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

Fujian Province Office, China

603-1, 6th Floor, Building B20, Chengyi North Street, Software Park, Jimei District, Xiamen City, Fujian Province, China
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Analysing the Costs Faced by Consumers in the Consumer Market--A Framework for Analysing Consumption

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Abstract: Upgrading the consumption structure is an important condition for achieving sustainable economic growth. On the basis of reviewing the frontier research on consumption cost at home and abroad, this paper gives an overview of the connotation of consumption cost and analyses its impact on consumption; at the same time, combining with the development trend of the digital economy, it tries to introduce the rational negligence theory into the consumption cost, and analyses the theoretical mechanism of the impact of consumption cost on the upgrading of the consumption structure from the perspective of rational negligence.

Keywords: Consumption Structure; Consumption Cost; Rational Negligence

Published: Mar 11, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.186>

1.Introduction

Consumption is the basis of economic growth and, moreover, the engine that drives economic growth. In recent years, with the continuous upgrading of China's consumption structure, there has been an increasing number of studies on the trend of changes in the consumption structure, influencing factors and growth effects. Compared with the research on total consumption, which focuses on the long-term and overall, consumption structure pays more attention to the characteristics of consumption at different stages of development, and to the changes in consumer choice mechanisms behind the upgrading of consumption structure.

In traditional economic analysis, cost is the basis for analysing the economic behaviour of manufacturers in their pursuit of profit maximisation, and is at the heart of manufacturer theory; however, existing consumer theory research, which tends to focus on discussing the impact of income, has largely ignored the role of cost on consumer utility and consumption choices. In fact, consumers often spend more than they earn (Kappes et al, 2021), and the total value of resources spent on the consumption process far exceeds the purchase price of the goods or services, which is essentially the cost of consumption. In the 1930s Keynes put forward the concept of the consumption function and the absolute income hypothesis, in which the institutions, traditions, and capital-technological equipment determine the distance between consumers and goods. In the 1950s, Modigliani, Brumberg and Friedman followed Keynes's series of assumptions and, on the basis of them, put forward the life-cycle model of consumption and the model of persistent income, respectively, which enriched the concept of "income".

In the 1970s, Lucas's rational expectations hypothesis and Hall's random walk model emphasised the importance of the past consumption. Random walk model highlighted the irrational expectations and uncertainty under the rational man assumption that had been neglected in the past consumption theories, and Hall argued that there are other factors affecting consumption other than income, and since then the critique of rational expectations has given rise to the theory of rational negligence. In fact, the traditional consumption theory involves income only as the wealth that can pay for the price of consumer goods, without considering the constraints of other costs in consumption behaviour on the structure of consumption, and after the mid-1980s, the theories of "oversensitivity" and "oversmoothness" were proposed, and the random walk hypothesis was challenged. After the mid-1980s, the "oversensitivity" and "oversmoothness" theories were proposed to challenge the random walk hypothesis. In particular, the theoretical hypothesis of liquidity constraints, which led to the validation of a large number of empirical hypotheses, has led to a situation in which individuals actually consume less than they are expected to consume, and the path of consumption is no longer smooth. As a result, most of the attention of researchers other than income has been focused on credit constraints on consumption, ignoring the role of other factors in reality that constrain consumption.

In the early 21st century, Sim (2003) formalised the theory of rational negligence and argued that rational negligence exists in all aspects of the economy, including consumption. As the information acquired in consumption is beyond the scope of consumers' processing ability, thus they rationally choose to ignore part of the information, leading to different consumption behaviours. The degree of difficulty in acquiring and processing information varies greatly between different types of consumption, and rationally negligent behaviour towards different consumption leads to different consumption structures. Considering the data collection, analysis and decision-making prior to the implementation of the behaviour, and recognising the constraints of information acquisition and processing on consumption behaviour, the rational negligence theory is closer to reality than the rational man hypothesis. In traditional theories of consumption, changes in consumption are mainly a quantitative reflection of consumer income, Hamilton & Griskevicius (2019) viewed monetary expenditure as a cost of consumption to study the impact of financial constraints on consumer behaviour, and Payne (1982) verified the relationship between inputs and outputs in the consumption process through a cost-benefit framework, which all using monetary units of consumption as the cost of inputs. The rational neglect theory further takes into account the constraints paid by consumers to process and react to information. Watkins & Knight (1922) argued that if the cost of considering and estimating the disposable income for consumption exceeds the value of the consumer goods, consumer behaviour will no longer be rational. In this case, it is necessary to introduce consumption costs to carry out further research. However, most of the existing research on the cost of consumption is only fragmented and singularly centred around one part of it, for example, Rocklage & Nordgren (2021) examined the cost of emotional numbness in the consumption process without being supported by a unified, anchored definition or theory. Based on the rational negligence theory, Liraya (2011) found that due to the limited attention span of an individual and the limited ability of an individual to process information and the slow updating of information by the consumer, thinking about decision making, transport, and communication gaming also incur costs in the consumption process, but these costs are difficult to be measured in monetary terms. From the perspective of economics, consumers will rationally allocate their resources in order to maximise their utility, and estimate the cost of the resources they expect to spend, and consider how to reduce the cost of consumption through rational arrangements in order to increase the utility of consumption. From the perspective of the relationship between income, cost and consumption, disposable income is proportional to the consumption budget, so that the budget constraints formed by income on consumption will gradually weaken with the continuous increase of disposable income (income effect declines), but on the contrary, the cost of the consumption process in order to obtain the goods, information decision-making in advance of the cost of the final consumption of net utility is directly affecting the net utility of the final consumption (the cost effect rises), the effect on the The impact of changes in the structure of consumption is obvious. Therefore, to explain changes in the consumption structure at different stages of development, an analysis of consumption costs that incorporates both monetary expenditures in the pre-consumption period as well as the costs of other resource expenditures is needed. At this point, the cost of consumption is not limited to monetary expenditure, but is the cost, excluding the price of goods, that consumers pay to allocate their own resources and to implement consumption in order to obtain a certain consumption utility.

The structure of this paper is arranged as follows: in the second part, we review the frontier literature on consumption cost research, analyse the concept and connotation of consumption cost, and explore the measurement of consumption cost; in the third part, we analyse the accelerating and heterogeneous effects of consumption cost on the upgrading of the consumption structure from the perspective of rational neglect; in the fourth part, we explore the interrelationships between the digital economy and consumption cost from the perspectives of digital technology, digital products and digital ecology; in the fifth part, we review the relevant literature and elaborate the current topics that still need in-depth research. In the fifth part, it reviews the related literature and elaborates the current topics that still need in-depth research.

The marginal contribution of this paper lies in expanding the concept of consumption cost and examining the influencing factors of the upgrading of consumption structure as well as the theoretical mechanism behind it from the perspective of consumption cost. On the basis of existing research on consumption cost, the relationship between consumption cost and the digital economy is discussed from the perspective of rational negligence, taking into account the impact of changes in institutions, technology and capital on rational negligence in the digital economy, and the impact of consumption cost on the upgrading of the consumption structure in the context of the digital economy is further explored.

2.The nature of consumer costs: decision-making and access

2.1 Study of the impact of consumption costs

Costs are a category of value in a commodity economy category of value that is the value of commodities component of a commodity. Broadly speaking, the effort exerted by the producer is known as the cost of production and is the most obvious cost and relative to the price. Adam Smith in *The Wealth of Nations* mentions that 'the true cost of a given commodity to any one who desires to obtain it, is the toil which must be expended to obtain it' (1776, p. 21). The effort and price that a consumer has to pay to perform a certain consumption behaviour and acquire the value of a good is then the cost to the consumer, and this consumption cost includes both some of the transaction costs of the consumption process and the non-transaction costs of the consumer himself. In a consumer market with a low level of economic development, with a single form of consumption, asymmetric information, and limited consumer power, the costs borne by merchants are transferred to the price of consumer goods, and the expenditures for the actual purchase of goods or services by the consumer include both the production costs of goods and services, as well as a variety of consumer costs, including consumer searches, acquisition of information, and consumer decision-making. However, with the development of the consumer market, some of the corresponding costs are separated from the price of goods, and some services that help decision-making and consumption gradually develop into independent commodities. Kozinets & Ashman (2017) point out that with the development of the commodity economy and the consumer market, the concern for consumption costs began to rise, and extends to a series of consumption costs due to the relationship between limited income and the desire to consume. contradiction brought about by a range of consumption costs. Galbi & DA (2001) used empirical evidence to analyse the impact of different pricing methods and acquisition and switching costs on the elasticity of demand for a given product in long distance telephone services in the US. Thus, although monetary expenditures are easiest to quantify in the actual consumption process, consumption costs excluding commodity prices can still influence consumer behaviour to a greater extent.

Focusing on the consumption process to see, the traditional friction variables such as distance, shopping time, shop layout, and new friction variables such as web design and app operation, as well as each of the specific scenarios such as communication, trust, logistics, payment, etc., are important factors affecting consumers' purchases and consumption, which is a specific manifestation of the cost of consumption in consumption as an economic activity. Sproles & Kendall (1986) found that as the consumer market shifts towards abundant supply, variety, and channel diversity, consumption is increasingly dependent on decision aid systems (e.g., word of mouth, etc.). Typically, an increase in the cost of consumption limits the range of choices available to consumers in terms of the type of goods they wish to purchase and affects the efficiency of the consumer market and consumer welfare. The constraining effect of consumption costs on consumer behaviour is also gradually becoming evident. Lower consumption costs mean that consumption behaviour becomes easier to implement, which will strengthen the consumption impulse of the original consumption structure of a single group (Lee, 2014); and for the group with a richer consumption structure, the shift in the cost of consumption means that he will demand a lower

cost of consumption of goods in similar products, or even be willing to pay a certain price in exchange for a lower cost of consumption, which further gives rise to the consumption of third-party services between consumers and sellers. When analysing the trade costs of cross-border e-commerce platforms, Xuenan Ju (2020) found that cross-border e-commerce helps to reduce the traditional fixed trade costs, while the transformation of consumption patterns in the Internet environment makes the variable costs in cross-border consumption gradually sensitive. These variable costs in the consumption process are different from the production costs that are included in the price, thanks to the development of the Internet and the digital economy, especially the services brought by the "platform" in the platform economy to cut costs, which has changed the composition of the traditional consumption of consumer costs, the manifestation of consumer costs and the attitude of consumers to them.

Taken together, consumption costs can be narrowly defined as the costs, excluding the price of goods, incurred by consumers in collecting consumption information, allocating their own resources and carrying out consumption behaviours in order to obtain a certain amount of consumption utility. Specifically, it refers to the costs of money, time, energy and the ability to process information, including decision-making costs and acquisition costs, that are incurred from the creation of the desire to consume to the implementation of consumption behaviours, which, together with income, have an impact on consumption behaviours.

2.2 Decision-making costs

Traditional consumption theory focuses on preferences and income constraints, but in addition, consumers' perceived decision-making effort to obtain and process information about each product to achieve the expected utility is also an important factor influencing consumers' choices, as demonstrated by VanBergen & Chen (2022), who showed that consumers are more inclined to make decisions by using rational reasoning than by perceived preferences. The process of rational reasoning and decision-making involves both the collection of consumer information, the planning and anticipation of consumer utility, and the allocation of one's own resources, all of which require the consumer's effort. As early as 1980, Steven M. Shugan conducted a study on the cost of thinking in the consumer decision-making process, defining the costs of consumer decision-making to include, but not limited to, the prevalence of information, the multitude of alternatives, time pressures, the consumer's limited ability to process information, and thinking about choosing an option. According to Higgins & Jun (2020). Decision-making costs arise from the consumer's quest for appropriate, suitable, and correct decisions, and identifies the difficulties and efforts faced by consumers in making utility predictions and consumption choices for different consumer products based on characteristics as well as preferences. This effort reflects the conflict between the finite nature of their resources and the infinite nature of their consumption desires, which allows for the definition of a clear and measurable unit of thought.

For the same type of consumption, the decision costs vary with the environment and the market, and differ across consumption behaviours. Firstly, the information sets contained in different consumer products are usually specific and therefore heterogeneous. Attribute information presents scale and thus has a significant impact on consumer decision-making, not only does the cost of acquiring different sets of information vary, but the decision-making cost of finding the best product from one set of more varied products may be much smaller than the decision-making cost of finding the best product from another set of less varied products (Wilcox & Prokopec, 2019). Heterogeneity caused by information also converges or diverges with information. Second, decision costs are constrained by consumer ability. In practice, consumers do not have random choice characteristics, but are more likely to show tendency characteristics after memory learning, and the consumption cost after repeatedly performing the same consumption behaviour will gradually decrease, for example, without repeatedly acquiring the inherent information of the already consumed product. Zhang Xiao (2021) argues that it is necessary to consider the social learning of online reviews and the self-learning behaviour of offline experience, and establish consumer social learning models and self-learning models for online and offline information search channels respectively, in order to explore consumer utility. The consumer utility models established by previous studies do not take into account consumer learning behaviours, thus making it difficult to accurately describe consumer preferences and behaviours. Finally, based on the rational neglect theory, consumers will make selective decision-making cost simplification through the

judgement of their own resources, and together with the utility to determine the specific behaviour of consumers. Otto & Martin (2022) argued that concentrated information is not always important, consumers can simplify the decision-making rules by hierarchical sorting, filtering and ignoring the unimportant information, so as to reduce the decision-making costs. This simplified decision-making behaviour is not only found in different stages and contexts of the same consumption, but also between different types of consumption. Kupor & Laurin (2020) point out that different decision-making behaviours also produce different consumption behaviours, and explain why, in the actual process of consumption, consumers usually choose a "satisfied" decision over a "satisfied" one. "decision rather than the "optimal" decision. The reason for this is that the simplified rule makes consumption decisions significantly less costly, compensates for some of the loss of consumption utility, and results in net utility.

The impact of the balance between decision costs and consumer utility on consumer behaviour is confirmed by John R. Hauser (1990). Excessive decision costs lead consumers to make comparisons in fewer decision sets, and this "fewer" is reflected not only in a reduction in the number of choices, but also in a reduction in decision time. Products that do not require effort to evaluate and make decisions are preferred by consumers. From the consumer's point of view, the easier it is to evaluate and make a decision, the lower the decision cost, and the same decision cost can be used to compare and choose from a larger set of decisions. This is especially true for experiential goods as well as services, whose information and utility can only be judged after the product is purchased or used, and it is difficult to obtain information through pre-consumption efforts (Stigler, 1961). Therefore, from the practical point of view, excessive decision-making costs often lead consumers to choose to abandon such consumption. Some scholars' studies on the difference between the concept of green consumption and actual actions have found that green consumption is also in line with this conclusion, with Xiao Jie (2022) introduced information richness into green consumption, focusing on the effects of different self-construals and temporal distance on consumers' green consumption decisions, and found that higher information preferences produce stronger purchase intentions. Zhang Mei (2022) analysed the dilemmas and breakthroughs in the application of eco-labels for green commodities, and concluded that the limitations of one's own knowledge, the indirectness and uncertainty of the information provided, and the "greenwashing" behaviour of enterprises would cause distrust in their information, thus limiting their application.

2.3 Acquisition costs

Unlike decision costs on consumption, which link benefits to individual perceptual views and are choice costs that arise from the psychological level, access costs are costs that affect consumption as determined by the production system, the consumption environment, the system, and the consumer's ability. These include time (Yuan Ming, 2020), transport (Wang Lei, 2021), and expertise (Song Quanyun, 2019). In a relatively stable consumer market, acquisition costs have received little attention in traditional consumption theory due to the uniformity of the consumer market and fewer major changes in acquisition costs. Specifically, acquisition costs are concerned with the effort involved in obtaining the power to consume a given good, mainly in the form of exchange, both direct and indirect. They are most commonly and intuitively expressed in terms of monetary expenditures, but are not limited to monetary expenditures. Monga & Bagchi (2017) find that for consumers, resources such as time can be used for consumption in the same way as money, and that such acquisition costs are typically tied to the social production system, as well as to the institutions and habits of the consumer market. In general, an increase in social productivity and the optimisation of institutions significantly reduces the cost that consumers have to pay to obtain a good and helps them to obtain a good more easily. Historically, hierarchical societies often reflect their class value by making it more difficult to acquire knowledge and art; low productivity societies need to spend more money on transporting goods, thus giving rise to the phenomenon of "speciality"; countries with underdeveloped trade may even have great price differences for the same commodity in different cities. As societies develop, all of these aspects change, and access costs tend to decline. What's more, the concept of access cost is also enriching its connotation, gradually shifting from the measurement of time and distance to the study of the convenience of purchasing a certain commodity, i.e. the theory of accessibility of goods and services (Nedungadi & Hutchinson, 1985). Wang Qi (2022) argues that rural logistics is an important link between urban and rural production and consumption, and that the improvement of market accessibility can not only release the consumption potential of the region, but also greatly reduce interregional consumption inequality and differences in

consumption structure caused by differences in market accessibility.

Analysed from the perspectives of time, distance, cost and threshold in the consumption process, we can find that the concepts of acquisition cost and accessibility are relatively similar, and few scholars have indeed made a distinction between the two in their studies. However, when analysed in depth, the difference between the two lies in the following: on the one hand, accessibility focuses on the psychological conversion of the cost of obtaining consumer goods, and measures the degree of difficulty in the process of consumption; on the other hand, acquisition cost focuses on the cost of obtaining a certain consumer product, which is directly related to the time spent, money paid, and effort expended in obtaining the consumer product, and so on. At the same time, acquisition cost and accessibility are a set of relative concepts. The degree of accessibility in the concept of accessibility is closely related to the measurement of acquisition cost, and its improvement will lead to the reduction of acquisition cost, and vice versa will lead to the increase of acquisition cost; and the change of convenience in the concept of accessibility corresponds to the increase or decrease of the cost price paid for the process of reaching consumption. increase or decrease in the cost price. Accordingly, access costs can also be viewed as the costs of crossing barriers to consumption, which vary across different types of consumption in different social contexts depending on the cost of access, and vary with changes in consumer markets, institutions, and technology.

The most intuitive example of acquisition costs lies in tourism consumption, which from its inception to its popularity is also accompanied by changes in its acquisition costs, not changes in its consumer prices such as entrance fees and tour fares, but the costs between the decision to travel and the actual acquisition of consumer utility through monetary exchange are the acquisition costs that affect the popularity of the tourism industry. Vale (2020) examines how absolute geographic distances in tourism consumption are associated with different levels of travel costs under the consumer market, including a range of costs incurred in the consumption process such as time, communication, comfort, and cost. In the category of tourism consumption, acquisition costs can be understood as expenditures made to arrive at a destination for tourism consumption (Gehrke & Reardon, 2020; Reitsamer & Brunner-Sperdin, 2017; Zhu & Diao, 2020), and are the power to gain access to tourism consumption in order to cost price paid, rather than the price of tourism consumption. Among other things, the effect of transport on geographic distance and the degree of monopoly and coordination in the market can bring about changes in tourism costs, which are often considered to be the main factors influencing tourists' travelling decisions in tourism consumption (Hooper, 2015; Park, 2019; Reitsamer, 2017). Ceccato (2020) examined the accessibility of tourism development and found that a range of policies developed for the disabled tourism market to reduce their transport, communication, and access costs have contributed significantly to the development of the disabled tourism market.

Looking beyond the specific type of consumption that is tourism, acquisition costs are present in all aspects of consumption, and Nelson (1974) examines goods with added value or experiential goods, and finds that they often raise the barriers between consumer goods and consumers by charging membership fees and deposits. Throughout the existing research, it can be found that this part of the increased acquisition cost is not a cost that producers and merchants must pay during the process of production, sales and consumption of consumer goods, but a cost that sellers attach to consumers in order to ensure the smooth running of consumption, increase their own sales interests and the "distance" between consumers and consumer goods. It is a cost imposed by the seller on the consumer in order to ensure the smooth running of the consumption, increase his own sales interests and the "distance" between the consumer and the consumer goods.

3. Consumption costs and consumption behaviour

3.1 Rational Negligence and the Cost of Consumption

Traditional consumption theories, both Life Cycle Theory or Durable Income Theory, are based on the assumption that actors are perfectly rational; however, the assumption of perfect rationality does not correspond to our observed reality, and a large body of empirical studies also proves the point that actors are not always rational. In light of this, the New Keynesianism proposes the concept of rational negligence. Sims (2003) argues that information processing capacity constitutes a constraint on economic agents due to the processing of information capacity constraints, negligent behaviour arises. It is worth noting that this negligent behaviour does not arise because the economic agent is irrational, but precisely because it is rational. These costs are generated by information, but they are not constituted by information alone. At the same time, it breaks

the original perception that lack of information creates information asymmetry, which in turn harms consumer welfare. Woolley & Rise (2021) argue that in the face of these costs, even though there is more information available today than ever before, consumers often ignore it. Or not as rational expectations stated at every point in time, they choose to update themselves with new information already at their disposal, which comes at an additional cost. Wang Jun (2013) argues that due to limitations in the "capacity" to process and react to income information and the need to acquire information requires This limitation and constraint creates endogenous information friction, resulting in consumers not being able to make accurate and quick decisions. In actual consumption, consumers need to process and reflect on much more than income information, including information about the attributes of consumer goods and social information, and Mittelman & Andrade (2020) found that consumers rationally choose to ignore relatively unimportant information, focusing on the impact of what is in front of them and ignoring unseen information in the consumption environment that they are unlikely to consider spontaneously. information. Thus, faced with these costs, economic agents choose to be negligent, i.e., consciously ignore certain information, or not, as is rational expectations says, choosing to update the new information already available at each point in time. Irmak & Sen (2017) find that a consumer who is browsing and is exposed to new, unknown information about a good already in his or her shopping cart experiences more cognitive dissonance due to the lack of information about the corresponding new attribute in the competing good, which makes it difficult to make a judgement based on the new information. At this point, rational consumers will choose to ignore this newly acquired information about the product. This is a reflection of the well-known fact, suggested by Akerlof & Yellen (1985), that a moderate deviation from the optimal choice in a near-optimal situation does not have a significant impact. People use a piece of information very infrequently, not because they cannot use it accurately and the utility of using it is low. Therefore, the limited information-processing capacity has to be used for other, more important purposes.

3.2 Heterogeneous effects of consumption costs on consumption

Consumption structures at different stages of social development have their own characteristics, in which the cost of consumption of different types of consumption naturally has certain differences, and the specific impact of the cost of consumption on consumption behaviour also has different degrees and forms. The impact of consumption cost on the upgrading of consumption structure is not single, but has a certain duality. With the continuous enrichment and updating of consumer goods, the content of consumption cost is also expanding, the type and degree of consumption cost to be paid for the purchase of different consumer goods have certain differences, and the consumer's decision-making response to different consumption cost also has certain differences. On the one hand, the reduction of access costs makes people with a single consumption structure more willing to consume goods or services that they would not otherwise consume, and thus promotes the popularisation of hedonistic and educational consumption among the general public in order to upgrade the consumption structure. For example, the promotion and development of accessible travelling is facilitated by the reduced difficulty of accessibility (Frye, 2015; Ceccato, 2020). In particular, access costs arise before the consumption behaviour and are sunk costs, and switching costs are formed when consumer behaviour shifts. Geyskens & Warlop (2008) argued that immediate consumption will stimulate consumption more than the absence of an immediate consumption opportunity because people tend to prefer products with high feasibility (greater ease of use) for the sake of an upcoming decision (Lee & Zhao, 2014; Wan & Agrawal, 2011). Liang & Tung's (2014) study also verified that sunk costs incurred by paying prior to consumption behaviour usually have a significant impact on actual consumption. It can be seen that the impact of acquisition costs varies in the face of different types of consumption. Rosário & Raimundo (2021) and Liang (2022) analysed the acquisition costs such as dues and deposits in the behaviour of online shoppers, respectively, and concluded that acquisition costs have a greater impact on experiencing the product. This is because when making the trade-off between acquisition costs and consumption utility, the cost of information likewise influences this representation; searching for a product provides complete information about the product prior to purchase, whereas experiencing a product has attributes that can only be known after the product is purchased and used, or the relevant information search is more costly or difficult to carry out than obtaining a direct experience (Klein, 1998).

On the other hand, both decision-making and information costs influence consumers' negligent behaviour. As the cost of

decision-making decreases, consumers' rational negligent behaviour also decreases, and they are less likely to rationally choose to ignore potentially valid information because it is too much and difficult to process. At the same time, it makes the people with rich consumption structure initially put forward higher requirements for quality, function and other additional attributes of consumption, instead of being satisfied with basic functional needs, thus promoting the improvement of consumption quality to achieve the upgrading of consumption structure. The information cost in the process of consumer decision-making determines the size of the consumer decision-making set, and its impact on consumption is mainly reflected in the perceived differences and price sensitivity in the process of consumption. Whether rational consumers who are not inclined to plan, most of them will consider opportunity costs when they perceive constraint prompts, except that consumers who are inclined to plan will consider opportunity costs even if they are not prompted by direct constraints (Spiller, 2011).

3.3 Impact of consumption costs on the upgrading of the consumption structure

Based on reinforcement learning theory, direct summaries of relevant information in consumption, and indirect feedback from recent or past time information, are able to influence decision-making and other goal-directed behaviours in complex and possibly unexpected ways (Langdon & Niv, 2019). The two major learning capabilities of memory and comprehension, and the increasing ease of searching for information on services on the Internet, have the potential to alter individual consumption decisions and their seeking behaviours (Chen & Tsai, 2018), fundamentally negating the invariance of consumption costs, especially decision-making costs. In real life, consumer decision-making typically makes judicious use of previews as well as online reviews to aid decision-making based on consumer product characteristics (e.g., quantity, price point, and variance). However, not all online reviews help consumers learn, and Choi & Oh (2019) found that consumers' desire to consume through previews decreases with increased reading of partially in-page reviews. Low-quality reviews that struggle to provide valid information not only do not reduce consumption costs through consumer learning, but are also ignored by consumers because they increase the cost of processing information. Meanwhile, Tsai & Soman (2021) argued that consumers usually seek to be consistent with other consumers. This both exacerbates the propensity to purchase a particular consumer product after memory learning and increases the cost of aligning consumers with other consumers after acquiring more low-quality information. Therefore, the continuous development of consumption influences the change of consumer structure, and is also closely related to the continuous improvement of consumers' learning ability and channels, and technological and institutional advancement, which can significantly reduce the cost of collecting and processing information, and thus influence specific consumer behaviour through the reduction of consumption costs.

With constant consumption costs, as technology improves and becomes more widespread, emerging products that were originally sold at high prices and had barriers to consumption access will gradually open up markets as the value of the technology declines and economies of scale increase, and resolving the barriers to consumption and lowering the cost of consumption is a key factor in rapidly increasing the share of consumption on top of it (Kapustin & Grushevenko, 2020). However, the cost of consumption, the price of goods and the experiential utility of consumption, together influence consumer behaviour. Kanay & Cézéra (2021) found that labelling in the form of numbers and graphics can effectively increase consumer understanding of the product and reduce the decision-making cost of that consumption behaviour through indirect feedback of information. And the utility of the experience of the same commodity is fixed, in the case of technology sinking, product price reductions are consistent, the consumption of the same commodity will be accelerated with the reduction of costs, but also can accelerate the breaking of consumption barriers through the reduction of consumption costs, and promote the upgrading of the consumption structure. At the same time, the scarcity caused by high consumption costs gives some added value to some consumption, when the utility is proportional to the cost, and the more difficult to obtain consumption the higher its experiential utility (Park & Spence, 2022). Overall, human learning ability has a decreasing influence on consumption cost, and on this basis, the influence of external factors on consumption cost can also accelerate the time needed for consumption structure change to a certain extent, and will further accelerate the transformation and upgrading of consumption structure.

