			Coupon rate<Median		
	CAR4	CAR5	CAR6	CAR4	CAR5	CAR6
Day [0, 4] *Green	-3.9125** (1.5430)	-3.4515** (1.5513)	-3.8164** (1.5390)	2.0456** (0.9470)	2.1791** (0.9471)	2.4440** (0.9465)
Day [5, 9] *Green	3.7864** (1.5430)	4.2584*** (1.5513)	3.6516** (1.5390)	2.7560*** (0.9470)	2.8867*** (0.9471)	2.6293*** (0.9465)
Day [10, 14] *Green	4.7123*** (1.5430)	5.6816*** (1.5513)	2.9601* (1.5390)	0.2345 (0.9470)	0.3819 (0.9471)	1.1457 (0.9465)
Day [14, 19] *Green	4.4622*** (1.5430)	4.7762*** (1.5513)	4.1285*** (1.5390)	0.4671 (0.9470)	0.6029 (0.9471)	0.4672 (0.9465)
N	73	75	70	72	74	69
Individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Considering the comparison involving diverse industries, to enhance the precision of the results, this analysis is confined to the examination of industry-adjusted CAR (CAR4, CAR5, CAR6), for the DID result comparison. N is the number of observations, the upper number in each cell is the estimated coefficient of interest β in each period for each CAR and the number in the bracket is the corresponding standard error. All cumulative abnormal returns (CAR) are expressed in units of percentage (%). *, **, *** denote statistical significance at 10%, 5%, 1% respectively

6. Long-term difference in difference study for green bonds

6.1 Difference in difference study methodologies for long-term

In the subsequent phase of my research, I investigated the long-term impacts of green bond issuance. Initially, I employ the DID analysis to examine whether the issuance of green bonds leads to sustained positive abnormal returns or enhances the overall value of the issuing firms in the long run. Formally, I estimate:

$$CAR_{it} = \beta \times Green_i \times Month_t + Controls + \alpha_i + \alpha_t + \epsilon_{it}$$

$$Tobin's Q_{it} = \beta \times Green_i \times Month_t + Controls + \alpha_i + \alpha_t + \epsilon_{it}$$

Where CAR_{it} is the monthly cumulative abnormal return of the issuer company of bond i in $Month_t$. $Green_i$ is the dummy variable (treatment dummy) that equals one if the bond i is green bond and equals zero if the bond i is not green bond. $Month_t$ is the categorical variable for each month. $\alpha_i, \alpha_t, \epsilon_{it}$ are the individual (bond) fixed effects, time fixed effects and error term. $Tobin's Q_{it}$ is the Tobin's Q for bond i in $Month_t$, which equals firm's market value divided by firm's book value. I employ the DID analysis with and without control variables at the bond level or the firm level separately and some control variables are absorbed by the individual fixed effects.

The long-term DID analysis results, as presented in Table 14, indicate that the issuance of green bonds does not lead to significant changes in CAR, industry-adjusted CAR, or Tobin's Q. This suggests that, in the long run, green bond issuances do not enhance the issuing firm's value nor secure sustained investor recognition. If the temporal scope is extended to one year or even longer, the results derived from the DID analysis exhibit similar patterns. Contrasting these findings with the short-term DID analysis, which showed positive CAR around green bond announcements, it appears that the benefits conferred by green bond issuances are transient in nature. The discrepancy between the short-term positive impact and the lack of long-term value enhancement prompts further investigation into the underlying reasons for this phenomenon. My subsequent research will delve into potential explanations for why green bonds appear to offer only short-term advantages to issuing firms, without translating into long-term value creation or investor endorsement.

Table 14: long-term DID result for the green bonds

	CAR		CAR industry adjusted		Tobin's Q	
Month -2	-2.2547 (2.8967)	-2.8211 (2.5275)	-2.3367 (2.3896)	-1.7927 (1.9755)	0.0124 (0.0409)	0.0094 (0.0492)
Month -1	-1.2705 (2.8966)	1.4584 (2.5275)	0.1338 (2.3895)	0.2799 (1.9755)	0.0160 (0.0409)	0.0175 (0.0492)
Month -0	-2.2845 (2.8976)	-0.3269 (2.5275)	-0.4666 (2.3903)	0.6355 (1.9755)	0.0206 (0.0409)	0.0290 (0.0492)
Month 1	-1.1686 (2.9038)	-2.9359 (2.5275)	-1.5725 (2.3954)	-3.4217* (1.9755)	0.0319 (0.0410)	0.0465 (0.0492)
Month 2	-3.8254 (2.8964)	-2.5010 (2.5275)	-1.1120 (2.3893)	-1.5256 (1.9755)	-0.0184 (0.0409)	0.0072 (0.0492)
Month 3	-2.7213 (2.8950)	-1.2442 (2.5275)	-2.9616 (2.3881)	-0.3288 (1.9755)	0.0263 (0.0409)	0.0288 (0.0492)
Month 4	-0.7200 (2.8949)	0.7694 (2.5275)	-0.3934 (2.3881)	-0.3364 (1.9755)	-0.0142 (0.0409)	-0.0005 (0.0492)
Month 5	-4.5913 (2.8945)	-0.5327 (2.5275)	-2.9371 (2.3878)	-0.7102 (1.9755)	-0.0369 (0.0409)	-0.0354 (0.0492)
Month 6	0.9011 (2.8962)	-0.6693 (2.5275)	-0.8880 (2.3891)	-0.6462 (1.9755)	0.0127 (0.0415)	-0.0109 (0.0498)
N	107	107	107	107	107	107
Controls	Yes	No	Yes	No	Yes	No
Individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

N is the number of observations, the upper number in each cell is the estimated coefficient of interest β in each period for CAR and Tobin's Q, and the number in the bracket is the corresponding standard error. All cumulative abnormal returns (CAR) are expressed in units of percentage (%). *, **, *** denote statistical significance at 10%, 5%, 1% respectively

6.2 The underlying drivers of long-term impact

The theoretical foundation underpinning the potential long-term value enhancement of firms through green bond issuance rests on the premise that the regulatory requirements attached to these bonds can drive improvements in a firm's ESG governance levels, thereby enhancing operational efficiency. Given the challenges in quantifying ESG governance standards, I employ the Wind ESG score as a proxy to examine this issue. The comprehensive Wind ESG score is constituted of two components: a management practice score (out of a total of 7 points) and a score for controversial incidents (out of a total of 3 points). This scoring system holistically reflects a company's level of ESG management practices along with its exposure to significant emergent risks. The Wind ESG index framework is comprehensive, encompassing 3 dimensions, 25 issues, and over 300 indicators. Utilizing advanced technologies such as artificial intelligence and big data, Wind tracks and gathers ESG information from over 22,000 data sources, providing investors with timely and objective bases for investment decisions. This approach enables a nuanced and detailed analysis of a company's ESG performance, crucial for understanding the impact of green bond issuances on firm value in the long term.

Employing a methodology analogous to my previous research, I conducted the DID analysis to ascertain the impact of green bond issuance on firms' ESG scores. The results shown in Table 15 indicate that issuing green bonds does not significantly enhance a company's ESG score, implying no substantial improvement in ESG governance. Several factors might contribute

to this outcome. The first one is the "greenwashing" concern. There is a possibility that some of these green bonds could be involved in "greenwashing", failing to meet the requisite environmental objectives and oversight standards of green bond issuance, which is a widespread phenomenon as mentioned^{[29][30][31]}. Moreover, given that the regulatory framework for green bonds in China is still developing and is misaligned with international green bond certifications and standards, the prevalence of "greenwashing" could be more pronounced. This misalignment potentially undermines the ability of green bonds to positively influence a company's actual ESG performance. Previous research has delved into the implications of "greenwashing" by Chinese companies, a practice where firms misrepresent their environmental impact or sustainable initiatives^[17].

The second one is rigid management in state-owned enterprises. Over 80% of green bonds in China are issued by central or local state-owned enterprises. The management practices in these organizations tend to be more rigid, making it challenging to enhance governance levels through ESG practices. The third one is imperfect ESG standards and regulatory framework in China. The current ESG standards and regulatory framework in China may not be sufficiently robust. This limitation potentially undermines the effective assessment and supervision of ESG practices, including those related to the issuance of green bonds. This analysis suggests that merely issuing green bonds does not automatically translate into enhanced ESG performance, underscoring the need for more stringent standards and practices in the green bond market, particularly in the context of Chinese issuers.

Table15: ESG score DID result for the green bonds

	Wind ESG Score	Wind ESG Score
Month -2	-0.0920 (0.1058)	-0.0286 (0.0687)
Month -1	-0.1008 (0.1058)	-0.0368 (0.0687)
Month -0	-0.1549 (0.1057)	-0.1006 (0.0687)
Month 1	-0.1162 (0.1060)	-0.0595 (0.0687)
Month 2	-0.0589 (0.1058)	-0.0308 (0.0687)
Month 3	-0.0378 (0.1057)	-0.0102 (0.0687)
Month 4	-0.0574 (0.1057)	-0.0436 (0.0687)
Month 5	0.0323 (0.1057)	0.0049 (0.0687)
Month 6	0.0181 (0.1058)	0.0015 (0.0687)
N	107	107
Controls	Yes	No
Individual fixed effects	Yes	Yes
Time fixed effects	Yes	Yes

N is the number of observations, the upper number in each cell is the estimated coefficient of interest β in each period for Wind ESG score, and the number in the bracket is the corresponding standard error. *, **, *** denote statistical significance at 10%, 5%, 1% respectively

6.3 The underlying drivers of short-term impact as comparison

The preceding section highlighted that the issuance of green bonds did not lead to long-term improvements in corporate

ESG governance levels, hence failing to bolster long-term firm value. It begs the question: what accounted for the positive CAR observed around the announcement of green bond issuances? To address this, I examined the effect of green bond announcements on the trading volume of the issuer's stock. For this purpose, several indicators of trading volume are employed, including the average daily trading volume, the percentage of the company's daily trading volume relative to the total daily trading volume of A-shares market, and similarly, the percentage relative to the industry's average trading volume. All the trading volume data is downloaded from Wind database.

As inferred from the results showcased in Table 16, there is a notable increase in the trading volume of the issuer's stock around the announcement date, particularly after the announcement of the green bond issuance. The less significant increase in trading volume prior to the announcement date is also reasonable, as the circulation of insider information is naturally limited and uncertain compared to public disclosures. It can be surmised that the green bond issuance announcements have augmented stock trading volume, possibly because these announcements serve as a positive news event that captures investors' attention. This can be explained by the Limited Attention Theory, which is introduced by Egeth and Kahneman^[2]. Although green bonds may not enhance a firm's ESG performance in the long term due to challenges such as "greenwashing" that cast doubt on their legitimacy, the announcement of their issuance is indeed a generally positive event. It garners increased attention toward the company's stock, augments trading volumes, and thus contributes to a rise in the firm's stock price in the short term. This finding is consistent with existing research, which suggests that positive news—especially news related to ESG—can generate positive returns for stocks^{[10][11][32][33][34]}.

Table16: ESG score DID result for the green bonds

	Coupon rate \geq Median		
	CAR4	CAR5	CAR6
Day [-10, -6] *Green	0.7267 (0.4974)	0.6317 (0.4929)	8.8422 (7.9357)
Day [-5, -1] *Green	0.8072 (0.4974)	0.8114* (0.4929)	2.7652 (7.9357)
Day [0, 4] *Green	1.3715*** (0.4974)	1.3387*** (0.4929)	14.5619* (7.9357)
Day [5, 9] *Green	1.3113*** (0.4974)	1.4964*** (0.4929)	10.8519 (7.9357)
Day [10, 14] *Green	1.0333** (0.4974)	1.2279** (0.4929)	24.5068*** (7.9357)
Day [14, 19] *Green	0.4600 (0.4974)	0.8497* (0.4929)	16.2474** (7.9357)
N	179	179	179
Individual fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes

N is the number of observations, the upper number in each cell is the estimated coefficient of interest β in each period for Wind ESG score, and the number in the bracket is the corresponding standard error. *, **, *** denote statistical significance at 10%, 5%, 1% respectively

7. Conclusion

This study employs event study methodology and DID analysis to investigate the short-term and long-term effects of green bond issuance on corporate capital market performance. The results of the event study regarding the short-term impact of

green bond issuance on stock prices indicate the occurrence of positive CAR in the window period around 10 days before and after the event. Upon further segmentation, positive CAR is significant in the range from 1 day before the announcement to 5 days before and from 5 days after to 9 days after, while CAR is slightly negative but not significant in the range from the announcement day to 4 days after. A comparison with event studies on conventional bond issuance supports the inference that these significant positive CARs are indeed attributed to the "green" attributes of green bonds rather than the bond issuance itself.

Utilizing green bonds as the experimental group and conventional bonds as the control group, the DID analysis of the short-term impact on stock prices aligns with the event study analysis that positive significant CAR indeed exists before and after the issuing announcement of green bonds. The DID result also demonstrates that the positive significant CAR brought about by green bond issuance expands from the 5-9 days range to the 5-14 days range post announcement. However, upon extending the observation period and applying the DID analysis method to study the long-term impact of green bond issuance on stock prices and firm value, it is evident that green bond issuance does not lead to a significant increase in stock price or company value in the six months or longer following the issuance, contradicting the short-term research results. This lack of enhancement is attributed to the absence of an improvement in the company's ESG governance level in the long term, rendering it unrecognized by investors—a potential consequence of the lack of clarity in "greenwashing" and green bond standards and regulations. In contrast, green bond issuance in the short term generates abnormal returns and is associated with increased stock trading volumes, consistent with the limited attention theory, where the issuance of green bonds as positive news attracts more attention to the company.

Similar event study and DID analysis embarked on ESG bonds on a larger scale and green bonds subjected to trimmed abnormal returns yield analogous results, although the significance of CAR before the announcement date is less robust. Furthermore, heterogeneous analysis of the impact of green bond issuance reveals a more significant effect on public utility companies and central state-owned enterprises. Additionally, compared to higher coupon rate bonds, lower coupon rate bonds notably alleviate the pressure of negative abnormal returns on and after the announcement day in the 3-4 subsequent days.

The conclusions drawn from this study on Chinese green bonds harmonize with the existing research on green bonds in other countries and feature detailed short-term influence and underlying mechanisms. Moreover, this study conducts a comparative analysis of the short-term and long-term effects of green bonds and delves into the underlying mechanisms. These research findings are consistent with the characteristics of the Chinese capital market.

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The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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Research on the Internal Logic, Practical Dilemmas and Promoting Policies for Improving Income Distribution through Digital Transformation of Industries

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Abstract: Income distribution is an important issue in China's modernisation path, and is a key part of achieving the goal of common wealth. In the era of booming digital transformation, digital factors can improve income distribution and promote the realisation of common wealth through the skill premium, lowering the entry barrier to work, easing capital deepening and improving resource mismatch. However, due to the constraints of the digital transformation process itself, the substitution of data elements for labour elements has resulted in skill unemployment, the diffusion path of digital transformation has exacerbated the widening of the income gap, and the free qualities of the digital era have exacerbated the oppression of capital on labour. Therefore, it is necessary to take a multi-pronged approach and make joint efforts from the perspectives of the government, enterprises, and labourers to give full play to the positive effects of digital transformation on improving income distribution, and to promote the substantial progress of common wealth.

Keywords: Income Distribution; Labour Income Share; Digital Transformation; Common Wealth

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The issue of labour income distribution has long been a focus of research. Since the 18th National Congress, income distribution has been raised to an exceptionally important position by the Party Central Committee. The report of the 20th CPC National Congress also re-emphasised the need to solidly promote common wealth, improve the distribution system, and build a coordinated and complementary system for primary, redistribution and third distribution. The main reason for this is that while China's economy has developed rapidly and achieved world-renowned great achievements, whether the people can share the fruits of development is a more important issue. And with the progress of big data, the Internet, cloud computing, artificial intelligence and other digital technologies, the development of digital transformation in all sectors of society has flourished, causing a disruptive impact on the internal logic of income distribution and growth. It has led to a redistribution of income between labour and capital, which has had a significant impact on the achievement of the important goal of advancing common prosperity (Li Xiaoyuan and Zhong Chenglin, 2024)^[1] However, digital transformation is a double-edged sword to improve income distribution, and while empowering the labour force to reach higher value realisation through technology (Chen Menggen and Zhou Yuanren, 2021^[2]), its unbridled development will also produce serious substitution of labour (Wang Yongqin and Dong Wen, 2018^[3]). Therefore, against such a background, clarifying the mechanism of the impact of the digital

transformation of industries on income distribution, especially the labour income part of it, identifying the realistic dilemmas in the process of development, and proposing corresponding policy recommendations accordingly, are of great practical significance for the improvement of the structure of the future income distribution and the achievement of the goal of common prosperity.