4. Consumer markets in the digital economy

4.1 Study on the impact of the digital economy on the structure of consumption

With the popularisation and promotion of the new generation of digital information technology and the arrival of the tide

of the digital economy on a global scale, the application of cloud computing, big data, the Internet of Things, mobile computing, smart cities and other emerging digital technologies has made the system, technology and other factors that are not susceptible to short-term changes in Keynes's theory of consumption always face the impact of digitisation, and the consumption traditions and habits have given way to the more convenient and diversified modes of operation in the new economy. Various industries, including consumption, are changing at an extraordinary rate. A new round of upgrading of the consumption structure is taking shape. Consumption habits that used to be regarded as unchanging, and consumption costs such as the efforts made to obtain consumer goods, are changing along with the changes in the consumer market, and the impact of the improvement of consumers' capabilities and qualities on their consumption behaviours is becoming more and more significant. For example, as information becomes more widely available and consumers learn, the cost of processing information for decision-making is declining. Meanwhile, with the development of technology and the improvement of institutions, communication-based consumption behaviour is easier to make attribute judgments (Zhang, 2021). Pancer & Noseworthy (2019) stated that as digital elements are gradually embodied in every aspect of daily life, the readability of information is gradually improving, and in turn, the cost of consumption will also decline. As a notable example, the impact of the digital economy on the upgrading of the consumption structure deserves due attention, Chiles & McMackin (1996) have demonstrated that the popularity of Internet consumption is due to the significant reduction in transaction costs. The digital economy as a further development of the Internet, the display of product information, the enrichment of the review system, the community interaction system, etc., all have a significant impact on the reduction of transaction costs. Park & Kwon (2022) have also proved that the higher the accuracy of the information about the attributes of the products that are not known, the more the willingness to consume will be promoted.

The application of digital technology has enhanced the convenience of consumption, giving rise to a range of intermediary services that help to reduce the cost of consumption. The combination of this service-based consumption and consumption amenities significantly reduces the emotional, material, time and ability costs that need to be invested in consumption, as well as some of the thresholds for consumption, and improves the sustainability of consumption by reducing the costs of a large amount of consumption with a small amount of monetary resources (Seregina & Weijs, 2017). On the other hand, the gradual application of digital technology in various aspects of consumption makes it easier to separate and value create consumption costs from the act of consumption. When consumption costs become a commodity, consumers need to pay an additional cost for this type of service, which gives them the possibility of becoming a commodity on their own. Competition and trade in a transparent consumer market ensures consumer utility and creates new consumer welfare. However, what role does the cost of consumption play in the upgrading of the consumption structure, and what role do the Internet and the digital economy, as products of technological development, play in the influence of the cost of consumption on consumption habits and the structure of consumption, which still needs to be further researched.

4.2 Research on reducing consumption costs in the digital economy

4.2.1 Digital technology and consumer costs

In the past, information retrieval and searching was usually a major barrier to consumption in the real economy, and for goods that can be searched for prior to purchase, and for which information is gathered to aid decision-making, has a high degree of certainty (Suwelack & Hoyer, 2011) which makes consumers more dependent on information when purchasing such products, and leads to such consumer goods requiring higher information searching and analysing skills, as well as having stronger barriers to consumption and exclusivity. Dietvorst & Bartels (2022) argue that algorithms are more likely to be used to maximise benefits than human decision makers. The development of technologies such as big data and artificial intelligence in the digital economy enables the use of certain devices to convert various information, including: graphics, text, sound, and images, into electronic computers that can recognise the Binary numbers "0" and "1" after computing, processing, storing, transmitting, disseminating, and restoring, through the visual organisation (Van der Lans & Wedel, 2021), visual breadth (Streicher & Bühler, 2021), and visual width (Streicher & Bühler, 2021) brought about by the click-stream data. Streicher & Büttner, 2021) expansion to accelerate consumer product search and reduce related decision-making, acquisition costs. At the same time, new ways of consuming in the digital economy make it easy for consumers to find other customers'

opinions online, including quality, sustainability, and price (Lu & Yao 2018). A study by Dabholkar & Sheng (2012) further affirms that the use of decision-making tools derived from digital technology to analyse information about goods to further assess product utility can further reduce the decision-making costs of consumption. Although over-abundance of information can help reduce decision costs by providing exhaustive decision elements, it can also increase the cost of time spent on decision making due to the increase in information elements collected, expanding the decision set, digital technology has never had more than one side to it, and has more significant duality in assisting consumers in decision making through digital, information elements. You & Fei (2022) argued that i.e. digital technology helps to disseminate more information, but also makes the perceived time cost greater; Rathee (2021) stated that digitised logistical distances shorten the relative logistical time at absolute distances, but affects the consumer's psychological perception of distance as an acquisition cost.

And the impact of digital technology on consumption costs also includes the quality of information. On the one hand, high-quality information can help consumers better understand the differences between two goods beyond price, but low-quality information can only result in additional decision-making costs for consumers. Lo & Tojib (2019) find that lowering the cost of searching for high-quality information reduces consumers' price sensitivity by creating a greater perceived difference between different consumptions. Accordingly, once the search cost of low-quality information is lower than that of high-quality information, it leads to an increase in the cost of this type of consumption. On the other hand, low-quality information leads consumers to perceive the product as a less typical version of its category, thus increasing price judgement costs but lowering quality expectations (Baskin & Liu, 2021), which not only makes it difficult to help with decision making, but also exacerbates the consumer's rational negligence and intensifies the selective ignoring of the information that has been collected. Therefore, intelligence reduces quality search costs and can have the opposite effect on differentiation and price sensitivity, due to the fact that intelligence filters out a range of alternatives and recommends only a few alternatives that perfectly match the customer's quality preferences (Diehl & Lynch, 2003). Perrigot & Pénard (2013) found that most of these factors enhance online shopping intentions and behaviours by billing consumption costs extra. Although the impact of the expansion of the decision set on decision costs is uncertain, from the perspective of consumption costs, the application of digital information technology greatly reduces the control of consumption costs by digital elements of consumption costs, and provides possible room for manoeuvre to guide the direction of the upgrading of the consumption structure (Lin Chen et al., 2020).

4.2.2 Digital products and consumer costs

Digital products are based on exchanges in digital format or delivered via the Internet in a bit stream, eliminating the physical boundaries between production and use, and the new "digital+" forms of consumption born from digital elements have different manifestations, which can be broadly classified into three categories: digital information and entertainment; digital tools; and digital goods. Li et al. (2020) argues that a digital economy based on high-tech development, business and social transformation, and information-driven changes in the region's growth can create new value chains and further remove the traditional barriers to business history, and considers research directions in which traditional consumption is closely linked to the digital economy, such as artificial intelligence, the platform economy, digital trade, and fintech innovation. For consumers who would otherwise have had to forgo experiences due to cost thresholds, the value of experiences gained through the loss of some utility far exceeds the net utility experienced in the past at high cost. Qianqian Li (2021) studied experience-based consumption based on Internet social scenarios, which transforms the high cost threshold of traditional experience-based consumption into network social costs, but allows consumers to feel the interest and enjoyment of participating in openly hedonic experience-based consumption in the process.

Tan & Cheng (2016) argued that while digital goods industries such as entertainment, software, and publishing are growing rapidly, traditional supply chain contractual models have failed to evolve with the new digital economy. The creation of new digital products has created other barriers while reducing some of the costs of consumption. The development of digital products based on the digital economy inevitably puts higher demands on consumers to apply digital technology and equip the digital society. Guan Leining (2022), in introducing the new type of consumption in the meta-universe, mentions that digital products within the meta-universe are transformed from one-way communication from merchants to consumers to

multi-subject instant interaction, which is also based on certain digital devices. The price of digital products will often not include the relevant equipment, which is more likely to generate bundled sales with new consumption costs compared to physical goods. Bockstedt & Goh (2014) stated that while the reduced transaction and search costs of digital products increase the diversity of supply-side offerings, customised bundling may introduce new types of frictions in the consumption process.

4.2.3 Digital ecology and consumer costs

The digital economy in consumption is mainly embodied in the combination of digital elements and various aspects of consumption, which promotes the intelligentisation of the consumption process, gives rise to new consumption methods and guides new consumption habits. In reality, e-commerce has replaced brick-and-mortar consumption to a certain extent (Ding & Lu, 2015; Lee & Handy, 2017), and young people have reduced the frequency of brick-and-mortar shopping while doing e-shopping (Shi & Witlox, 2019; Saphores & Xu, 2021), however that older people still tend to do offline shopping rather than online shopping. This is due to the reduced cost of consumption in the digital economy, which itself places certain demands on consumers' ability to use digital technology, creating a new cost of consumption that is reflected differently in different types of consumption (Arranz-López & Soria-Lara, 2022). At the same time, under the same consumer market, there are different consumption costs for different consumers, and the same-side and cross-side effects of consumer feedback platforms reduce the cost of consumers' fulfilment of their power to varying degrees, but the cross-side network effects of the platforms generate economic considerations and thus new costs (Kozinets & Chimenti, 2021). In the ecology of the consumer market in the digital economy, the process of consumer consumption is the process of storing consumer memories and habits in the consumer market, which can be retrieved at any time, enabling sellers to collect and analyse information and needs of different customers at a very low cost, reducing the decision-making costs arising from the transmission of communication and information, and reducing the cost of acquiring personalised goods and reducing barriers to transactions by means of a flexible and adaptive production system as well as a mass production method of tailor-made production. acquisition cost of goods, reduce transaction barriers, reduce market friction, and promote the upgrading of a new type of consumption structure (Chang, 2019). In addition, the digital consumption ecology collects and provides product and commodity information while providing consumption venues, reducing the information cost for online buyers to search for desired items and also exploiting underutilised private resources (Basili & Rossi, 2020). But this reduction in the cost of consumption depends on the application of technologies such as deep learning to artificial intelligence, and is even more determined by the institutional and ecological logic of the consumer market in the digital economy (Lu, Taihong, 2017).

5. Literature Review and Topics for Further Research

The structure of consumption and the stage of social development are mutually constraining, promoting and symbiotic. As society develops, the consumer market and consumption habits will continue to change in line with changes in institutions, capital and technology, and the structure of consumption is bound to escalate at different stages. In modern society, the consumer market has become more and more active, with a wide variety of goods and services, and the ways and forms of consumption are also being constantly innovated. The information, time communication and psychological distance conveyed by different consumption methods are different (Kaju & Thomas, 2018), and consumers will choose different products or different consumption behaviours due to different negligence behaviours and incur costs to match. Consumption costs are a niche topic and rational negligence is an emerging theoretical proposition. Happily, the existing literature has explored the study of consumption costs under the rational negligence perspective, resulting in a valuable body of literature. However, in the mainstream consumption research paradigm, economists' studies on the proposition of "why the consumption structure is upgrading" are more based on the rational consumer hypothesis and centred around income, ignoring other influencing factors to a considerable extent, which makes it difficult to accurately explain the causes of the upgrading of the consumption structure. In particular, in the second and third consumption upgrading that is gradually advancing under the continuous progress of science and technology, has the influence of technology, institutions and economic patterns on consumption upgrading been neglected? Or what kind of influence does it have on the consumption structure? From the perspective of the upgrading trend of consumption structure and the impact of consumption costs on it, based on the research progress in the existing literature, there is still a need for in-depth studies including but not limited to the following topics:

From the consumer's point of view, can the factors that determine his or her consumption behaviour and structure be expanded and deepened? How do consumer habits determine the cost of consumption? These are all questions worth pondering. The different resources that consumers have at their disposal for consumption can be translated into different combinations of costs, which are varied and do not relate to utility on an increasing or decreasing scale. Some consumption costs can only be invested in such a way as to avoid a bad outcome, but for a given consumer good, the utility obtained in the end is likely to be the same, regardless of how much time is ultimately spent on understanding it and how much cost is invested in it. This shows that consumer costs are not static, but consumer utility is difficult to change. With the accumulation of consumer experience as well as the continuous development and improvement of consumption technology and institutions, the ability of consumers increases and negligent behaviour decreases, and under the premise of unchanging consumption utility, the change of consumption cost will promote the increase of consumption and structural upgrading. Based on the theory of rational negligence, this change will bring about differences in the consumption structure, different types of consumption and different consumption behaviours of the cost of consumption there are differences, the overall cost of consumption can only increase the net utility of consumers, but can not be between different types of consumption to produce behavioural decision-making differences, the cost of a certain consumption will bring about the cost of a consumption in the overall consumption of an increase in the proportion of the cost of the cost of the cost of the cost of the cost of the cost of the cost of the cost of the cost. And what factors influence differences in consumption costs? It is worth exploring in depth in the future.

Looking at consumer markets, whose institutions and technologies have a direct impact on consumption costs, how do environmental changes in consumer markets and consumer habits determine consumption costs? How to measure the change of consumption cost under a specific consumer market? All are the problems that need to be solved nowadays. Consumption costs under market competition are decreasing, and consumption costs may also become new consumer goods. The attribute of information explosion in the digital ecology expands the way consumers obtain information about the attributes of commodities, the innovation of data algorithms can assist consumers in decision-making through scientific and technological means, and the upgrading of the digital industry greatly reduces the cost of production and circulation within various types of consumption, which in turn can reduce the cost of acquisition for consumers. The upgrading of the consumption structure is not only a shift in the proportion of consumption types, but also implies that an originally scarce or new type of consumption is gradually becoming popular among the general public, which is a historical development phenomenon that inevitably occurs with the reduction of consumption costs. The upgrading of the consumption structure is the process of shifting from essential to non-essential consumption, and it is also the process of a new type of consumption gradually coming into thousands of households, non-essential consumer goods gradually transformed into essential consumer goods sinking process, and it is the process of forming a new consumer market. Consumption cost is one of the gears, and the faster it turns, the faster the upgrading of the consumption structure will be, and the direction of the gear's rotation also influences the direction of the upgrading of the consumption structure, and the dynamic relationship between the consumption cost and the consumption structure in different socio-economic environments, and the mechanism of the influence between the consumption cost and the upgrading of the consumption structure are waiting to be analysed more in depth.

Rational negligence highlights the profound impact of consumption costs on the upgrading of the consumption structure. Due to the high cost of consumption, the ability to process and react to information in the rational negligence theory constrains consumers' understanding of attribute information and decision-making on consumption behaviour, and a lower ability generates excessive consumption costs, reinforcing consumers' judgement on price and ultimately ignoring other factors that may be involved in decision-making (Baskin & Liu, 2021). For information that is difficult to access and process, consumers rationally consider it to be relatively unimportant information, leading to the choice to ignore them, which places higher demands on consumers' ability to process information. Different consumer market mechanism determines different information costs, the same information on the ability of the requirements also have differences, lower decision-making costs can avoid because of the high cost of processing part of the information generated by the rational negligence, on the contrary, the reduction of rational negligence can also strengthen the importance of information, information on the attributes

of consumer goods will also reduce some of the cost of consumption, weakening its constraints on the consumption behaviour of the economic agents, and further promote consumption. Promote consumption. In general, there are mutual constraints and influences between consumption cost and rational negligence, but how to verify the correlation between rational negligence and consumption cost and the influence mechanism and how to study it in depth is still a topic to be answered.

In the era of digital economy, how does this new economic form with "digital" as the centre of gravity promote the upgrading of the consumption structure by reducing the cost of consumption through rational negligence? In the era of digital economy, science and technology have changed the rules and habits of the consumer market, and big data technology has made information no longer a scarce resource, and the transformation of the value of consumer information has brought about changes in the consumption system. The "ability" to collect and process information in the process of consumption has been highlighted, and with the improvement of the "ability", the cost has been reduced, and consumers can make more rational choices, think about the costs behind consumption, and reduce the negligence of some information compared to the past; The digitisation of consumer markets and rules has greatly reduced the cost of acquiring part of the consumption, increasing the net utility of the consumption while the experiential utility of the consumption remains unchanged, leading to a shift in the original consumption structure. This further validates that income is not enough to fully explain the formation mechanism of this consumption upgrade, and the proposal of consumption cost breaks through the income-consumption research framework and explains the problem of the direction and speed of the upgrade of the consumption structure, which was difficult to explain through income in the past. In future research, the digital economy and the cost of consumption will be a pair of concepts that grow together, how does the digital economy ecology change the connotation of the cost of consumption? How does it affect the consumption structure? Further research is needed.

Funding

no

Conflict of Interests

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

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The Role of Artificial Intelligence in Sustainable Development and Industrial Transformation

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Abstract: Artificial Intelligence (AI) is transforming global industries, offering unprecedented opportunities for sustainable development and economic growth. This paper examines AI's dual role as a driver of productivity and innovation, as well as its potential to address environmental challenges and reshape global trade. By analyzing AI's applications in agriculture, energy, manufacturing, and transportation, we highlight its ability to optimize resource use, reduce carbon emissions, and promote circular economies. Additionally, we explore AI's impact on global trade, from supply chain optimization to cross-border service innovation. However, the rapid adoption of AI raises challenges, including labor market disruptions, ethical dilemmas, and regulatory gaps. This paper concludes with policy recommendations to ensure AI's benefits are equitably distributed and aligned with global sustainability goals.

Keywords: Artificial Intelligence; Sustainable Development; Industrial Transformation; Policy Implications

Published: Mar 11, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.185>

1.Introduction

The advent of Artificial Intelligence (AI) marks a pivotal moment in the evolution of global industries, with profound implications for economics, management, and sustainable development. As AI technologies—ranging from machine learning to natural language processing—become increasingly integrated into business operations, they are redefining traditional economic models, reshaping global trade, and driving the emergence of new industries. This transformation is not merely technological but also structural, as AI disrupts existing markets, creates new opportunities, and reconfigures the competitive landscape.

From an economic perspective, AI is a double-edged sword. On one hand, it promises to boost productivity, reduce costs, and unlock new sources of value creation. On the other hand, it poses significant challenges, such as job displacement, income inequality, and the concentration of economic power in the hands of a few dominant tech firms. For managers, AI offers tools to optimize decision-making, enhance customer experiences, and innovate business models. Yet, it also demands new skills, ethical considerations, and strategic foresight to navigate the complexities of an AI-driven economy.

This paper seeks to address these dynamics by focusing on the intersection of AI, sustainable development, and industrial transformation. It explores how AI is transforming industries, examines its impact on global trade, and proposes innovative strategies for governments, businesses, and society to harness AI's potential while mitigating its risks. By grounding the discussion in specific economic and managerial contexts, this paper aims to provide actionable insights for policymakers, business leaders, and academics.

2.The Economic Impact of AI: Opportunities for Growth and Innovation

2.1 Productivity Enhancement

One of the most significant contributions of AI to the economy is its ability to enhance productivity. By automating routine tasks and optimizing complex processes, AI enables businesses to produce more with fewer resources. For example, in manufacturing, AI-powered predictive maintenance systems reduce downtime and improve operational efficiency. In logistics, AI algorithms optimize supply chain management, reducing costs and delivery times. According to a report by McKinsey, AI could contribute an additional \$13 trillion to global GDP by 2030, primarily through productivity gains (McKinsey Global Institute, 2020).

However, the economic benefits of AI are not evenly distributed. While large corporations and tech-savvy industries are reaping the rewards, smaller businesses and traditional sectors often struggle to adopt AI due to high costs and a lack of expertise. This disparity underscores the need for policies that promote inclusive access to AI technologies, such as subsidies for small and medium-sized enterprises (SMEs) and investments in workforce training.

2.2 Innovation Acceleration

AI is also a catalyst for innovation, enabling the development of new products, services, and business models. In the financial sector, AI-driven algorithms are transforming investment strategies, risk management, and customer service. For instance, robo-advisors use AI to provide personalized financial advice at a fraction of the cost of traditional advisors. In healthcare, AI is accelerating drug discovery and enabling precision medicine, where treatments are tailored to individual patients based on their genetic profiles (Davenport & Ronanki, 2018).

The innovation potential of AI extends beyond individual industries to the broader economy. By fostering cross-sector collaboration and enabling the integration of data from diverse sources, AI is driving the emergence of new ecosystems. For example, the convergence of AI, the Internet of Things (IoT), and 5G technology is creating smart cities, where data-driven solutions improve urban living while generating economic value.

2.3 Creation of New Economic Value

AI is not only enhancing existing industries but also creating entirely new ones. The rise of generative AI, for instance, has given birth to a burgeoning market for AI-generated content, from text and images to music and video. This market is expected to grow exponentially, with IDC predicting that generative AI will account for 33% of the total AI market in China by 2027.

Moreover, AI is enabling the monetization of data, a resource that has become as valuable as oil in the digital economy. Companies are leveraging AI to extract insights from vast datasets, creating new revenue streams and competitive advantages. However, this trend also raises concerns about data privacy and security, highlighting the need for robust regulatory frameworks (Bessen, 2019).

3.The Role of AI in Sustainable Development and Environmental Impact

3.1 Optimizing Resource Use and Reducing Waste

AI's ability to analyze vast amounts of data in real-time makes it an invaluable tool for optimizing resource use across various industries. In agriculture, for example, AI-powered precision farming techniques enable farmers to monitor soil conditions, weather patterns, and crop health with unprecedented accuracy. By leveraging AI, farmers can optimize irrigation, reduce fertilizer use, and minimize waste, leading to more sustainable agricultural practices (World Economic Forum, 2023). Similarly, in manufacturing, AI-driven predictive maintenance systems can reduce material waste by ensuring that machinery operates at peak efficiency, thereby extending the lifespan of equipment and reducing the need for frequent replacements (McKinsey Global Institute, 2020).

Moreover, AI can help in the efficient management of water resources, which is critical for sustainable development. AI algorithms can predict water demand, detect leaks in water distribution systems, and optimize water usage in industries such as agriculture and manufacturing. For instance, in California, AI-based water management systems have been deployed to address the state's chronic water shortages, resulting in significant water savings and improved resource allocation.

3.2 Reducing Carbon Emissions through Smart Energy Management

The energy sector is one of the largest contributors to global carbon emissions, and AI has the potential to significantly reduce its environmental impact. AI algorithms can optimize energy consumption in real-time by analyzing data from smart grids, predicting energy demand, and adjusting supply accordingly. For instance, Google has used AI to reduce the energy consumption of its data centers by 40%, demonstrating the potential for AI to drive significant reductions in carbon emissions (Davenport & Ronanki, 2018). Furthermore, AI can facilitate the integration of renewable energy sources into the grid by predicting fluctuations in solar and wind energy production, ensuring a stable and efficient energy supply.

In addition to optimizing energy use, AI can also play a role in reducing emissions from transportation. Autonomous vehicles, powered by AI, have the potential to reduce traffic congestion and improve fuel efficiency. AI can optimize traffic flow in real-time, reducing idle times and minimizing fuel consumption. Moreover, AI can enable the development of more efficient public transportation systems, further reducing the carbon footprint of urban areas. For example, AI-powered traffic management systems in cities like Singapore have reduced traffic congestion by up to 20%, leading to lower emissions and improved air quality (World Economic Forum, 2023).

3.3 Promoting Circular Economies through AI-Driven Innovation

The concept of a circular economy, where resources are reused, recycled, and repurposed, is gaining traction as a sustainable alternative to the traditional linear economy. AI can play a pivotal role in enabling circular economies by optimizing supply chains, reducing waste, and facilitating the reuse of materials. For example, AI-powered platforms can match waste materials from one industry with the needs of another, creating new opportunities for resource sharing and reducing the overall environmental footprint. Additionally, AI can enhance recycling processes by automating the sorting of materials, improving the efficiency and accuracy of recycling operations.

AI can also support the development of sustainable products by enabling the design of materials that are easier to recycle or have a lower environmental impact. For instance, AI can be used to simulate the environmental impact of different materials during the product design phase, allowing companies to make more sustainable choices. This approach not only reduces waste but also aligns with consumer demand for environmentally friendly products. For example, companies like Adidas are using AI to design shoes made from recycled materials, reducing the environmental impact of their products and appealing to eco-conscious consumers (World Economic Forum, 2023).

4. AI-Driven Trade Transformation: Opportunities and Challenges

AI is reshaping global trade practices and models in multiple ways, from supply chain optimization to service trade innovation and the digitization of policy regulation, with impacts spanning the entire trade value chain. This section systematically elaborates on the specific applications and potential challenges of AI in trade, integrating technological features with international trade demands.

4.1 Optimizing Global Supply Chain Management

Foundational AI should lead to more efficient manufacturing and supply chains, as well as leading to productivity gains across services sectors as foundational AI systems assist in information retrieval and support services delivery across education, health care, and professional services (McKinsey & Company, 2023). By integrating historical data and real-time information, AI significantly enhances supply chain forecasting accuracy and responsiveness. For example, Amazon uses AI algorithms to analyze regional market demand and logistical bottlenecks, dynamically adjusting inventory distribution to reduce logistics costs by 20% and minimize resource waste. Toyota leverages an AI-driven “just-in-time” production system to monitor component supply in real time, cutting production delay risks by 30%. In risk management, AI platforms can predict disruptions caused by natural disasters or geopolitical events (e.g., the Suez Canal blockage) and automatically plan alternative routes. This capability has enabled manufacturers in Vietnam and Malaysia to diversify procurement amid U.S.-China tech decoupling. Additionally, AI facilitates green transformation: Unilever prioritizes low-carbon suppliers by tracking full lifecycle carbon emissions, while Maersk optimizes shipping routes and speeds using AI, reducing per-vessel carbon emissions by 12%, advancing sustainable supply chains.

4.2 Promoting Cross-Border Service Trade

AI is likely to impact international trade in various ways (Meltzer, 2018). AI breaks down language and geographic barriers, expanding the boundaries of service trade. For instance, eBay's built-in machine translation enables real-time multilingual communication, boosting Latin American sellers' exports to Spanish-speaking countries by 17.5%. Indian IT firm Infosys enhances legal document processing efficiency by 40% using AI translation systems. In professional services, Butterfly Network's portable AI devices transmit ultrasound images to Indian doctors for remote diagnosis, reaching remote areas in Africa and Southeast Asia. Educational platform Coursera uses AI to recommend personalized courses, with international users exceeding 60%. Collaboration tools like GitHub Copilot further dissolve geographic constraints: Ukrainian developers working with Silicon Valley firms shorten project delivery cycles by 25%, fostering global knowledge sharing and specialization.

4.3 Smart Trade Policy and Regulation

A related impact on trade could be increased trade in services or in this case in design or intellectual property (IP) rights (McKinsey Global Institute, 2019). AI demonstrates high efficiency in trade policy formulation and compliance management. Singapore Customs' AI tool 'TradeTrust' automates verification of electronic documents, slashing clearance times from 3 days to 4 hours. The World Customs Organization (WCO) employs AI fraud detection systems to identify abnormal customs declarations with 90% accuracy. To counter geopolitical risks, South Korean semiconductor firms use AI to simulate impacts of U.S. chip export controls on China, swiftly adjusting export strategies. The EU applies natural language processing (NLP) to analyze historical trade agreements, aiding negotiators in identifying contentious clauses. AI models also evaluate economic benefits of agreements; for example, Australia refined digital tax and data flow rules by simulating the Digital Economy Partnership Agreement (DEPA), enabling precision in policymaking.