1.The internal logic of the digital transformation of industry to improve income distribution and enable common prosperity

The transformation of industrial development into digitalisation is a major trend in the world today, and the transformation of various industries into digitalisation is an important breakthrough for innovation and development. Digitalisation promotes the transformation and upgrading of traditional industries, and will have a profound impact on the form of employment as well as labour income. With the continuous deepening of research, more and more researchers believe that the digital transformation of industries is also an important influence on the proportion of labour income. On the one hand, digital transformation can speed up the flow of production factors to enhance the total factor productivity of enterprises and improve production efficiency; on the other hand, it will also directly or indirectly affect the distribution of income between capital and labour, affecting the distribution of labour income.

1.1 Skill-biased mechanisms

The core of digital transformation remains technological progress, and the type of technological progress will have an asymmetric impact on capital and labour (Yu, Donghua and Chen, Ruying, 2020)^[4]. One of the main manifestations of this in labour income issues is the bias towards skills and unskills. The skill-unskill bias of digital technologies affects the labour income share through both the skill premium and the lowering of the entry barriers to jobs. On the one hand, the development of digital technology will create many new high-skilled jobs, such as programmers, and the increasing demand for high-skilled labour will lead to a skill premium, which will increase the income share of high-skilled labour (Duan Wei et al., 2023)^[5]; on the other hand, the application of digital technology will bring back many job opportunities that have been covered up in the era of factory labour, and will increase the number of low-skilled labour jobs, such as takeaway workers, live streaming bandwagoners, which require lower skills from the labour force and may not have a skill premium, but such jobs can lower the entry threshold of the job (Yuan Dongmei et al., 2021)^[6], and the labour force is able to enter the labour market at a much lower cost, and the income level of many originally low-income or zero-income labourers has been increased significantly, leading to a significant increase in the overall The proportion of labour income rises, leading to an improvement in the structure of income distribution.

1.2 Capital deepening mechanism

The deepening of the digital transformation of industries will have a reducing effect on the degree of capital deepening, which will be manifested in the driving effect of the data element on the digital labour element. Under the digital economy, the rapid development of e-commerce economy, sharing economy and other new forms and modes of business has generated a large demand for flexible, communicative and service-oriented labour. And through the efficient integration of big data, the factors within the economic system accelerate the free flow and optimal allocation, making the large number of idle and flexible labour elements in the market as fully utilized as possible, adapting to the large demand for such labour on the digital economy platform. As a result, under the leadership of new industries and modes, unskilled jobs involving multiple types of operations, sales, management and services, including network operations, online sales, e-commerce customer service, short-video auditing, and takeaway riders, have continued to emerge. In particular, in the field of living services, new types of jobs such as webcasting, takeaway riders, and online car drivers created through the clustering of online platforms have greatly broadened the pathways and channels of employment, and increased the share of labour income in national income. These new types of jobs are generally characterised by low employment thresholds, few time and space constraints, and flexible hiring methods, which are conducive to absorbing the employment of special groups such as laid-off workers, people with disabilities, and retired military personnel, thus creating more employment opportunities for low- and middle-income earners, and moreover contributing to social stability and security. The digital labour force has comparative advantages in terms of creativity, complexity, flexibility and service, etc., so the data factor and the digital labour force factor can well complement

each other, thus promoting a substantial increase in the efficiency of labour production, and thus increasing the share of income obtained by the digital labour force factor.

1.3 Resource mismatch mechanisms

The digital economy can alleviate distortions in factor allocation, and the degree of factor mismatch has an important impact on the level of income (Jiao, Yinxue, and Bai, Peiwen, 2021^[7]). On the one hand, digital transformation can alleviate the mismatch problem within the labour force. The main reason is that digital transformation can make the access to information smoother, and reduce the mismatch of labour by opening up the channels for labour to find jobs (Qiu et al., 2023^[8]). In the traditional society, the labour force is in a more vulnerable position in the labour market, for the employment market information is not enough to grasp, it is more likely to appear bad money to expel good money lemon market, thus making the market overall wage level are lower. If the labour force can grasp sufficient information in the employment market and achieve free movement, then the labour force can find more suitable jobs for themselves, and the labour force can move to the jobs that are most suitable for them, which can raise the wage level of the labour force group as a whole, increase marginal income, and ultimately increase the share of labour income. On the other hand, digital transformation can alleviate the problem of mismatch through structural jobs. The development of digital transformation will give rise to a part of new types of jobs and change the work structure of the labour force. Before digital transformation, some enterprises occupied a monopoly position in the market due to their mastery of key resources and technologies, and with limited resources, a large number of ordinary labourers are difficult to enter such industries and give full play to their potential, thus making part of the labour resources wasted (Zhang Tao et al., 2013^[9]). However, with the development of digital transformation, the speed of market change accelerates, the market structure is constantly changing, and it is difficult for the traditional advantageous enterprises to continue to maintain their dominant position, while the speed of corporate imitation is increasing, making it difficult for the emerging industries to form a monopoly position in a short period of time. In turn, the key elements are difficult to be monopolized, and the labour force that was not fully utilized has been fully utilized, and the labour force is also able to make its own salary level rise through spontaneous mobility which is conducive to the reasonable mobility of the elements to achieve a better allocation (Wen Yanbing & Lu Xueqin, 2018^[10]), and ultimately achieve the optimization of the income distribution structure.

2. Digital transformation of industries to improve the reality of the dilemma encountered in income distribution

2.1 Substitution of data elements for labour elements resulting in skilled unemployment

Data elements will inevitably have a substitution effect on traditional labour elements. Digitally processed work has a clear comparative advantage over traditional work that is repetitive, procedural and manual in nature, significantly increasing production efficiency and reducing production costs, so data elements will, under certain conditions, substitute for traditional labour elements that are less economically efficient in the production process, thereby reducing the share of income they receive. The substitution of traditional labour factors by data factors will further lead to a reduction in the market demand for traditional labour factors and a decline in the number of traditional jobs offered, thus causing a certain degree of employment shock and wage squeeze on traditional workers (Li, Mingguai and Cao, Yutao, 2024.)^[11] The substitution effect is mainly concentrated in traditional industries. Traditional industries such as traditional manufacturing and traditional service industries are located at the low end of the industrial chain, which contains many production links with high repetitiveness and substitutability and low labour productivity. Therefore, intelligent technology will impact these low-end manufacturing and service industries with a very high productivity, which will make the traditional workers in these two types of industries face the risk of unemployment. For example, production line workers in traditional manufacturing industries and retail and wholesale and law and order maintenance workers in traditional service industries are jobs that are simple and repetitive, and thus have a higher risk of being replaced by AI. The World Bank's World Development Report 2019: The Changing Nature of Work points out that AI is replacing thousands of repetitive, low-skill jobs around the world; and the McKinsey Global Institute predicts that nearly 20 per cent of job functions in China will be replaced by automation by 2030. As a result, the negative effects of the development of the digital economy on labour and employment will lead to a decline in the share

of traditional workers in national income. Moreover, this negative impact of substitution is likely to be felt over a longer period of time and on a wider scale. The impact of digital transformation on labour and employment will intensify as the development of digital technologies deepens. In the early stage of digital development, the digital industry, due to its own scale limitations, has a relatively narrow scope of application in other fields, and the resulting labour employment impact is mainly concentrated in low-skilled manual workers, such as production line workers, bookkeepers, etc.; with the further development of digitalisation, the resulting employment impact will be extended to medium-skilled cognitive workers, such as administrators and research assistants. . This long-term and far-reaching impact of the digital transformation will further reduce the share of labour income in national income distribution.

2.2 Diffusion path of digital transformation exacerbates widening income gap

Since the digital transformation of industries is a slow and long-term process, there is bound to be a certain sequence in the process of its development. In the process of its development, there are bound to be differences in the progress of digital transformation between different industries and regions. Industries more closely linked to information technology and developed regions will be the first to complete the transformation, while traditional industries and relatively backward regions to carry out the transformation process is slower. In different industries, there will be different levels of technology diffusion due to differences in information dissemination and other factors. Different levels of technology diffusion will directly lead to differences in development. At present, the integration of China's digital transformation and various industries shows a reverse development trend of 'three, two, one'. The tertiary industry is developing more rapidly, while the primary and secondary industries are lagging behind; at the same time, the degree of digital transformation in East and Central China is significantly higher than that in the western region. This difference in the speed of digitalisation diffusion across regions and industries will lead to significant differences in total factor productivity and income levels across regions and industries (Schiff & Wang, 2006)^[12]. Due to the low level of digital transformation, a digital divide has been created between late-developing industries and regions and early-developing industries and regions, and the labour force is less effective in sharing the digital dividend, making it difficult to achieve leapfrog growth in their income through the accumulation of digital wealth. On the other hand, as a result of enjoying the digital development dividend, the labour force's income has been able to grow geometrically, ultimately leading to a gradual widening of the income gap between the two groups of people.

2.3 The freeing qualities of the digital age exacerbate the oppression of labour by capital

In an era of active digital transformation in all industries, the exploitation of labour by capital has evolved more intensely compared to the industrial era. With the freedom of working time and place brought about by digitalisation, capital has been able to further absorb the fragmented time of the labour force (Wen Xiaonian and Ouyang Bin, 2024^[13]). There is a soft deprivation of the eight-hour workday, leave, and various benefits gained in the otherwise proletarian struggle. There is not only explicit exploitation of others, but also invisible exploitation of the self. Especially in the case of platform jobs and informal jobs built on the back of digital transformation, the establishment of a pay system that is closely related to income has led to the spontaneous extension of working hours to their physical and psychological limits in order to obtain a higher level of income and to escape from the risk of unemployment. In this situation, digitalisation has reconfigured the order of the mode of production and lifestyle through the logic of capital proliferation, achieving a shift from 'factory socialisation' to 'social factoryisation' through digital production (Yan Kunru and Li Yi, 2023^[14]). As a result, although the labour force received higher total remuneration, the income per unit of time of the labour force actually declined, and capital was able to maximize the capture of all the surplus value of the labour force, achieving a substantial increase in capital income, resulting in a further deterioration of income distribution.

3. Digital transformation of industry Advancement policies to improve income distribution to achieve common prosperity

3.1 Governments should strongly encourage and promote digital transformation across industries

3.1.1 Strengthening of digitisation-related policies and regulations

First, top-level design should be strengthened, the spirit of the 20th Party Congress should be fully implemented, and guiding documents on the integration and development of the digital economy and the real economy should be issued. The

digital transformation of industries should be firmly regarded as a new driving force for achieving common prosperity. In encouraging industries to undergo digital transformation, governments at all levels should also actively formulate matching digitalisation policies and strive to promote their implementation. On the one hand, it is necessary to formulate supportive policies, such as financial support policies and tax incentives, to encourage backward enterprises to carry out digital transformation from the financial aspect; on the other hand, it is necessary to encourage advanced enterprises to continue to be the first to try, and to deeply explore the application mode of digital elements to release the digital dividend, so as to drive the backward enterprises with advanced enterprises, and ultimately realise the promotion of the digital transformation of the whole industry.

Secondly, it is necessary to strengthen digital security legislation, develop a monitoring and early warning mechanism, and clarify the attribution of property rights while rationally regulating the market. Large enterprises in the industry often exist in the natural monopoly attributes, especially in the data era, the phenomenon of the law of two or eight is getting stronger. A small number of enterprises occupy the vast majority of resources and markets, which can easily lead to the formation of economies of scale, but also easily lead to monopoly, price discrimination and other detrimental to the rights and interests of upstream and downstream enterprises and consumers. In order to overcome this dilemma, government regulation is needed to protect the legitimate rights and interests of individuals and organisations, as well as information security. Specifically, including, strengthen for digital enterprise data collection and digital mining process of transparency and rationality of supervision, trying to achieve a balance between technological innovation and reasonable competition; the establishment of a sound digital security management system, timely and effective treatment of data security crisis; strengthen for data security risk monitoring, data security without dead angle, etc., to create a safe environment for the development of digital development.

Thirdly, the government should take the lead in improving the industrial digitisation index system, with the indicators as the starting point for the introduction of subsequent policies and development cornerstone. An important reason for the current low level of industrial digitisation is the lack of a standardised industrial digitisation indicator system to measure its level. Therefore, the government can designate a unified and standardised indicator system to measure the digitisation level of enterprises in various industries and create a good atmosphere for digital transformation.

Fourth, through supportive policies to guide digital consumption, to consumption reverse to promote digital transformation. Take the lead in promoting the combination of digital technology and public facilities by learning from Japan's experience in building a 'super-smart society', encouraging consumers to use digital products and services, prompting consumers to discover the convenience of digitisation, and establishing a digital lifestyle for consumers, so as to reverse the changes in consumers' lifestyles, reflections on their thinking, and consumption patterns. industries to complete digital transformation.

Fifth, accelerating the establishment of a digital government and leading digital development through the establishment of a digital government. Government departments will take the lead in taking the lead in the digital transformation of business modules, actively building digital organs, accelerating the promotion of open government, exploring a regulatory model based on digital technology, achieving an accurate match between the needs of society and enterprises, creating more multi-level service scenarios, achieving a rational allocation of resources and further releasing the digital dividend.

3.1.2 Develop a distribution system that matches the digitisation of the industry

First of all, we should always adhere to the principle of striking a balance between efficiency and fairness, and improve the mechanism of market-determined remuneration for various factors of production. In particular, it is necessary to increase the remuneration of technology and knowledge factors. Enterprises should provide more incentives to labourers who make more contributions at the technical level. Improve the incentive mechanism for the fruits of skills, and sound the mechanism for sharing the benefits of skills, so as to achieve the sharing of the dividends of digitisation.

Second, develop a more fair and reasonable secondary distribution system. Due to the natural spatial mobility advantage of digital elements, the real economy in the process of digitisation will appear in the separation of income and geospatial space, while the existence of digital products and digital services also exacerbates the ambiguity of the main body of taxation, and impacts on the original tax system. Therefore, a fairer and more reasonable tax system, such as a digital adjustment tax,

should be established to overcome the challenges posed by industrial digitisation to the redistribution system. At the same time, it is necessary to improve basic public services, especially the unemployment assistance mechanism, so as to minimize the impact that low-skilled labour may suffer in the process of industrial digital transformation.

Third, the third distribution mechanism should play an important role. Enterprises should enhance their own sense of social responsibility, and should encourage enterprises with the ability and willingness to actively participate in charitable and public welfare undertakings, and make use of the advantages of the Internet and other digital industries to carry out mutual assistance and mutual aid activities in education, science and technology, and livelihood construction. To help labourers who lack the means to accumulate their own human capital to obtain the enhancement of human capital, so as to participate in production and life in a more advantageous role of workers, in order to increase the proportion of labour income that they can ultimately obtain. At the same time, certain tax incentives should be given to enterprises that participate in charitable activities, in order to create a social atmosphere conducive to the development of charitable endeavours.

3.1.3 Improvement of digital talent training mechanism

First, skills training should be carried out in cooperation with research institutes, universities and enterprises. In the process of industrial digitisation, skilled labour will be able to gain more from their own skills, so talent training mechanisms should be improved and skills training for the labour force should be strengthened. Provide inclusive, society-wide online and offline labour skills training courses to teach skills that meet the needs of enterprises that have completed digital transformation, lower the threshold for learning digital technology, and upgrade unskilled and low-skilled labour to high-skilled labour, so that the benefits of digitisation benefit the labour force more. Within the enterprise to encourage enterprises to carry out labour force digital skills training, the development of financial subsidy policies and talent preferential policies to encourage enterprises to actively complete the staff digital skills training, in particular, we should pay attention to the combination of digital skills and practical skills of cross-composite personnel training.

Secondly, encourage colleges and universities to open special specialties for training digital talents and set up special colleges. Through the adjustment of university majors and colleges, we should convey the message of the importance of digital talents to the society. Strengthen the construction of postdoctoral research mobile stations and workstations in the digital field, and increase the training of postdoctoral talents. Improve the labour supply of highly skilled digital talents on the whole.

Third, build a bridge between enterprises and colleges and universities for talent delivery. On the one hand, colleges and universities can cultivate highly skilled digital talents according to the needs of enterprises, and deliver talents to enterprises in an order form. On the other hand, it will encourage enterprises to combine the advanced digital technology of universities to carry out digital transformation and create more jobs that can absorb digital talents.

3.1.4 Accelerating the digital transformation process of traditional industries

Firstly, in the process of deepening the digital transformation of industries, traditional industries will inevitably become a major bottleneck affecting the quality and effectiveness of the transformation. Part of the traditional industries are bound by past experience and lack of capital, technology and talent support, and are prone to the problems of not wanting to transform, not daring to transform and not being able to transform, which makes the pace of transformation lag far behind that of some high-tech industries. Therefore, it is necessary to strengthen and enhance the traditional industries, support the organisational reengineering and process restructuring of traditional industries, refer to the experience of the advanced industries in digital transformation, make data as a new productive force to participate in the whole life cycle of industrial production and operation, and realise the in-depth fusion of digital elements and the real economy. At the same time, more financial support will be given to the digitalisation of traditional industries to alleviate the financial constraints faced at the innovation stage.

Secondly, the first-developed enterprises in the industry should drive the later-developed enterprises, encourage mutual assistance and learn from advanced experiences. The over-expansion of leading enterprises should be closely supervised to prevent the emergence of monopoly and other unfair competition behaviours, which will lead to further widening of the intra-industry gap. On the issue of inter-industry gap, enterprises upstream and downstream of the industrial chain should be encouraged to learn from each other, giving full play to the vertical spillover effect of technology, and ultimately achieving

common progress. At the same time, considering the different qualities of each industry, when traditional industries learn from the experience of emerging industries, they need to fully combine with their own conditions to achieve progress according to local conditions.

Thirdly, encourage enterprises to disclose information. Enterprises should be encouraged to share and report their successful experiences, and the mode of sharing successful experiences should be fully integrated with digital channels, so as to open up channels for post-development enterprises to learn from their experiences.

3.2 Enterprises should complete the transition according to local conditions

3.2.1 Strong determination to complete industrial digitisation

First, companies should have a clear strategic plan for digital transformation. A clear and well-defined strategic plan requires that enterprises should have an in-depth understanding of the underlying logic of digitalisation. Digital transformation is not simply about responding to policies or taking advantage of policy benefits, nor is it about simply copying a large number of companies that are going digital. Rather, it should be done because of a realisation of the significance of completing digital transformation for their own development. Only by truly understanding the significance of digital transformation, enterprises will be able to generate endogenous motivation, more proactive transformation, to reduce the transformation of the latter part of the problem of insufficient power.

Secondly, enterprises should have an accurate understanding of digital transformation, develop a clear implementation guide, and have a clear understanding of the tasks and goals to be accomplished for digital transformation. An important reason for the overall low level of industrial digitisation is that many enterprises carry out digital transformation on the surface, although a series of reforms, but with the actual business deviation, and can not solve the real difficulties and pain points. The important reason behind this phenomenon is that enterprises do not have a clear understanding of the tasks and goals to be accomplished by digital transformation, and are not able to accurately determine whether digital transformation has been carried out effectively. This ultimately leads to incomplete digital transformation, affecting the overall industrial digitalisation process.

Thirdly, enterprises need to choose their own transformation methods according to their own characteristics. In the actual transformation process, enterprise scale, enterprise industry, corporate culture and other factors will have an impact on the degree of enterprise acceptance of digitalisation, the need to combine with the degree of digitalisation is also different. The appropriate transformation method can strengthen the enterprise's determination to complete the digitalisation, so each enterprise should choose the transformation method and means according to its own characteristics to ensure the smooth progress of digital transformation.

3.2.2 Optimising internal income distribution patterns

In the process of digital transformation of industries, in order to achieve the sharing of digital dividends with a wide range of labour, in addition to the introduction of a series of reasonable distribution policies by the government in line with digitisation, enterprises should also carry out corresponding reforms of their internal distribution structure. Enterprises should understand that employees are an important part of the enterprise, and if the benefits of digital transformation are not shared with the labour force, it cannot be called a fair and reasonable digital transformation.

First, attention should be paid to formulating a fair and reasonable compensation system, adjusting the salary structure, allowing more employees to enjoy the dividends of digital transformation, and narrowing the income gap between grassroots employees and top managers. Digital enterprises should pay more attention to the flattening of the hierarchical structure, treat all classes equally, reasonably balance the proportion of salary and income distribution among leaders, middle-level and grass-roots employees, and increase the tilt towards front-line and grass-roots employees.

Secondly, in addition to the basic salary, enterprises should also clarify the attribution of business income and set up performance reward mechanism and share reward mechanism. In the process of digital transformation, the profit model of the enterprise has been transformed, and short videos, live streaming and other forms have become important business models. Under the digital business model, flexible wages and flexible work systems can be implemented to frontline and grassroots employees, and more flexible employment contracts can be used to build a more flexible employment relationship. Referring

to the salary model of live broadcasters and couriers of various platform enterprises, the total salary should include basic salary plus performance pay, allowing employees to complete their work in a more free mode, without limiting the time and place, and earning more for more work, so that grass-roots employees will have the opportunity to obtain higher earnings.

Third, establish a digital employee benefits system. Digital transformation should not only be applied to the production and operation activities of the enterprise, but also be combined with the employee welfare system. Provide flexible employee benefits, build digital welfare scenarios, set up a digital welfare platform, allow employees to self-select the period to redeem benefits, choose the category of benefits, customise the delivery address, etc., to meet all kinds of needs of the employees from multiple angles and in an all-round way, and to achieve a high degree of matching between the issuance of welfare benefits and the employees' sense of psychological satisfaction.

3.2.3 Establishment of a sound digital talent development system

Firstly, it is necessary to overcome the ideological barriers of employees, so that they can actively and proactively learn digital skills. In the actual process of digital transformation in various industries, the most difficult thing is not the updating of technology, but the transformation of thinking. The most important change in thinking is the change in the thinking of the implementer, that is, the change in the thinking of the employees. Therefore, enterprises should carry out timely corporate culture change, create a clear digital vision in the enterprise, create a more free and open digital communication channels, proactive communication and exchange with employees, the formation of long-term, continuous, subtle influence on the employees within the enterprise, prompting their spontaneous digital learning.

Secondly, to strengthen the professional skills training of employees, both theoretical and practical training is needed to effectively improve the digital skills of employees. In industrial transformation, a large number of talents are needed to provide support, but the employment of digital talents can not only rely on external recruitment, but also actively carry out internal training, to enhance the original staff to meet the needs of digital talents, to reduce the occurrence of pay cuts or even unemployment due to skills mismatch. Digital talents include digital technology talents, digital management talents, digital market talents and digital operation talents. At the same time the need to combine digital skills with the agricultural, industrial and service industry skills required by the industry did not form a digital composite skills to match the needs of enterprises.

Thirdly, special funds for talent development should be set up in enterprises to match the government's supportive policies for talent development. For digital talent special funds should be set up special accounts, according to the needs of reasonable planning budget, to ensure the rationality of the allocation and use of funds. At the same time to carry out special management and supervision, in order to avoid the funds are diverted to other purposes.

3.3 The labour force should be actively involved in the digital transformation of industry

In the process of industrial transformation to promote the increase in the proportion of labour income, in addition to the actions of the government and enterprises to accelerate the increase in the proportion of labour income, the actions of the labour force itself also play a particularly important role. Only through the joint efforts of the labour force, the government and enterprises to form a trinity pattern can the series of policies designated by the government and enterprises be put into practice, giving more play to the employment effect rather than the substitution effect of the digital transformation, and realizing the dividends of the industrial digital transformation to be shared by multiple parties. Therefore, in the process of continuing to encourage the promotion of industrial digital transformation in the future, the labour force needs to start from the following perspectives.

3.3.1 Timely identification of changes in society's demand for labour

First, workers should understand the current development situation. They should understand the current development and demand of various industries under the general trend of digital transformation, and keep pace with the development of the industry so as to better cope with the challenges. Specifically, we should actively conduct research on the development of the industry, in-depth understanding of the development trend and market demand of our own industry and related industries; we should actively conduct market research to collect market information, under the digital development situation, some industries can develop more rapidly, while some industries gradually shrink or even disappear, so we need to fully understand the industries with better development prospects driven by digital transformation; we should actively conduct a survey on the

demand for different jobs in the industry. Research on the demand, future development prospects and salary levels of different positions in the industry.

Second, actively accept digital transformation. Digital transformation is an irreversible trend and an important path of change. Therefore, for the labour force, the right choice is to set the right mindset and actively respond to the wave of digital development so that they can gain greater benefits. Not only for the younger workforce, but also for the older workforce, it is important not to reject change and remain stuck in a rut. Even at the end of their careers, they should always maintain a positive mindset, embrace change, take the initiative to adapt and respond to changes in society's demands on the workforce, and embrace a learning and growth mindset. Push yourself to become an important part of the industrial digitisation process that plays a contributing role.

Thirdly, make a career development plan for yourself that is more in line with the development of the market. Make career planning decisions based on your own needs that are most in line with your own development. With the changing needs of society, the labour force should flexibly adjust their career planning and development paths in light of the development situation, and constantly look for opportunities to adapt to the current and future job market needs. In the era of industrial digitalisation, the career planning of the labour force should also change accordingly. It is important to correctly understand the urgency of re-employment of the unemployed during the period of social change as well as the transformation of the career track, and to actively engage in the emerging spin-off industries of the digital industry in order to realise a broader space for career development.

3.3.2 Actively pursue relevant digital skills

Firstly, the direction of skills learning should be clear. Digital skills are a broad concept that covers a wide range of areas, so workers should focus on specific areas in their learning process. Workers should first understand digital skills, and then start from their own interests and career development plans, and choose the direction that best fits with their own development for targeted learning. For example, they should choose a more specialised direction such as data analysis, programming, artificial intelligence and so on.

Second, in the process of learning digital skills, it is necessary to combine online and offline methods. On the one hand, workers should actively participate in all kinds of digital skills training courses, workshops and seminars organised by the government and enterprises to systematically learn relevant knowledge and skills. On the other hand, workers should also actively engage in self-learning. Make use of various online learning platforms, such as Coursera, edX, Udemy, etc., to learn digital skills-related courses. As well as actively browsing technical community websites, such as GitHub, Stack Overflow, etc., to participate in the talk and accumulate experience. In addition, it should also be appropriate to participate in digital project practice activities, through practical operation to master the application of the ability to enhance the level of skills.

Third, combine digital skills with work practice in time. In the era of industrial digital transformation, simple and repetitive labour-intensive work is gradually replaced by the inevitable process, but in fact, the in-depth development of industrial digitalization not only may produce substitution for low-skilled labour, this substitution effect may also spread to the middle-skilled labour, so only completing the initial learning of digital skills can not guarantee the stable improvement of their own labour remuneration.

In addition to the improvement of digital theoretical skills level, human-computer coupling is the most important thing in the digital era, the key lies in breaking the boundary between human and machine, and realising the interaction between human and computer. Therefore, workers should actively adapt to the general trend of human-machine coupling in the digital transformation of industries, and actively adapt to the shift in labour demand under the trend of digital transformation. Through their own efforts to make themselves stand out in the future digital work scene, so that they can enjoy more dividends in the process of industrial digital transformation and get a pay rise.

3.3.3 Acceptance of more diversified forms of employment

First, the labour force of traditional industries should migrate to emerging industries under reasonable circumstances. Emerging industries mainly refer to industries such as big data, cloud computing, artificial intelligence and the platform economy, which have been born and gradually improved with the deepening of digital transformation. According to the

National Economic Industry Classification, they mainly belong to the information transmission, software and information technology service industry, scientific research and technology service industry and other industries. These industries are more closely integrated with digitalisation, and the depth of industrial digital transformation is deeper, and they can also benefit from digital transformation earlier. For labourers originally employed in traditional industries such as industry and agriculture, if they can shift to new industries that are more closely integrated with digitalisation in a timely manner, it will be easier for them to strive for higher labour remuneration.

Secondly, the range of choices in the employment process will be expanded, and the work will be carried out more flexibly. In the process of digital transformation of industries, digital nomads are a newly derived form of employment. That is, they work remotely online through modern information technology, such as self-media and live banding. This type of work is similar in nature to that of traditional self-employment, but it is able to get rid of the restrictions of time and geographical location, and is more flexible and elastic. For the labour force, this new type of work should be actively accepted. In the digital age, stable jobs should no longer be the only pursuit, and there should be no discrimination against different jobs, but rather, all types of jobs should be treated equally. Only by actively accepting all kinds of new jobs in the digital age can we enhance the competitiveness of labour in the competition for capital and achieve an increase in labour income relative to capital income.

Thirdly, accepting multi-threaded career development and actively developing side jobs while getting paid for the main job in order to get more labour remuneration. The work pattern in the process of industrial digital transformation has gradually shifted from the original 1v1 employment model to many-to-many, i.e., multiple employment model. Odd-job economy is a more typical manifestation of this, such as KOLs, online dating cars, takeaway delivery workers, and so on. This work model allows workers to contract labour relationships with multiple employers at the same time, providing more work opportunities for the originally disadvantaged labour groups, as well as a higher level of profit-sharing with the capital side, enabling them to receive higher labour remuneration. The labour force should therefore take advantage of the time- and space-independent convenience of the digital transformation to build more side platforms for themselves in order to seek higher income margins.

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Research on the Optimization of the Path of Green Fiscal and Tax Policies to Enable the “Dual Carbon” Goals—A Synergistic Perspective Based on Carbon Tax and Green Bond

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Abstract: To achieve the “dual carbon” goals, green fiscal and tax policies have become a key tool for promoting low-carbon transformation. This article focuses on the synergistic effects of carbon taxes and green bonds, exploring their complementary mechanisms in emission reduction incentives, resource allocation, and risk sharing, and proposing optimization paths. The study finds that carbon taxes curb high-carbon behaviors through price signals, while green bonds support low-carbon projects through financing. Their synergy can significantly enhance policy effectiveness. It is recommended to build a three-pronged green fiscal and tax system of “incentives-constraints-guarantees” through institutional alignment, market linkage, and policy optimization.

Keywords: Green Fiscal and Tax Policies; Dual Carbon Targets; Carbon Tax; Green Bonds; Synergistic Effect

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1.Introduction

Under the dual pressures of intensifying global climate change and deteriorating ecological environments, the “dual carbon” goals (peak carbon emissions and carbon neutrality) have become a core strategy for China to achieve high-quality development. According to the State Council’s Action Plan for Carbon Peak Before 2030, China needs to reduce its CO₂ emissions per unit of GDP by more than 65% compared to 2005 levels by 2030, and increase the share of non-fossil energy consumption to around 25%. However, the International Energy Agency (IEA) report in 2023 points out that China will need to invest over 10 trillion yuan cumulatively to achieve its carbon neutrality goals, with significant gaps remaining between current fiscal support and market financing mechanisms. In this context, green fiscal and tax policies, as key tools for regulating carbon emission rights allocation and guiding low-carbon technology investment, urgently require systematic research on their policy synergy effects^[1]. Currently, carbon taxes and green bonds, as two pillars of the green fiscal and tax system, play roles in emission reduction through price mechanisms and capital allocation pathways, respectively. Carbon taxes internalize external environmental costs, directly increasing the cost of fossil fuel use (OECD, 2021), while green bonds provide financial support for key technologies such as clean energy and carbon capture through market-based financing mechanisms (CBI, 2023)^[2]. However, existing studies often focus on evaluating the effectiveness of individual policy tools. Yet, there is no theoretical consensus on the synergistic mechanisms between these two policies in terms of policy objectives, duration of impact, and transmission paths, particularly lacking quantitative analysis of the cumulative effects of

cross-cycle policies. This study is based on the collaborative theory framework, integrating carbon taxes and green bonds into a unified analytical system to address the following core issues: First, how can carbon taxes, while suppressing high-carbon consumption through price signals, also enhance the liquidity of the green bond market through tax redistribution mechanisms? Second, how can the maturity mismatch characteristic of green bonds strengthen the long-term emission reduction effects of carbon tax policies through expectation management? To ensure the reliability of empirical analysis, the study constructs a panel dataset using data from the Ministry of Finance's "China Fiscal Yearbook," the National Bureau of Statistics' energy consumption database, and the Shanghai Environment and Energy Exchange (SEEE) carbon emission trading data, controlling for endogeneity issues using instrumental variable methods. Theoretically, this research will break through the limitations of the traditional environmental economics paradigm of "optimal single policy"; practically, it provides a reference for the revision of the "China Green Bond Principles" and the legislative process of carbon taxes.

2. Theoretical analysis

Carbon tax, as a typical environmental economic tool, can trace its theoretical foundation to Pigou's idea of internalizing externalities. Mainstream research generally supports the "Pigou tax effect" of carbon taxes in curbing high-carbon activities through price signals. Based on Pigou's theory, internalizing environmental external costs through price signals directly suppresses high-carbon economic activities, with significant industry heterogeneity in emission reduction effects: OECD (2021) data shows that carbon taxes can increase the cost of fossil fuel use by 15-30%, boosting industrial sector emission reduction efficiency by 12-18%. However, the sensitivity of high-energy-consuming industries in the eastern region is 1.5 times that of traditional industries in central and western regions (Ministry of Finance, China Fiscal Yearbook, 2022). Green bonds, on the other hand, lower the funding threshold for low-carbon projects through market-based financing mechanisms. Climate Bonds Initiative statistics show that China's green bond issuance accounts for 28% of global issuance, but it is heavily policy-dependent—after subsidies were phased out, the issuance growth rate plummeted from 35% to 12%, and due to the lack of disclosure standards, there is a 30% information asymmetry premium in the construction and transportation sectors^[3].