4.4 Sustainable Trade and Circular Economy

AI provides critical support for trade's green transition. Apple tracks carbon emissions across iPhone component supply chains, prioritizing renewable energy suppliers to achieve full supply chain carbon neutrality by 2025. Dutch firm AgriChain uses AI to verify sustainable coffee bean certifications, promoting "fair trade" labeling. In resource recycling, BASF's AI platform directs plastic waste exports to Southeast Asian recycling plants, cutting landfill waste by 150,000 tons annually. Singaporean startup BlueOak improves e-waste sorting efficiency by 3x using AI to recover precious metals. On the consumer side, Amazon's "Climate Pledge Friendly" label uses AI to filter low-carbon products, while H&M analyzes consumer preferences to expand recycled fiber product lines, driving a 35% sales increase in sustainable goods and steering green consumption trends.

4.5 Challenges and Policy Recommendations

AI's application in trade faces multiple challenges. Data localization policies (e.g., China's Cybersecurity Law) restrict cross-border data flows, hampering AI model optimization. Free trade agreements must strengthen data mobility clauses. The technological gap among SMEs is stark—only 15% possess AI capabilities—necessitating international aid and training programs (e.g., the EU's Digital Europe Programme). Algorithmic bias risks exacerbating trade inequity; auditing mechanisms and transparency in AI decision-making are essential, alongside WTO-led fairness standards. Geopolitical tech restrictions (e.g., U.S. chip export controls on China) may widen technological disparities, requiring multilateral coordination (e.g., via G20) to harmonize export rules and prevent global AI ecosystem fragmentation. Balancing innovation incentives with risk management is key to achieving an intelligent, green, and equitable new trade order.

5. The Ethical Imperative

5.1 Addressing Bias and Ensuring Fairness in AI Systems

One of the most pressing ethical challenges in AI is the issue of bias. AI systems are only as unbiased as the data they are trained on, and if that data reflects historical inequalities, the AI systems can perpetuate and even exacerbate those inequalities. For example, AI algorithms used in hiring processes have been found to favor certain demographics over others, leading to discriminatory outcomes. To address this, businesses and policymakers must prioritize the development of fair and transparent AI systems. This includes implementing rigorous testing and validation processes to identify and mitigate biases,

as well as ensuring that AI systems are designed with diversity and inclusion in mind (Davenport & Ronanki, 2018). Moreover, AI systems must be designed to be explainable, meaning that their decision-making processes should be transparent and understandable to users. This is particularly important in high-stakes applications such as healthcare, criminal justice, and finance, where AI-driven decisions can have significant consequences for individuals and society. Explainable AI not only helps to build trust in AI systems but also allows for greater accountability and oversight (Bessen, 2019). For example, in healthcare, AI systems used to diagnose diseases must be able to explain how they arrived at a particular diagnosis, allowing doctors to verify the accuracy of the AI's conclusions and make informed decisions about patient care (World Economic Forum, 2023).

5.2 Global Cooperation in AI Governance

Given the global nature of AI development and deployment, international cooperation is essential to ensure that AI benefits all of humanity. This includes establishing global standards for AI ethics, data privacy, and security. Organizations such as the United Nations and the World Economic Forum have already begun to address these issues, but more work is needed to create a cohesive global framework for AI governance (World Economic Forum, 2023). By fostering collaboration between nations, industries, and civil society, we can ensure that AI is developed and used in ways that promote global prosperity and well-being.

One example of global cooperation in AI governance is the European Union's General Data Protection Regulation (GDPR), which sets strict guidelines for data privacy and security. The GDPR has influenced AI development by requiring companies to ensure that their AI systems comply with data protection laws, thereby promoting ethical AI practices. Similar efforts are needed on a global scale to address the ethical challenges posed by AI and to ensure that its benefits are shared equitably. For instance, the United Nations has launched initiatives to promote the ethical use of AI in developing countries, focusing on issues such as data privacy, algorithmic bias, and the digital divide.

5.3 Empowering Marginalized Communities through AI

AI has the potential to empower marginalized communities by providing access to education, healthcare, and economic opportunities. For example, AI-powered educational platforms can offer personalized learning experiences to students in underserved areas, helping to bridge the educational gap (Bessen, 2019). Similarly, AI-driven healthcare solutions can improve access to medical services in remote regions, enabling early diagnosis and treatment of diseases (Davenport & Ronanki, 2018). However, to realize this potential, it is crucial to ensure that AI technologies are accessible and affordable to all, particularly those in developing countries. This requires targeted investments in AI infrastructure and capacity-building initiatives, as well as policies that promote the equitable distribution of AI's benefits.

In addition to improving access to essential services, AI can also empower marginalized communities by enabling them to participate in the digital economy. For instance, AI-powered platforms can connect small-scale farmers in developing countries with global markets, allowing them to sell their products at fair prices and improve their livelihoods. Similarly, AI can enable entrepreneurs in underserved regions to access financial services, such as microloans, that were previously unavailable to them (World Economic Forum, 2023). For example, in Kenya, AI-powered mobile banking platforms like M-Pesa have revolutionized access to financial services, enabling millions of people to participate in the formal economy and improve their economic prospects.

6. Conclusion

The rise of AI represents a transformative moment for economies, management, and society as a whole. While AI offers unprecedented opportunities for growth, innovation, and sustainability, it also presents significant challenges that must be addressed through thoughtful policies, ethical considerations, and global cooperation. Our analysis highlights AI's potential to optimize resource use, reduce carbon emissions, and promote circular economies, as well as its transformative impact on global trade, from supply chain optimization to cross-border service innovation.

However, the rapid adoption of AI raises critical issues, including labor market disruptions, ethical dilemmas, and the need for robust regulatory frameworks. Policymakers must prioritize inclusive access to AI technologies, foster global cooperation in AI governance, and ensure that the benefits of AI are equitably distributed. By understanding the economic, managerial,

and societal implications of AI, stakeholders can develop strategies that maximize its benefits while mitigating its risks. As we navigate this new era, the integration of AI into economic and managerial practices will be key to unlocking its full potential and ensuring a prosperous future for all.

Funding

Ziying Liu and Cantao Wu would like to express their gratitude for the support provided by the University Student Innovation and Entrepreneurship Training Program.

Conflict of Interests

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

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Building HVAC Electric Load Demand Prediction: Balancing Learning Rate and Hidden Layers for Improved Model Performance

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Abstract: This study examines the performance of a predictive model for building HVAC electric load demand under three distinct conditions. The analysis focuses on two key metrics: the coefficient of variation of the root mean square error (CVRMSE) and the coefficient of determination (R^2). Results indicate a notable disparity in model fitting across the conditions. For conditions 1 (learning rate =0.0001, hidden layer =7) and 3 (learning rate =0.0001, hidden layer =5), an increase in iteration rounds leads to a decrease in CVRMSE, signifying enhanced prediction accuracy. Conversely, condition 2 (learning rate =0.01, hidden layer =7) exhibits an increase in CVRMSE with more iterations, suggesting reduced accuracy. The R^2 values consistently rise with additional iterations across all conditions, indicating improved model fit. However, condition 2 presents a slightly larger discrepancy between the training and test sets compared to conditions 1 and 3. These findings highlight the varying impacts of iteration on model performance across different scenarios. The study underscores the importance of tailoring model parameters, such as learning rate and hidden layers, to specific conditions to optimize predictive accuracy. This research contributes to the understanding of how iterative processes and model configurations affect the accuracy and reliability of HVAC load predictions, offering insights for future model development and application in energy management systems.

Keywords: Neural Network; Machine Learning; Learning Rate; Hidden Layer; Electric Load Demand Prediction

Published: Mar 11, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.178>

1.Introduction

Energy is a crucial foundation for a country's long-term stable development. However, as society continues to develop, modernization is rapidly advancing. With population growth, the demand for a higher quality of life increases, leading to a rising demand for energy. Energy production is gradually failing to keep up with consumption, resulting in an energy crisis. Nowadays, it has become the most concerned global issue. According to Energy Information Administration (EIA) of the US, global energy demand is expected to rise by 50% over the next 30 years, with carbon emissions projected to increase by 35% compared to 2020 ^[1]. Among the global energy consumption, the building sector contributes to 36 % ^[2], the heating, ventilation, and air conditioning (HVAC) system accounts for about 50% ^[3] of the total energy consumption in a typical building. Therefore, optimizing HVAC operations offers significant potential for energy savings. Among the existing methods

for optimizing operations, deep learning models present significant advantages. These models can use raw data to predict the short-term power demand of HVAC systems. This allows for the identification of daily peaks and troughs in power demand and helps outline the approximate demand curve. By analyzing the influence of each variable on power demand, deep learning models enable the development of more effective energy-saving plans.

Currently, there are three main types of methods for predicting energy consumption: white-box models, black-box models, and grey-box models. The white-box model is a physical energy model of a building, based on detailed building parameters and heat balance equations. However, it is time-consuming and requires prior knowledge. The grey-box model combines building physical information with historical data sources. But a notable disadvantage is that it does not account for internal heat gains and occupant behavior ^[4]. The most representative of these is the RC model (resistance-capacitance model), a widely used hybrid model. It effectively represents both the physical components of a building and its dynamic processes. For example, it models heat transfer through the external envelope and changes in regional air. Usually, physical models offer higher prediction accuracy compared to statistical models. However, developing detailed physical energy models for each building can be a tedious task. As an alternative, black-box models have gained popularity in recent years due to the rapid development of big data technologies.

Based on previous studies, some studies have identified a variety of machine learning algorithms. Common algorithms include Support Vector Regression (SVR) ^[5, 6], Random Forest (RF) ^[6, 7], XGBoost ^[8, 9], Deep Learning, and Artificial Neural Networks (ANNs) ^[10]. ANN is a nonlinear statistical algorithm inspired by biological neural network, which has powerful learning, training and prediction functions.

The BP neural network is a common artificial neural network model known for its strong nonlinear mapping ability and adaptability. In this study, the BP neural network is used to model the HVAC electric load demand of buildings. The neural network is trained and optimized using historical data. Once training is complete, new data is input into the neural network for prediction, yielding the corresponding output results. Through this method, the key parameters such as learning rate and the number of hidden layers are explored. The proposed method, based on the BP neural network prediction model, offers several advantages: (1) It has strong nonlinear mapping ability and adaptability, allowing for more accurate predictions of electric load demand; (2) It features low computational complexity, enabling fast predictions. The HVAC electric load demand prediction method is implemented using the MATLAB programming language, and the method's effectiveness and accuracy are verified. The research findings provide valuable insights for the rational planning of air-conditioning electric load demand.

2. Methods

2.1 Determination of influencing factors

The electricity consumption of air conditioning systems generally includes three main components: the heating and cooling sources, the working fluid transmission systems, and the air conditioning units along with terminal equipment. Each of these components involves numerous and complex influencing factors, resulting in a wide variety of elements affecting the overall air conditioning load. Therefore, it is necessary to analyze and identify the primary influencing factors. Below are several key areas:

Building Characteristics and Thermal Load Factors: This section focuses on building area and volume, the thermal insulation performance of the building envelope, and fresh air requirements. These factors significantly influence the thermal load and, consequently, the electricity consumption of air conditioning systems.

External Environment and Climatic Factors: Outdoor temperature, humidity, and wind speed are critical external factors impacting power consumption. Understanding these climatic influences is essential for accurate load prediction and energy management.

Air Conditioning System Factors: This includes the system type, equipment energy efficiency, pipeline design, and control systems. These internal factors determine how effectively the system operates and its overall energy efficiency.

This study begins by introducing the data sources for air conditioning load. A literature review is conducted to select factors influencing electricity demand, ensuring a comprehensive analysis of the factors affecting air conditioning load. Next,

the preprocessing process of load data is described in detail. By constructing and selecting features, the diversity of input parameters for the model is enriched. Finally, the evaluation metrics for load prediction are introduced, and appropriate metrics are selected to ensure the accuracy of the model's predictions.

2.2 Data description

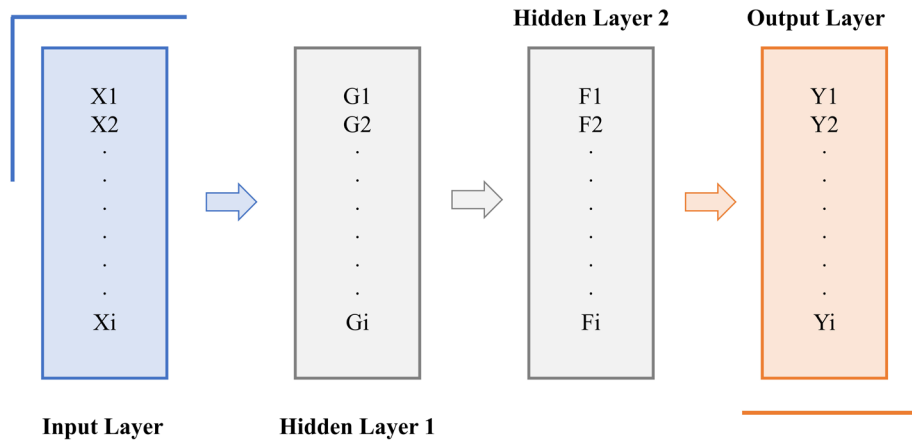
The data to be analyzed in this research are retrieved from a small office building. The total floor area is around 522.0 m². One month data are collected with a collection interval of 60 min. The variables included in this database contains five-time variables the dry bulb, relative humidity, wind speed, total floor area, cooling temperature set point. The building roof type is attic roof with wood joint^[11]. The cooling type is air source heat pump. This study selected the most important input feature variables in Table 1 to simplify the model, and some not important variables such as airtightness are neglected.

Table 1. Input variable ranges for the small office buildings.

No.	Input Feature Variables	Unit	Value
1	Dry Bulb	°C	[−32.8, 37.0]
2	Dew Point	°C	[4, 100]
3	Relative Humidity	%	[0, 14.9]
4	Atmos Pressure	Pa	[81300,102800]
5	Wind Speed	m/s	[22.78, 25.00]

The power demand of the air conditioning system is related to the indoor and outdoor temperatures, the indoor area and Atmos pressure. Feature set is constructed using unsupervised deep learning. As shown in Fig. 1, the deep auto-encoder model developed has a symmetric structure with four layers in total.

Fig. 1: Schematic of the deep auto-encoder model for feature extraction.



The entire dataset is divided into training, validation, and testing data with proportions of 70%, 15%, and 15%, respectively. Deep learning models include several hidden layers, and the training process is complex. In this study, four parameters of the deep learning models are optimized: (1) the number of hidden layers, (2) the dropout ratio at the input layer, (3) the learning rate (LR), and (4) the activation function. It should be noted that the number of neurons in each hidden layer is set as constant in this study to reduce the computational load associated with parameter optimization. The rule of thumbs in neural network is Eq. (1).

$$\frac{\text{No.of inputs} + \text{No.of outputs}}{2} \quad (1)$$

Since the sample data units are not uniform, it is necessary to normalize the initial data before using MATLAB software to train the neural network. Normalization not only accelerates the training speed but also improves the model's generalization ability and expands its scope of application. The normalization process ensures that all input features are on a similar scale, which helps the neural network learn more effectively. The normalization formula is as follows:

$$Z = \frac{X - X_{\min}}{X_{\max} - X_{\min}} \quad (2)$$

Where, X represents the original data value; X_{\min} is the minimum value in the dataset, and the X_{\max} is the maximum value.

3.Results and discussion

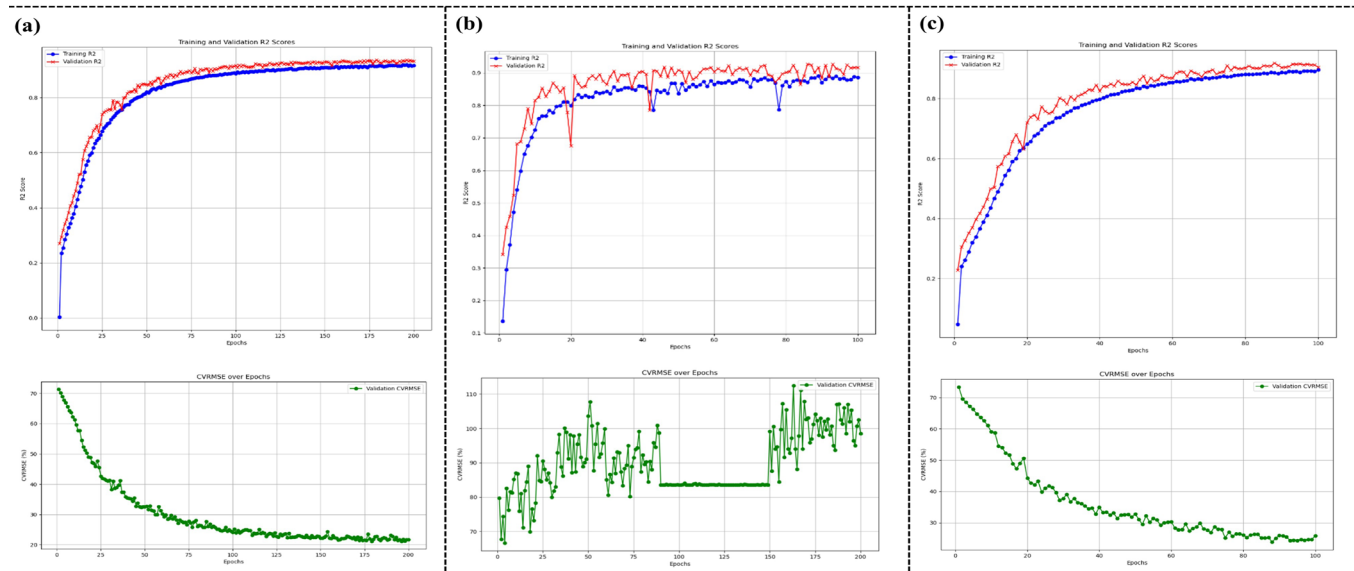
As shown in Table 2, three working conditions are set to compare the influence of learning rate (LR) and hidden layer on the Electric load demand prediction of building air-conditioning.

Table 2. Working condition setting.

Parameters	Condition 1	Condition 2	Condition 3
LR	0.0001	0.01	0.0001
Hidden layers	7	7	5
The Proportion of Testing Data	0.2	0.2	0.2

Fig. 2 illustrates the fitting results under three different conditions, revealing a significant gap among them. The CVMSE (Coefficient of the variation of the root mean square error) values indicate that as the number of iteration rounds increases, the overall trend of CVMSE decreases in working conditions 1 and 3, leading to improved model prediction accuracy. In contrast, working condition 2 shows an opposite trend. Similarly, the R^2 (R^2 scores) values increase with more iteration rounds across all three conditions. However, the difference between the training set and the test set in condition 2 is slightly higher compared to conditions 1 and 3.

Fig. 2: Results: (a) Condition 1, (b) Condition 2, and (c) Condition 3.



Additionally, research indicates that increasing the number of hidden layers can enhance the model's complexity, thereby improving its ability to handle nonlinear problems. This improvement helps the model fit complex data more accurately. However, adding more hidden layers also significantly extends the training time. Moreover, too many hidden layers may lead to decreased performance on the validation set, as indicated by an increase in CVMSE.

On the other hand, the choice of learning rate also significantly impacts the model's training effectiveness. A lower learning rate can help the model converge more stably, avoiding overshooting the global optimum. However, if the learning rate is too low, it may result in excessively long training times. Conversely, a higher learning rate can speed up training but may cause the model to get stuck in local optima, increasing the risk of overfitting. Therefore, it is crucial to find a balance between the learning rate and the number of hidden layers during model training to ensure both accuracy and generalization capability.

4.Conclusion

This study underscores the crucial role of learning rate and hidden layer configuration in predicting building HVAC electric load demand. The findings indicate that scenarios with a lower learning rate and an optimal number of hidden layers, such as

conditions 1 and 3, generally achieve superior prediction accuracy. This is reflected in the decreasing CVRMSE values and increasing R^2 scores as iteration rounds increase. Conversely, condition 2, which employs a higher learning rate, yields less favourable outcomes, highlighting the need for careful parameter selection.

The research suggests that adding more hidden layers can improve the model's capacity to manage complex, nonlinear data. However, this can lead to longer training times and potential overfitting, as indicated by higher CVRMSE on the validation set. Similarly, while a lower learning rate supports stable convergence, it may extend training duration. In contrast, a higher learning rate can speed up training but may cause the model to become stuck in local optima.

Thus, finding the right balance between learning rate and hidden layer configuration is essential for optimizing both the model's accuracy and its ability to generalize. This balance ensures that the model not only fits the training data effectively but also performs well on new, unseen data.

Funding

no

Conflict of Interests

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

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Financial Risks and Measures in Corporate Mergers and Acquisitions

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Abstract: In recent years, with the general strengthening of China's national strength, mergers and acquisitions have become more frequent. Mergers and acquisitions can strengthen a company's strength and achieve maximum value big. Mergers and acquisitions are complex economic activities with many interests that can involve some financial risks. Therefore, preventing financial risks has become a challenge for companies. Key factors for successful mergers and acquisitions. This article analyses various risks and their causes in the process of mergers and acquisitions and proposes some control measures.

Keywords: Merger and Acquisition Projects-Financial Risk; Control Measures

Published: Mar 22, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.202>

Introduction

So far, developed countries overseas have experienced a wave of mergers and acquisitions.

In the 1990s, foreign countries had already launched There have been five mergers and acquisitions already, and each round has been more intense than the previous one Intense. After such a long period of practical research. Research shows that corporate mergers and acquisitions have become an excellent enterprise. The best way to develop mature enterprises George, winner of the Bell Prize in Economics, also wrote this Empower enterprises with a high strategic position in mergers and acquisitions Values advocate that there are no such well-known foreign companies from an external perspective, they occurred through mergers and acquisitions and compatibility The initial wave of mergers and acquisitions by Chinese companies

In 1984, Bank of China Group and China Resources Group jointly established Hong Kong Kangli Company has also taken over and opened for business Chinese enterprises are gradually moving from immaturity to maturity Merger and acquisition channels. According to relevant statistics, domestically and the procurement market has ranked third in the Asian M&A market.

The position is sufficient to prove the development of Chinese corporate mergers and acquisitions Rapid development has brought various benefits to the domestic economy.

What benefits? But operators need to pay attention The benefits and risks of mergers and acquisitions coexist in order to obtain greater rewards, equal or Therefore, all enterprises will double their risk management Operators can handle merger and acquisition risks more reasonably matter.

1.Venture capital in modern corporate mergers and acquisitions problem analysis

1.1 Pricing risk

Pricing risk is mainly reflected in mergers and acquisitions in two aspects: 1. The pricing of the merger far exceeds that of the acquired company. The actual value of square. This will trigger a wave of capital. After the merger, it will not be possible to obtain costs and expected benefits.

This will also lead to higher expected liabilities and interest rates. Interest burden affects the existing production and operation of enterprises. Camp situation.

1.2 Financial risk

Financing refers to the use of various reasonable means by a company. The activity of obtaining sufficient financial assets through finance. The emergence of capital risk is related to financing methods. Different methods lead to different financial risks.

Exactly the same. Equity financing accompanies the disruption of company stability. The risks of fixed operations and debt financing are accompanied by capital risk of gold chain breakage and stagnation of mixed financing. Post financial crisis, etc.

1.3 Debt repayment risk

Debt repayment risk is caused by corporate mergers and acquisitions. Generally speaking, it is caused by insufficient debt paying ability. Purchasing will bring a large amount of debt to the enterprise. Therefore, the company may not be able to repay its debts on time. Business risk. Generally, companies choose long-term loans. Various methods, such as loans, short-term loans, leveraged buyouts, etc. The fusion path is used to obtain sufficient funding. Regardless of the method chosen, it requires the efforts of the enterprise. A certain cost is a certain degree. The danger of repaying debts.

1.4 Integrate risks

After the company merger, one party will replace the other. One party has the right to manage, manage, and make decisions. During this period, personnel, culture, and systems after the merger and acquisition. There are significant differences in degree system, job scope, etc.

Uncertainty, together with some things the integration of risk factors affects the factors of enterprise integration risk. Renowned for strategic cooperation and human resources collaboration. Province, asset cooperation, etc.

2. Effective measures to control financial risks in corporate mergers and acquisitions

2.1 Transparent information and clear management objectives

As the core content of corporate mergers and acquisitions, information should be transparent and truthful. Gender will directly determine the quality of business and potential financial risks in corporate mergers and acquisitions. These proportions are also closely related. Inaccurate or outdated information. This will seriously affect the decision-making of the management team and may lead to various problems during the acquisition process. Due to various issues, administrators must improve the transparency of information. Administrator's request.

We need to start from different levels to ensure the quality of information and fully reflect merger and acquisition activities. Various practical situations of the process to improve the quality of corporate mergers and acquisitions and reduce risks. Implement effective control. Firstly, managers need to understand the actual situation of the target enterprise and have a clear understanding of the main tasks. Comprehensively analyze the business, value management model, and core competitiveness. Administrators. Collect relevant data through information technology and on-site research.

In the actual process of mergers and acquisitions, understanding the specific situation of the target company and based on its authenticity. Determine whether there is a merger risk based on the actual situation. When there is a risk of mergers and acquisitions, it is necessary. If the risk is assessed as high, mergers and acquisitions cannot be carried out to reduce the risk.

The probability of an enterprise facing economic risks. At the same time, financial personnel also need to analyze the objectives. The company's financial statements show its operating conditions and accounting information is the main basis for pricing merger and acquisition projects. However, due to various factors. Due to various factors, the accounting methods of most companies nowadays are quite flexible.

Financial statements cannot fully reflect the actual situation of the enterprise. Enterprises respond to finance. Data coordination, high-quality financial statement replication, project asset integration. The value is fully reflected, and the

acquirer can understand the actual situation of the enterprise Administrators can make effective decisions. In the specific work process, the administrator

Properly utilize various resources, coordinate the resource system, and pay attention to other resources of the target party.

This ensures the quality of information. For example, debt risk, where debt refers to the operational processes of a business.

This is an inevitable content in China, and debt data will directly determine the financial situation The probability of danger occurring. Therefore, enterprises must combine on table and off table data resources to achieve differentiation Analyze potential pitfalls in financial statements and conduct comprehensive analysis The rationality and scientificity of risk control.

Secondly, managers also need to clarify the management objectives of the acquirer. research and development in the current M&A process, most company executives have a correct understanding and The importance of acquisition targets leads to relatively free merger and acquisition activities, lacking core content.

During the evaluation process, only the financial condition of the target company is assessed, without considering the following factors:

Comprehensive evaluation from multiple perspectives such as future prospects, core competitiveness, and cultural values These factors will affect the future development and subsequent development of the enterprise The quality of exhibitions is also closely related. Therefore, managers must clarify the purpose of the merger and acquisition Deepen the understanding of merger and acquisition risks and enhance one's ideological awareness. Play your role and carry out internal activities on a regular or irregular basis Training activities for managers to acquire financial risk knowledge

Master financial risk prevention measures and respond quickly when risks occur.