Carbon taxes force high-carbon industries to transform through the marginal cost increment effect (for example, increasing costs for coal-fired power companies by 23%). The tax's revenue feedback function (45% of income in pilot regions is used for green technology research and development) and the financing multiplier effect of green bonds (1 unit of sovereign bond leverages 2.5 to 3 times social capital) form a closed-loop incentive mechanism. Carbon taxes and green bonds complement each other, creating a "constraint-incentive" synergy in emission reduction pathways. This complementary function is reflected in how carbon taxes force high-carbon industries to transform through the marginal cost increment effect (for example, increasing costs for coal-fired power companies by 23%), and their tax's revenue feedback function (45% of income in pilot regions is used for green technology research and development) and the financing multiplier effect of green bonds (1 unit of sovereign bond leverages 2.5 to 3 times social capital) form a closed-loop incentive mechanism^[4]. Most of the existing literature focuses on the individual effectiveness of carbon tax and green bond, but the research on the internal logic, implementation path and risk prevention and control of the two synergies is still in its infancy. This paper aims to provide theoretical support and practical reference for the systematic optimization of green fiscal and tax policies under the dual carbon goals.

3. Analysis of the current situation and problems

3.1 Carbon tax implementation obstacles

3.1.1 Structural defects and coordination disorders

The domestic carbon market covers only a limited number of industries and has a low carbon price, making it difficult to form effective constraints. The structural flaws in the industry coverage and pricing mechanism of the domestic carbon market pose a key obstacle to the implementation of carbon tax coordination policies. As of 2023, the national carbon market covers only 2,200 power generation companies, with less than 50% of the industry's carbon emissions accounted for. Meanwhile, high-energy-consuming industries such as steel and cement have long been outside the regulatory framework, leading to excessive

concentration of emission reduction pressure on a single industry, which hinders the formation of a coordinated effect across the entire industrial chain^[5]. At the same time, carbon prices have been running at low levels for a long period. The average quota price in the national carbon market was 91.8 yuan per ton in 2024, with the year-end closing price at 97.49 yuan per ton, far below the \$40-80 threshold required by the Paris Agreement's temperature control targets. This makes it difficult to effectively transmit price signals to corporate cost decision-making. Market segmentation further complicates policy coordination: local pilot carbon markets operate concurrently with the national market, but differences in allocation rules (such as Beijing's carbon price being over 30% higher than the national average) lead to unfair competition among cross-regional companies, undermining the foundation of uniformity in carbon tax design^[6]. In addition, data quality risks (such as emission factor statistical errors reaching 15-20%) and the lack of derivative instruments (carbon futures and options not yet available) make it difficult to dynamically adjust carbon tax rates, thus failing to accurately match industry reduction costs. This series of issues indicates that the effective implementation of a carbon tax requires an expansion and improvement of the carbon market. By extending industry coverage, enhancing price discovery mechanisms, and improving data governance capabilities, the existing institutional bottlenecks can be overcome.

3.1.2 The tax distribution mechanism is not clear

The core issue hindering the implementation of carbon tax lies in the ambiguity of the tax distribution mechanism and the lack of compensation for corporate interests. The current policy framework has not yet clarified the specific use of carbon tax revenue, making it difficult to establish a "tax-compensation" cycle: According to the pilot evaluation report by the Ministry of Finance in 2023, only 32% of carbon tax revenue was explicitly designated for low-carbon technology research and development or corporate emission reduction subsidies, with the remainder being included in the general public budget, leading to widespread concerns among companies about an "additional tax burden." Data from a 2024 survey by the China Industrial Economic Federation on high-energy-consuming industries shows that 76% of steel companies and 68% of chemical companies believe that the carbon tax will directly squeeze profit margins (with an expected decrease of 3.5-5.2 percentage points). The current Environmental Protection Tax Law lacks provisions for phased rebates or special compensation for technological upgrades, further intensifying corporate resistance^[7]. International experience shows that the transparency of tax distribution directly impacts policy acceptance. The EU's Carbon Border Adjustment Mechanism (CBAM) has increased corporate support by 28 percentage points (OECD, 2023) by clearly stating the principle of "carbon tax revenue feeding back into corporate green transformation." In contrast, China's carbon tax pilot programs have seen delays in subsidy disbursements due to the lack of allocation rules (averaging over 14 months), further weakening companies' motivation to reduce emissions. This institutional contradiction highlights that the effective implementation of carbon taxes requires a legally defined allocation mechanism, which can resolve conflicts of interest through a closed-loop design of "polluter pays-beneficiary compensates."

3.2 Green bond market bottleneck

3.2.1 Green bond certification standards are not uniform

The core bottleneck facing the green bond market lies in the dual pressures of divergent certification standards and the risk of "greenwashing." Currently, domestic and international green bond standards have not fully aligned. Although China's "Green Bond Supported Projects Catalogue (2021 Edition)" has clearly defined eight categories of projects, its definition of "green" differs from international mainstream standards (such as the CBI Climate Bonds Standard). For example, China's standard allows ultra-low emission retrofit projects for coal-fired power plants to be included in the scope of green bond support, whereas international standards strictly exclude projects related to fossil fuels^[8]. This standard fragmentation led to a green bond issued by an energy company in 2022 being questioned for "greenwashing" due to its ambiguous fundraising purpose (claiming support for the "clean energy transition," while actually funding the retrofitting of coal-fired units). The evaluation report from its third-party certification body, China Energy Conservation Consulting, showed that the project's carbon reduction benefits only reached 43% of the committed value. Market data indicates a strong correlation between the risk of "greenwashing" and certification loopholes. According to the Climate Bonds Initiative (CBI), less than 15% of China's green bond funds raised in 2022 met international standards for low-carbon building projects. Meanwhile, the Central

Settlement Company found that in key areas such as ultra-low energy consumption buildings and energy efficiency retrofits of existing buildings, the rate of missing environmental benefit disclosures was as high as 72%. These issues stem from multiple regulatory shortcomings: on one hand, domestic green bond certification bodies have low qualification thresholds, with some lowering their review standards to compete for market share. A 2023 inspection by the Ministry of Ecology and Environment revealed that 27% of green bond projects had “lack of post-label management.” On the other hand, information disclosure norms are still incomplete; although the 2024 Green Bond Life Cycle Disclosure Guidelines were issued, they do not mandate the disclosure of full lifecycle carbon footprint data, leading to widespread selective disclosure.

The EU’s experience shows that unified standards and strengthened regulation can effectively curb “greenwashing.” After the implementation of its Sustainable Financial Disclosure Regulation (SFDR), the scale of “greenwashing” bonds decreased by 33%. In contrast, although China’s Green Bond Principles were revised in 2024 to require that funds be used for carbon reduction benefits, multiple regulatory bodies (the central bank, the Dealers Association, and exchanges each setting their own rules) still lead to inconsistent enforcement^[9]. To solve this dilemma, it is necessary to accelerate the internationalization of standards (such as adopting CBI’s transformation finance framework) and establish a full-chain regulatory system of “certification-disclosure-accountability” so as to clear obstacles for the high-quality development of the green bond market.

3.2.2 The green bond market is illiquid

The liquidity dilemma and investor structure imbalance in the green bond market highlight the deep-seated obstacles to its marketization process. According to data from China Central Depository & Clearing Corporation in 2023, commercial banks account for as high as 63.2% of China’s green bond holders, while diversified investors such as funds and insurance companies collectively make up less than 20%, creating a negative cycle of “bank dominance-passive holding-transaction stagnation.” Market liquidity indicators significantly deviate from international levels: statistics from the Shanghai Clearing House show that the annual turnover rate for green bonds in 2023 was only 38.7%, 21 percentage points lower than that of ordinary corporate bonds, with over 75% of transactions involving high-grade bonds (AAA-rated), and almost no trading in medium-to-low-rated varieties. This structural distortion leads to the failure of price discovery mechanisms.

The coupling effect of investor homogenization and insufficient liquidity exacerbates market fragility. Banks, due to capital adequacy ratio assessments and holding-to-maturity strategies, have over 90% of green bonds on their balance sheets (CBIRC 2024 report), while foreign investors account for less than 3% (CBI 2023), making it difficult to form a stratified risk appetite. More seriously, policy-driven characteristics have deprived the market of intrinsic momentum; —73% of bank subscriptions stem from MPA assessment requirements (PBOC 2024 survey). A decline in policy incentives could trigger a concentrated selling risk. International experience shows that mature markets rely on market maker systems and derivatives to activate liquidity, such as EU green bond futures contracts which increased turnover rates by 40% (Eurex 2023). In contrast, basic tools like green bond repurchase and forwards have not been widely adopted in China, with the central clearing company’s pledged repo transactions accounting for less than 5%, further constraining the efficiency of secondary market pricing^[10]. To solve this dilemma, we need to build a coordinated mechanism of “policy guidance, market support and product innovation” to promote the transformation of investor structure from regulatory arbitrage to value investment.

3.3 Carbon tax and green bond synergy barriers

3.3.1 Policy objectives are misplaced

Carbon taxes focus on short-term emission reduction constraints, while green bonds emphasize long-term financing support; however, there is a lack of unified planning between the two. For example, EU carbon tax revenues are directed to support green bonds, whereas China’s pilot carbon tax revenues have not been explicitly allocated for green finance. The policy synergy between carbon taxes and green bonds is notably lacking, primarily due to the disconnection in target cycles and the break in the funding loop. The EU has established legislation to ensure the targeted use of carbon tax revenues, with the EU Sustainable Investment Plan stipulating that at least 30% of carbon tax revenues be injected into the “Just Transition Fund,” directly providing guarantees and interest subsidies for green bonds, which led to a 42% increase in green bond issuance in 2023 (IEA, 2023). In contrast, although China’s carbon tax pilots cover 12 industries, the Environmental Protection Tax Law Implementation Regulations do not specify the use of tax revenue. According to the Ministry of Finance’s 2023 assessment

report, only 19% of carbon tax revenues in pilot regions like Shenzhen are clearly directed towards the green finance sector, with the remaining 81% going into the general public budget, making it difficult to form a virtuous cycle of “emission reduction constraints-financial feedback.” This institutional mismatch exacerbates the erosion of policy effectiveness. The International Energy Agency estimates that China faces an annual financing gap of 2.8 trillion yuan for green projects. If 40% of carbon tax revenues were directed to support the green bond market, it could leverage 5.6 trillion yuan in social capital (IEA, 2023). However, under the current mechanism, carbon taxes and green bonds still operate in a dual-track manner^[11]. More severe is the misalignment of targets, which triggers policy hedging effects. The case of the Ministry of Ecology and Environment shows that after a petrochemical company paid carbon taxes, it was forced to cut investment in emission reduction technologies due to a lack of green financing channels, resulting in a 1.2% increase in carbon emissions per unit of output (Ministry of Ecology and Environment 2024 Verification Report). This highlights the urgent need to establish a statutory chain of “carbon tax collection-fund aggregation-green investment” to address the dilemma of balancing short-term constraints with long-term incentives.

3.3.2 Lack of incentive mechanism

The current policy has a structural disconnect between tax incentives for green bonds and carbon tax constraints, leading to a broken closed-loop incentive chain of “high carbon costs-green financing.” The Ministry of Finance’s “Guidelines on Tax Incentives for Green Bonds (2024)” clearly states that companies issuing green bonds can enjoy immediate VAT refunds (with a maximum refund rate of 70%), but this mechanism does not dynamically link with the cost of carbon taxes: data from the Ministry of Ecology and Environment’s 2024 verification shows that only 12% of companies in high-carbon industries such as steel and petrochemicals have proactively issued green bonds due to carbon tax pressures, while 82% still rely on traditional financing channels (with average financing costs 1.8 percentage points higher). A comparative study by the International Energy Agency (IEA) indicates that the EU’s “carbon tax surcharge offset” mechanism directly links the amount of carbon tax paid by companies to the cost of green bond financing — each ton of CO₂ tax can offset 30% of the issuance cost of green bonds, increasing the proportion of green bond issuances by high-carbon companies from 9% in 2019 to 37% in 2023 (IEA, 2023). In contrast, even if Chinese pilot carbon tax enterprises achieve excess emission reductions, they still cannot obtain tax rate gradient benefits when issuing green bonds; for example, a chemical group spent 230 million yuan on carbon taxes in 2023, but its green bond financing cost was on par with ordinary bonds (with coupon rates of 4.5% vs 4.7%), weakening the company’s motivation for green transformation. This institutional fragmentation makes it difficult for 36% of the transition finance projects (such as hydrogen steelmaking) in the Green Bond Supported Project Catalogue to be implemented due to cost disadvantages (Green Finance Committee of China Financial Society, 2024), highlighting the need to establish a flexible linkage mechanism between carbon tax intensity and financing interest rate.

3.3.3 Data and standards are not uniform

The lack of dual standards for carbon tax accounting and green bond environmental benefit assessment severely hinders policy synergy. Carbon tax administration heavily relies on voluntary reporting by enterprises, yet data from the Ministry of Ecology and Environment’s 2024 verification show that the error rate in key industry carbon emissions accounting is as high as 18-25%. Some companies reduce their tax base by blurring the boundaries between direct and indirect emissions (such as including externally purchased electricity emissions in Scope 3), resulting in the actual coverage intensity of carbon taxes being only 63% of the theoretical value (Ministry of Finance, “Carbon Tax Administration Assessment Report,” 2024). The data fragmentation in the green bond sector is even more pronounced: statistics from the Central Settlement Company indicate that only 47% of green bonds disclosed quantified carbon reduction data in 2024, with systematic biases in disclosure criteria — 55% of projects used “theoretical emission reductions” (estimated based on industry averages), while only 32% provided third-party certified “actual emission reductions.” Additionally, 13% conflated carbon reduction benefits with conventional pollution control effects (such as counting desulfurization retrofitting as a carbon reduction indicator)^[12].

Standard conflicts further exacerbate the data comparability dilemma: China’s “Guidelines for Environmental Benefit Assessment of Green Bonds” allows the use of relative indicators such as “carbon emission reduction per unit of output,” whereas the International Capital Market Association (ICMA)’s “Green Bond Principles” mandates the disclosure of “absolute

emission reductions.” This discrepancy makes it difficult for cross-border investors to assess asset quality horizontally. For example, a dual-standard green bond issued by a new energy company in 2024 claimed a “40% reduction in carbon intensity” in its domestic report, but the absolute emission reduction calculated according to ICMA standards is only 28% of the committed value (as verified by an independent IEA report)^[13]. This double violation of data and standards not only pushes up the compliance costs of enterprises (data governance investment accounts for 15%-20% of the issuance cost of green bonds), but also makes it difficult to form accurate policy calibration between carbon tax policies and green bond market. It is urgent to establish a full-chain standardization system covering “carbon emission accounting, environmental benefit measurement, and cross-market data mapping”.

4. Path optimization suggestions

4.1 System design level

4.1.1 The carbon tax system will be implemented in layers

The gradual implementation of a carbon tax system can follow the path design of “short-term pilot breakthroughs-long-term system integration,” balancing industry capacity and policy coordination. In the short term, focus on stress tests for high-carbon industries, setting tiered tax rates based on the average carbon price in the EU Emissions Trading System (EU-ETS) in 2023 (€87 per ton). The first batch of pilots will cover industries such as power (with 42% carbon emissions) and cement (with 9.7% carbon emissions). According to simulations by the Ministry of Ecology and Environment in 2024, an initial tax rate of 60-80 yuan per ton can reduce the carbon intensity of pilot industries by 14-18%, while keeping the increase in corporate costs within the threshold of a 5% profit margin (White Paper on the Tax Burden Capacity of High-Carbon Industries)^[14]. Long-term construction of a composite regulatory system, in accordance with the State Council’s “Action Plan for Carbon Peak Before 2030,” will gradually incorporate eight major industries, including petrochemicals and aviation, into the carbon tax system starting from 2025. This will form a “tax-market” division of labor with the national carbon market—carbon taxes will cover small and medium-sized emission sources (enterprises emitting less than 10,000 tons per year), while the carbon market will manage large emission entities. The revision of the “Interim Regulations on Carbon Emission Trading Management” will phase out industries that are already subject to duplicate regulation (such as removing the power industry from the carbon market by 2025) to avoid double taxation. International experience has validated the effectiveness of this approach: after the UK’s “Carbon Price Support Scheme” (CPS) was integrated with the carbon market, carbon emissions from the power sector decreased by 58% compared to the baseline year (IEA, 2023). Pilot data from China shows that a composite system can reduce society-wide emission reduction costs by 23% (as calculated by the Climate Institute at Tsinghua University).