Resulting in the expansion of risks and affecting the entire M&A activity. The management also needs to switch the transmission method Fully understand the company's operating model, understand its market size, and determine its goals.

Comprehensively analyze the future development direction and production and operation mode of the enterprise to avoid confusion.

Conflicts may arise in subsequent merger and acquisition activities, resulting in financial risks. enterprise management

Managers should clarify the financial and operating capital status and combine them with the actual situation of the enterprise

Comprehensively analyze the current situation to make decisions more scientific and reasonable Fundamentally reducing the possibility of financial risks, making corporate mergers and acquisitions more reasonable.

2.2 Establish a sound evaluation system and expand financing channels

The value evaluation system will directly determine the quality and financial risks of corporate mergers and acquisitions

There is a close relationship between the two. Managers need to establish and understand a sound value evaluation system.

Based on the actual situation and development of the target enterprise Confirm the correctness and reasonableness of the merger and acquisition. The research results show that currently, the majority of enterprises in China There are certain problems with the enterprise value evaluation system, and managers are not familiar with it. 080 Modern Marketing Week finance and economics

Due to the lack of in-depth exploration and awareness of its importance, it has led to the occurrence of corporate mergers and acquisitions.

Pricing risks seriously affect the economic and social benefits of enterprises. So the management team

Personnel should start from different levels to reduce the probability of pricing risks and improve efficiency The success of mergers and acquisitions. The administrator conducts a comprehensive evaluation of the target enterprise to determine the objectives The value of target enterprise mergers and acquisitions. Reasonable evaluation methods can be developed during this process to avoid Avoid major errors that may cause various problems in enterprise evaluation.

To improve it Information quality requires enterprise managers to accurately analyze the comprehensive data of bidding enterprises.

Reduce M&A pricing risk through accurate analysis of financial and operational conditions

Probability. At the same time, it is necessary to adopt appropriate evaluation methods and increase the number of evaluators

Comprehensive quality makes asset evaluation more standardized. Administrator available Establish an information

technology evaluation model to understand the past and future development of the enterprise, To reduce pricing risk, conduct a forward-looking assessment of the business situation. Enterprise managers construct corresponding evaluation systems based on actual situations. Reduce the probability of pricing risk occurring at the same level to ensure greater accuracy and reliability.

Improve the likelihood of successful mergers and acquisitions.

In addition, enterprises should also broaden their financing channels and build reasonable financing channels Structure. At present, most enterprises in China mainly adopt internal financing methods in the financing process Financing, stock financing, and debt financing all have certain differences under different financing methods Different. Enterprises should make reasonable choices based on their business scale, financial condition, and profitability.

Choose the appropriate financing method and conduct a thorough analysis of different financing methods The scientificity and rationality of financing structure. Methods for handling different financing methods Unlike other financing methods, financing also encounters corresponding problems. For example, in debt financing During this process, the company mainly borrows money from investors, who become creditors.

After expiration, the enterprise will repay the corresponding principal and interest according to the agreed interest between both parties This will lead to excessively high interest rates and gradually increasing merger and acquisition costs. So the enterprise Managers must balance and reduce operational risks while considering financing risks.

Thoroughly analyze risks. Enterprises should reasonably expand financing channels and combine with the Internet Evaluate business capabilities and compensation through trend expansion Comprehensively analyze the actual situation of the enterprise and formulate corresponding management systems.

Reduce the probability of financing risks occurring.

2.3 Corporate asset restructuring and innovative management mechanism

Business leaders must be aware that financial risks associated with mergers and acquisitions are not limited to the merger and acquisition process also involves corresponding risks after the completion of the transaction. Therefore, After the completion of company mergers and acquisitions, it is necessary to integrate financial risks and implement effective controls.

Firstly, managers must restructure their assets. Asset restructuring can to some extent Assist management personnel in understanding the specific assets of the company after the completion of the merger and acquisition, in order to avoid delays in the subsequent process There are many problems in the financial control process. The buyer must submit to the buyer By integrating advanced management concepts into existing businesses, effective management is provided Optimize and innovate culture and business models to enable acquiring companies to gain Obtain corresponding vitality, improve the utilization rate of company assets, and realize the business model of both parties in the merger and acquisition Unity can be achieved. Meanwhile, the buyer must also dispose of non-performing assets during the merger process.

Once completed, the integration of its assets is the main process for achieving synergies,

This is also an important way to establish the company's core competencies and innovation capabilities. According to mergers and acquisitions Once the merger and acquisition plan is completed, it is unreasonable to manage the assets of the acquired company correctly.

Assets can be sold to offset debts, or transferred in different ways non performing assets reduce the likelihood of financial risks occurring. If issued after the completion of mergers and acquisitions Serious financial risks have arisen, making it difficult for the merger results to align with the initial objectives.

Consistency, or inability to achieve merger and acquisition goals due to changes in the external environment of the company. The company must withdraw the corresponding investment to avoid significant losses.

Secondly, enterprises need to innovate their management mechanisms. The company needs to clarify two main principles Then elaborate on the principles of integration, the organic combination of financial accounting and management accounting, and make its management mechanism more accurate and reliable, and reduce the likelihood of financial risks occurring.

Firstly, the principle of integration. After the merger is completed, the acquirer must rely on the professional knowledge of its team God, make reasonable use of information technology to share various data resources, such as financial information

Improve the efficiency of data usage (including business information and information) by both parties involved in mergers and acquisitions to ensure the smooth operation of the company Integration of business models. The second is the organic combination of financial accounting and management accounting.

The principle of organic integration of financial accounting and management accounting mainly involves the merger and acquisition process.

The commercial and financial activities of postal enterprises are highly complex, therefore they need to be based on the accounting reporting system as the core, plan company activities reasonably and establish a planning and control system, do a good job in forecasting, and achieve full process management. Mergers and Acquisitions Managers need to rethink organizational structure, and determine the size and scale of financial institutions based on the actual situation after mergers and acquisitions, and design financial institutions reasonably. The operational management structure enables financial managers to clearly define their professional responsibilities and take them seriously. Carry out risk management work responsibly.

3. Conclusion

In a highly dynamic business environment, mergers and acquisitions of companies occur at various levels. Each section has many variables. Therefore, it is necessary to fully understand and improve the risks of mergers and acquisitions.

Fine management is particularly important. The company must continuously update its risk management strategy to: Ensure that every step is down-to-earth and every decision contributes to the success of the merger and acquisition. Ultimately, companies that are flexible and able to seize opportunities will have more opportunities. It is possible to write one's own brilliant chapter at the forefront of the M&A wave.

Funding

no

Conflict of Interests

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

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Research on Personnel Turnover of Beijing Qinghu Software Limited Company

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Abstract: With the improvement of China's economic level, the loss of enterprise personnel is very common. The large number of personnel loss in Internet enterprises has aroused more and more attention. No matter any enterprise, human resources are extremely important, an enterprise without human resources can not be said to have core competitiveness. Human resources also affect the trend of enterprises. Due to the rapid development of the Internet, the phenomenon of staff loss is quite obvious. It is of great significance to analyze the reasons of personnel turnover and put forward corresponding solutions for the sustainable and healthy development of relevant enterprises. Software co., LTD., Beijing green lake as the research object, analysis software co., LTD., Beijing green lake personnel loss situation, influence and reason, through on-the-spot investigation method and interview method, and other forms, from the external environment factors, internal factors and their employees, and other Angle, analyze the root cause of the high staff turnover rate, Then put forward the concrete measures to reduce the loss of personnel in Beijing Qinghu Software Co., LTD. Namely, enterprises should improve the system of performance evaluation, compensation system reform, strengthen the employees' career training, build scientific promotion mechanism, strengthen enterprise culture construction work together, should not only focus on employee's work ability, but also pay attention to employees for the identity of the enterprise, let employees to wuxi, proud of working in the enterprise, reduce staff turnover. At the same time, attracting more excellent employees to join the company aims to effectively reduce staff turnover, enhance the level of human resource management, and provide reference for similar companies to deal with staff turnover.

Keywords: Staff Turnover; Human Resource Management; Beijing Qinghu Software Limited Company

Published: Mar 20, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.204>

1.Introduction

1.1 Research background

Nowadays, the Internet plays an important role in our daily life, and our life is inseparable from the Internet. The competition among Internet companies is becoming more and more fierce. As the main part of enterprises, employees play a particularly important role in the competition of Internet enterprises. Employees in an enterprise can move freely. When employees are dissatisfied with the enterprise, they will leave the existing enterprise, which will lead to the loss of personnel, increase the operating cost of the enterprise, hit the morale of employees and weaken the competitiveness of the enterprise. The brain drain of enterprises will do great harm to enterprises. Therefore, how to keep employees in the enterprise has become a key factor for the sustainable and healthy development of the enterprise.

1.2 The purpose and significance of the study

Employees create wealth for enterprises, which is also an important part of enterprise development. The competition between enterprises is, in the final analysis, the competition between people. With excellent employees, you can be in an advantageous position in the industry competition and then succeed. Therefore, we should start with the brain drain of enterprises, analyze the factors that cause brain drain, and make targeted suggestions to reduce the probability of brain drain of enterprises and make enterprises succeed in the competition.

This paper will take Beijing Qinghu Software Co., Ltd. as an example, through studying the staff turnover of Beijing Qinghu Software Co., Ltd., analyze the reasons and put forward countermeasures to reduce the staff turnover rate.

1.3 Literature review

1.3.1 A summary of foreign research

The research on the brain drain of enterprises in western developed countries is earlier, which can be traced back to the beginning of last century. Scholars have studied the brain drain from different angles and obtained some results:

Maslow's hierarchy of needs theory holds that human needs are divided into physiological needs, security needs, social needs, respect needs and self-realization needs, and these needs are ascending step by step. This theory can effectively combine people's needs with enterprise personnel management measures under the background of the continuous improvement of people's material living standards in China, and provide reference for enterprises to formulate relevant current and human resource management measures.

Herzberg (1965), an American psychologist, put forward the theory of two factors, namely, incentive factors and health care factors, which have a restrictive effect on the development of enterprises. Incentive factors are satisfaction factors, which make people feel satisfied and motivated, such as personal achievements, job promotion, rewards, etc. Health care factors, that is, dissatisfaction factors, refer to factors other than work, such as employees' working environment, enterprise policies, and colleagues' relations. The two factors will have different effects on employees, and the incentive factors can motivate employees to exert their potential, improve work efficiency and bring satisfaction. However, health care factors can not bring satisfaction, but can only eliminate the negative emotions of employees. Enterprises can comprehensively use incentive factors and health care factors according to their own conditions, so as to improve the job satisfaction and performance of employees and reduce the turnover rate.

Muchinsky and Morrow(1980) analyzed the problems related to negative brain drain, and put forward that the factors affecting brain drain mainly include the following three factors: work-related factors, personal factors and economic factors. These three factors correspond to the organization, the personal quality of employees and the external economic environment. MichaelE(2006) thinks that the problem of brain drain can be solved through incentives. When employees are in the burnout period, enterprises can improve their work enthusiasm through various incentives, such as making appropriate improvements to the enterprise performance appraisal system, directly linking employees' performance with employees' performance, or making targeted career plans for employees.

Kumar and Shekhar (2012) selected employees of India's Polybydron Pvt.Ltd as the research objects, and used questionnaires and interviews to study their loyalty to the enterprise. The results show that employee loyalty will be seriously affected by organizational factors, and organizational reward policy, organizational culture and organizational flexibility are the most important influencing factors.

Eisenberger (2013) believes that the factors that affect employees' loyalty include organizational identity, and employees must express their recognition of the company from the bottom of their hearts before they are willing to pay more and harder work for the company.

Soojin kim (2017) and others believe that the relationship between organizational employee relations and just organizations is positively correlated. The factors that have a negative correlation with employee turnover tendency mainly include the quality of organizational employee relations and organizational fairness.

Nivetha Santhanam (2017) and others believe that even if the human resource management of an organization has been improved, the violation of psychological contract will still lead to employee turnover.

In a word, most of the research on employee turnover abroad examines the factors such as salary, training, labor market structure, unemployment rate and so on from the macro level. Because China's national conditions and market development are different from those of foreign countries, we can't copy the theory directly, but should make a concrete analysis according to China's characteristics.

1.3.2 Summary of domestic research

Chinese scholars started their research on brain drain late. At the beginning, they only paid attention to the translation of foreign research. However, with the rapid development of China's economy, the turnover of personnel within enterprises is becoming more and more frequent, which makes domestic scholars deeply discuss the problem of brain drain and set off an upsurge in China.

Research on the influencing factors of brain drain:

Liu Hongxia (2016) believes that the space for personal development is relatively small, and employees find it difficult to make progress; The imperfect incentive system can't effectively improve the work efficiency of employees, which are the main reasons for the brain drain.

Tong Lingling and Ding Mengmeng (2016) proposed that the social credit mechanism needs to be further improved, which is also one of the reasons for the brain drain. China's market economy is developing faster and faster. In the market economy, "keeping promises and honoring contracts" is very important for China's economic development, and social credit is composed of everyone's personal credit. John Wen Jia (2018) and others suggested that the reasons for the brain drain of enterprises also include corporate culture, and enterprises with good corporate culture are often more attractive to employees. In addition, for most post-90s people, they will pay special attention to the corporate culture of recruiting enterprises when applying for jobs, hoping to work in enterprises that are more in line with their own pursuit of corporate culture. Guo Yue (2019) believes that for private enterprises, the reasons for brain drain include the following aspects: absolute power, cronyism, too little welfare, imperfect incentive mechanism, single management method, and lack of attention to talent training. Sean (2021) considered the reasons of staff turnover from two aspects: internal factors and personal factors of employees. Through comprehensive analysis, it was concluded that the reasons affecting staff turnover included age, working years, living conditions and resignation experience.

Research on the countermeasures of brain drain:

Zeng Siqun (2017) and others believe that the most important thing for employees to participate in the work is salary, so in order to attract employees, it is necessary to increase the salary of employees first, and then provide employees with more room for promotion. He ye (2018) believes that enterprises need to pay attention to the setting of posts, which is conducive to further improving labor cost efficiency. Lang Xiaobo (2018) believes that business leaders need to pay attention to the ideological fluctuation of employees and give them enough care, not just the performance of employees. When employees encounter difficulties in life, they should provide necessary help and care to improve their sense of identity with the enterprise, which is also a means to solve the brain drain. Wang Yu (2019) believes that corporate cohesion can be reflected through corporate culture. With a good corporate culture, it is easier to attract and retain employees. Li Meng (2019) believes that spiritual motivation plays a beneficial role in personnel stability. Zhu Jing (2019) proposed that enterprises should pay attention to the development space of employees and create more promotion opportunities for outstanding talents, which will help employees to better plan their careers and effectively prevent seniority. Fan Qin's (2021) research shows that brain drain will cause cost loss to enterprises, which will lead to the decline of the company's cohesion and affect the company's image. And put forward a series of solutions. Wang hong (2021) studied the reasons for the brain drain of state-owned enterprises and put forward solutions. Zhang Chen (2021) analyzed the brain drain problem of Company B, and put forward corresponding solutions by combining the incentive theory, salary and welfare theory and organizational culture theory.

1.3.3 literature review

By analyzing the above research results, we can find that most scholars study the brain drain of large and medium-sized state-owned enterprises, and the data of these enterprises may be relatively complete and of great significance. However, with the development of economy, some private Internet enterprises have made great contributions to China's national economy, and

the brain drain problem of these enterprises is very serious, but few Chinese scholars have studied it. Based on the theoretical results of brain drain at home and abroad, combined with the characteristics of Chinese enterprises, it has become the focus of current academic circles to discuss the problem of brain drain. In this paper, it is of great practical significance to study the current brain drain in the Internet industry.

1.4 Research contents and methods

1.4.1 Research content

Specifically, this paper studies from the following aspects: First, introduce the characteristics of the Internet industry, and point out the status quo and human resources of Beijing Qinghu Software Co., Ltd..

Second, in view of the staff turnover of Beijing Qinghu Software Co., Ltd., the reasons for the staff turnover are analyzed from three aspects: external environmental factors, enterprise management factors and personal factors of employees.

Third, based on the analysis of the reasons for the brain drain of Beijing Qinghu Software Co., Ltd., some suggestions are put forward to reduce the brain drain, which can provide some reference for other companies in the Internet industry.

1.4.2 Research methods

Literature research method

Based on the existing research, referring to a large number of relevant documents on personnel flow, and combining with relevant case analysis, this paper sorts out and summarizes relevant documents, and points out the research direction and focus of this paper.

Field investigation method

In this paper, Beijing Qinghu Software Co., Ltd. is selected as the research object, and according to the data of staff turnover of Beijing Qinghu Software Co., Ltd., the reasons for staff turnover are analyzed and the corresponding countermeasures are put forward.

Interview method

In the process of empirical research, through interviews with the employees of Beijing Qinghu Software Co., Ltd., more direct, specific and real first-hand information can be obtained.

2. Basic concepts and related concepts

2.1 The concept and characteristics of brain drain

2.1.1 “Brain drain” concept

Brain drain is also called Employee Turnover, which is employee turnover in English. Generally speaking, there are two different definitions in broad sense and narrow sense. Broadly defined as: the change of an individual's status as a member of an organization refers to the transformation of employees from one working state to another. In a broad sense, “brain drain” is “personnel flow”, that is, the process of employees leaving their original jobs and moving towards new jobs.

In a narrow sense, it is defined as: people who get paid from the company break the relationship with the company, that is, based on the principle of position, the change of personnel in the organization caused by the change of employees' positions, also known as “job hopping”. In a narrow sense, “personnel flow”, that is, “brain drain”, that is, employees leave their jobs voluntarily, not because of the company's will. In order to reduce the brain drain, enterprises will take many measures to prevent the brain drain, thus reducing the brain drain.

2.1.2 Types of “brain drain”

Brain drain can be divided into two categories: overt brain drain and covert brain drain. If an employee resigns because of dissatisfaction, this actual loss is called “obvious loss”. If an employee is not satisfied with his job, but he doesn't leave, he slacks at his post, which is called “hidden drain”. The negative impact of this hidden loss on enterprises is usually difficult to detect, so its destructiveness is greater than the obvious loss.

2.1.3 “Brain drain” characteristics

First, the group. On the one hand, the lost employees have group characteristics. On the other hand, it refers to the collective loss behavior. Such a loss will make the company lose its competitiveness and even face the danger of bankruptcy. Recently, one of the main characteristics of talent flow within enterprises is “collective resignation”. Instead of decreasing, the situation

of these technical backbones and middle and senior executives collectively jumping ship is increasing and spreading all over the company.

Second, profit-seeking. This is that the employee's resignation is directly related to his own interests and the realization of his own goals. Some of these people are for a better material life, some are for work, and some are for a stable life. Employee turnover tends to personal interests and personal goals. These employees can be divided into three types: material, environmental and stable. Ordinary workers have clear goals, most of which are for material benefits. At the same time, they also work hard and are willing to work overtime, so as to attract them better. While middle managers or professional technicians pay more attention to good working environment, harmonious working atmosphere and clearer and more predictable working prospects. Such people are quick-thinking and innovative. Although they may not all do well, if they can be influenced by an influential corporate culture, they will have great power.

Third, normalization. Today, with the rapid development of science and technology, in the era of knowledge economy, the role of talents is becoming more and more prominent. Under the background of global economic integration, many multinational companies take the China market as their strategic focus, and the first thing these multinational companies have to do is to establish their own turf, and local development is also inseparable from local talents. Therefore, when they came to China, the first thing they had to do was to dig people. Therefore, for a long time, talents, especially management talents and technical talents, will become the target for major companies and become scarce resources. Therefore, the flow of people between companies will be a normal state.

2.1.4 “Brain drain” impact

The increase in labor costs:

The company's labor cost includes four aspects: acquisition cost (recruitment cost), development cost (training cost), use cost (employee's salary and welfare), and turnover costs (loss caused to the company by resignation). If the employee turnover is too fast, the acquisition cost, development cost and turnover costs of the company will be high, and the profit will be reduced, thus directly increasing the company's operating costs. An employee has not brought much benefit to the company in the first few months or six months, but the company is cultivating him.

The loss of technology and customers:

Frequent brain drain will take away the company's business and technical secrets, as well as the company's major customers. And all this is the company spent a lot of money, material resources, manpower and time to get, but because of this, the company's secrets will be exposed, and the relationship between customers and the company will collapse, and eventually fall into the hands of other companies. At this time, enterprises should invest more time, energy and funds to resist risks and attract more customers. This will have a great impact on the competitiveness of the company, and even lead to the company being at a disadvantage in the competition.

2.2 The basic theory of brain drain

2.2.1 Hierarchy of needs theory

Maslow's hierarchy of needs theory is a behavioral science theory put forward by American psychologist Abraham Maslow in his Theory of Human Motivation in 1943. This book divides people's needs from low to high into five levels, namely, physiological needs, security needs, social needs, respect needs and self-satisfaction. While satisfying their own needs, there is also a need for self-transcendence, but in Maslow's hierarchy of needs theory, most people will combine self-transcendence with self-satisfaction needs.

2.2.2 Two-factor theory

Herzberg, an American psychologist, put forward the two-factor theory in 1959. He divided the relevant factors in the enterprise into two types, namely, satisfaction factors and dissatisfaction factors. Satisfaction factor refers to the factors that can make people satisfied and motivated. Dissatisfaction factors, that is, health care factors, refer to factors that are easy to produce opinions and negative behaviors. He believes that these two factors are the main factors that affect employee performance.

2.2.3 Expectation theory

Expectation theory is an incentive theory put forward by Victor frum, a famous psychologist and behavioral scientist in North America, in Work and Motivation in 1964. It holds that the strength of a behavioral tendency depends on the expected strength of the individual for the possible result of this behavior and the attraction of this result to the actor.

The theory put forward above will be applied in analyzing the causes of brain drain and putting forward corresponding measures.

3.Beijing Qinghu Software Co., Ltd. staff turnover and causes analysis

3.1 Development of Beijing Qinghu Software Co., Ltd.

Beijing Qinghu Co., Ltd. was established in September 2018 with the address of Haidian District, Beijing. Its main business is software development, software services, data processing and product design. Beijing Qinghu Software Co., Ltd. has operation department, marketing department, finance department, technology department, comprehensive department and other departments.

The company has gradually expanded from a team of 8 people in 2018 to the current 124 people, and the human resources framework of Beijing Qinghu Software Co., Ltd. has undergone great changes. There are 36 people in the operation department, and there are 30 people at present, mainly because of the large loss of product managers and programmers; There are 37 people in the marketing department, and there are currently 31 people, mainly because of the loss of marketing managers and subordinates; There are 6 people in the finance department, and there are 9 people at present; There are 50 people in the technical department, and there are currently 39 people; There are 15 people in the comprehensive department, and there are 15 people at present.

Table 1 Analysis of employee post structure

(Unit: person)

Department	Number of people	Proportion
Operational department	30	24.19%
Marketing department	31	25%
Finance department	nine	7.26%
Technical department	39	31.45%
Integrated Department	15	12.10%

Data source: calculated from the data provided by human resources of Beijing Qinghu Software Co., Ltd. in 2022.

According to the classification of employees' ages, as shown in the figure, it can be found that most employees of Beijing Qinghu Software Co., Ltd. are under 35 years old. There are 35 people aged 20-25, accounting for 28.2%; There are 74 people aged from 25 to 35, accounting for 59.7%; There are 15 people aged 35 to 40, accounting for 12.1%. It can be seen that the company's personnel are younger.

Table 2 Analysis of the age structure of employees in the company

(Unit: person)

Age group	Number of people	Proportion
20 ~ 25 years old	35	28.2%
25 ~ 35 years old	74	59.7%
35 ~ 40 years old	15	12.1%

Data source: calculated from the data provided by human resources of Beijing Qinghu Software Co., Ltd. in 2022.

3.2 Beijing Qinghu Software Co., Ltd. Analysis of the current situation of staff turnover

The statistics of staff turnover in Beijing Qinghu Software Co., Ltd. in recent years are as follows: Among the resignees, business development personnel and technical staff account for a large proportion, and 120 people can do sample research. According to the survey data, the positions with the highest turnover rate in this company are 55% in the technical

department, 40% in the operation department, 10% in the comprehensive department and 5% in the finance department. Generally speaking, the turnover rate of Internet companies will not exceed 15%. From the data point of view, the technology department, operation department and marketing department of the company all exceed the normal turnover range. Generally speaking, staff turnover will inevitably occur in enterprises, so as long as it is not particularly high (not more than 15%), it is within a reasonable range. When it exceeds 20%, it will actually affect the normal operation of the enterprise. In Beijing Qinghu Software Company, there are as many as 55% technical department staff loss and as many as 40% operation department staff loss, both of which are important departments of the company, which are beyond the scope of general loss. As a software company, the technology department is the core competitiveness of the enterprise, and also holds the important resources of management. The loss of these personnel plays a vital role in the sustainable and healthy development of the enterprise.

Table 3 Turnover rate of personnel in various departments of the company

	Technical department	Operational department	Integrated department	Finance department
Annual turnover rate	55%	40%	10%	5%

Data source: calculated from the data provided by human resources of Beijing Qinghu Software Co., Ltd. in 2022.

In addition, most of the resignees in Beijing Qinghu Software Co., Ltd. are business development personnel and technical employees under 35 years old. And these two parts of employees are indispensable for an Internet enterprise. The loss of these employees has brought great losses to enterprises, so we should try our best to improve the treatment of these employees, reduce the loss of personnel and reduce the losses of enterprises.

3.3 Analysis of the reasons for the brain drain of Beijing Qinghu Software Co., Ltd.

We will generally consider the factors that cause brain drain from three aspects: external environmental factors, competition in the same industry and economic development. Enterprise management factors mainly refer to the internal management system and the characteristics of the industry. Psychological factors, education level and age of employees are personal factors of employees. According to the above survey results, this paper will also analyze the above three aspects.

3.3.1 External environmental factors

At present, the Internet industry market is developing rapidly, and the competition is intensifying. Under the general environment of rising wages and impetuous mentality of personnel in the whole Internet industry, it is inevitable for employees to “jump ship”. At present, there is a contrast between supply and demand in the Internet talent market, which lacks both high-end talents and low-end talents, and at the same time there is a general surplus of talents. This is also one of the reasons for the high employee turnover rate in the Internet industry.

The salary of the industry is high. With the rapid economic development today, the Internet industry has become one of the promising high-paying industries. Facing the demand of excellent employees, the company will give higher salaries in order to compete for talents.

There are many opportunities for promotion. The internet industry has a wide development space. As long as you have strong professionalism and rich work experience, there are many opportunities for promotion and salary increase.

Good development prospects. There is a big gap in post personnel in the Internet industry, new technologies are constantly emerging and updated in the industry, and emerging jobs are gradually increasing, so there is a huge demand for talents in the market.

3.3.2 Enterprise management factors

Among all the factors of brain drain, the most direct one is enterprise management. If we want to use directional measures to avoid brain drain and employee turnover, this factor should also be the first concern. At the same time, the control of enterprise management factors is in the hands of enterprises themselves, and enterprises should pay close attention to it and make good use of it. The main responsible party of brain drain is the enterprise itself. If employees don't recognize the enterprise culture, business philosophy, support and abide by the principles and policies of the enterprise, then there will be conflicts of goals and interests between the enterprise and employees. Even if employees do not resign in a short time,

because these conflicts are not resolved in time and properly, employees will inevitably have the idea of resigning. Generally speaking, people are used to stability, so except for special circumstances, most employees still want to work safely in the company. The employees who left their jobs have their own ideas, but in the final analysis, the most important problems are the following two: either they are dissatisfied with the salary and think that they have not received the same remuneration as they paid; Either think that leaders do not attach importance to themselves and have a low sense of existence and belonging in the enterprise. On the whole, enterprises should be the dominant party in avoiding employee turnover. From this point of view, although the employee turnover of Beijing Qinghu Software Co., Ltd. is not exactly the same, it is indeed the same in terms of not giving employees a balanced and sufficient development space and imperfect relevant rules and regulations. From the perspective of company management, the factors of employee turnover are as follows:

Performance appraisal system. Software development of Internet enterprises is often high risk and high income, at the same time, it needs a lot of investment, and the work content is different from other work. Affected by the nature of this job, how to scientifically evaluate employee performance has become a big problem. If employees think that they have actually paid a lot, but the official evaluation results are not satisfactory, then they will naturally have the idea of job-hopping.

Pay system. The simplest and most direct idea of ordinary employees is to earn high remuneration through hard work. If employees think that their salary is not proportional to the difficulty of the work, their enthusiasm for work will be greatly dampened, and then they want to leave.

Promotion. When software R&D personnel have accumulated rich work experience, they are no longer simply satisfied with their current positions, but also need the company to provide positions equivalent to their strength. On the one hand, this will give employees a full sense of accomplishment and enhance their motivation; On the other hand, the promotion of the position also provides more opportunities for employees to learn and exercise, and constantly improves the ability of employees. If the enterprise can't do this effectively, it is likely to lead to the loss of employees to external enterprises.

3.3.3 Personal factors of employees

There are various reasons for employees to leave their jobs. Usually, when employees leave their jobs, they will say that they are due to personal reasons. But this is just a move by employees to cover up their actual reasons for leaving. At present, through the investigation of the reasons for leaving employees, it is found that there is a great difference between the reasons for leaving employees in the resignation report and the actual reasons for leaving employees. Therefore, it is of great significance to find out the real reasons for leaving employees to reduce the turnover.

Income. According to the results of the resignation survey, most of the resigned employees still think that the companies they have worked for before have not given them satisfactory wages. To better meet the physiological needs. The most direct and fundamental thing to meet people's physiological needs is material satisfaction. When employees choose whether to work in an enterprise, the first consideration is often the salary. Once the salary cannot meet their personal expectations, employees often leave their jobs.

Career development. The results of turnover survey show that employees do not take income as the only consideration when choosing positions. According to Maslow's hierarchy of needs theory, once people have security and meet their physiological needs, they will pursue the realization of self-worth. Post-80s and post-90s employees pay more attention to whether the post can provide opportunities to realize self-worth and maximize personal development.

Age structure. Research shows that age is an important factor affecting employee turnover, and it is inversely proportional to employee turnover. Young employees are more likely to have job mobility, while older employees are relatively less likely to change. More than 90% of the employees of Beijing Qinghu Software Co., Ltd. are under 35 years old, which is a high-risk age group for job changes. According to the survey results, most of the employees who left the company are under 30 years old. These young employees have less work in the enterprise, less nostalgia for the enterprise and lower loyalty. Once employees feel that their jobs are unattractive and lack development space, they can easily jump to other companies and pursue better development.

There are many reasons for the staff turnover of Beijing Qinghu Software Co., Ltd., and the competitiveness of the Internet industry is one aspect, but we can't ignore the reasons of the enterprise itself and the employees themselves.

4.Countermeasures and suggestions to reduce the staff turnover of Beijing Qinghu Software Co., Ltd.

According to the analysis of personnel turnover factors of Beijing Qinghu Software Co., Ltd., this paper puts forward specific suggestions to prevent personnel turnover or minimize the personnel turnover rate.

4.1 Improve the performance evaluation system

According to the above, it can be seen that the performance evaluation system of Beijing Qinghu Software Co., Ltd. has great defects, which is one of the reasons for the brain drain. According to Herzberg's two-factor theory, satisfaction factor or incentive factor is of great significance to employees. When employees of a company think that there are many satisfaction factors, it is not easy for them to have the idea of leaving their jobs, otherwise it will cause serious brain drain. Therefore, building a perfect performance evaluation system can provide reference and motivation for employees to work actively and motivate employees to work hard. Therefore, it is necessary to build a multi-level assessment and evaluation system. Innovation and excellence evaluation mechanism, from human evaluators to institutional evaluators, from simple performance evaluation scoring mode to performance process management mode to promote performance achievement, is goal-oriented, uses salary to push back tasks, gradually optimizes the salary ratio, releases the internal driving force, and urges employees to manage themselves under the guidance of goals.

4.2 Reform the salary system

Under the environment of market economy, the high salary expected by employees. The employee's salary is the factor to keep himself and his family alive. When the employee's salary can't meet his living needs, he may leave. Therefore, whether the salary system can truly reflect the value of talents has become a key factor affecting the flow of talents. The salary level of Beijing Qinghu Software Co., Ltd. is not high and the brain drain is serious, so it is urgent to establish a scientific and effective salary incentive system. The company must first clearly understand the salary, which is not only a cost, but also a way to help the company achieve its set goals. Salary can not only attract and retain excellent employees, but also make the company get greater financial benefits. A good salary and reward system can provide more talents for enterprises. Therefore, it is very necessary to establish a scientific and reasonable salary system, and on the basis of this system, enterprises must link salary compensation with employees' performance, so as to motivate employees, improve employees' performance and prevent brain drain.

4.3 To strengthen employee career training

According to Maslow's hierarchy of needs theory, employees not only have low-level needs such as physiology and safety, but also have higher-level needs such as respect and self-realization. For example, whether you are respected in the company, whether you can realize your value in your current job and future job, etc. When employees' high-level needs are not met, they will also choose to leave. Therefore, with reference to each employee's personal conditions, fully mobilize the enthusiasm of employees, give full play to their personal advantages, and coordinate and unify employee value with enterprise value, not only to create value for the company, but also to make them feel the maximum extension of their own value. Through employees' short-term goals and long-term goals, they can know their own thoughts and desires in time, actually participate in the implementation of employees' goal plans, guide their career development direction, analyze and help employees achieve their goal plans, master employees' ideological trends, and relieve negative emotions in time, so that they can have goals and directions for their own development, thus reducing the turnover rate of employees.

4.4 To build a scientific promotion mechanism

At present, the biggest reason for the loss of Beijing Qinghu Software Co., Ltd. is the limited personal development space. Therefore, under the premise of meeting the material needs of knowledge workers, the company can provide them with a better career plan, so that they have more opportunities to upgrade their careers and make their careers develop further. After making career planning for its employees, Beijing Qinghu Software Co., Ltd. needs to help them complete their career planning in various ways, especially in promotion and career development. Promotion can make employees feel their value and satisfaction better, and at the same time, it can help them achieve better development in their careers and take on more responsibilities in the company. Therefore, a reasonable employee promotion channel can greatly mobilize these professional

people and give full play to their work enthusiasm, which is not only conducive to the construction and development of the team, but also can reduce the frequent loss of Beijing Qinghu Software Co., Ltd. We should make full use of the positive role of the promotion system in enterprise management. First of all, it is necessary to create a fairer and more perfect post adjustment and promotion mechanism, and implement the basic concept of “those who are capable are superior and those who are mediocre are inferior”, so that employees can feel justice and justice in their work and provide them with a fairer and more just working platform.

4.5 To strengthen the construction of corporate culture

Any enterprise, if it wants to create a good corporate image, must first have advanced business concepts and values based on society and the masses, and then fully show them to the public, so that the public can trust their own brands. So as to strengthen the brand building of enterprises and establish a good and harmonious corporate image in society. If you want employees to be loyal to the brand and willing to serve the enterprise, it is far from enough to rely solely on wages. Only by building a solid brand culture and value concept, can employees feel their deep-seated value embodiment, so that employees can love their jobs and be dedicated. Beijing Qinghu Software Co., Ltd. has established its own corporate image in the local area, and it is well-known in the local area, but it still lacks the values that can really unite people's hearts and cannot make employees feel proud and proud because of their work. The company needs to continue to work hard in the following aspects, earnestly build corporate image and spread corporate culture: it is far from enough for new employees to only have personnel training and job training before they officially take up their posts. Professional ability is only one of the basic standards for auditing employees' quality, and it is more important to root corporate culture and brand image in employees' hearts. Formulate the Employee Handbook, including business philosophy, value pursuit, spirit, development history, purpose, development strategy and enterprise system. Enhance employees' sense of identity with the enterprise. At the same time, we should create a harmonious working atmosphere, give employees meticulous care and love, put people first, pay attention to the process, and enhance employees' sense of belonging to the enterprise.

5. Summaries

Today, with the rapid development of the Internet industry, more and more people are engaged in Internet enterprises, and correspondingly, a large number of industry personnel are lost. We should not only pay attention to the rapid development of the internet, but also pay attention to the brain drain under the development of the industry, and it is of great significance to put forward countermeasures in combination with relevant theories. The analysis of this paper is based on the relevant important theories in the field of employee turnover. By using the methods of literature study, field investigation and interview, combined with the actual situation of Beijing Qinghu Software Co., Ltd., this paper studies and analyzes this problem, and finds that the reasons for employee turnover include the impetuous external environment that maximizes employees' pursuit of interests, problems in internal management mechanism of enterprises, unreasonable performance evaluation mechanism, imperfect salary system and limited personal career development. According to the reasons of brain drain, the corresponding countermeasures are put forward, such as timely understanding the development of the industry, grasping the overall situation of the industry and the company's situation, improving the salary mechanism, perfecting the performance evaluation system, strengthening the career training of employees, constructing a scientific promotion mechanism, and strengthening the construction of corporate culture.

Funding

no

Conflict of Interests

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

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Construction of Enterprise Financial Performance Evaluation System

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Abstract: This article is dedicated to discussing the construction methods and implementation processes of the enterprise financial performance evaluation system, as well as the challenges and corresponding countermeasures. Firstly, it elaborates on the concept of enterprise financial performance evaluation and its construction factors. Secondly, it describes the theoretical basis of the components of the enterprise financial performance evaluation system, including relevant theoretical models and models. Subsequently, it expounds on the methods and techniques for constructing the enterprise financial performance evaluation system, including the selection of KPI indicators and the determination of weights. Then, it presents the implementation process of constructing the enterprise financial performance evaluation system, including preparatory work, indicator design, and the establishment of evaluation models. Finally, it discusses the difficulties faced in constructing the enterprise financial performance evaluation system and proposes corresponding countermeasures. Through the exploration in this article, it can provide specific theoretical and practical guidance for the continuous improvement of the enterprise's financial performance evaluation system.

Keywords: Enterprise Financial Performance Evaluation; Evaluation System Construction; Performance Indicators; Implementation Steps

Published: Mar 20, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.205>

In today's highly competitive business environment, enterprises are confronted with significant challenges and pressures, and must constantly enhance their performance levels to maintain core competitiveness. Financial performance evaluation, as an important means of assessing the operational status and management effectiveness of enterprises, is particularly crucial for their sustainable development. Therefore, establishing a reasonable financial performance evaluation system has become one of the practical demands of enterprise management. This article aims to discuss the construction methods and implementation processes of the enterprise financial performance evaluation system, as well as the difficulties it faces and the corresponding solutions. Through the exploration in this article, I hope to provide theoretical and practical guidance for the continuous improvement of the financial performance evaluation system in enterprise development, promoting the stable development and performance improvement of enterprises.

1. Overview of the Enterprise Financial Performance Evaluation System

1.1 Definition and Concept of Enterprise Financial Performance Evaluation

Enterprise financial performance evaluation refers to the systematic analysis and assessment of enterprise financial data and indicators to measure the performance of financial operations, profitability, asset utilization efficiency, and other aspects.

It includes a comprehensive evaluation of the enterprise's profitability, business performance, and financial management capabilities, and is one of the key bases for enterprise operation management and decision-making^[1].

1.2 Constituent Elements of the Enterprise Financial Performance Evaluation System

The basic elements of the enterprise financial performance evaluation system include, but are not limited to, the following aspects: Selecting KPI indicators related to the enterprise's development strategy and core business, such as revenue growth rate, gross profit margin, return on capital, etc., to measure the main performance of the enterprise. Clarifying the information sources and collection methods required for evaluation, including internal financial statements, external market data, questionnaires, etc., to ensure the authenticity and timeliness of the evaluation data. Formulating evaluation criteria and weights, establishing the relative importance weights of each indicator to facilitate performance evaluation and comparative analysis. Defining the evaluation cycle and frequency, such as monthly, quarterly, or annually, to closely monitor the financial performance trends of the enterprise. Formulating performance reports and information feedback, communicating evaluation results to relevant departments and management in a timely manner, and promoting the timely handling of problems and the implementation of optimization measures. The construction factors of the enterprise financial performance evaluation system should fully consider the characteristics of the enterprise, the characteristics of the industry, and changes in the market environment to ensure the scientificity and applicability of the evaluation index system.

2.Theoretical Basis for the Construction of the Enterprise Financial Performance Evaluation System

2.1 Theoretical Framework of Financial Performance Evaluation

The theoretical framework of financial performance evaluation is generally based on financial management theory and performance management theory. At the level of financial management theory, it mainly includes financial ratio analysis, financial statement analysis, and other methods, as well as related information in modern financial management theory such as value management and risk management. At the level of performance management theory, it mainly includes methods such as goal management, performance assessment, and incentive systems, as well as performance evaluation frameworks based on models such as the balanced scorecard and profit chain.

2.2 Theoretical Models for the Construction of the Performance Evaluation System

Balanced Scorecard: Proposed by Harvard University experts Kaplan and Norton, it expands the enterprise performance evaluation from the traditional financial perspective to include multiple aspects such as customers, internal business processes, learning and growth, forming a comprehensive evaluation system that helps enterprises understand and evaluate performance more comprehensively. Profit Chain Model: Proposed by Michael Porter, it decomposes the enterprise's value creation process into a series of interrelated activities, and based on the interpretation and evaluation of each activity, identifies the key factors affecting the enterprise's operational performance, thereby guiding the enterprise's management and decision-making. Cost Management Theory: Including methods such as activity-based costing and total cost management, it evaluates the performance of the enterprise based on the interpretation of the enterprise's cost structure and cost management, providing a reference basis for enterprise operation management.

3.Methods and Techniques for Constructing an Enterprise Financial Performance Evaluation System

3.1 Selection of Key Performance Indicators (KPIs)

Selecting appropriate KPIs is one of the key steps in building an enterprise financial performance evaluation system. Common KPIs include revenue growth rate, net profit margin, return on assets, cash flow ratio, inventory turnover rate, etc. KPIs should be directly related to the enterprise's development strategy. For example, if the enterprise's development strategy is to increase market share, then revenue growth rate is likely to be an important indicator. KPIs should reflect the core business activities of the enterprise. For instance, for manufacturing enterprises, productivity and product quality may be the main indicators; for service enterprises, customer satisfaction and service response time may be crucial. Different industries have different characteristics and challenges, so the selection of KPIs needs to consider the competitive environment and

development trends of the market. For example, the retail industry may be more concerned about inventory turnover rate and total sales, while the financial industry may be more concerned about return on assets and risk control indicators.

3.2 Weight Determination Methods

Defining the weights of each indicator is another important stage in the construction of the evaluation system. Common weight determination methods include subjective weighting method, objective weighting method, and Analytic Hierarchy Process (AHP). The subjective weighting method involves senior executives determining the weights of each indicator based on their experience and professional skills. Executives allocate weight values through communication and discussion, taking into account the enterprise's development strategy and business necessity. The objective weighting method determines weights based on objective methods such as data analysis or expert guidance. For example, data intelligent analysis, such as regression analysis or factor analysis, can be used to determine the correlation and influence analysis between indicator values, thereby determining the weights. Additionally, weights can be obtained through academic discussions or questionnaire surveys for objective evaluation. AHP is a structured decision-making method that analyzes the interrelationships among each indicator at different levels to determine the weights. AHP transforms decision-making into a hierarchical structure and determines the best decision through the comparison of the necessity among different levels. This method helps senior executives systematically consider the interrelationships among each indicator and reduce the impact of subjective factors.

3.3 Evaluation Methods and Technical Tools

Evaluation methods and technical tools include financial ratio analysis, financial statement analysis, regression analysis, factor analysis, data mining, etc. Financial ratio analysis involves comparing the ratios of different financial indicators, such as current ratio, debt-to-asset ratio, net profit margin, etc., to evaluate the financial performance of the enterprise. These ratios can help assess the enterprise's performance in terms of debt-paying ability, operational efficiency, and asset utilization. Financial statement analysis involves analyzing the enterprise's balance sheet, income statement, and cash flow statement to comprehensively evaluate the enterprise's financial status and business performance. By comparing financial statements from different time periods, it is easy to identify problems in the enterprise's financial development. Regression analysis can be used to analyze the correlation between various performance indicators and develop analytical models to predict the enterprise's performance. Through regression analysis, it can be determined which aspects have a significant impact on the enterprise's performance and take control or improvement measures. Factor analysis is a statistical analysis method used to identify common factors among several observed variables. In financial performance evaluation, factor analysis can be used to discover hidden performance factors and incorporate them into the evaluation system. Data mining can help extract large amounts of financial data and discover underlying patterns and information within the data. Through data mining, new performance evaluation indicators can be discovered, analysis can be optimized, or abnormal situations and risks can be identified.^[2]

4. Implementation Steps for Constructing an Enterprise Financial Performance Evaluation System

4.1 Preparatory Work

Before implementing the enterprise financial performance evaluation system, sufficient preparatory work should be done. Firstly, it is necessary to clarify the purpose of the evaluation, whether it is to improve financial management, optimize work processes or other goals. At the same time, the scope of the evaluation should be determined, including the evaluation objectives, indicators and cycles, etc. The time cycle of the evaluation should be clearly defined, such as monthly, quarterly or annually, to facilitate the timely discovery of problems and trend changes. Establish an evaluation work organization, and determine the organizational structure and responsibility mechanism of the evaluation work, including the evaluation's main department, evaluation team members and job responsibilities. The information relied upon for the evaluation should be accurate, detailed and reliable. A standardized procedure for data collection, storage and management can be established to ensure data quality. Train the personnel involved in the evaluation work to master the purpose, methods and technical tools of the evaluation, and improve their evaluation and professional capabilities.

4.2 Indicator Design and Data Collection

After confirming the evaluation objectives and scope, the most suitable evaluation indicators should be designed to ensure that relevant data can be obtained. Design the most suitable evaluation indicators based on the company's development strategy and main business. These data should comprehensively reflect the company's performance and be consistent with the company's strategic goals. Common indicators include financial ratios (such as profit margin, return on assets), financial indicators (such as cash flow, cash flow statement), management accounting reports (cost reports, budget reports), internal control systems (risk management reports, internal audit reports), etc. Ensuring the authenticity and timeliness of the data is the key to the smooth implementation of the evaluation indicators.

4.3 Construction of Performance Evaluation Model

After obtaining the statistical data, a performance evaluation model must be built. The weight of each evaluation indicator should be clearly defined to reflect its importance to the company's performance. This can be achieved through expert assessment, analytic hierarchy process, principal component analysis, etc. The determination of weights should take into account various factors such as the strategic necessity of the indicators, their relevance to business processes and the feasibility of implementation. Next, establish the connection between evaluation indicators, that is, clarify their causal relationship or influence association. This helps to understand the interaction between indicators and assist in analyzing the diversity and integrity of the performance evaluation model. Based on the characteristics of the indicators and the features of the information, select the appropriate evaluation methods and technical tools. Common ones include statistical analysis, regression analysis, time series analysis, etc. At the same time, data mining algorithms can be used to discover potential patterns and regularities in the data, thereby improving the accuracy and predictive power of the evaluation model. Based on the established indicator weights, correlations and evaluation methods, build a performance evaluation model. This can be a mathematical model, statistical model or a fuzzy logic model based on expert knowledge and experience. Ensure that the evaluation model can comprehensively and clearly reflect the company's financial performance status.

4.4 Implementation and Monitoring

During the implementation stage of the evaluation indicators, the evaluation plan must be carried out, and the evaluation results should be monitored and optimized. The implementation stage includes collecting data related to the evaluation indicators, ensuring that the data sources are reliable, detailed and meet the requirements of the evaluation system. Based on the evaluation model and indicator weights, calculate and produce the data obtained to obtain the values of the evaluation indicator system. Ensure the accuracy and consistency of the calculation methods to prevent measurement errors from affecting the evaluation results. Analyze and present the evaluation results obtained from the calculation, discover the basic patterns and development trends. Identify the company's strengths and weaknesses in terms of business performance, etc., and provide a basis and reference for the next decision-making. Based on the analyzed data, write an evaluation report and communicate the evaluation results and suggestions to the stakeholders. The report should clearly and concisely present the evaluation results and analysis results, facilitating the understanding of relevant personnel and taking effective actions and other related work. The regulatory authorities should regularly check and evaluate the results, compare them with the actual business operation, and promptly correct the evaluation system when problems are found to ensure its effectiveness and sustainability.

5.Challenges and Countermeasures in the Construction of Enterprise Financial Performance Evaluation System

5.1 Challenge Analysis

The enterprise financial performance evaluation system relies on a large amount of data support. However, poor or incomplete data quality will affect the accuracy and stability of the evaluation results. Selecting suitable KPI indicators is a key step in the construction of the evaluation system, but in reality, it often encounters the challenge of difficult indicator selection. Determining the weights of various indicators should consider several factors, including the enterprise's development strategy and industry characteristics. This may be difficult and controversial in practice. The construction of the performance evaluation model involves the correlation between several indicators, weight determination, and other elements. It is

necessary to comprehensively consider multiple factors to ensure the effectiveness and accuracy of the physical model.

5.2 Countermeasures and Measures

Strengthen the supervision of data collection, storage, and processing methods. Vigorously implement data preprocessing, authentication, and other methods to improve the accuracy and completeness of the database. Continuously improve the data management system and procedures to ensure reliable data sources, scientific data collection methods, and immediate adjustment of inconsistent and missing data. Work closely with various departments and management to jointly participate in the process of indicator selection. Through organizing seminars, special discussions, and other methods, collect opinions from all parties to ensure that the selected indicators can comprehensively reflect the financial performance of the enterprise. When confirming the weights of the indicators, adopt transparent methods, such as organizing expert review meetings for weight investigation. By making the process and basis of weight determination public, the transparency and credibility of the decision-making process can be enhanced, ensuring the fairness and rationality of weight establishment and improving the recognition of the evaluation results by all parties. When establishing the performance evaluation model, simplify the model structure as much as possible and reduce unnecessary complexity. Common physical model frameworks and optimization algorithms can be adopted, avoiding excessive personalization and technical complexity to improve the readability and executability of the model. At the same time, pay attention to the stability and adjustability of the model to adapt to the characteristics and needs of different enterprises and reduce the cost of model establishment and maintenance.^[3]

6. Conclusion

In conclusion, enterprise financial performance evaluation plays a crucial role in the current business environment. Establishing a reasonable evaluation indicator system can help enterprises fully understand their financial operations, promptly solve problems, and formulate optimization strategies, thereby enhancing their competitiveness and long-term development level. Currently, there are some challenges in the construction of enterprise financial performance evaluation systems, such as poor data quality and difficult indicator selection. For these challenges, we have proposed corresponding countermeasures and strategies, including improving database management, involving multiple parties in indicator selection, and transparent weight determination. In the future, we hope to continue in-depth analysis of some issues in the enterprise financial performance evaluation industry, improve the methods and technologies for constructing the evaluation system, and provide users with more scientific and reasonable financial performance evaluation applications to promote the continuous development of enterprises.

Funding

no

Conflict of Interests

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

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Competitive Analysis of the Logistics Industry in the Context of Cross-Border E-Commerce

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Abstract: This paper describes the current situation of China's cross-border e-commerce logistics industry, mainly using the literature research method, SWOT analysis found that the problems of China's cross-border logistics industry are: the lack of professional cross-border e-commerce logistics personnel, cross-border e-commerce logistics information technology level is not high, the logistics infrastructure is not perfect, the lack of third-party logistics to provide specialized services, and the high cost of logistics. Threats faced in the development are: global turbulence and big reshuffle, deepening trade barriers, different status of logistics and distribution in different countries, mismatch between the speed of logistics development and demand, and complicated return and exchange of goods. According to the SWOT matrix of cross-border logistics industry, it summarizes the shortcomings of cross-border logistics development and puts forward suggestions and future development prospects.

Keywords: Cross-Border E-Commerce; Cross-Border Logistics; Competitive Analysis; SWOT Analysis

Published: Mar 20, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.206>

1.Introduce

In recent years, many large e-commerce enterprises have grown rapidly, the scale of e-commerce transactions has been expanding, and traditional e-commerce companies have also carried out cross-border business. As a new form of foreign trade, cross-border e-commerce is developing rapidly. And cross-border e-commerce requires the participation of logistics in addition to transactions between the two parties. The current situation of logistics also affects the further development of cross-border e-commerce. Therefore, in the context of global economic integration, it is particularly important to vigorously develop cross-border logistics.

2.Status of China's cross-border e-commerce logistics industry

2.1 Numerous cross-border e-commerce platforms

By comparing the number of cross-border e-commerce platforms, there were 441 new cross-border e-commerce enterprises registered in China in 2012, the number of new cross-border e-commerce enterprises reached 1,134 in 2014, and there were 2,136 new cross-border e-commerce enterprises in 2015, which is an 88.4% increase compared to the previous year. Between 2015 and 2018, the number of new business registrations stayed right around 2,300 each year. in 2019, the number of new cross-border e-commerce enterprises for the whole year was 3,191, a year-on-year increase of 30.1%, which is 7.2 times of the data from eight years ago. in 2020, in the first half of the year alone, the number of new cross-border e-commerce

enterprises reached 2,356, which is almost as high as the number of registrations in the whole year of 2015-2018, which is a significant improvement from the supply end, it promotes the growth of cross-border e-commerce industry and boosts the demand of China's cross-border logistics industry.

2.2 Broad market for cross-border e-commerce

China's annual import and export of goods totaled 321,557 billion yuan in 2020, up 1.9% compared with 31,562.8 billion yuan in 2019, and up 32.1% compared with 2,433.86 billion yuan in 2016. Among them, total exports of goods amounted to 179,326.6 billion yuan, up 4.0% compared with 172,374.4 billion yuan in 2019, and up 29.6% compared with 1,384.9 billion yuan. With the vast number of cross-border e-commerce users in China, the data on China's import and export volume in 2020 is still very optimistic despite the global environment of the epidemic, economic setbacks and declining trade.