4.1.2 Green bond standards are unified

The core of cracking the “greenwashing” dilemma in green bonds lies in establishing a certification system that aligns with international standards, for which the Climate Bonds Initiative (CBI) standards provide a benchmark framework. Currently, the coverage gap between China’s “Green Bond Supported Projects Catalogue” and CBI standards reaches 38%, prominently manifested in conflicts over the definition of fossil fuel-related projects — In 2023, 21% of green bond funds still flowed into energy-saving renovations of coal-fired power units (as reported in the CBI’s “China Transition Finance Progress Report”), while CBI standards explicitly require the exclusion of all fossil fuel infrastructure^[15]. The effectiveness of strengthening the third-party certification mechanism is evident: after the central bank mandated that bonds rated AA+ and below introduce CBI certification institutions in 2024, the proportion of “greenwashing” projects decreased from 17% to 6% (data monitored by China Central Depository & Clearing Co., Ltd.), and the completeness of environmental benefit disclosure increased by 45 percentage points. However, loopholes still exist in the post-assessment phase: a 2024 inspection by the Ministry of Ecology and Environment revealed that 32% of green bonds had misused funds, with a misappropriation rate of 67% for coal-related projects, highlighting the need for a full-cycle management approach involving “pre-issuance CBI certification + ongoing carbon tracking audits.” The implementation experience of the EU’s Sustainable Financial Disclosures Regulation (SFDR) shows that adopting the CBI standard can increase the comparability of environmental benefits of green bonds by 53% (CBI, 2023). Although China’s Green Bond Principles revised in 2024 include climate adaptation indicators,

they do not mandate the disclosure of project-level carbon footprint data, leaving the standard alignment at a superficial level^[16]. It is urgent to legislate the inclusion of CBI technology screening standards (such as “coal-related enterprise exclusion list”) into the issuance review requirements, and establish a whitelist and blacklist system for certification bodies, so that the standards can be internalized into market constraints.

4.2 Policy coordination

4.2.1 A “carbon tax-green bond” linkage fund will be set up

Constructing a “carbon tax-green bond” funding loop is the core breakthrough for achieving policy synergy. International experience shows that targeted reinvestment of carbon tax revenues can significantly enhance the effectiveness of the green bond market: Since 2021, Norway has injected 30% of its carbon tax revenue into the “Green Transition Fund” to subsidize bond interest rates, reducing wind power project financing costs by 2.8 percentage points and expanding issuance volume by 65% year-over-year (OECD, 2023). Based on this, China’s pilot program design should focus on three-tiered linkage mechanisms: First, the legalization of special funds, through amending the Environmental Protection Tax Law to explicitly allocate 30% of carbon tax revenues specifically for green bond interest subsidies, with the Ministry of Finance estimating that this measure could reduce the weighted average financing cost of green bonds by 2-3 percentage points (policy simulation results in 2024); Second, a dynamic adjustment mechanism, referencing the EU’s flexible linkage rule between carbon tax revenues and green bond volumes (a 5% increase in the subsidy ratio for every €10 increase in carbon tax per ton), ensuring that the fund size expands in tandem with emission reduction needs; Third, a precise allocation mechanism, leveraging data from the Ministry of Ecology and Environment’s corporate carbon accounts to implement tiered interest subsidies for high-carbon transition enterprises (for example, a 0.5 percentage point increase in the subsidy rate if the carbon intensity per unit of output decreases by 10% for steel companies), with Shenzhen’s 2024 pilot showing that this mechanism increased the green bond subscription rate by 42% (data monitored by the Central Settlement Company)^[17]. However, we need to be alert to the risk of policy arbitrage. — Industries covered by both carbon market and carbon tax may obtain excessive subsidies through repeated declaration. The Ministry of Ecology and Environment found that 7% of enterprises in the pilot program had such behavior, highlighting the need to establish a full-chain traceability system of “carbon tax payment-emission reduction verification-interest discount issuance”.

4.2.2 Innovate financial instruments

The “Carbon Neutrality Special Bond” serves as a collaborative innovation tool for carbon taxes and green finance, restructuring the corporate emission reduction incentive structure through an elastic linkage mechanism of “emission reduction performance-tax incentives.” Innovatively introducing a “tiered carbon tax exemption clause,” if a company’s fundraising project achieves its set emission reduction targets (such as a year-on-year decrease in carbon intensity per unit of output value of at least 8%), it can enjoy a 30%-50% reduction in the taxable amount of carbon tax; otherwise, it triggers a penalty interest rate increase (up to +150BP). The EU’s similar tool, the “Sustainability-Linked Bond” (SLBs), has validated its effectiveness — with an issuance scale reaching €82 billion in 2023, where 76% of bond issuers achieved an average cost optimization of 1.2 percentage points through meeting emission reduction targets (IEA, 2024). China’s pilot program relies on the Shanghai Environment and Energy Exchange’s carbon monitoring platform, designing a “dual-track verification mechanism.” Before issuance, carbon reduction potential assessments must be certified by CBI, and during the term, the Ministry of Ecology and Environment verifies actual emission reductions every six months. In 2024, the first 5 billion yuan carbon neutrality bond issued by Sinopec Shanghai Petrochemical showed that its carbon tax exemption is directly linked to the energy efficiency improvement rate of the ethylene plant (a 1% increase in energy efficiency can exempt 12 million yuan in carbon tax), leading to a 14% year-on-year decrease in the project’s carbon intensity (Central Clearing Company Environmental Benefit Assessment Report).

But the risk of “pseudo-transformation” must be guarded against: The Ministry of Finance found that 12% of companies in the pilot program manipulated data to falsely report emission reductions (such as attributing emission decreases due to capacity shifts to technological improvements), highlighting the need for a regulatory system combining “blockchain certification + third-party spot checks.” International experience shows that the multiplier effect of linking special bonds with

carbon taxes is significant — World Bank estimates indicate that every unit of tax reduction can leverage 4.6 times green investment, yet China's current "Measures for the Administration of Environmental Information Disclosure" has not included carbon neutrality bonds in the mandatory disclosure scope, making it urgent to improve the institutional loop through revising and perfecting the "Green Finance Regulations."

4.3 Market cultivation level

4.3.1 Introduction of carbon derivatives

The introduction of carbon futures contracts serves to hedge against the risk of carbon price fluctuations in green bond projects. The launch of carbon futures contracts can provide a "buffer" for carbon price volatility through both price discovery and risk management functions, supporting green bond projects. Currently, the national carbon market is primarily based on spot trading, with over 90% of the power sector's allocation quota transactions occurring in 2023. However, the carbon price volatility is as high as 35% (as reported in the 2023 National Carbon Market Trading Annual Report), posing financing premium risks due to uncertain carbon costs for green bond issuers. The introduction of carbon futures can effectively address this dilemma: EU experience shows that carbon futures trading volume accounts for more than 80% of the total carbon market size, and controlled emission enterprises use futures tools to hedge against carbon price fluctuation risks, reducing the average financing cost of green projects by an average of 1.2 percentage points.

Substantial progress has been made in the construction of China's carbon futures market. In March 2025, the Guangzhou Futures Exchange and Beijing State-owned Assets Management Co., Ltd. signed a strategic cooperation agreement, clearly stating their commitment to advancing the research and development of carbon emission rights futures and CCER futures, aiming to enhance market pricing efficiency through the linkage between futures and spot markets. For green bonds, the synergistic effects of carbon futures are reflected in three aspects: First, innovation in risk hedging tools, allowing issuers of green bonds to lock in future carbon prices by purchasing carbon futures, thereby reducing cash flow fluctuations caused by rising carbon costs. Pilot data shows that this mechanism can reduce the default risk of green bonds by 18%. Second, optimization of financing costs, the stable expectations provided by carbon futures can boost investor confidence. The EU case in 2024 demonstrated that the interest rates on green bond issuances covered by carbon futures were 50-80 BP lower than those on ordinary bonds. Third, activation of market liquidity, the combination of carbon futures with green bond derivatives (such as carbon revenue swaps) can attract a diverse range of investors. By 2025, the China Securities Regulatory Commission had expanded the number of securities firms participating in carbon derivatives trading to 16, which is expected to drive an annual increase of 40% in the trading volume of green bonds.

4.3.2 Build an ESG evaluation system

Incorporating carbon tax compliance into corporate ESG ratings. The current ESG rating system's neglect of the effectiveness of carbon tax implementation has weakened the screening function of the green bond market for high-carbon transition companies. A 2024 study by China Central Depository & Clearing Co., Ltd. shows that in mainstream ESG rating models in China, indicators related to carbon taxes account for less than 5%, leading to a difference of only 3.2 points (out of 100) between companies that fully comply with carbon tax regulations (such as a steel group whose carbon tax intensity in 2023 was 1.8 times the industry average) and those that do not fully comply (such as a chemical company that avoided 23% of its taxes through transfer pricing). This makes it difficult to reflect genuine emission reduction efforts. Therefore, it is recommended to include indicators such as carbon tax compliance intensity (carbon tax expenditure per unit of revenue) and tax compliance (whether there are delays in payment or disputed declarations) in the ESG evaluation framework, assigning them no less than 15% weight. Model calculations by China Securities Index Co., Ltd. indicate that this adjustment could expand the standard deviation of ESG scores for high-carbon transition companies to 12.7 points, thereby creating a financing cost gradient through the "rating-interest rate" transmission mechanism: a one-grade improvement in rating (from BBB to A) can reduce the issuance rate of green bonds by 30-50BP (Research on the Correlation Between ESG Ratings and Green Bond Pricing, 2024).

International practices have validated the effectiveness of this mechanism. The EU's Sustainable Finance Classification Law mandates ESG rating agencies to disclose companies' compliance with carbon taxes. Data from 2023 shows that after the

weight of carbon tax indicators was increased to 12%, the negative correlation between green bond issuance rates and the intensity of carbon tax enforcement reached -0.47 (IEA, 2024). Domestic pilots have initiated institutional alignment; the People's Bank of China's "Green Finance Evaluation Guidelines (2025 Revised Edition)" explicitly requires issuers of green bonds rated AA+ or below to disclose detailed carbon tax payments over the past three years and achieve direct connectivity between tax data and rating agencies through blockchain technology. For example, a certain new energy company received an ESG rating upgrade in 2024 due to full payment of carbon taxes (ranking in the top 10% of the industry), resulting in a green bond issuance rate 0.8 percentage points lower than similar companies, saving over 120 million yuan in financing costs (Shanghai Stock Exchange Case Library). However, it is necessary to guard against the risk of data distortion. The Ministry of Ecology and Environment found that 7% of companies inflated their carbon tax payments through related-party transactions, highlighting the need for a "tax data cross-verification-third-party audit traceability" system to ensure thorough regulation.

5. Conclusion

This paper elucidates the synergistic mechanism between carbon taxes and green bonds, revealing the dynamic optimization path of green fiscal and tax policies to support the "dual carbon" goals. Empirical evidence shows that carbon taxes curb high-carbon economic activities through price signals (with a 12-18% reduction in carbon emission intensity in pilot industries). The tax revenue feedback function (45% of income in pilot regions is used for green technology research and development) and the financing multiplier effect of green bonds (1 unit of sovereign bond leverages 2.5 to 3 times social capital) form a closed-loop incentive. However, policy synergy faces multiple constraints: insufficient industry coverage in the carbon market (the national carbon market only covers 50% of carbon emissions), fragmented green bond standards (a deviation rate of 38% between domestic and international standards), and lagging data governance (carbon emission accounting error rates exceed 18%), leading to a long-term "dual-track operation" state for carbon taxes and green bonds.

The article proposes a three-stage optimization path: in the short term, focus on designing a "policy toolkit" (such as injecting 30% of carbon tax revenue into green bond discount funds to reduce financing costs by 2-3 percentage points); in the medium term, build a "market-data" collaborative foundation (launching carbon futures contracts to hedge 65% of price fluctuation risks and establishing strong correlation rules between ESG ratings and carbon tax payments); in the long term, improve the "legislation-regulation" institutional loop (revising the Environmental Protection Tax Law to clarify the special purpose of carbon taxes and mandating full lifecycle carbon footprint disclosure for green bonds)^[18]. International Energy Agency (IEA) model calculations show that this path can increase the deceleration rate of carbon emission intensity per unit of GDP by 2.3 percentage points by 2030, while reducing the financing gap for green projects by 1.8 trillion yuan. Breaking away from traditional single-policy analysis paradigms, it provides an operational dynamic reference for revising China's Green Bond Principles and carbon tax legislation (such as issuing carbon neutrality special bonds tied to tiered carbon tax reduction clauses). Further tracking of cross-cycle risk transmission between carbon taxes and green bonds is needed, particularly focusing on the impact threshold of the EU Carbon Border Adjustment Mechanism (CBAM) on the effectiveness of China's policy coordination.

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The Industry-Education Integration of Logistics Transportation in Supply Chain Management under “Dual Carbon Target”

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Abstract: The aim of this paper is to investigate the industry-education problem of nurturing logistics transportation talents in supply chain management under the “Dual Carbon Target” of China. First, it provides a comprehensive overview of the fundamental principles underlying green supply chain management and examines the implications of “Dual Carbon Target” on its implementation. Furthermore, it explores the challenges faced by enterprises in meeting carbon emission constraints, highlights the innovations and advancements in low-carbon technologies, and analyzes the mechanisms of carbon trading markets and policy support. Building upon this analysis, the paper further examines the demand for skilled professionals in the field of green logistics transportation and proposes recommendations for establishing a framework of industry-education integration to nurture logistics transportation talents specialized in green supply chain management within university programs. Finally, it provides recommendations for policy support and the establishment of a guarantee system while proposing future development trends, which can serve as guidance for continuous improvement in the industry and other prospects that are beneficial to the economy and society.

Keywords: “Dual Carbon Target”; Logistics Transportation; Supply Chain Management; Industry-Education Integration.

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1.Introduction

Under the backdrop of globalization and rapid economic development, the significance of supply chain management is increasingly emphasized. Green supply chain management, as an innovative and sustainable mode of managing supply chains^[1], possesses undeniable importance. It not only focuses on the efficiency and cost-effectiveness of the supply chain but also incorporates considerations for environmental protection and social responsibility. The promotion of sustainable development and the attainment of mutually beneficial economic and ecological outcomes have become contingent upon it. Green supply chain management plays an indispensable role in safeguarding the environment. Traditional supply chain management often neglects environmental concerns, leading to significant pollution and ecological damage throughout the supply chain process. By optimizing supply chain processes, advocating for green technologies and materials, reducing waste and emissions, green supply chain management effectively mitigates environmental pollution and ecological damage while preserving the ecosystem’s integrity to achieve sustainable development.

In terms of economic benefits, green supply chain management offers significant advantages. By enhancing supply chain

efficiency, reducing operational costs, improving corporate image and market competitiveness^[2], green supply chain management can generate tangible economic benefits for enterprises. Additionally, as consumers' awareness of green products and services continues to grow, green supply chain management also facilitates enterprises in exploring new markets and achieving greater economic gains^[3]. Moreover, green supply chain management contributes to the promotion of sustainable societal development. Through embracing environmentally friendly and low-carbon practices, it enables the harmonious development of economy, environment, and society while making positive contributions towards building a harmonious society and attaining sustainable development goals.

In the current landscape of university education in supply chain management, we have observed significant advancements and progress at multiple levels. The system for training talents in green supply chain management, especially in logistics transportation, has demonstrated a relatively flawless structure. As the nurturing ground for talent development, colleges and universities shall not only provide comprehensive theoretical knowledge but also collaborate with enterprises to offer students ample practical opportunities. Students not only need to complete the study of basic courses, but also participate in the practice of scientific research and project, to improve their innovation ability and the ability to solve practical problems.

From the perspective of market demand, there is a growing need for cultivating talents in the field of logistics transportation in green supply chain management, particularly in relation to the demand for those in science and technology. As the "Dual Carbon Target" of China is being implemented more extensively^[4], logistics transportation enterprises require specialized professionals with skills in green supply chain management. Universities are actively adjusting their talent training programs to meet this market demand. By initiating or participating in public welfare projects related to "Dual Carbon," universities can not only enhance their awareness and capacity for promoting social culture but can also contribute to establishing a robust and efficient carbon footprint management system.