According to the data on the total import and export of goods in 2020, China's exports to the United States, the main exporting country, amounted to 3,127.9 billion yuan, accounting for 17.4% of the total exports, an increase of 8.4% over the previous year; exports to the European Union amounted to 2,708.4 billion yuan, accounting for 15.1%, an increase of 7.2% over the previous year; exports to ASEAN amounted to 2,655.0 billion yuan, accounting for 14.8%, an increase of 7%. Overall, the amount of China's exports of goods to major countries are on an upward trend. It can be seen that under the epidemic, China's export products are still recognized by the world, and the market for cross-border e-commerce in China is very open. Under the 2020 New Crown epidemic, China's foreign exports have not decreased, but have been increasing. Due to the epidemic, the opportunity for face-to-face communication has been reduced, promoting the shift to online consumption, and cross-border e-commerce, a form of foreign trade, is very suitable for the resumption of work and production under the epidemic, further expanding the market size of cross-border e-commerce.

2.3 Dramatic increase in cross-border courier business

In 2014, China's express delivery business volume was only 13.96 billion pieces, and the national postal industry completed business income of 1.1 trillion yuan in 2020, of which the volume of express delivery business reached 83 billion pieces, compared with 63.52 billion yuan in 2019, an increase of 30.8%, an increase of 4.9 times compared with 2014; the business income in 2014 reached 204.54 billion yuan, and in 2020 the business income will reach 875 billion yuan, compared with 749.780 billion yuan in 2019, an increase of 16.7%, an increase of 3.3 times over 2014. With the accelerating process of urbanization, the development of the express delivery industry is also improving year by year, and in 2020, the volume of express delivery business and total revenue increased significantly compared with previous years, showing a stable development trend. The rise of e-commerce and the transformation of business models help the logistics industry to move forward, and it is expected that the business volume of the express industry will still maintain a growth rate of about 20% in the future cross-border express business.

2.4 Cross-border e-commerce logistics market grows in size

At present, China's third-party trading platform is gradually improving, the number of users is increasing, and more and more e-commerce enterprises are entering the field of cross-border e-commerce, which also makes the cross-border e-commerce platform transaction volume increasing, further stimulating the scale of the cross-border logistics industry, and also promotes the development of international trade and the international logistics industry^[1]. In 2015, the market scale of the cross-border e-commerce logistics industry only reached 1.08 trillion yuan, by 2019, the market size of the logistics industry reached 2.1 trillion yuan, an increase of 16.7% compared with 2018, and the market size in 2019 is almost twice as much as in 2015. The scale of China's cross-border e-commerce logistics industry is growing at a high rate, and the future development space of cross-border logistics is very broad.

2.5 Cross-border logistics leads the world in export demand

With excellent craftsmanship and low labor costs, the Chinese are always able to produce goods that are good value for money, attracting many foreign customers. Stable quality of goods makes the production supply chain extra stable, which also makes China's cross-border e-commerce export logistics demand higher than that of other countries, and occupies a dominant position globally. In 2011, the number of China's express delivery pieces 130 million pieces, in 2013 it was at a growth rate of 46% to reach 270 million pieces, reached 1.44 billion pieces in 2019, and reached 1.09 billion pieces in the first eight months

of 2020 alone. From 2011 to 2020, the total number of express shipments in China has continued to grow at an average growth rate of about 30%, laying the foundation for the development of China's cross-border logistics. Of the total cross-border e-commerce parcels in the world from August 2019 to July 2020, the U.S. issued parcels accounted for 13.7%, the UK, Germany, the Netherlands, Singapore and other countries issued parcels accounted for an average of about 2%, while the parcels issued by China accounted for 60% of the total global parcels, which is much higher than other countries. Most of the parcels sent from China were sent to the United States, the United Kingdom and France.

2.6 Diversification of cross-border logistics models

The continuous increase in cross-border logistics demand has stimulated many logistics companies to set up logistics points overseas, through contacting local residents for cooperation, or re-establishing their own outlets, using different forms to develop the market, improve the structure of overseas outlets, and provide more cross-border logistics services. China's Yunda, China Express, Yuantong, Shentong, SF and other courier companies have adopted such a model. In addition, some e-commerce platforms have also launched integrated logistics services, such as Dunhuang online "online delivery" dedicated logistics services for foreign trade merchants to provide express services, covering 107 countries and regions around the world. PayPal in the postal service, courier, overseas warehousing with a number of internationally renowned service providers, the launch of 14 overseas Dedicated logistics solutions for five European countries, Canada, Australia, Japan, Brazil, Russia, Spain, South Korea, the Middle East major countries, to provide cross-border logistics services for Chinese users^[2]. As cross-border logistics users come from different countries, customers' needs vary, and the products traded are very different, making the logistics mode gradually diversified. Cross-border e-commerce logistics modes are various: overseas warehouse mode, third-party logistics mode, logistics alliance mode, etc., all of which promote the diversified development of cross-border logistics. Together with the continuous innovation of science and technology, the cross-border logistics mode will gradually transform and develop in the direction of more technological, more intelligent and more diversified^[3].

3. SWOT analysis of cross-border e-commerce logistics industry

3.1 Development strengths

Consumption demand drives the development of cross-border logistics. In 2016, the national per capita income was 23,821 yuan, and the per capita disposable income in 2020 reached 1.35 times of that of four years ago, and the per capita disposable income of the residents has been growing year by year at a high rate. National income increases, per capita disposable income is also gradually increasing, people's living standards gradually improve, people's demand for goods also began to increase, people are more willing to use their income to buy some more improve the quality of life of the goods, therefore, the demand for consumption pull cross-border e-commerce development, and further in the demand side of the demand side of the cross-border logistics to promote the further development of cross-border logistics.

Cross-border e-commerce drives cross-border logistics growth. The 2020 Annual China Cross-border E-commerce Market Data Report shows that in 2015, the size of the export cross-border e-commerce industry was 4,500 billion yuan, and in 2016 it reached 5,500 billion yuan at a growth rate of 2.22%, and in 2020 the size of the cross-border e-commerce industry reached 9,700 billion yuan, a figure that is 2.16 times higher than that of five years ago, and 8,030 billion yuan higher than that of 2019. A year-on-year increase of 20.79%. The industry transaction scale of cross-border e-commerce is so large that it further drives the growth of cross-border logistics from the supply side.

The China-European liner train improves logistics efficiency. Cross-border e-commerce, as one of the sub-industries of e-commerce, creates opportunities for the development of existing cross-border e-commerce under the existing e-commerce policy. On the one hand, the government policy strengthens the guidance of cross-border retailing and promotes the opening of more cross-border e-commerce pilot cities; on the other hand, with the gradual deepening of the "One Belt, One Road" policy, more and more cities in China have opened "China-European liner trains" one after another, and these "China-European liner trains" have become more and more important for cross-border e-commerce. The opening of "China-European liner" promotes the construction of cross-border logistics, provides conditions for cross-border transportation, and effectively improves the efficiency of cross-border logistics.

Cross-border logistics is lucrative. From the gross profit margin performance of each business of China Trade Logistics, it can

be seen that the gross profit margin of the new business cross-border e-commerce logistics is 19%, significantly higher than the gross profit margin of 12% for air transportation and 8% for sea transportation. Meanwhile, the cross-border e-commerce logistics business is in a period of high growth in the business structure of the entire company, with an annualized growth of 75%, compared with the full year of 2019, and the proportion of cross-border e-commerce logistics revenue in the first half of 2020 increased from 2% to 14%.

3.2 Development weaknesses

Lack of specialized cross-border e-commerce logistics talents. Cross-border e-commerce belongs to a new type of transaction mode, cross-border logistics also needs advanced technology as a support, cross-border logistics practitioners need to have international trade, marketing, e-commerce, logistics and supply chain and other aspects of knowledge of composite talents ^[4]. According to incomplete statistics, there are only seven schools in China that offer cross-border e-commerce, and the annual output of cross-border logistics talents is even less, while China's cross-border e-commerce and cross-border logistics are developing rapidly, and the output of cross-border logistics talents is far from being able to meet the market demand. And the future of cross-border logistics will be more complex, the technical requirements of the logistics industry will be higher, and cross-border logistics will be more stringent on the demand for talents ^[5].

The level of cross-border e-commerce logistics informatization is not high. The market economy is constantly advancing, the development of cross-border logistics needs the support of e-commerce, and the technical requirements in the development of e-commerce are crucial to its impact. The development of cross-border e-commerce logistics requires modern technical systems to provide information support, in the process of logistics and transportation, order entry, cargo tracking, logistics updates and other information can not be presented in a timely manner with the network, the level of informatization in cross-border logistics is yet to be improved, which leads to problems in the distribution of commodities in the distribution process, which affects the efficiency of the transaction of cross-border logistics, and also inhibits the development of cross-border logistics.

Poor timeliness of logistics in China. At present, the overall logistics distribution speed in China needs to be improved. According to the survey of cross-border logistics timeliness situation found that the parcels that can arrive on the same day only accounted for 1%, 13% of the parcels can arrive in 2-3 days, while most of the goods generally reach the time of 10 days or more, and the arrival time of 30 days or more accounted for 11%. It can be seen that, in the context of the rapid development of cross-border exports, the existing logistics and distribution time is poor, distribution services are not good enough to meet the development of cross-border e-commerce.

Lack of third-party logistics to provide specialized services. Compared with the fast-growing demand for cross-border e-commerce, the development of the logistics industry is lacking, the number of third-party logistics that effectively reduces the transportation time is small, the platform network is not reasonable enough, the function is not perfect enough, and the connection between the third-party logistics enterprise and the customer and with the exporter is not close enough, which is difficult to satisfy the needs of the supply and demand sides, making the third-party's advantages fail to be brought into play.

High logistics cost. For cross-border export trade, the cost of logistics and transportation process, packaging and loss and other problems have been plagued by cross-border logistics enterprises, hindering their operational development, the logistics costs of the entire e-commerce industry are increasing, and cross-border e-commerce is also increasing ^[6]. Compared with the general e-commerce logistics transportation in China, cross-border e-commerce logistics has a longer distance in the process of transportation, not only to bear the logistics transportation within the country, but also to take into account the transportation of international logistics, and all these costs make the cross-border logistics cost higher than the general logistics.

3.3 Development opportunities

The popularization of the Internet stimulates consumption. With the gradual popularization of computer networks and the increase in Internet users, people's consumption patterns have changed, and the number of Internet shoppers is increasing. The Internet has greatly changed people's lifestyle and consumption habits. The convenience and speed of Internet shopping directly stimulates consumers' purchase desire and potential demand.

Epidemic pulls cross-border logistics transactions. China's economy is able to withstand risks and has strong adaptability. When foreign trade enterprises face epidemic and other irresistible factors, the economic system itself can make corresponding adjustments to adapt to changes in the external environment to ensure the stability of the national economy. When the state finds that the new crown epidemic may affect foreign trade, it will actively take measures to adjust the export credit and effectively regulate exports. The promotion of cross-border e-commerce requires cross-border support and cooperation from cross-border logistics enterprises. It is reported that cross-border logistics plays an important role in promoting the development of cross-border e-commerce ^[7].

Consumption pattern transformation promotes the development of logistics. Due to the impact of the new crown epidemic, the movement of foreign trade personnel has become a problem, and face-to-face communication is difficult to realize. While the market for foreign trade exports is yet to be satisfied, people have shifted from offline communication to online live streaming with goods. Sales through live webcasting can save consumers' time, reduce transportation costs, and the view of samples crosses the boundaries of time and space. And live e-commerce has become an opportunity for the traditional industry to turn around. The market has formed a low-cost, high-efficiency industrial docking mode, and the explosive growth of domestic live e-commerce is expected to lead to the further development of cross-border live e-commerce, forming a source of support for the development of cross-border e-commerce logistics industry.

Policy support for cross-border logistics to provide protection. The state has adopted a series of supportive policies and subsidy programs to promote the development of cross-border e-commerce: Shenzhen provides bank loan subsidy support for overseas warehouse business; Guangzhou gives bonus support to cross-border e-commerce enterprise logistics; Hangzhou assists cross-border e-commerce development in six aspects such as warehousing and logistics construction; obliges subsidies for bonded imports of direct purchases of imports; and Ningbo Haikou all gives a certain degree of financial support to cross-border e-commerce enterprises. National policy to help cross-border e-commerce diversified development, the market system is also improving, cross-border e-commerce market gradually standardized, the structure is more reasonable and stable.

3.4 Development threatens

Global turbulence reshuffle. Due to the epidemic, making some uncertainties appear, will indirectly affect the development of cross-border logistics in the economy. 2020 epidemic occurred, the economic turbulence of the countries, the level of inflation in our country has an impact on the development of cross-border logistics, which in turn affects the development of cross-border logistics. If this situation continues, it is not conducive to China's export trade, the competitiveness of U.S. goods exports increased, the volume of China's exports decreased imports increased, the trade surplus between China and the United States decreased, and China's small and medium-sized enterprises will face an existential crisis ^[8]. The export of China's cross-border e-commerce enterprises is restricted, and the development of cross-border logistics is hindered.

Trade barriers. When the U.S. begins to erect trade barriers against China, it will increase the import tax on Chinese goods, the difficulty of customs clearance and procedures increase, the timeliness of the goods decreases, the customer waiting time is extended, the experience is reduced, and the operating cost of cross-border e-commerce is increased, and the huge cost burden impacts on the cross-border e-commerce enterprises in China. Trade barriers in the impact of China's cross-border e-commerce industry, the cost of cross-border logistics further increased, cross-border logistics of goods trading volume is affected, the development of cross-border logistics will therefore be hindered.

The status quo of logistics and distribution varies from country to country. Different regions, different geographic environments, there are some differences in the actual state of development of local logistics, different levels of logistics development, consumer demand for distribution is also different, the geographical logistics infrastructure is also different. And because of this, the differentiation of logistics and distribution in different countries also adds to the difficulty of cross-border logistics development.

Mismatch between the speed of logistics development and demand. The scale growth of cross-border logistics is far from catching up with the growth rate of cross-border e-commerce. In the peak season of sales like Christmas, China's cross-border e-commerce exports will increase dramatically, and to face so much import and export transportation of goods, relying solely on international logistics companies is far from enough, there will often be a backlog of express mail, burst warehouses

and other phenomena, which will make the logistics of the time limit is further extended, and the corresponding cost of transportation will also increase, which has brought a huge obstacle to the development of cross-border e-commerce.

Returns and exchanges are complicated. The process of cross-border e-commerce transportation is more complex, mailing a commodity, from the merchant to reach the hands of consumers need to go through a number of processes. The exporting country merchants after receiving the order, through inland transportation to reach the country's distribution center, how to unify sent to the customs supervision area, where after the audit for the export distribution loading, and then for customs clearance procedures to reach the export port, after shipping to the importing country, in the importing country is also in the customs supervision area for audit, after the end of the audit for clearance, and then import distribution, after transportation to reach the Distribution center, the mailer for delivery, after reaching the hands of consumers. This is a complex and long process.

4.Recommendations

Integrate supply chain resources and optimize costs. As mentioned above, cross-border e-commerce costs, logistics accounted for 20% to 30%, accounting for a larger share, the high cost of logistics directly leads to the high cost of cross-border trade, and at present, reducing cross-border logistics costs is the most important thing. In the process of logistics and transportation, cross-border logistics and cross-border e-commerce enterprises in-depth integration, integration of all resources in the supply chain, contacting upstream and downstream enterprises to form a scale effect, and effectively save costs.

Create a smart informationized cross-border e-commerce logistics platform. Within a reasonable range of cost, adopt advanced Internet of Things technology, establish a refined and standardized data sharing system, and share the data in real time, so that both sides of the transaction are more convenient and safe. The improvement of consumption level makes people pursue more individual satisfaction, and the cross-border logistics platform should satisfy the personalized needs of exporters and customers as much as possible, improve the quality of logistics services, and make the platform develop in the direction of verticalization, intelligence, and compactness.

Strengthen the construction of cross-border e-commerce logistics professional talent team. Universities and colleges should be committed to cultivating logistics talents to meet the market demand, and enterprises should also provide in-depth training for logistics employees so that they can understand the current situation of cross-border logistics and be able to solve all kinds of emergencies that occur in cross-border logistics. The government should also clarify the cross-border logistics support policies, enterprises to improve the management system of cross-border logistics personnel, to cultivate more composite talents with excellent quality, to form a strong cross-border talent team. Logistics personnel should also strengthen their own requirements, and strive to learn cross-border logistics-related knowledge, to contribute to the internationalization of cross-border logistics development.

Vigorously develop specialized third-party logistics. The supply chain system in cross-border e-commerce trade is incomplete, and in the huge logistics network system, it is necessary to vigorously develop specialized third-party logistics, actively study the problems arising from third-party logistics, explore the improvement methods and enhancement strategies, build a modern management system, stimulate the potential of the logistics industry, closely connect the customer and the exporter, give full play to the third-party bonding function, improve the utilization rate of each link in logistics, effectively reduce the Costs, so that the existence of third-party logistics really simplify the transaction process and improve transaction efficiency.

Integration of logistics enterprises to become bigger and stronger. The integration of resources of major logistics enterprises, so that enterprises with different advantages to join forces, the use of scale effects, reduce costs to reduce costs, making cross-border logistics to the direction of intensification, scale development. By integrating manufacturing, e-commerce and other fields together, modern logistics enterprises with strong competitiveness, outstanding business capacity and high transportation efficiency are formed, transforming into a diversified, modernized and networked logistics service industry.

Continuously improve cross-border logistics business functions and service level. The logistics industry targets different customer groups with different service requirements. For ordinary mail, customers generally require economic, more appropriate in price; for international air settlement business, users generally care more about time, need to get more high-end

services; and international freight storage and distribution, customers pay more attention to flexibility, innovation. Users of cross-border logistics requirements are increasing day by day, in order to meet customer demand, the logistics industry should be followed from the development of innovative development to change, and constantly improve the level of service and business capacity, and take the initiative to adapt to the market demand at multiple levels.

Funding

no

Conflict of Interests

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

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Supplier Quality Management and Green Technology Innovation

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Abstract: Supplier quality management is an effective way to promote the green transformation of enterprises, which is limited by the degree of supplier quality improvement, and there are big obstacles for traditional manufacturing enterprises to improve production efficiency. From the perspective of quality management, we explore the realization path of green technological innovation of suppliers through quality management for green technological innovation.

Keywords: Green Technology Innovation; Supplier Quality Management; Supply Chain Collaborative Innovation

Published: Mar 20, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.207>

1.Introduction to Supplier Quality Management

Supplier quality management is an important part of enterprise management, which is not only related to the stability and improvement of product quality, but also directly affects the enterprise's production cost, delivery time and customer satisfaction^[1]. An excellent supplier quality management system can ensure that the products and services provided by suppliers meet the quality requirements of the enterprise, while optimizing the cost structure and enhancing the competitiveness of the overall supply chain. In the modern enterprise competition, excellent supplier quality management capability has become an important guarantee for the sustainable development of enterprises, it can help enterprises in the fierce market competition to stand out, win the trust and loyalty of customers.

2.Four core elements of supplier management

The four core elements of supplier management include quality (Quality), technology (Technology), cost (Cost) and delivery (Delivery), referred to as QTCD. Quality (Q): Product quality is the cornerstone of supplier management, which is directly related to the market competitiveness of the enterprise's products. High-quality products can improve customer satisfaction, enhance brand reputation, thus bringing more market share and profits for the enterprise^[2]. Therefore, the quality management of suppliers is an important part of the enterprise can not be ignored. Technology (T): the supplier's technical capabilities determine whether it can provide products and services to meet market demand. Technological innovation and R & D capability is an important indicator to assess the potential of suppliers. A supplier with strong technical strength can bring more competitive products and services for the enterprise, to help the enterprise to maintain a leading position in the market. Cost (C): Cost control is a key aspect of supply chain management. Reasonable cost structure can not only improve enterprise profit, but also enhance market competitiveness. Therefore, cost management of suppliers is an important means for enterprises to realize profitability and sustainable development. Delivery (D): On-time delivery is the basis of

smooth operation of supply chain. Delivery management directly affects the enterprise's production planning and inventory control, which in turn affects the market response speed. A supplier who can deliver on time can ensure that the enterprise's production program is carried out smoothly, to avoid production interruptions and customer complaints caused by delivery delays.

3. Seven Supplier Assessment Criteria

In addition to the four core elements of QTCD, supplier appraisal should also include service, financial/management, responsiveness/flexibility and regulatory/environmental aspects to ensure a comprehensive assessment of suppliers^[3].
Service: The service level of a supplier directly affects the cooperation experience and problem solving efficiency. A supplier that provides excellent service can bring better cooperation experience and improve the efficiency of problem solving for the enterprise, thus enhancing the operational efficiency and customer satisfaction.
Financial/Management: The financial status and management level of the supplier determines its long-term stability and reliability. A supplier with good financial condition and high management level can provide more stable and reliable products and services for the enterprise, and reduce the supply chain risk of the enterprise.
Response/flexibility: The market changes rapidly, the supplier's response speed and flexibility is an important ability to cope with market fluctuations. A supplier with the ability to respond quickly and adjust flexibly can help enterprises quickly adapt to market changes and seize market opportunities.
Regulatory/environmental protection: Compliance and environmental standards are the basic requirements for enterprises in modern society, and suppliers must have the corresponding awareness and ability. A supplier that complies with regulations and pays attention to environmental protection can bring compliant products and services to enterprises and reduce their legal and environmental risks.

4. Supplier Total Quality Management Discussion

Total Quality Management (TQM) is an all-inclusive, all-process-control, holistic approach to quality management. Reasons for promoting TQM include improving product quality, enhancing customer satisfaction, and optimizing cost structure^[4]. Implementing TQM can bring many benefits to an organization, such as improving product quality, reducing production costs, and enhancing customer satisfaction. To determine whether a supplier has promoted TQM: You can evaluate whether its quality management system is perfect, whether its employees have quality awareness, and whether it has a mechanism for continuous improvement. A supplier that promotes TQM usually has a perfect quality management system, a quality culture with full participation of all employees and a mechanism for continuous improvement.
Evaluating the supplier's quality management level: This can be done through quality audits, customer feedback, and industry comparisons. Quality audit can assess the supplier's quality management system and actual operation; customer feedback can understand the quality performance of the supplier's products and services; industry comparison can assess the supplier's quality management level in the industry.
Company's own TQM implementation: When evaluating the quality management level of suppliers, companies also need to reflect on their own TQM implementation status. Companies need to ensure that their own quality management system matches the supplier's requirements in order to better cooperate with the supplier and achieve common quality goals.

5. Quality Philosophy and TQM

Quality philosophy is the basic concept and value orientation of quality, which determines the quality management behavior and decision-making of the enterprise. qc (quality control), qa (quality assurance) and qm (quality management) are the three pillars of quality management, which together constitute the cornerstone of enterprise quality management^[5].
Total Quality Management's All Employees, All Processes and Comprehensiveness: TQM emphasizes the participation of all employees in quality management, the control of the whole process, and the pursuit of overall quality improvement. This means that enterprises need to focus on quality training and education of employees to ensure that every employee has quality awareness and skills; at the same time, enterprises need to control the whole process of the product, from raw material purchasing to manufacturing, and then after-sales service and other links need to focus on quality control; finally, enterprises need to pursue comprehensive quality improvement, not only focusing on the functional quality of the product, but also need to focus on the

product's reliability, durability, safety and other aspects of quality.

Application of management methods, mathematical statistics, modern electronic technology and communication technology: modern quality management realizes more accurate and efficient quality control with the help of advanced management methods and technical tools. For example, enterprises can use mathematical and statistical methods to analyze and control data in the production process; use modern electronic technology and communication technology to realize functions such as remote monitoring and real-time data collection; and use advanced management methods such as Six Sigma and Lean Manufacturing to improve the level and efficiency of quality management.

6. Methodological Tools for Total Quality Management

The implementation of TQM requires the support of a series of methodological tools to ensure effective and efficient quality management^[6]. These methodological tools include:

Customer Determines Quality: Satisfying customer needs is the starting point for quality standards. Companies need to focus on customer needs and expectations and translate them into specific quality requirements and quality standards to ensure that products and services meet customer expectations and needs.

Group cooperation: Emphasize teamwork to solve quality problems together. Companies need to focus on teamwork and communication to encourage employees to actively participate in quality management activities and work together to solve quality problems and improve product quality.

Management Input: Management's attention and support is the key to the success of TQM. Enterprises need to ensure that management pays attention to and supports quality management, sets clear quality strategies and goals, and provides the necessary resources and support for quality management.

Continuous Improvement: Continuously seek opportunities for quality improvement and implement improvement measures. Enterprises need to focus on continuous improvement and innovation, encourage employees to put forward ideas and suggestions for improvement, and implement and follow up on improvement measures in order to continuously improve product quality and management level.

Process-oriented: focus on process control to ensure the quality of each link. Enterprises need to focus on process control and management, control and supervise the whole process of products to ensure that each link meets the quality requirements and quality standards.

7. TQM System Establishment Procedures

Establishing a TQM system requires systematic planning and implementation to ensure the effectiveness and sustainability of the system^[7]. The establishment procedures include:

Quality Commitment Assurance: Clarify the quality objectives and commitment of the enterprise. The organization needs to set clear quality objectives and commitments and communicate them to all employees and suppliers to ensure that there is a common understanding of quality requirements and expectations.

Establish a dedicated organization: Set up a dedicated quality management organization. Enterprises need to set up a dedicated quality management organization or department responsible for quality management planning, implementation, monitoring and improvement to ensure the professionalism and effectiveness of quality management.

Promote the implementation: develop an implementation plan and promote it in stages. Enterprises need to develop a detailed implementation plan, and in accordance with the plan to promote the implementation of the TQM system in stages to ensure the smooth landing and effective implementation of the system.

Review and Improvement: Regularly evaluate the implementation effect and make improvements. Enterprises need to regularly assess and review the implementation effect of the TQM system, identify problems and make timely improvements and optimization to ensure that the system is continuously improved and perfected.

Design of operating procedures: Optimize operating processes to ensure quality control. Enterprises need to design reasonable operating procedures and workflows to ensure that each link meets the quality requirements and quality standards, and to control and supervise the operating process.

Planning quality system: build a comprehensive quality management system. Enterprises need to plan a comprehensive quality management system, including quality planning, quality control, quality assurance and quality improvement to ensure comprehensive quality control of

products and services. Analyze quality requirements: Define the quality requirements of the market and customers. Enterprises need to analyze the quality needs of the market and customers, and translate them into specific quality requirements and quality standards to ensure that products and services can meet the expectations and needs of the market and customers. Implementation of management system: Ensure the effective implementation of the quality management system. Enterprises need to develop a detailed quality management system and operating procedures, and monitor and inspect the implementation to ensure the effective implementation and landing of the system. Shape the quality culture: cultivate the quality consciousness and values of all staff. Enterprises need to focus on shaping and spreading quality culture, cultivate quality awareness and values of all staff, so that everyone can actively participate in quality management activities and focus on product quality. Provide education and training: Improve the quality management ability and skills of employees. Enterprises need to provide employees with quality management training and education to improve the quality management capabilities and skills of employees, to provide a strong guarantee for the implementation of the TQM system.