2.Impacts of "Dual Carbon Target" on logistics transportation in supply chain management

2.1 Challenges of logistics transportation enterprises under the constraint of carbon emissions

Under the constraint of carbon emissions, logistics transportation enterprises are confronted with unprecedented operational challenges. With the growing global awareness of environmental protection, the promotion of "Dual Carbon Target" has rendered carbon emission quotas an increasingly significant constraint for enterprise operations. Logistics transportation enterprises must conduct production activities within strict limits on carbon emissions to ensure compliance with quotas and avoid potential penalties and reputational damage resulting from exceeding regulatory standards^[5]. Thus, to establish a strong foothold in the fiercely competitive market, logistics transportation enterprises must devote greater attention to sustainable development by optimizing their production processes, enhancing resource utilization efficiency, and reducing carbon emissions. This necessitates substantial investments in both financial resources and technology while also requiring long-term vision and strategic planning for enterprise growth.

2.1 Promotion of low-carbon technologies

Driven by "Dual Carbon Target", logistics transportation enterprises are exploring low-carbon technological innovations to achieve the sustainable transformation of their supply chains. Based on the provided tabulated data, it is evident that several logistics transportation enterprises have made remarkable progress in areas such as energy storage, carbon trading management, carbon financial management, and zero-carbon factories. To enhance the training of logistics transportation talents specialized in green supply chain management, it is recommended that universities and research institutions strengthen their collaboration with enterprises and jointly establish an industry-education integration model. By enabling students to actively participate in low-carbon technological innovation projects, they can not only enhance their practical skills and foster innovative thinking but also gain a deeper understanding of the actual demands of logistics transportation enterprises, thereby establishing a robust foundation for future career development. Simultaneously, logistics transportation enterprises should reinforce the recruitment and training of talents specialized in technological green supply chain management to provide a solid talent pool that supports low-carbon technological innovation. Through such collaboration, we can collectively propel the advancement of technological green supply chain management and contribute to achieving "Dual Carbon Target".

2.3 Carbon trading market and policy support

To actively encourage logistics transportation enterprises' participation in the carbon trading market, the government has also implemented a series of policy support and incentive measures. For instance, tax incentives and financial support have been provided by the government to promote green supply chain management and low-carbon technology innovation activities among logistics transportation enterprises. The implementation of the policies not only reduces emission reduction costs for businesses but also enhances their market competitiveness, thereby promoting the establishment and development of green supply chains. The government also plays a crucial role in regulating and enforcing the carbon trading market ^[6]. It has enhanced oversight of corporate carbon emissions and imposed stringent penalties on those exceeding emissions, ensuring the equitable, impartial, and efficient functioning of the market.

2.4 Strategies for sustainable development of logistics transportation enterprises

The core content of sustainable development strategies for logistics transportation enterprise lies in the establishment of sustainable development goals. Logistics transportation enterprises should set clear targets and strive for efficient utilization of resources based on their own actual situation. Emission reduction targets encompass reducing carbon emissions and waste generation, while resource utilization efficiency targets involve enhancing energy utilization efficiency and minimizing water consumption. To accomplish these objectives, logistics transportation enterprises should formulate detailed action plans that include technological innovation, equipment upgrading, process improvement, and other measures. Regular assessment of goal achievement is necessary to ensure successful implementation.

3.The training of green supply chain and technology talents in logistics transportation

3.1 Problems of the existing education system

The lack of specialized courses and training programs in technological green supply chain management within the existing education system hinders students' ability to meet the practical demands of this field in terms of knowledge reserves and skill level. To address this issue, it is essential for the education system to enhance the integration and organization of technological green supply chain management concepts ^[7], while establishing a comprehensive training program and curriculum framework that enables students to fully acquire relevant knowledge and skills. However, the current education system falls behind industry demand in talent training for logistics transportation in technological green supply chain management. With the continuous improvement of social awareness regarding green environmental protection, the demand for talents in logistics transportation and technological green supply chain management is increasing. However, the existing education system's training mode and curriculum fail to keep up with industry development, resulting in a significant gap between talent training and industry demand.

3.2 Trend of industry development and demand for technology talent

With the strengthening of environmental protection regulations by governments worldwide and the growing consumer preference for eco-friendly products, green supply chain management industry is witnessing a rapid surge in technological development. Consequently, there will be a significant increase in demand for logistics transportation supply chain professionals with a strong environmental consciousness within the realm of supply chain management ^[8]. The individuals must not only possess expertise in traditional logistics transportation and supply chain management knowledge but also demonstrate profound environmental awareness and an unwavering commitment to sustainable development. The rapid growth of the industry will generate a demand for logistics transportation supply chain professionals with specialized expertise in various fields. However, there is a relative scarcity of highly skilled talents proficient in technological green supply chain knowledge and skills. This situation will somewhat impede the swift progress of the industry.

4.Design of training green supply chain and technology talents in logistics transportation

4.1 Optimization of curriculum

With the continuous enhancement of societal environmental awareness, technological green supply chain management has emerged as a pivotal determinant for logistics transportation enterprises' competitiveness. Consequently, it is imperative to augment the inclusion of technology and green supply chain management courses in the curriculum. The optimization

of curriculum should be directed towards interdisciplinary approaches by integrating diverse knowledge domains such as engineering, management, and economics ^[9]. These courses should focus on fostering students' innovative and practical abilities while guiding them to apply acquired knowledge in resolving real-world challenges. By incorporating interdisciplinary courses into their education, students can broaden their perspectives and enhance their overall aptitude to better adapt to future societal demands.

Case analysis and practice are crucial for enhancing students' ability to solve practical problems. Successful cases of technological green logistics transportation in supply chain management should be incorporated into the curriculum for thorough analysis and discussion. Through case studies, students can gain a comprehensive understanding of the practical operations and application scenarios related to technological green supply chain management, thereby improving their capacity to apply acquired knowledge in real-world situations. Simultaneously, practical teaching serves as an essential means of fostering problem-solving skills among students by providing opportunities such as internships and projects that enable them to exercise their abilities and qualities.

4.2 Strengthening of practical skills

Encouraging students to actively engage in innovative and entrepreneurial activities is a crucial approach to foster their innovation consciousness and practical competence. Schools can organize competitions on logistics transportation supply chain management, among other initiatives, to provide a platform for students to showcase their talents. Through active participation in these activities, students can enhance their capacity for innovative thinking and practical application while deepening their understanding of logistics transportation in green supply chain management. Additionally, inviting industry experts for school lectures and guidance sessions can offer students more opportunities for learning resources and hands-on experiences.

Arranging internships for students in logistics transportation enterprises is an effective approach to enhance their practical capabilities ^[10]. By participating in technological green logistics transportation projects within the enterprise, students can gain a profound understanding of actual business operations and acquire specific processes and methods related to green supply chain management. This internship and training model facilitates the application of theoretical knowledge into practical work, thereby improving students' professional competence and practical skills. Simultaneously, logistics transportation enterprises can also identify suitable talents through internships and training programs, providing robust support for their own development.

4.3 Construction of teaching staff

The construction of the teaching staff is crucial for cultivating talents of logistics transportation in green supply chain management, and it requires strengthening from multiple perspectives. Introducing exceptional talents serves as a significant approach to enhancing the teaching staff. By actively recruiting individuals with profound knowledge and experience in the field, we can rapidly elevate the overall competence of our teachers and establish a solid talent foundation for nurturing future experts in this field. Additionally, reinforcing training programs and communication channels also proves to be an effective means of improving teacher quality. The organization of teachers' participation in logistics transportation supply chain management can enable them to timely grasp the latest concepts and technologies in green supply chain, thereby enhancing their professional level and teaching ability. University-enterprise cooperation is also an essential approach to strengthen the construction of teaching staff. By establishing cooperative relationships with green logistics transportation enterprises, training can enhance their practical guidance skills, enabling them to better meet the requirements for educators in green supply chain management.

5. Conclusions and prospects

5.1 Summary of research

The paper aims to explore the impact of the "Dual Carbon Target" on the education of logistics transportation talents in supply chain management. We emphasize that there is a need to revise the training direction for educating students in logistics transportation of green supply chain management. Traditional education in logistics transportation focuses on efficiency improvement and cost control. However, in the new digital era, greater emphasis shall be put on students' understanding

of green and low-carbon concepts as well as enhancing their abilities for technological innovation in green logistics transportation. The implementation of the “Dual Carbon Target” for cultivating logistics transportation talents necessitates a comprehensive innovation in curriculum, teaching methods, and practical activities. Furthermore, the paper stresses the importance of practicality in talent development. By means of case analysis, field investigation, and other approaches, students can acquire theoretical knowledge on logistics transportation in supply chain management and apply it to solve real-world problems. Such a practical training approach contributes to enhancing students’ overall quality and innovative capabilities, enabling them to better meet market demands under “Dual Carbon Target”.

5.2 Development trend

With the increasing global awareness of environmental protection, the green low carbon concept is gradually gaining popularity. In the future, this concept will become the mainstream values across all sectors of society and drive industries towards a more environmentally friendly and sustainable direction. Technological innovation serves as another crucial factor in promoting the development of logistics transportation in green supply chains. As big data technologies such as Internet of Things mature, their application will play an increasingly important role in logistics transportation supply chain management. The utilization of the technologies will enhance the efficiency of managing and reduce costs for logistics transportation enterprises.

The realm of green logistics transportation supply chain management encompasses various domains, and future advancements will place greater emphasis on cross-border collaboration and cooperative development. By amalgamating the resources and technological advantages from diverse industries, we can collectively propel the technological innovation and progression of green logistics transportation in supply chain management. The trend towards cross-border cooperation and collaborative development will facilitate the establishment of a more comprehensive and efficient industrial chain and ecosystem within the sphere of green supply chain management.

5.3 Contributions to the industry, economy and society

With the growing focus on environmental protection and sustainable development, the promotion and implementation of the findings presented in this paper hold immense potential and profound significance. Primarily, within the current context of increasingly stringent environmental regulations and intense market competition, achieving a green and low-carbon transformation has become pivotal for logistics transportation enterprises to enhance their competitiveness. The promotion and application of the findings in this paper can also have a positive impact on regional economic development. The introduction of green and low-carbon technologies will drive the growth of related industries, such as energy-saving and environmental protection equipment, clean energy, thereby creating new opportunities for regional economic expansion. Cultivating talents with expertise in technological and green and low-carbon concepts will provide support for the innovative development of the regional economy. The talented logistics transportation individuals will dedicate themselves to research and developing more advanced green and low-carbon technologies to facilitate the eco-friendly transformation and upgrading of the regional economy.

Finally, the promotion and application of the findings in this paper will also contribute to enhancing overall environmental awareness in society. Through the dissemination and implementation of green and low-carbon technologies, individuals will develop a deeper comprehension of the significance of environmental protection, thereby fostering a sustainable lifestyle that is both environmentally friendly and resource-efficient. Simultaneously, by propagating and advocating for the principles of green living and low-carbon practices, individuals can be inspired to actively engage in environmental conservation initiatives, thus making valuable contributions towards the Earth’s sustainable development.

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Conflict of Interests

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

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Employee Retention of Internship Management Trainees for Hospitality Corp.X: A Research Based on Herzberg's Two-Factor Theory

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Abstract: In response to the persistent issue of internship management trainees at Hospitality Corp.X being reluctant to remain employed after completing their internships in recent years. This study investigates the underlying causes through questionnaire surveys, Herzberg's Two-Factor Theory (hygiene factors and motivational factors), and factor analysis. The findings reveal that trainees' overall job satisfaction score averages merely 2.53 ± 0.68 (on a 5-point scale), with key influencing factors including: compensation and benefits (lowest score, mean=2.3579), career development (unclear promotion pathways), work content (repetitive and monotonous tasks), psychosocial environment (ineffective communication and psychological stress), and organizational management (rigid processes and unfair performance evaluations). Comparative analysis demonstrates that the hotel's intern compensation and benefits significantly lag behind local industry peers. To address these issues, recommendations are proposed, such as optimizing compensation structures, restructuring career development frameworks, diversifying job responsibilities, enhancing psychological support systems, and streamlining management processes. These measures aim to improve trainees' retention willingness while ensuring the stability of service quality and competitive advantage for the hotel.

Keywords: Job Satisfaction; Herzberg's Two-Factor Theory; Hospitality Industry; Compensation and Benefits; Organizational Management

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1.Introduction

Established in 1996 as the successor to the Southwest Timber Market Guesthouse, Hospitality Corp.X has evolved over nearly three decades into Yunnan Province's largest independent hotel by scale. Specializing in conference services, the hotel boasts 1,677 guest rooms, 36 conference facilities, and a staff of over 2,200 employees. With a capacity to host 6,000 guests simultaneously for conferences, dining, and accommodation, it is renowned as the "Conference Capital of Southwest China." In recent years, alongside its expanding business operations, Hospitality Corp.X has experienced rapid growth in employee numbers. However, this workforce expansion has been accompanied by high turnover rates among grassroots employees. The hotel's HR department faces daily inflows and outflows of employees, resulting in a heavy workload that leaves little capacity to address critical issues such as skills training and the implementation of employee benefits. As a quintessential service-oriented industry, the hospitality sector evaluates excellence not only through physical infrastructure but also through

service quality. Under modern industry standards, the provision of attentive and personalized service is a key determinant of a hotel's service reputation. However, frequent turnover among grassroots employees leads to inconsistent service delivery, ultimately undermining the hotel's service quality, brand reputation, and operational stability.

While contemporary research in corporate human resource management suggests that a moderate level of employee turnover can reflect natural merit-based attrition, which may benefit organizational health, excessive short-term turnover and an inability to retain talent introduce significant operational instability. Such issues not only escalate training and management costs but also inflate labor replacement costs. Furthermore, they risk eroding morale among remaining staff, potentially triggering a “domino effect” of resignations that destabilizes workforce cohesion. Consequently, organizations must proactively monitor grassroots employee retention and implement targeted strategies to reduce attrition rates, thereby ensuring workforce stability and sustained employee engagement.

To address this challenge, the hotel has established university-industry collaboration agreements with local multiple higher education institutions. Through these partnerships, it recruits final-year students majoring in hospitality management as management trainees for internships, with the expectation of transitioning them into full-time roles post-graduation. This strategy serves three purposes:

The first, mitigating grassroots staffing gaps caused by high turnover through immediate workforce supplementation. The second, developing a leadership pipeline by grooming trainees for future managerial positions. The third, addressing graduate employment pressures for participating universities, creating a tripartite benefit structure for the hotel, higher education institutions, and students.

Per the collaboration agreements, trainees are required to sign employment contracts with the hotel prior to completing their internships to formalize their post-graduation employment. However, all current trainees have declined to enter into such agreements, explicitly reserving the right to pursue alternative career paths after their internships conclude.

To address this issue, we integrate human resource management theories with Hospitality Corp.X's operational context to identify the underlying causes of management trainees' reluctance to remain employed post-internship. Based on this analysis, targeted recommendations and practical solutions are proposed to enhance management trainees' retention willingness.

2.Theoretical Foundation and Literature Review

2.1 Theoretical Foundation

A review of the literature reveals that Hospitality Corp.X's challenge in retaining management trainees post-internship aligns with broader workforce attrition patterns across industries. Job dissatisfaction, driven by unmet needs—whether material (e.g., compensation), psychological (e.g., recognition), or a combination of both—emerges as the primary determinant of turnover. This phenomenon is strongly supported by Herzberg's Two-Factor Theory, which distinguishes between hygiene factors (e.g., salary, working conditions) that prevent dissatisfaction and motivators (e.g., career growth, responsibility) that foster engagement. When either category fails to meet employee expectations, attrition risks escalate.

A seminal framework in human resource management, Herzberg's Two-Factor Theory (also known as the Motivation-Hygiene Theory), proposed by American management scholar Frederick Herzberg in the 1950s, provides a robust explanation for the observed phenomenon. This theory posits that employees' job satisfaction is influenced by two distinct categories of factors—hygiene factors and motivators—each fulfilling divergent functional roles. The definition of hygiene factors is basic environmental and contextual elements such as salary, benefits, working conditions, and peer relationships. The function of these factors address employees' fundamental needs for financial security and workplace stability. Their absence directly triggers job dissatisfaction, potentially leading to resentment or disengagement. While adequate hygiene factors prevent dissatisfaction, they alone cannot foster long-term commitment or motivation. The definition of motivators is intrinsic drivers including achievement, recognition, professional growth opportunities, challenging responsibilities, and a sense of purpose. The function of these factors fulfill higher-order psychological needs, cultivating job satisfaction, intrinsic motivation, and loyalty. The motivators elevate performance and retention by enabling employees to derive meaning and pride from their work.

The Herzberg's theory underscores the dual necessity of addressing both hygiene factors and motivators to retain employees

effectively. Neglecting either category jeopardizes retention: poor hygiene factors drive dissatisfaction, while insufficient motivators fail to inspire sustained engagement. This dual framework aligns with Hospitality Corp.X's challenge, where management trainees' reluctance to stay may stem from deficiencies in compensation (hygiene) and career development prospects (motivators).

2.2 Literature Review

Scholarly research on employee turnover has proliferated since the emergence of modern enterprises, with a substantial body of research emerging across disciplines. Investigative efforts have primarily focused on three core dimensions: work environment (encompassing physical conditions, managerial practices, and organizational culture), alternative employment opportunities (influenced by labor market fluidity and industry competitiveness), and job satisfaction (encompassing both intrinsic and extrinsic motivational factors). These studies collectively underscore the multifaceted nature of attrition, where dissatisfaction in any single dimension may catalyze turnover intentions, while systemic improvements across these domains can significantly enhance retention outcomes. Regarding the application of Herzberg's Two-Factor Theory in hospitality human resource management, the study by Tsai et al. (2010) empirically validated this framework through a survey of hotel employees in Taipei City. Their findings demonstrated that compensation (representing a hygiene factor) and promotion opportunities (a motivator) significantly influence employee retention or turnover. Building on this precedent, the present research narrows its focus to job satisfaction as a critical mediator between these dual factors and retention outcomes. Prior studies in this domain consistently highlight how deficiencies in either hygiene factors (e.g., inadequate pay) or motivators (e.g., stagnant career paths) disproportionately affect service industry employees, whose job performance is tightly coupled with emotional and psychological engagement. As evidenced in prior discussions, employees' job satisfaction directly influences turnover rates. Furthermore, within the service industry, job satisfaction significantly impacts service quality and organizational competitiveness. To this end, we have conducted a focused review of literature pertaining to hospitality employees' job satisfaction, synthesizing existing findings through two lenses, include driving factors and organizational impacts.

2.2.1 Drivers of Job Satisfaction

The synthesis of the literature identifies three primary drivers of employee job satisfaction, include job-related factors, organizational management practices, and reward systems.

Regarding job-related elements, compensation and promotion emerge as critical determinants. Wen et al. (2022) found that pay satisfaction and advancement opportunities significantly enhance employee engagement while reducing turnover intentions. Similarly, Tian and Pu's (2008) study on China's hospitality industry confirmed career development prospects as a pivotal predictor of satisfaction. Leadership and peer relationships further amplify these effects: Matzler and Renzl (2006) demonstrated that trust in management and colleagues indirectly strengthens employee loyalty through satisfaction, while Cai et al. (2010) revealed that leadership quality and internal marketing (e.g., communication support) positively correlate with satisfaction, whereas job stress exerts a counteractive influence.

Regarding organizational management factors, in terms of institutionalized management, Tao et al. (2013) developed a model demonstrating that standardized management practices in hotels—through regulating managerial behaviors and strengthening organizational culture—indirectly enhance employee job satisfaction. Additionally, professional competency and training play a critical role: Mekoth et al. (2023) emphasized that professional skill development programs improve work continuity among hospitality staff, with job satisfaction acting as a mediating variable in this relationship.

Regarding incentive systems, Mazlan et al. (2021) found that financial rewards (e.g., performance-based bonuses) directly enhance hotel employees' satisfaction, thereby fostering loyalty. However, non-financial rewards—such as work environment enhancements or recognition programs—require integration with complementary strategies (e.g., career development initiatives) to achieve comparable effectiveness.

2.2.2 Organizational Impacts of Job Satisfaction

The organizational implications of employee job satisfaction are multifaceted. Firstly, it reduces turnover rates: multiple studies confirm that satisfaction curbs turnover intentions by enhancing engagement (Wen et al., 2022) or loyalty (Mazlan

et al., 2021). Secondly, it elevates service performance: Fang et al. (2021) noted that highly satisfied employees are more inclined to deliver quality services, creating a virtuous cycle of “satisfaction-service quality-organizational competitiveness”. Liu and Yang (2009) further demonstrated that employee satisfaction indirectly influences corporate profitability through customer satisfaction. Thirdly, it fosters organizational commitment: Cai et al.’s (2010) integrated model revealed significant positive correlations among job satisfaction, organizational commitment, and job performance, highlighting satisfaction’s role as a linchpin for sustained workforce alignment and productivity.

2.2.3 Literature Synthesis

The review of existing literature reveals that most studies employ structural equation modeling (SEM) to analyze path relationships among variables (Matzler & Renzl, 2006; Wen et al., 2022), while some integrate artificial neural networks (ANNs) to predict dynamic satisfaction patterns (Tian & Pu, 2008). The findings consistently recommend that organizations enhance job satisfaction through institutionalized management practices (Tao et al., 2013), financial incentives (Mazlan et al., 2021), and career development support (Tian & Pu, 2008), thereby reducing employee turnover and strengthening organizational competitiveness. These methodological approaches and conclusions provide critical guidance for the design and execution of the present investigation.

Factor Analysis is a statistical method used to identify latent structures among variables, categorized into Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) (Fabrigar et al., 1999). EFA is applied in hypothesis-free contexts to extract common factors through dimension reduction, explaining variable correlations (Costello & Osborne, 2005), and it serves as a robust tool for uncovering latent drivers of satisfaction. Fabrigar et al. (1999) emphasized that EFA simplifies variable structures via rotated factor loadings matrices, making it particularly suited for exploratory research. In hospitality human resource management, Liu and Yang (2009) utilized EFA to extract factors such as “work environment” and “management support”, providing empirical foundations for targeted satisfaction interventions.

While both Principal Component Analysis (PCA) and EFA are dimension reduction techniques, but PCA focuses on variance maximization, whereas EFA explains underlying relationships among variables (Jolliffe & Cadima, 2016). Given the objectives of this study is identify factors influencing internship management trainees’ job satisfaction at the hotel and propose Herzberg’s Two-Factor Theory-informed optimizations. EFA is methodologically appropriate for its capacity to reveal latent constructs in exploratory settings.

3. Research Methodology

This study employs a questionnaire survey method to investigate the reasons behind internship management trainees’ reluctance to accept post-internship employment at Hospitality Corp.X. A structured questionnaire was administered to all internship management trainees from partnered universities currently working at the hotel.

3.1 Questionnaire Design

The questionnaire was structured based on Herzberg’s Two-Factor Theory and tailored to the practical work experiences of the internship management trainees. A widely validated instrument for assessing general job satisfaction named The Minnesota Satisfaction Questionnaire (MSQ) has served as the foundational framework. The MSQ includes 20 items spanning diverse dimensions of workplace interactions, with demonstrated high reliability (Cronbach’s alpha coefficients ranging from 0.85 to 0.91). To align with the hotel’s operational context, adaptations were made to incorporate factors specific to hospitality trainees, such as career development pathways and psychosocial support systems. The final questionnaire utilized a 5-point Likert scale (1 = strongly dissatisfied; 5 = strongly satisfied) for quantitative analysis.

The questionnaires were administered in paper format and targeting all internship management trainees at the hotel. A total of 228 questionnaires were distributed, with 228 returned and 227 deemed valid, the valid response rate is 99.56%.

3.2 Reliability and Validity Analysis of Questionnaire Results

Reliability analysis of the collected questionnaire data, measured via Cronbach’s alpha coefficient, yielded a value of 0.943. According to established psychometric standards (Nunnally, 1978), Cronbach’s alpha ranges from 0 to 1, with values above 0.7 indicating high internal consistency. The coefficient of 0.943 in this study demonstrates excellent reliability, confirming that the questionnaire design is logically structured and the collected data are highly consistent and reliable.

Following reliability and validity analyses, the suitability of the questionnaire data for information extraction was further assessed using the Kaiser-Meyer-Olkin (KMO) measure, a standard validity assessment tool for evaluating the appropriateness of exploratory factor analysis (EFA). The KMO statistic ranges from 0 to 1, reflecting the ratio of partial correlations to total correlations among all variables. A value closer to 1 indicates stronger validity and greater suitability for extracting latent factors (Kaiser, 1974).

Table 1. KMO Measure and Bartlett's Test of Sphericity

Measurement Tool	Value
Kaiser-Meyer-Olkin (KMO) Measure	0.852
Bartlett's Test of Sphericity	
Chi-Square (χ^2)	5185.462
Degrees of Freedom (<i>df</i>)	610
Significance (<i>p</i> -value)	<i>p</i> <0.001

As evidenced in Table 1, the Kaiser-Meyer-Olkin (KMO) measure of 0.852 exceeds the conventional threshold of 0.8, indicating excellent sampling adequacy and validating the dataset's suitability for information extraction through factor analysis. Furthermore, Bartlett's test of sphericity yielded a statistically significant result ($\chi^2=5185.462, p<0.001$), robustly rejecting the null hypothesis of variable independence. These outcomes collectively confirm the dataset's structural validity and appropriateness for Exploratory Factor Analysis (EFA). Consequently, EFA will be employed to identify latent constructs underlying management trainees' job satisfaction, aligning with the study's objective to derive actionable insights for retention strategy optimization.

3.3 Descriptive Statistics of Questionnaire Items

Descriptive statistics for responses to individual questionnaire items are summarized to highlight the central tendency and variability of trainees' satisfaction ratings. For conciseness, minimum (Min), maximum (Max), and mean (M) values are reported (see Table 2). This streamlined presentation focuses on identifying critical areas of dissatisfaction, such as low mean scores in compensation or career development.

Table 2. Descriptive Statistics of Questionnaire Item Scores

Item	N	Min	Max	Mean
My salary and benefits are highly reasonable	227	1.00	5.00	2.3579
The hotel has provided clear career development planning	227	1.00	5.00	3.1148
My work is valuable and meaningful	227	1.00	5.00	3.0145
My job performance is evaluated fairly	227	1.00	5.00	3.1106
Leadership maintains open communication with grassroots staff	227	1.00	5.00	3.1357
Leaders make sound decisions	227	1.00	5.00	3.5986
I am not required to engage in unethical practices at work	227	1.00	5.00	3.7493
My job responsibilities are stable	227	1.00	5.00	3.6873
Leaders provide timely recognition for good performance	227	1.00	5.00	3.6254
The hotel provides adequate tools/resources to ensure work efficiency	227	1.00	5.00	3.8524
Opportunities for cross-departmental skill development are available	227	1.00	5.00	3.9385
I understand the hotel's operational goals and related measures	227	1.00	5.00	3.5432

Item	N	Min	Max	Mean
I have opportunities to mentor colleagues	227	1.00	5.00	3.4845
I am granted sufficient autonomy in my work	227	1.00	5.00	3.5641
Certain tasks allow independent decision-making without reporting to leaders	227	1.00	5.00	3.5726
I can complete my tasks independently without interruptions	227	1.00	5.00	3.8573
My working environment is satisfactory	227	1.00	5.00	3.7241
Strong teamwork exists among colleagues	227	1.00	5.00	3.8372
Interdepartmental collaboration is efficient	227	1.00	5.00	3.8567
I frequently receive/give help during work	227	1.00	5.00	4.1975

Notes:

N = 227 (valid responses).

Likert scale: 1 = strongly dissatisfied; 5 = strongly satisfied.

As shown in Table 2, the items with relatively low scores in terms of job satisfaction are: “My salary and benefits are highly reasonable”; “My work is valuable and meaningful”; “My job performance is evaluated fairly”; “I am granted sufficient autonomy in my work”; and “Leadership maintains open communication with grassroots staff”.

3.4 Factor Analysis of Variables

To identify the latent factor structure influencing internship management trainees’ job satisfaction, we conducted Exploratory Factor Analysis (EFA) on the questionnaire variables. As established in prior sections, the dataset’s suitability for EFA was confirmed by a KMO measure of 0.852 and a significant Bartlett’s test of sphericity ($\chi^2=5185.462, p<0.001$).

Table 3. Factorial Variance Analysis of Questionnaire Data

Item	Initial	Extraction
My salary and benefits are highly reasonable	1.000	0.648
The hotel has provided clear career development planning	1.000	0.821
My work is valuable and meaningful	1.000	0.749
My job performance is evaluated fairly	1.000	0.721
Leadership maintains open communication with grassroots staff	1.000	0.824
Leaders make sound decisions	1.000	0.831
I am not required to engage in unethical practices at work	1.000	0.734
My job responsibilities are stable	1.000	0.835
Leaders provide timely recognition for good performance	1.000	0.861
The hotel provides adequate tools/resources to ensure work efficiency	1.000	0.731
Opportunities for cross-departmental skill development are available	1.000	0.769
I understand the hotel’s operational goals and related measures	1.000	0.828
I have opportunities to mentor colleagues	1.000	0.789
I am granted sufficient autonomy in my work	1.000	0.751
Certain tasks allow independent decision-making without reporting to leaders	1.000	0.819

Item	Initial	Extraction
I can complete my tasks independently without interruptions	1.000	0.812
My working environment is satisfactory	1.000	0.724
Strong teamwork exists among colleagues	1.000	0.732
Interdepartmental collaboration is efficient	1.000	0.711
I frequently receive/give help during work	1.000	0.613

Extraction Method: Principal Factor Analysis.

Communalities represent the extent to which the original variance of each variable can be explained by the extracted common factors. As shown in Table 3, the minimum communality extraction value across all items is 0.613, with most exceeding 0.7. This indicates that the extracted common factors account for over 60% of the variance in the original variables, with minimal loss of explanatory information. Consequently, the derived factors exhibit robust explanatory power in interpreting trainees' job satisfaction, validating the effectiveness of the exploratory factor analysis (EFA) in capturing the latent structure of satisfaction dynamics.

After extracting the communalities, we further introduce the total variance explained to demonstrate the number of factors extracted through the analysis, and the cumulative variance contribution rate of the extracted factors to the total variance of all original variables.

Table 4. Total Variance Explained Analysis of Questionnaire Data

Component	Initial Eigenvalues			Extraction Sums of Squared Loading			Rotation Sums of Squared Loading		
	Total	% of Vari- ance	% of Cumu- lative	Total	% of Vari- ance	% of Cumu- lative	Total	% of Vari- ance	% of Cumu- lative
1	9.001	45.007	45.012	9.001	45.007	45.012	4.158	20.789	20.789
2	2.011	10.048	55.485	2.011	10.048	55.485	3.739	18.693	39.482
3	1.527	7.634	62.696	1.527	7.634	62.696	3.492	17.458	56.940
4	1.452	7.250	69.938	1.452	7.250	69.938	2.169	10.844	67.784
5	1.278	6.388	75.647	1.278	6.388	6.326	1.708	8.541	76.326
6	0.615	3.074	79.463						
7	0.514	2.571	81.961						
8	0.468	2.339	84.315						
9	0.403	2.013	86.357						
10	0.376	1.879	88.241						
11	0.358	1.788	89.978						
12	0.339	1.694	91.673						
13	0.299	1.497	93.182						
14	0.273	1.367	94.546						
15	0.252	1.259	95.845						
16	0.231	1.153	96.946						
17	0.187	0.933	97.895						
18	0.155	0.776	98.458						
19	0.141	0.706	99.376						
20	0.125	0.627	100.000						

Extraction Method: Principal Factor Analysis.

Rotation Method: Varimax with Kaiser Normalization.

As shown in Table 4, the initial eigenvalues of the first five components exceed 1.0, indicating that these five common factors adequately explain the variance in job satisfaction determinants. In other words, these five factors essentially represent all original influencing variables, allowing the consolidation of the initial 20 variables into five comprehensive dimensions. Consequently, only these five factors were retained for our analysis. Notably, their cumulative variance contribution rate reaches 75.647%, demonstrating robust explanatory power for the underlying constructs of job satisfaction.

After extracting five common factors through Principal Factor Analysis, it is necessary to define these factors rationally based on practical contexts to enable reasonable interpretation of their influence on job satisfaction. Following comprehensive consideration of practical circumstances and empirical insights, the five factors are defined as: compensation and benefits, career development, work content, psychosocial environment, and organizational management.