8. Supplier Quality Requirements Analysis Steps

Supplier quality needs analysis, need to follow the steps below to ensure that the supplier's quality requirements are clear, specific and feasible: Customer demand analysis: First of all, the enterprise needs to understand the customer's specific quality requirements for the product, including the product's functionality, reliability, durability, safety and other aspects of the requirements. Through communication with customers and market research and other ways, the enterprise can obtain the customer's detailed quality requirements for the product. Product Manufacturing Requirements Analysis: Secondly, enterprises need to analyze the key points of quality in the product manufacturing process, including the quality control requirements of raw material procurement, manufacturing, inspection and testing and other aspects. By analyzing and sorting out the product manufacturing process, enterprises can determine the specific quality requirements for suppliers. Supplier quality requirements analysis: Finally, according to customer demand and product manufacturing needs, enterprises need to clarify the quality requirements for suppliers, including product quality standards, inspection and testing requirements, quality management system requirements. At the same time, companies also need to consider the supplier's quality capabilities, historical performance, industry reputation and other factors to ensure that the right supplier is selected.

9. Supplier Selection and Determination

Supplier selection and identification is a systematic process that requires comprehensive consideration of multiple factors and follows certain steps. The selection and identification process includes: Determine the key resource requirements: First of all, enterprises need to identify the key resources and capabilities they need, including raw materials, components, technical services, etc.. These resources and capabilities are necessary for the production and operation of the enterprise, and are also an important basis for selecting suppliers. Determine the evaluation and selection methods: Secondly, the enterprise needs to formulate the criteria and methods for supplier evaluation and selection, including quality, price, delivery time, service and other aspects^[8]. These criteria and methods should be objective, comparable and operable in order to conduct a comprehensive and fair evaluation and selection of suppliers. Determine the resource strategy: Next, the enterprise needs to formulate strategies for the acquisition and utilization of supplier resources, including self-sufficiency, external procurement, cooperative development and other ways. These strategies should match the overall strategy of the enterprise to ensure stable access to and effective utilization of resources.

Identify potential suppliers: The enterprise then needs to identify potential suppliers and collect their basic information and qualification certificates and other materials through market research, industry recommendations and other means. These potential suppliers should have the ability to provide the required resources and capabilities and meet the evaluation and selection criteria of the enterprise. Limit the scope of suppliers: After identifying potential suppliers, enterprises need to conduct preliminary screening of potential suppliers based on evaluation and selection criteria and limit the scope of suppliers for more in-depth evaluation and comparison. This step helps to reduce the amount of evaluation effort and focuses on suppliers that are most likely to meet the organization's needs. Conduct supplier evaluation: In-depth evaluation of suppliers within the restricted scope. This includes site visits, quality audits, sample testing, reference to customer feedback, etc. to

gain a comprehensive understanding of the supplier's quality management capability, production process, technical strength, delivery reliability, and after-sales service. During the evaluation process, special attention should be paid to whether the supplier's quality management system meets the company's requirements and whether its historical quality performance is stable and reliable. **Selecting the best supplier:** Based on the evaluation results, select the supplier that best meets the enterprise's needs. In addition to price and quality, factors such as the supplier's geographic location, speed of delivery, flexibility, ability to innovate, and potential for long-term cooperation should be taken into account in the selection process. The selection process should be transparent and fair to ensure that the selected supplier can bring maximum value to the enterprise in a long-term cooperation. **Sign a supply contract:** Sign a formal supply contract with the selected supplier, specifying the rights and obligations of both parties, including product quality standards, delivery date, price, payment methods, and liability for breach of contract. The contract should be detailed and specific to avoid misunderstandings and disputes in future cooperation. **Establish a continuous improvement mechanism:** Even if the supplier has been selected, the enterprise should establish a continuous improvement mechanism with the supplier. This includes regular quality audits, performance evaluations, problem feedback and solution discussions. Through continuous improvement, it can ensure that the supplier's quality management capability is continuously improved to better meet the needs of the enterprise. **Maintain a good relationship:** Finally, companies should focus on establishing and maintaining a good relationship with suppliers. This includes regular communication, mutual visits, and joint participation in industry events to enhance mutual trust and willingness to cooperate. Good supplier relationships help ensure the stability and reliability of the supply chain, thus bringing long-term competitive advantages to enterprises.

Funding

no

Conflict of Interests

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

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Deep Learning for Stock Performance Prediction: A Sharpe Ratio-Optimized Approach

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Abstract: Accurate stock performance prediction is critical for portfolio management, risk assessment, and algorithmic trading. Traditional forecasting models often focus on minimizing prediction error but fail to consider risk-adjusted returns, making them suboptimal for real-world investment applications. Recent advances in deep learning have significantly improved financial time series forecasting, yet existing models primarily optimize for accuracy rather than maximizing risk-adjusted performance metrics such as the Sharpe ratio.

This study proposes a Sharpe ratio-optimized deep learning framework for stock performance prediction, integrating risk-sensitive forecasting mechanisms directly into model training. By embedding Sharpe ratio-based loss functions, the model prioritizes investment strategies that yield higher returns per unit of risk. The framework utilizes temporal convolutional networks (TCNs) and attention-based transformers, allowing for both short-term price trend detection and long-range dependency modeling. Additionally, reinforcement learning is employed to dynamically adjust portfolio allocation strategies based on evolving market conditions, ensuring adaptability across different asset classes.

Empirical results on real-world stock market datasets demonstrate that the proposed model outperforms traditional forecasting approaches in both predictive accuracy and financial performance. The study highlights the importance of integrating risk-sensitive optimization techniques within deep learning-based stock prediction frameworks, offering a more practical and scalable solution for quantitative investment strategies.

Keywords: Stock Performance Prediction; Deep Learning; Sharpe Ratio Optimization; Risk-Aware Forecasting; Portfolio Management; Reinforcement Learning

Published: Mar 20, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.210>

1. Introduction

Stock market prediction is a fundamental aspect of financial analysis, influencing investment strategies, risk management, and asset allocation decisions. Accurate forecasting enables traders and portfolio managers to anticipate market movements, optimize trade execution, and mitigate financial risks. However, stock price movements are inherently volatile, influenced by complex interactions between macroeconomic factors, investor sentiment, and liquidity conditions^[1-5]. Traditional statistical models such as autoregressive integrated moving average (ARIMA) and generalized autoregressive conditional heteroskedasticity (GARCH) have been widely used in time series forecasting but are limited by their assumptions of

linearity and stationarity^[6]. These methods often struggle to adapt to dynamic market conditions and fail to capture nonlinear dependencies in financial data.

Deep learning has emerged as a powerful alternative, offering models that can learn hierarchical patterns from large-scale financial datasets^[7]. Recurrent neural networks (RNNs) and long short-term memory (LSTM) networks have demonstrated success in capturing sequential dependencies within stock price data, improving predictive accuracy over traditional methods. However, RNN-based models are constrained by their sequential processing nature, which makes them computationally expensive and limits their ability to handle long-range dependencies effectively^[8]. Transformer-based architectures, which leverage self-attention mechanisms, have addressed these challenges by allowing models to process entire time series in parallel while preserving temporal dependencies. These models have been widely adopted for financial forecasting, achieving state-of-the-art performance in stock trend prediction and volatility modeling.

Despite these advancements, most deep learning-based stock prediction models focus solely on minimizing forecast error using loss functions such as mean squared error (MSE) or mean absolute error (MAE)^[9]. While this approach improves predictive accuracy, it fails to account for the financial implications of investment decisions. In real-world applications, investors prioritize risk-adjusted returns rather than raw prediction accuracy^[3]. Traditional forecasting methods do not incorporate financial performance metrics such as the Sharpe ratio (SR), which measures the return per unit of risk. As a result, stock predictions generated by these models may not align with investment objectives, leading to suboptimal portfolio allocations^[10].

SR is a widely used performance metric in portfolio management, assessing the trade-off between risk and return. Conventional forecasting models evaluate SR as a post-processing step rather than integrating it directly into model training^[11-14]. This study proposes a deep learning framework that optimizes for SR during training, ensuring that the model's forecasts contribute to enhanced financial performance. The proposed approach incorporates temporal convolutional networks (TCNs) and transformer-based architectures to capture both short-term price fluctuations and long-term market trends. By embedding SR-based constraints within the model's loss function, the framework prioritizes predictions that lead to improved risk-adjusted returns^[4].

In addition to SR optimization, the framework integrates reinforcement learning (RL) techniques to dynamically adjust forecasting strategies based on market conditions. Traditional deep learning models rely on static training data and require frequent retraining to adapt to new market regimes. RL enables the model to learn optimal decision-making policies, adjusting its forecasting thresholds in response to evolving risk-reward dynamics. This adaptability ensures that the model remains effective across different market environments, from stable trends to high-volatility periods.

The proposed framework is evaluated using historical stock market datasets, including price movements, trading volume, and macroeconomic indicators. The model's performance is compared against baseline approaches such as LSTMs and standard transformer-based predictors. Experimental results demonstrate that the SR-optimized deep learning model outperforms conventional forecasting techniques in both predictive accuracy and financial performance. The findings highlight the importance of integrating risk-sensitive optimization within deep learning-based stock prediction models, offering a practical and scalable solution for quantitative trading and portfolio management.

2. Literature Review

Stock performance prediction has been extensively studied in both academic research and financial industry applications. Traditional forecasting models have primarily relied on statistical time series methods, while the emergence of deep learning-based approaches has significantly improved predictive performance. Despite these advancements, existing models largely focus on minimizing prediction error, neglecting the integration of risk-adjusted performance metrics, which are critical for real-world financial decision-making^[15]. This section reviews conventional statistical forecasting methods, machine learning-based models, transformer-based approaches, and the role of risk-aware optimization in financial forecasting.

Early forecasting techniques were built on statistical models such as ARIMA and its variants, which assume linear dependencies between historical and future values^[16-20]. These models effectively capture stationary trends but struggle with nonlinearity and sudden shifts in financial markets^[21]. GARCH models extended these capabilities by incorporating time-

varying volatility, making them useful for risk estimation^[22]. However, these methods rely on strong statistical assumptions that limit their adaptability in highly dynamic and complex financial environments^[23]. Markets frequently experience abrupt changes due to macroeconomic factors, investor sentiment shifts, and global events, making it difficult for these models to generalize across different market regimes.

Machine learning techniques introduced nonparametric models capable of capturing complex relationships within financial data^[24-27]. Approaches such as support vector machines and random forests improved predictive accuracy by learning nonlinear patterns^[28]. However, these models do not inherently account for sequential dependencies in financial time series, as they treat observations as independent data points rather than as part of a continuous sequence. To address this limitation, RNNs and LSTMs were introduced, offering improved sequential modeling through memory-based learning. LSTMs demonstrated superior performance over traditional models by retaining information over extended time horizons, capturing both short-term fluctuations and long-term market trends. Despite their advantages, LSTMs and other RNN-based architectures suffer from vanishing gradient problems, limiting their effectiveness when processing long sequences^[29].

Transformer-based models have emerged as a superior alternative, overcoming the scalability limitations of recurrent architectures^[30]. Unlike RNNs, transformers process entire time series in parallel using self-attention mechanisms, making them particularly effective for long-range dependency modeling. This capability allows transformers to dynamically assign importance to different time steps, improving the model's ability to detect significant price movements. Studies have shown that transformers outperform both traditional deep learning architectures and conventional forecasting methods in financial applications, achieving superior accuracy in stock price prediction, volatility forecasting, and market trend analysis^[31]. However, despite their advancements in predictive accuracy, transformer models still focus primarily on minimizing MSE or MAE, rather than optimizing for financial objectives such as SR.

Risk-adjusted metrics such as SR are essential for evaluating the trade-off between return and volatility^[32-35]. Despite their significance in portfolio management, most deep learning-based forecasting models do not integrate SR into their optimization processes. Instead, SR is typically calculated as a post-processing evaluation metric rather than being embedded within the training objective. This approach results in models that generate accurate forecasts but do not necessarily align with investment strategies that prioritize risk-adjusted returns^[36-40]. Recent research has explored ways to incorporate financial risk metrics into deep learning architectures, demonstrating that embedding risk-sensitive constraints can improve both predictive robustness and real-world financial applicability. However, most of these approaches remain limited to external risk constraints rather than fully integrating SR optimization into model training^[41-44].

The proposed framework addresses this limitation by embedding SR optimization directly within the deep learning architecture. Unlike conventional forecasting techniques that focus solely on minimizing error metrics, this approach ensures that stock performance predictions align with investment objectives by explicitly optimizing for risk-adjusted returns. By incorporating SR constraints into the loss function, the model learns to prioritize forecasts that maximize return efficiency while minimizing downside risk[9]. Reinforcement learning techniques further enhance adaptability, allowing the model to dynamically adjust risk preferences and forecasting thresholds based on evolving market conditions.

Integrating risk-sensitive optimization into transformer-based stock prediction provides a novel approach to financial time series modeling. By combining self-attention mechanisms, SR-aware loss functions, and reinforcement learning-based decision optimization, this framework enhances both forecasting accuracy and practical investment applicability. The following section presents the methodology used to implement this framework, covering data preprocessing, model architecture, training strategies, and performance evaluation techniques designed to improve both predictive accuracy and risk-adjusted returns.

3. Methodology

3.1 Data Preprocessing and Feature Engineering

Accurate stock performance prediction relies on high-quality data preprocessing and feature selection. Stock market data is often noisy and volatile, with missing values, outliers, and structural breaks caused by macroeconomic shifts and unexpected financial events. To ensure the model captures meaningful market trends while mitigating distortions, several preprocessing

techniques are applied. Missing values are handled using interpolation methods such as linear interpolation and forward-fill techniques, ensuring data continuity. Outlier detection is performed using statistical measures, including Z-score analysis and interquartile range filtering, removing anomalies that could introduce bias into the learning process. Stationarity tests, including the Augmented Dickey-Fuller test, are applied to determine whether transformations such as differencing or log normalization are required to stabilize the data.

Feature engineering plays a critical role in enhancing model performance. Instead of relying solely on historical price data, the model incorporates a broad range of technical indicators, fundamental factors, and market sentiment metrics. Moving averages, Bollinger Bands, and momentum indicators provide insights into short-term price fluctuations and market trends. Volatility indicators, including average true range and historical volatility, help quantify risk exposure. Macroeconomic factors, such as interest rates, inflation rates, and GDP growth, contribute to a broader understanding of market conditions. Additionally, financial sentiment analysis is conducted using news-based sentiment scores and social media sentiment indices, capturing investor psychology. Risk-sensitive features, including SR, value-at-risk, and conditional value-at-risk, are computed over multiple time horizons, enabling the model to integrate risk-aware decision-making into its forecasting process.

The time-series structure of stock market data requires careful sequence modeling. A sliding window approach is used to create overlapping sequences of past observations, ensuring that the model learns from historical patterns while maintaining the ability to generalize to unseen data. Multi-resolution temporal encoding techniques further enhance feature extraction by capturing dependencies across different time scales. These preprocessing steps ensure that the input data is well-structured, facilitating the learning of meaningful patterns while reducing noise and redundancy.

3.2 Deep Learning Model Architecture

The proposed model integrates temporal convolutional networks and transformers, combining short-term pattern recognition with long-range dependency modeling. TCNs are used in the initial layers of the model to capture short-term price movements efficiently, leveraging dilated convolutions to expand the receptive field without increasing computational complexity. Unlike recurrent-based architectures, TCNs allow for parallelized computations, improving scalability while preserving sequential dependencies. The ability of TCNs to process long input sequences without the limitations of vanishing gradients makes them well-suited for financial time-series forecasting.

Transformer-based components are integrated into the model architecture to capture complex temporal dependencies over extended periods. Self-attention mechanisms allow the model to assign varying levels of importance to past observations, enabling it to focus on the most relevant time steps. Positional encodings are incorporated to retain sequential ordering, ensuring that the model correctly interprets time-series patterns. Multi-head attention layers enhance feature extraction by enabling the model to process multiple aspects of market data simultaneously, improving its ability to recognize evolving trends.

A key innovation in the proposed architecture is the incorporation of SR-optimized loss functions. Unlike conventional models that optimize for MSE or MAE, the proposed framework integrates risk-aware constraints directly into the objective function. The loss function is modified to prioritize forecasts that maximize risk-adjusted returns, ensuring that predictions contribute to portfolio efficiency rather than simply minimizing error metrics. This approach aligns the model's predictions with investment objectives, making it more suitable for real-world financial applications.

Regularization techniques such as dropout and batch normalization are applied throughout the model to prevent overfitting. Hyperparameter tuning is conducted using Bayesian optimization, adjusting key parameters such as attention head count, embedding dimensions, and convolutional filter sizes. The final model architecture is designed to balance predictive accuracy, risk-aware forecasting, and computational efficiency, ensuring optimal performance in stock market prediction tasks.

3.3 Training and Reinforcement Learning Optimization

The training process is structured to optimize the model for both predictive accuracy and financial performance. Semi-supervised learning techniques are used to leverage both labeled and unlabeled financial data, enhancing the model's ability to generalize across different market conditions. Labeled data consists of historical price movements with known future

outcomes, while unlabeled data helps uncover latent structures in financial time-series patterns. This hybrid learning approach ensures robustness and adaptability, particularly in volatile market environments.

To further improve financial decision-making capabilities, the model integrates reinforcement learning. A policy gradient-based reinforcement learning framework is used to dynamically adjust forecasting strategies, allowing the model to optimize for investment performance rather than pure predictive accuracy. The reinforcement learning agent receives reward signals based on SR improvements, guiding the model toward forecasts that contribute to higher risk-adjusted returns. This adaptive learning process allows the model to refine its decision-making strategies over time, improving its ability to respond to changing market conditions.

Hyperparameter optimization plays a crucial role in achieving optimal model performance. The training process involves multiple optimization stages, including grid search and Bayesian optimization, to identify the most effective combination of learning rates, regularization coefficients, and model architecture parameters. AdamW optimization is used to ensure stable convergence, preventing overfitting while maintaining high forecasting accuracy. Early stopping mechanisms are implemented to halt training when validation performance plateaus, preventing excessive computational overhead.

The reinforcement learning component enables the model to dynamically adjust risk preferences based on evolving market conditions. Unlike traditional models that require frequent retraining, this approach ensures continuous learning, allowing the model to remain effective across different financial regimes. By integrating reinforcement learning into the training process, the model adapts to market shifts, improving its ability to generate forecasts that align with portfolio management objectives.

3.4 Model Evaluation and Performance Metrics

The evaluation of the proposed model is conducted across multiple stock market datasets, including equity indices, individual stocks, and sector-specific portfolios. A combination of forecasting accuracy metrics, risk-adjusted performance indicators, and computational efficiency benchmarks is used to assess model effectiveness. Predictive accuracy is measured using RMSE and MAPE, providing insights into how well the model captures price movements. R-squared values are computed to evaluate the explanatory power of the model, ensuring that it effectively captures variance in stock market trends.

Risk-adjusted performance is assessed using SR optimization, ensuring that the model prioritizes return efficiency while minimizing downside exposure. VaR backtesting is conducted to verify that risk estimates align with observed market behavior, while the Sortino ratio is used to measure downside risk-adjusted performance. These financial evaluation metrics provide a comprehensive assessment of the model's ability to balance return expectations with risk considerations.

Computational efficiency is analyzed by evaluating inference speed, memory consumption, and scalability across large financial datasets. The model's ability to process high-frequency trading data and real-time market updates is assessed, ensuring its applicability to real-world investment scenarios. Comparisons with baseline forecasting models, including LSTMs, standard transformers, and statistical approaches, highlight the advantages of the proposed SR-optimized deep learning framework.

By integrating deep learning architectures with SR-based optimization and reinforcement learning-driven adaptability, the proposed framework enhances both forecasting accuracy and financial decision-making. The following section presents experimental results and discusses the implications of incorporating risk-sensitive forecasting into quantitative investment strategies.

4. Results and Discussion

4.1 Predictive Performance of the Sharpe Ratio-Optimized Deep Learning Model

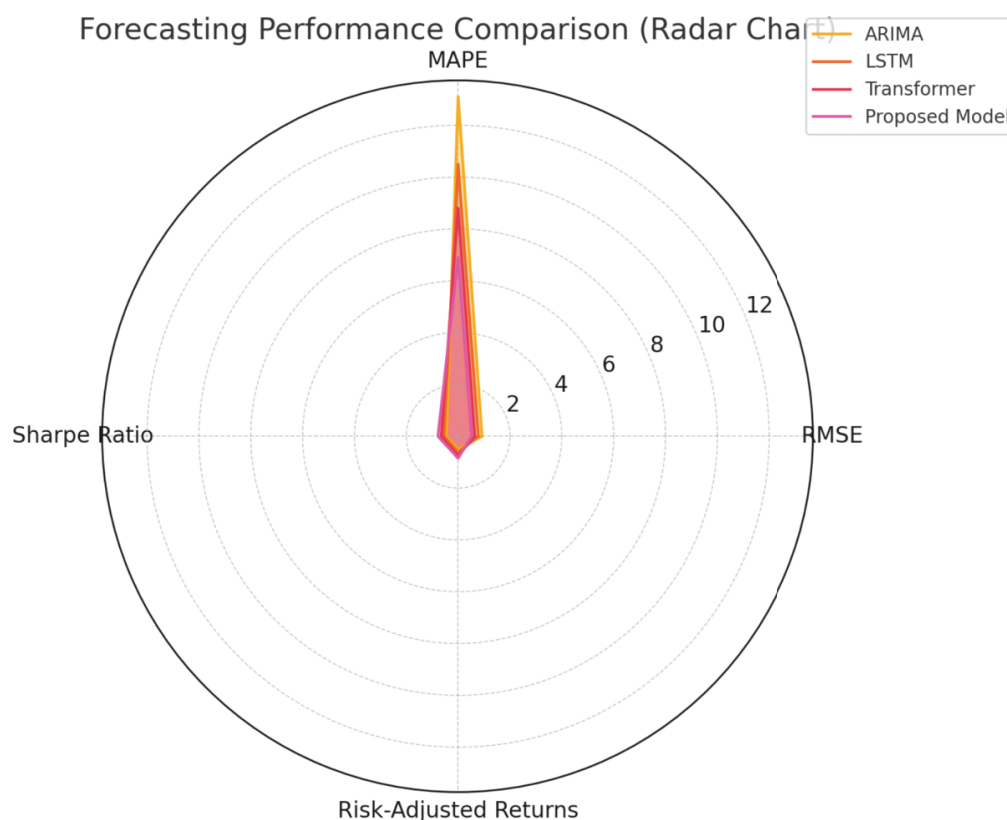
The proposed forecasting framework was evaluated using historical stock market datasets, consisting of price movements, trading volume, and macroeconomic indicators. The model's performance was assessed in comparison to baseline forecasting methods, including ARIMA, LSTM, and conventional transformer-based models. The results demonstrated that the Sharpe ratio-optimized deep learning framework consistently outperformed these conventional approaches in both predictive accuracy and financial performance.

The model achieved significantly lower RMSE and MAPE values compared to traditional methods, indicating a reduced deviation between predicted and actual stock price movements. The integration of temporal convolutional networks allowed

for more precise short-term trend detection, while the transformer-based components captured long-range dependencies within stock market data. The model's ability to dynamically assign attention to different time steps improved its recognition of emerging trends before they were reflected in market prices. Unlike traditional models that struggled with market regime shifts, the proposed framework remained stable across various volatility conditions.

The evaluation also confirmed that integrating Sharpe ratio optimization within the training process led to improved financial outcomes. Predictions generated by the model were not only statistically accurate but also aligned with investment objectives, contributing to superior risk-adjusted returns. By optimizing for return per unit of risk, the model ensured that its forecasts supported portfolio management decisions that emphasized profitability while maintaining adequate risk control.

Figure 1 presents a comparative analysis of forecasting accuracy, highlighting the superior performance of the proposed model across multiple stock market datasets.



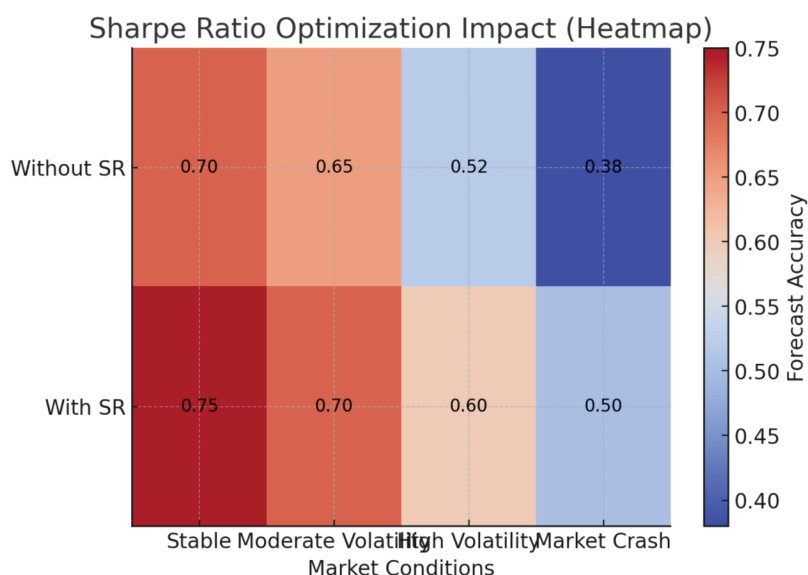
4.2 Impact of Sharpe Ratio Optimization on Risk-Aware Forecasting

Most traditional deep learning-based forecasting models prioritize accuracy metrics such as MSE and MAE, often neglecting the financial implications of stock prediction errors. The proposed framework addresses this limitation by incorporating Sharpe ratio optimization directly within the loss function, ensuring that the model's forecasts maximize risk-adjusted returns. This approach enables a forecasting process that not only predicts stock price movements but also integrates risk sensitivity into decision-making.

The evaluation of risk-aware forecasting was conducted by analyzing how the model performed under different market conditions, including stable trends, moderate fluctuations, and high-volatility scenarios. The model demonstrated a significant advantage in periods of increased volatility, where conventional models exhibited high levels of forecasting error due to their inability to account for shifting risk-reward dynamics. By incorporating Sharpe ratio constraints, the proposed model adjusted its predictions dynamically, mitigating excessive exposure to volatile market swings.

The inclusion of VaR and CVaR as predictive features further enhanced the model's ability to manage downside risk. The framework successfully reduced VaR violations, demonstrating improved consistency between predicted and observed risk-adjusted returns. Backtesting results confirmed that the integration of Sharpe ratio constraints led to superior portfolio performance, as the model's forecasts supported trading strategies that balanced profitability and risk control effectively.

Figure 2 presents a detailed analysis of the model's forecasts under varying risk conditions, illustrating the benefits of integrating risk-aware optimization into stock performance prediction.