Table 5. Unrotated Factor Loading Matrix

Item	Component				
	1	2	3	4	5
My salary and benefits are highly reasonable	0.731	-0.224	0.163	0.052	0.171
The hotel has provided clear career development planning	0.784	-0.179	0.173	-0.082	-0.197
My work is valuable and meaningful	0.721	-0.339	0.281	0.189	-0.086
My job performance is evaluated fairly	0.732	0.079	-0.071	-0.331	0.258
Leadership maintains open communication with grassroots staff	0.771	0.098	-0.109	-0.429	-0.189
Leaders make sound decisions	0.009	0.631	0.681	-0.005	0.069
I am not required to engage in unethical practices at work	0.691	0.298	-0.159	0.371	0.091
My job responsibilities are stable	-0.006	0.587	0.689	-0.071	0.039
Leaders provide timely recognition for good performance	0.697	-0.428	0.247	0.177	-0.161
The hotel provides adequate tools/resources to ensure work efficiency	0.719	0.162	-0.161	-0.381	0.127
Opportunities for cross-departmental skill development are available	0.637	-0.088	0.001	0.011	0.589
I understand the hotel's operational goals and related measures	0.731	-0.389	0.287	0.189	-0.135
I have opportunities to mentor colleagues	0.757	0.122	-0.168	-0.409	-0.067
I am granted sufficient autonomy in my work	0.552	-0.128	0.038	0.051	0.702
Certain tasks allow independent decision-making without reporting to leaders	0.778	-0.278	0.239	-0.066	-0.262
I can complete my tasks independently without interruptions	0.729	0.223	-0.047	-0.422	-0.208
My working environment is satisfactory	0.621	0.367	-0.248	0.348	-0.065
Strong teamwork exists among colleagues	0.681	0.268	-0.188	0.387	0.047
Interdepartmental collaboration is efficient	0.685	0.267	-0.159	0.311	-0.190
I frequently receive/give help during work	0.600	0.357	-0.162	0.223	-0.175

Extraction Method: Principal Factor Analysis.

As illustrated in Table 5, the unrotated factor loading matrix reveals that the majority of variables exhibit significantly higher loading on Component 1 compared to other components. This pattern indicates that all variables correlate more strongly with the first common factor, underscoring its predominant influence on job satisfaction relative to the remaining factors.

After observing the factor loading matrix obtained from the questionnaire data, we identified the need to simplify the factor structure and enhance the interpretability of each common factor. Currently, the most commonly used method is the Varimax orthogonal rotation method. In simple terms, this method rotates the initial loading matrix, essentially reorienting the coordinate system in a geometric sense. This approach allows the common factors to better explain the corresponding influencing factors. We subsequently applied this method to process the questionnaire component matrix data.

Table 6. Rotated Factor Loading Matrix

Item	Component				
	1	2	3	4	5
My salary and benefits are highly reasonable	0.582	0.2496	0.232	0.418	-0.023
The hotel has provided clear career development planning	0.679	0.461	0.227	0.089	0.008
My work is valuable and meaningful	0.789	0.123	0.221	0.218	-0.009
My job performance is evaluated fairly	0.188	0.651	0.202	0.482	0.025
Leadership maintains open communication with grassroots staff	0.312	0.831	0.241	0.061	-0.019
Leaders make sound decisions	-0.051	-0.008	0.069	0.021	0.922
I am not required to engage in unethical practices at work	0.213	0.175	0.759	0.279	0.043
My job responsibilities are stable	-0.029	0.028	0.016	-0.024	0.921
Leaders provide timely recognition for good performance	0.868	0.152	0.188	0.165	-0.091
The hotel provides adequate tools/resources to ensure work efficiency	0.152	0.719	0.263	0.351	-0.002
Opportunities for cross-departmental skill development are available	0.258	0.241	0.205	0.783	-0.032
I understand the hotel's operational goals and related measures	0.857	0.147	0.189	0.192	-0.028
I have opportunities to mentor colleagues	0.229	0.811	0.257	0.168	-0.046
I am granted sufficient autonomy in my work	0.218	0.132	0.141	0.843	-0.005
Certain tasks allow independent decision-making without reporting to leaders	0.779	0.431	0.161	0.057	0.004
I can complete my tasks independently without interruptions	0.249	0.812	0.268	0.021	0.089
My working environment is satisfactory	0.122	0.214	0.813	0.111	0.014
Strong teamwork exists among colleagues	0.223	0.141	0.784	0.252	0.003
Interdepartmental collaboration is efficient	0.278	0.259	0.739	0.027	0.021
I frequently receive/give help during work	0.162	0.286	0.687	-0.012	0.075

Extraction Method: Principal Factor Analysis.
Rotation Method: Varimax with Kaiser Normalization.

The data results in Table 6 represent the rotated factor loading matrix after applying the Varimax orthogonal rotation method, with convergence achieved after 5 iterations.

Next, the questionnaire data scores must be calculated to draw relevant conclusions. The component score coefficient matrix is presented in Table 7. Calculations revealed that the questionnaire's mean score is 2.53 ± 0.68 (on a 5-point scale).

Table 7. Component Score Coefficient Distribution

Score Range	Frequency	Percentage
0.65–1.97	44	19.38%
2.01–2.99	133	58.59%
3.04–3.90	50	22.03%

4. Research Findings and Discussion

4.1 Research Findings

By administering a job satisfaction survey to internship management trainees at the hotel and conducting exploratory factor analysis (EFA), the study revealed an overall job satisfaction score of 2.53 ± 0.68 (on a 5-point scale). Among the five primary factors extracted from the 20 questionnaire items—compensation and benefits, career development, work content, psychosocial environment, and organizational management—the compensation and benefits factor contributed most significantly to job satisfaction, accounting for over 45% of the variance, followed by career development at over 10%.

An analysis of individual item scores identified the following lowest-ranked dimensions (ascending order of dissatisfaction): “My salary and benefits are highly reasonable” (lowest mean score); “My work is valuable and meaningful”; “My job performance is evaluated fairly”; “The hotel has provided clear career development planning”; “Leadership maintains open communication with grassroots staff”.

The analysis of questionnaire data reveals that internship management trainees' reluctance to remain employed at Hospitality Corp.X post-internship is strongly linked to five dimensions: compensation, work content, career development, psychosocial environment, and organizational management. Under Herzberg's Two-Factor Theory (1959), compensation and psychosocial environment are categorized as hygiene factors, while work content, career development, and organizational management are fall under motivators. Next, we need to conduct a detailed assessment of the hotel's current practices in these key areas to formulate effective solutions.

4.2 Discussion

In order to contextualize the dissatisfaction with compensation at Hospitality Corp.X, we compared its salary and benefits structure with another local two peer hotels that share similar operational scales and also recruit management trainees from universities. The comparative findings are summarized in Table 8.

Table 8. Compensation and Benefits for Internship Management Trainees in Local Hotels

Category	Hospitality Corp.X	Luxury Hospitality Group A	Boutique Hotel Alliance B
Internship Salary	1,800 RMB/month	2,100 RMB/month	2,000 RMB/month
Employee Starting Salary	3,400 RMB/month	3,400 RMB/month	3,500 RMB/month
Staff Dormitory	4-person room, private bath-room	4-person room, private bath-room	4–6-person room, private bath-room
Accommodation Fee	Free	80 RMB/month/person	50 RMB/month/person
Utilities (Water, Electricity, etc.)	20 RMB/month/person	20 RMB/month/person	50 RMB/month/person
Staff Canteen	3 meals/day	4 meals/day	3 meals/day

Category	Hospitality Corp.X	Luxury Hospitality Group A	Boutique Hotel Alliance B
Meal Subsidy	Free	Free	10 RMB/day/person
Canteen Meal Standards	Basic Chinese meals	Chinese/Western buffet	Chinese buffet
Work Uniform	Spring/Autumn, Summer, Winter attire	Summer, Winter attire	Summer, Winter attire
Commute Shuttle	Not provided	Free	Free
Internship Insurance	Employer's Liability Insurance	Employer's Liability Insurance	Employer's Liability Insurance
Employee Insurance	Social Insurances	Social Insurances and Housing Fund	Social Insurances
Rest Days Policy	4 days/month (irregular)	6 days/month (irregular)	4 days/month (fixed)
Additional Benefits	Birthday allowances; team-building activities; holiday overtime pay	Birthday allowances; team-building activities; holiday overtime pay and allowances	Birthday allowances; team-building activities; holiday overtime pay and allowances

As evidenced in Table 8, Hospitality Corp.X lags behind its competitors (Luxury Hospitality Group A and Boutique Hotel Alliance B) across multiple dimensions of compensation and benefits for internship trainees. It directly contributes to trainees' dissatisfaction and attrition risks.

Grassroots roles at each hotel are characterized by highly repetitive and monotonous tasks across key operational departments, it contribute to trainee dissatisfaction and psychological strain. In the Housekeeping Department, daily responsibilities such as bed linen replacement, room cleaning, and amenity replenishment involve cyclical routines—staff often clean 15–20 rooms per shift under strict time constraints (e.g., 20 minutes per room), leading to physical fatigue and diminished engagement. Similarly, the Conference Services Department requires repetitive tasks like venue setup (table arrangement, signage placement) and material logistics management, which offer minimal cognitive engagement and exacerbate tedium. The Food & Beverage Department amplifies these challenges through standardized front-desk protocols: employees execute identical service routines (e.g., greeting guests, taking orders, clearing tables) over 50 times daily while adhering to stringent quality metrics (e.g., mandatory smile adherence, response times under 2 minutes), creating a high-pressure environment that compounds mental stress. This lack of task variety and intellectual challenge fails to align with these young trainees' expectations of skill development and role.

Regarding career development, it has been identified that while Hospitality Corp.X offers job rotation opportunities, it lacks clear promotion criteria post-rotation. Management trainees remain in entry-level roles for extended periods after their internships, with limited opportunities to advance to managerial positions. In terms of professional training, the hotel provides only basic operational training with monotonous content that is not linked to professional certifications. Additionally, there are no advanced courses focused on managerial competencies. During the internship period, trainees receive sporadic guidance from on-duty department supervisors or team leaders rather than having dedicated mentors. Given the hotel's high workload, supervisors are primarily occupied with their own responsibilities, leaving little time to mentor trainees, effectively relegating them to a "temporary labor force."

The Hospitality Corp.X's psychosocial environment exhibits significant deficiencies in management and crisis responsiveness. For instance, during peak conference seasons, internship management trainees in the Conference Services Department face erratic scheduling, including frequent mandatory overtime and last-minute shift extensions. However, these extended working hours are not compensated with overtime pay or compensatory time-off, fostering perceptions of exploitation and inequity.

Additionally, as a service-oriented industry, each hotel inevitably encounters unplanned urgent tasks and unjustified customer complaints, both of which impose substantial psychological stress on trainees. Despite these challenges, Hospitality Corp.X provides no formal psychological support mechanisms (e.g., counseling services), leaving employees to cope through

informal peer complaints, it makes that exacerbates disengagement and resentment.

Regarding organizational management, investigations reveal that Hospitality Corp.X suffers from cumbersome administrative processes, such as the requisitioning of low-value supplies in the Housekeeping Department and employee leave applications, both requiring three-tier leadership approvals that incur prolonged processing times and hinder operational efficiency. Additionally, while certain departments periodically collect employee feedback on work and living conditions, improvements are rarely implemented promptly. For instance, the unstable hot water supply in trainee dormitories, this is a issue reported by management trainees upon their entry, but it remained unresolved for three months. Such systemic inefficiencies and unaddressed grievances erode trust in managerial responsiveness.

5. Conclusions and Recommendations

Based on the findings from the aforementioned questionnaire survey and corresponding analysis of operational realities, the reluctance of Hospitality Corp.X's management trainees to remain employed post-internship primarily stems from the failure to synergism hygiene factors and motivators effectively. To improve trainees' retention rates, targeted and practical improvement measures should be formulated through the lens of Herzberg's Two-Factor Theory, addressing the five critical dimensions identified (compensation and benefits, career development, work content, psychosocial environment, and organizational management). These interventions aim to elevate trainees' job satisfaction and, consequently, their retention willingness. Specific recommendations include five points.

5.1 Compensation and Benefits

To address compensation and benefits, Hospitality Corp.X should first raise internship salaries from the current 1,800 RMB/month to 2,000 RMB/month, closing the gap with industry peers (e.g., Luxury Hospitality Group A at 2,100 RMB/month). To offset the increased labor costs, the hotel could moderately adjust accommodation fees (e.g., introducing a nominal 50 RMB/month dormitory charge) and utilities contributions (e.g., increasing from 20 RMB/month to 30 RMB/month), thereby alleviating the psychological disparity caused by salary inequity. Second, enriching employee benefits is critical: beyond existing holiday overtime pay, incentive-based perks such as post-internship education subsidies (e.g., 500 RMB/month for degree holders) could be introduced to boost retention willingness. Additionally, upgrading the staff canteen to a buffet format with diverse options (e.g., adding healthy meal stations and international cuisines) would enhance young trainees' daily living experience, aligning with their preferences for modern workplace amenities.

5.2 Work Content

Hospitality Corp.X can add some creative work tasks in addition to the daily work tasks of the trainees, such as letting the trainees participate in the hotel's wedding ceremony design, banquet scene layout, meeting process optimization and other tasks that need to think or put forward creativity, in order to stimulate their initiative and creativity, and at the same time can also provide them with a platform to show their knowledge and skills learned in school, enrich their work content and increase their sense of accomplishment. At the same time, it can also provide them with a platform to show their knowledge and skills learned in school, enrich their work content and increase their sense of accomplishment, and get rid of their stereotype that work is boring and tedious.

5.3 Career Development Perspective

While management trainees are provided with extensive rotational opportunities within the hotel, the absence of systematic career planning remains a structural deficiency. To address this, Hospitality Corp.X should implement a double master worker framework like, operational mentors from departmental units (e.g., front office, food & beverage) focus on skill-based coaching, while dedicated HR career consultants conduct quarterly developmental dialogues to align individual career aspirations with organizational talent strategies. A tiered career progression framework should be institutionalized, delineating clear benchmarks from the internship phase to supervisory roles (e.g., Intern → Team Leader → Department Supervisor), with each stage requiring competency validation through industry-recognized certifications such as the Golden Key Service Professional (hospitality service standards). This structure should be complemented by transparent promotion timelines (18-24 months for role transitions) and competency matrices specifying skill requirements at each tier (e.g., crisis resolution for team leaders, budget optimization for supervisors).

5.4 Psychological environment

As management trainees are essentially students transitioning into the workforce, their psychological resilience is generally weaker compared to full-time employees. In view of the mental pressure they suffer at work, Hospitality Corp.X can make targeted use of the lawn of the hotel, the gym and other places to organize some pressure-reducing activities, such as yoga classes, themed group building activities, candlelight concerts, book sharing sessions, etc., to relieve their mental pressure and enhance team cohesion. In addition, through the regular organization of symposiums between management and trainees, the establishment of the “General Manager Open Day”, the anonymous message board of WeChat, etc., so that the management can directly know their problems or demands, and then respond in a timely manner.

5.5 Organizational Management

The application of digital management tools can reduce operational costs and enhance efficiency in corporate organizational management. Hospitality Corp.X may utilize digital platforms such as Enterprise WeChat and DingTalk to optimize existing challenges, including streamlining requisition processes for guestroom department spare parts or low-value consumables, automating approval workflows for employee leave requests, shift adjustments, and temporary overtime work, thereby shortening procedural timelines. These tools also enable work hour verification for unplanned overtime, providing HR departments with auditable records for compensatory time allocation or subsidy disbursement. Furthermore, incorporating a “departmental management trainee retention rate” metric into KPI evaluations could incentivize organizational units to prioritize talent retention initiatives.

Conclusion

The reluctance of Hospitality Corp.X’s management trainees to transition into regular employees after post-internship, it fundamentally stems from a “demand-supply misalignment”. This problem means young employees’ aspirations for professional growth and value-driven work experiences remain unmet under the hotel’s existing human resource management framework. By systematically optimizing compensation and benefits (e.g., competitive salaries, education subsidies), career development pathways (e.g., dual-track advancement, mentor programs), job design (e.g., task rotation, autonomy enhancement), and organizational culture (e.g., transparent communication, psychological support), the hotel can achieve three synergistic outcomes: elevating trainees’ job satisfaction, improving post-internship retention rates, and ensuring grassroots team stability. This approach not only addresses immediate attrition risks but also strengthens service quality consistency, thereby reinforcing the Hospitality Corp.X’s brand identity as the “Conference Capital of Southwest China” through a motivated, skilled workforce capable of sustaining long-term competitiveness.

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Conflict of Interests

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

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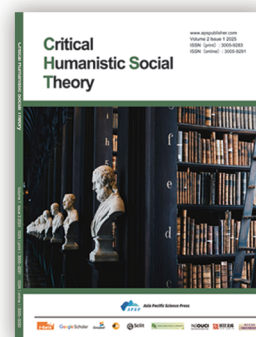
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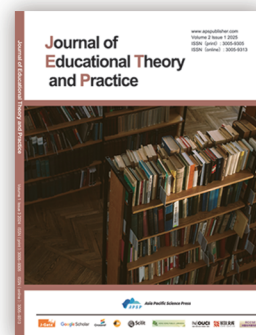
Asia Pacific Economic and Management Review is an international, peer-reviewed and open access journal which focuses on theoretical and applied studies of corporate and financial behavior. Aiming to promote the research in fields of business economics and management, it covers mainly but not limits to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