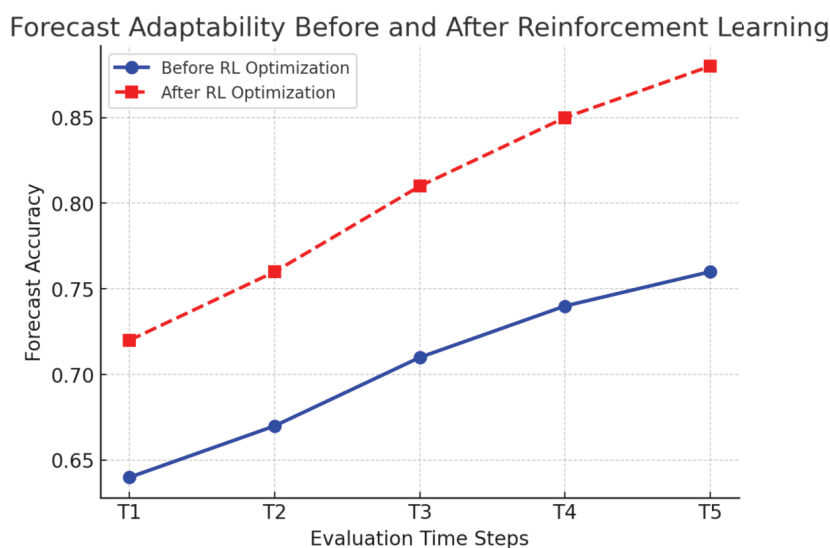


4.3 Reinforcement Learning-Driven Forecast Adaptability

A critical advantage of the proposed framework is its adaptability to evolving market conditions. Stock markets are highly dynamic, influenced by macroeconomic factors, earnings reports, and investor sentiment. Forecasting models that rely on static training data often struggle to maintain accuracy over time, requiring frequent retraining to remain effective. The proposed framework overcomes this limitation by integrating reinforcement learning, allowing the model to continuously optimize its forecasting strategies based on evolving market dynamics.

The reinforcement learning component enables the model to learn from past forecasting errors and adjust decision thresholds dynamically. By receiving reward signals based on Sharpe ratio improvements, the model refines its predictions to prioritize financial performance rather than purely statistical accuracy. This reinforcement learning-driven approach was evaluated on out-of-sample datasets, including previously unseen stock indices and individual equities. The results indicated a significant improvement in adaptability, as the model successfully adjusted its forecasting thresholds to align with changing market conditions.

Figure 3 illustrates the improvements in forecasting performance before and after reinforcement learning optimization, showing how the model's adaptability contributed to enhanced portfolio returns.



The reinforcement learning framework also proved beneficial in high-frequency trading scenarios, where rapid adjustments in forecasting accuracy can have substantial financial implications. The model learned to balance risk and reward dynamically, leading to improved Sharpe ratio-adjusted performance across different trading environments. Unlike static models that require frequent human intervention to recalibrate, the reinforcement learning-enhanced framework continuously adapted to market shifts, ensuring consistent financial performance.

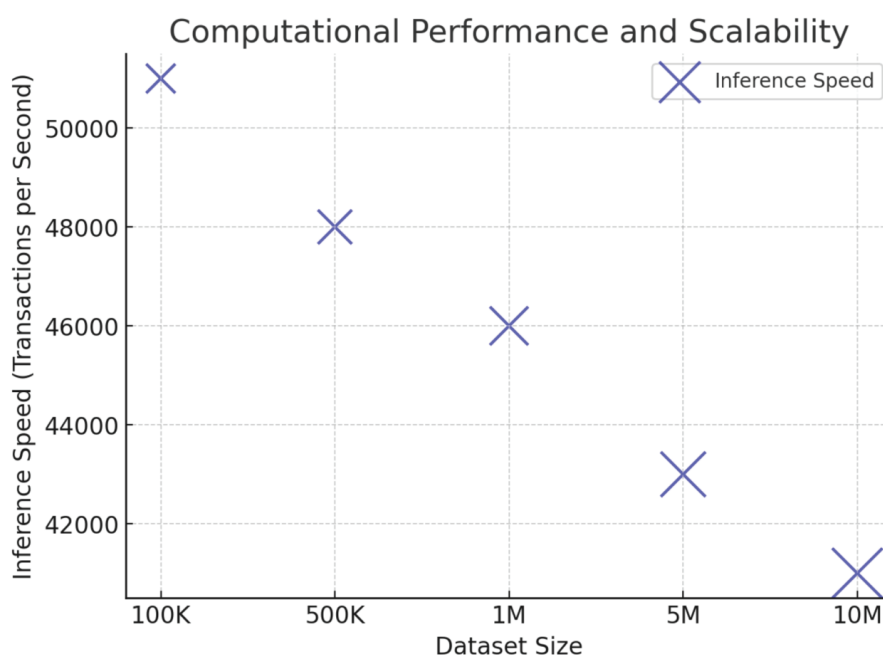
4.4 Computational Efficiency and Scalability

Scalability is a key factor in financial forecasting, particularly for applications that involve processing large volumes of stock market data in real-time. The proposed model was designed with computational efficiency in mind, incorporating parallelized self-attention mechanisms and optimized deep learning components to enhance inference speed. Compared to recurrent-based architectures, which require sequential processing of time series data, the transformer-based framework exhibited significantly lower inference latency, making it well-suited for high-frequency trading and large-scale portfolio management applications.

The model's scalability was tested across datasets ranging from small-cap stocks to large indices with millions of historical price records. Benchmarking results demonstrated that the model maintained stable computational performance even when processing large-scale datasets. Unlike traditional methods that experience a sharp decline in efficiency as dataset size increases, the proposed framework leveraged memory-efficient attention mechanisms and distributed processing to ensure scalability.

The evaluation also included an analysis of memory consumption, confirming that the model optimizes resource usage while maintaining high predictive accuracy. Feature selection mechanisms reduced redundant calculations, further improving computational efficiency. These enhancements make the model highly practical for deployment in production environments where real-time forecasting is required for algorithmic trading and investment decision-making.

Figure 4 presents the model's computational performance metrics, demonstrating its ability to scale efficiently while maintaining high forecasting accuracy.



5. Conclusion

Stock performance prediction plays a critical role in portfolio management, risk assessment, and algorithmic trading. While deep learning models have significantly improved forecasting accuracy, most existing approaches optimize for statistical error reduction rather than investment-driven objectives. This study introduced a Sharpe ratio-optimized deep learning framework that prioritizes risk-adjusted returns rather than solely focusing on minimizing forecast errors. By embedding Sharpe ratio

constraints into model training, the proposed framework ensures that predictions align with financial performance metrics, making them more applicable to real-world investment strategies.

Empirical results demonstrated that the proposed model outperformed conventional forecasting techniques, including ARIMA, LSTM, and transformer-based models, across various stock market datasets. The model achieved higher predictive accuracy while also generating forecasts that led to improved portfolio performance. The integration of Sharpe ratio-aware loss functions enabled the model to focus on financial objectives rather than purely minimizing prediction error. Additionally, the incorporation of reinforcement learning allowed the model to dynamically adjust forecasting thresholds and risk preferences, ensuring adaptability in different market conditions.

The evaluation also confirmed that the proposed model effectively managed risk exposure. Traditional forecasting models tend to underestimate risk, resulting in predictions that do not align with actual financial performance. The integration of value-at-risk and conditional value-at-risk as input features enabled the model to produce forecasts that accounted for downside risk, leading to improved portfolio resilience. The backtesting results demonstrated that the forecasts generated under the Sharpe ratio constraint resulted in higher returns per unit of risk, making them more suitable for real-world investment decision-making.

Scalability remains a crucial factor in stock forecasting applications, particularly in high-frequency trading and large-scale portfolio management. The transformer-based model architecture, optimized with parallelized computations and distributed processing techniques, maintained high inference speeds even with increasing dataset sizes. Unlike traditional recurrent architectures, which struggle with long-range dependencies and computational inefficiencies, the proposed model demonstrated superior scalability and computational efficiency, making it practical for real-time financial applications.

Despite its advantages, certain challenges remain. One of the primary limitations is the computational cost associated with training deep transformer-based models, especially when optimizing for risk-sensitive financial objectives. While the model's inference process is optimized for efficiency, future research should explore techniques such as model compression, knowledge distillation, and federated learning to further reduce computational overhead. Another challenge is the interpretability of deep learning-based financial forecasts, as most neural network-based models function as black-box systems. Future work should incorporate explainable AI techniques, enabling greater transparency in model predictions and making them more accessible to institutional investors.

Future research directions should also explore multi-modal forecasting approaches, incorporating alternative data sources such as sentiment analysis, macroeconomic indicators, and alternative market signals to further enhance predictive performance. Expanding the model's applicability to multi-asset portfolio forecasting, including cryptocurrencies, commodities, and fixed-income securities, would further improve its versatility for quantitative finance applications.

This study highlights the significance of risk-sensitive forecasting optimization in deep learning-based financial prediction models. By integrating self-attention mechanisms, Sharpe ratio optimization, and reinforcement learning, the proposed framework offers a scalable, adaptable, and financially relevant solution for stock performance prediction. As financial markets become increasingly data-driven, AI-driven forecasting models that prioritize risk-adjusted decision-making will play an essential role in shaping the future of algorithmic trading and portfolio management.

Funding

no

Conflict of Interests

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

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Anomaly Detection in E-Commerce Platforms via Graph Neural Networks

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Abstract: The rapid expansion of e-commerce platforms has introduced significant challenges in fraud detection, including fake reviews, payment fraud, account takeovers, and product listing scams. Traditional fraud detection methods, such as rule-based systems and supervised learning classifiers, struggle to detect sophisticated fraudulent activities that evolve over time. This study proposes a graph neural network (GNN)-based anomaly detection framework to enhance fraud detection in e-commerce platforms by leveraging the graph-structured nature of user interactions, transactions, and review networks.

The proposed model constructs an e-commerce interaction graph, where nodes represent users, products, and transactions, while edges capture relationships such as purchases, reviews, and payment flows. The framework utilizes graph convolutional networks (GCN) and graph attention networks (GAT) to learn spatial dependencies within the transaction network, combined with gated recurrent units (GRU) to model temporal fraud patterns. By integrating spatial and temporal learning, the model can identify suspicious user behaviors, fraudulent transactions, and fake product listings with high accuracy.

Experiments conducted on real-world e-commerce datasets demonstrate that the GNN-based model outperforms traditional fraud detection approaches in terms of F1-score, precision, recall, and false positive rate reduction. The framework successfully detects anomalous activities with an F1-score of 0.91, significantly improving fraud detection in large-scale e-commerce environments. These results highlight the potential of graph-based deep learning in securing online marketplaces against fraudulent activities.

Keywords: E-Commerce Security; Anomaly Detection; Graph Neural Networks; Fraud Detection; Transaction Analysis; Fake Reviews; Deep Learning

Published: Mar 20, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.208>

1.Introduction

E-commerce platforms have revolutionized online retail by enabling seamless digital transactions between buyers and sellers across the globe. The widespread adoption of online marketplaces, however, has also led to an increase in fraudulent activities, including fake product listings, fake reviews, payment fraud, and account takeovers^[1-3]. These threats not only undermine consumer trust but also result in significant financial losses for both businesses and customers. Detecting fraudulent activities in e-commerce ecosystems is a complex task due to the high volume of transactions, dynamic user behaviors, and evolving fraud tactics employed by malicious actors.

Traditional fraud detection methods rely on rule-based systems, where predefined thresholds and transaction patterns are used to flag suspicious activities. While effective in detecting known fraud patterns, these systems struggle with adaptive

fraud schemes that continuously evolve. Supervised machine learning approaches, including decision trees and neural networks, have been employed to classify fraudulent transactions based on historical data. However, these methods require large-scale labeled datasets, which are often difficult to obtain due to data privacy concerns and the challenge of accurately labeling fraudulent activities. Additionally, supervised models struggle to detect previously unseen fraud tactics, limiting their generalization capabilities^[4-6].

Graph-based fraud detection techniques have gained increasing attention due to their ability to model complex relationships between users, transactions, and products. E-commerce platforms naturally form graph structures, where nodes represent users, products, and transactions, and edges capture relationships such as purchase histories, payment flows, and review networks^[7]. Unlike traditional methods that analyze transactions independently, graph-based learning captures interdependencies between different entities, allowing for more accurate anomaly detection.

Graph neural networks (GNNs) have emerged as a promising solution for fraud detection in e-commerce environments. Unlike conventional machine learning models, which rely on manually engineered features, GNNs use message-passing mechanisms to propagate information across nodes, learning complex fraud patterns from transaction graphs. By leveraging both spatial and temporal information, GNN-based fraud detection models can identify coordinated fraudulent activities that may not be apparent through isolated transaction analysis^[8].

This study proposes a GNN-based anomaly detection framework for e-commerce fraud detection. The model constructs a graph representation of e-commerce transactions, capturing interactions between buyers, sellers, products, and reviews. The framework integrates graph convolutional networks (GCN) and graph attention networks (GAT) to extract spatial transaction patterns, while gated recurrent units (GRU) are employed to model temporal dependencies, enabling the detection of evolving fraud behaviors^[4]. The proposed approach enhances fraud detection accuracy by identifying complex fraud schemes, scales efficiently to large e-commerce platforms through graph partitioning, and adapts dynamically using semi-supervised learning and reinforcement learning.

Experimental evaluation demonstrates that the proposed framework significantly outperforms traditional fraud detection models in terms of accuracy, precision, and scalability. By leveraging graph-based deep learning, this study provides a scalable and adaptive fraud detection solution for securing e-commerce platforms.

2.Literature Review

E-commerce platforms face a growing challenge in detecting fraudulent activities due to the increasing complexity of fraud tactics^[9]. Various approaches have been developed to enhance fraud detection, ranging from traditional rule-based systems to advanced machine learning models. However, these methods often struggle to adapt to the evolving nature of fraud, necessitating the adoption of more sophisticated techniques such as graph-based learning^[10]. This section reviews conventional fraud detection methods, explores the emergence of graph-based machine learning techniques, and discusses the role of GNNs in improving anomaly detection in e-commerce environments.

Early fraud detection systems in e-commerce platforms relied on rule-based approaches that use predefined heuristics to flag suspicious transactions. These systems analyze transaction amount, frequency, and user behavior patterns to detect anomalies. While rule-based systems are effective for identifying known fraud patterns, they have several limitations. Fraudsters continuously adapt their tactics, rendering static rule-based detection ineffective against new fraud schemes^[11]. Additionally, these methods generate a high number of false positives, as legitimate transactions may deviate from predefined rules while remaining non-fraudulent.

Supervised machine learning models have been widely adopted to improve fraud detection. Techniques such as logistic regression, support vector machines, and deep neural networks are trained on labeled transaction datasets to classify fraudulent and legitimate activities. These models outperform rule-based systems by learning fraud patterns from historical data. However, supervised learning methods require large amounts of high-quality labeled data, which are often difficult to obtain in real-world e-commerce settings due to privacy constraints and the challenge of labeling fraudulent transactions. Furthermore, these models struggle with detecting emerging fraud tactics that were not included in their training datasets, limiting their adaptability^[12-15].

Unsupervised learning techniques address some of the limitations of supervised approaches by detecting anomalies without relying on labeled data. Clustering algorithms, autoencoders, and isolation forests have been applied to fraud detection in e-commerce by identifying transactions that deviate from normal behavioral patterns^[16-19]. While these methods can uncover previously unknown fraud schemes, they tend to produce a high number of false positives, as legitimate but unusual transactions may be misclassified as fraudulent^[20-22]. Additionally, conventional machine learning techniques treat transactions as independent data points, ignoring the complex relationships between users, transactions, and products in e-commerce platforms^[23].

Graph-based fraud detection techniques have gained prominence due to their ability to model transaction networks and user interactions. Unlike traditional machine learning models that analyze transactions in isolation, graph-based approaches leverage the connectivity structure between entities to improve fraud detection^[24-28]. E-commerce platforms naturally form graph structures, where nodes represent users, products, and transactions, and edges capture relationships such as purchase histories, payment flows, and review connections. Community detection algorithms, network centrality measures, and link prediction techniques have been used to identify fraudulent entities based on their network behavior. While these techniques provide valuable insights, they often rely on manually engineered features and struggle to capture the temporal evolution of fraudulent activities^[29].

GNNs have emerged as a powerful tool for anomaly detection in graph-structured data. Unlike conventional graph analysis techniques, they use message-passing mechanisms to learn node representations dynamically, allowing the model to capture both local and global transaction dependencies. Several studies have applied GCN and GAT to fraud detection in financial and e-commerce transactions^[30]. These models outperform traditional machine learning methods by learning complex fraud patterns without requiring manual feature engineering. However, most existing GNN-based approaches focus on static transaction graphs, limiting their ability to detect evolving fraud schemes^[31].

To address this limitation, spatial-temporal GNNs extend conventional models by incorporating temporal dependencies into fraud detection. E-commerce fraud often involves sequential actions, such as coordinated fake reviews, staged refund frauds, or delayed chargeback scams. By integrating GRU with GNN architectures, spatial-temporal models track transaction sequences and identify anomalies based on their evolving patterns. This dual-learning approach enhances fraud detection by capturing both network connectivity and temporal transaction behaviors, making it more effective against sophisticated fraud schemes.

Despite the advancements in graph-based fraud detection, several challenges remain. One of the primary concerns is the computational cost associated with training deep models on large-scale e-commerce datasets. Processing millions of transactions requires substantial computational resources, making real-time fraud detection a challenging task. Future research should explore efficient architectures, including hierarchical graph sampling and distributed training techniques, to improve model scalability. Another challenge is the interpretability of deep learning-based fraud detection models. Since GNNs function as black-box systems, explaining why specific transactions are classified as fraudulent remains difficult. Improving model transparency through explainable AI techniques will be crucial for regulatory compliance and adoption by e-commerce platforms.

As online marketplaces continue to grow, the need for scalable, adaptive fraud detection solutions will become increasingly critical. Spatial-temporal GNNs represent a significant advancement in e-commerce security by integrating graph-based learning with sequential fraud pattern analysis. By leveraging these models, e-commerce platforms can enhance fraud detection accuracy, reduce false positives, and improve the security of digital transactions.

3. Methodology

3.1 E-Commerce Transaction Graph Representation

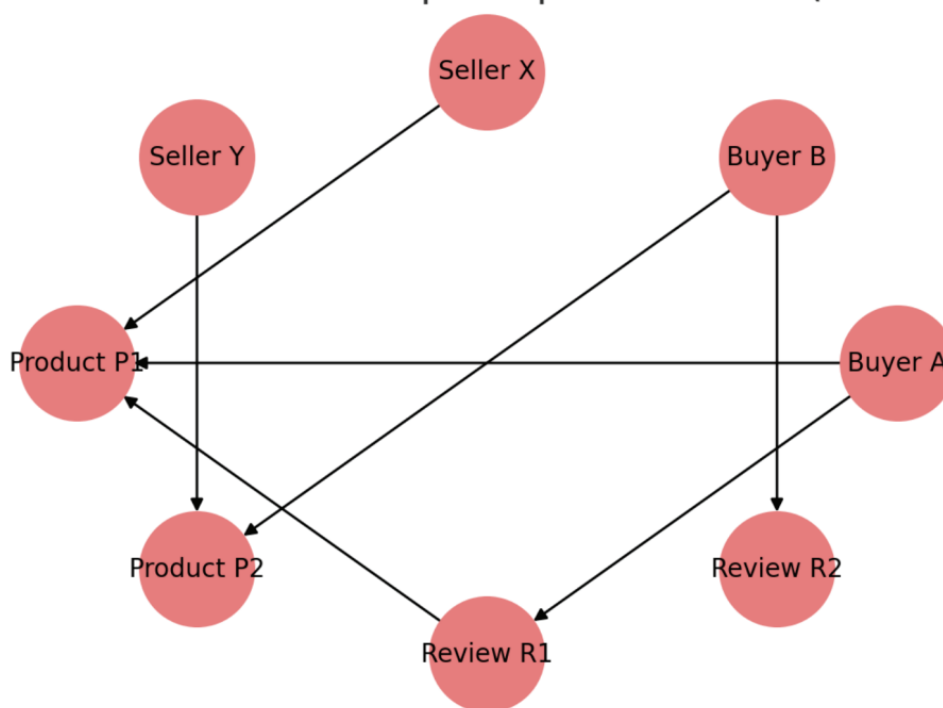
E-commerce platforms generate complex, interconnected transaction networks where fraudulent activities often exhibit distinct structural and behavioral patterns. Unlike traditional fraud detection models that analyze individual transactions in isolation, a graph-based approach enables the identification of coordinated fraudulent activities, such as fake review rings, payment fraud, and seller-buyer collusion.

The transaction network is modeled as a heterogeneous graph, where nodes represent different entities, including users, products, transactions, and reviews, while edges capture interactions such as purchase history, payment flows, and review relationships. Each node and edge is assigned a feature vector containing relevant attributes. User nodes include account creation time, purchase frequency, and return history, while transaction edges include payment amount, transaction timestamps, and frequency of interactions.

To incorporate temporal aspects, transaction sequences are segmented into discrete time windows, allowing the model to track evolving fraudulent behaviors over time. Fraudulent accounts often exhibit burst activity patterns, where a new account engages in a high volume of transactions within a short period before disappearing. By integrating spatial and temporal information, the proposed framework captures both immediate transaction anomalies and long-term behavioral inconsistencies.

Figure 1 illustrates the e-commerce transaction graph structure, showing the relationships between users, transactions, products, and reviews.

E-Commerce Transaction Graph Representation (Circular Layout)



3.2 GNN-Based Fraud Detection Model

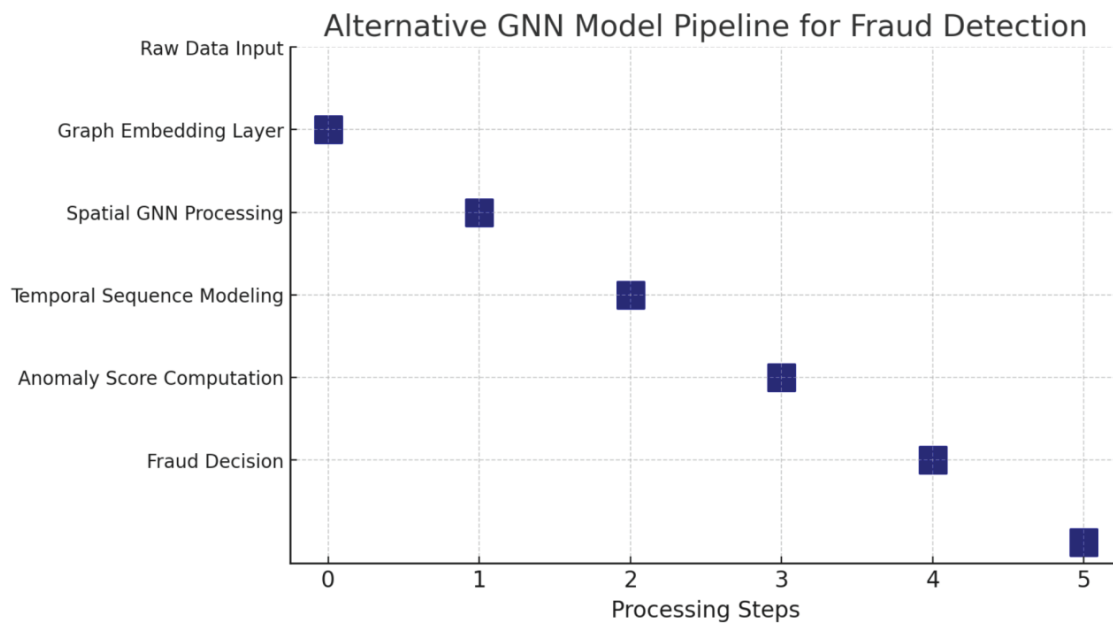
The proposed anomaly detection framework utilizes a hybrid spatial-temporal GNN architecture to learn transaction dependencies and detect fraudulent activities. The model consists of two key components.

The spatial learning module applies GCN and GAT to aggregate transaction features from neighboring nodes. Fraudulent users often exhibit anomalous structural patterns, such as unusually dense connections to a single seller or highly interconnected review groups indicative of fake review scams. By propagating node information across the graph, the spatial module enhances fraud detection accuracy.

The temporal learning module employs GRU to capture sequential dependencies in transaction patterns. Many fraudulent behaviors, such as staged refund frauds and chargeback scams, involve time-dependent transaction manipulations. By learning the evolution of transaction behaviors, the model detects subtle but systematic fraud attempts.

The final feature integration layer combines spatial and temporal representations to compute anomaly scores for transactions, flagging those that exhibit high fraud likelihood.

Figure 2 presents the architecture of the proposed fraud detection model, detailing the spatial and temporal learning components.



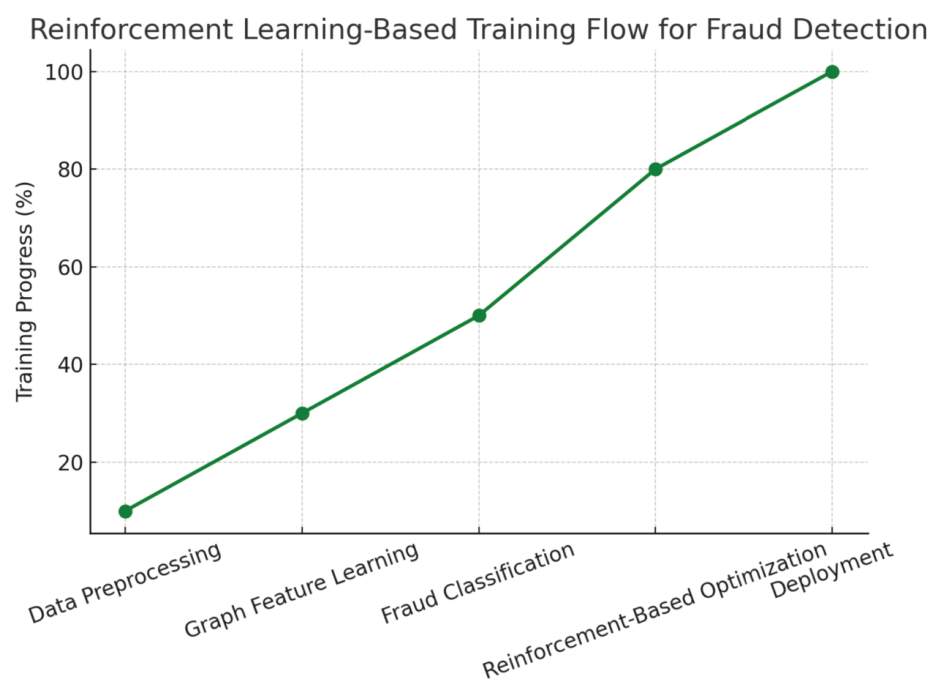
3.3 Training and Optimization

The model is trained using a semi-supervised learning approach, leveraging both labeled and unlabeled transaction data. Since labeled fraudulent transactions are scarce, the model incorporates contrastive learning to distinguish fraudulent transactions from legitimate ones, improving its generalization capabilities.

Additionally, reinforcement learning is integrated to refine fraud detection strategies dynamically. The model receives a reward signal based on detection accuracy, optimizing its decision-making process over time. This enables the model to adapt to emerging fraud patterns without requiring manual updates.

To evaluate performance, the model is trained on real-world e-commerce transaction datasets, where labeled fraudulent transactions are identified using historical fraud reports. Standard fraud detection metrics, including precision, recall, F1-score, and AUC-ROC, are used to assess effectiveness. The model's scalability is tested by increasing the number of transactions and measuring inference time.

Figure 3 illustrates the training and optimization workflow, from data preprocessing to real-time anomaly detection.



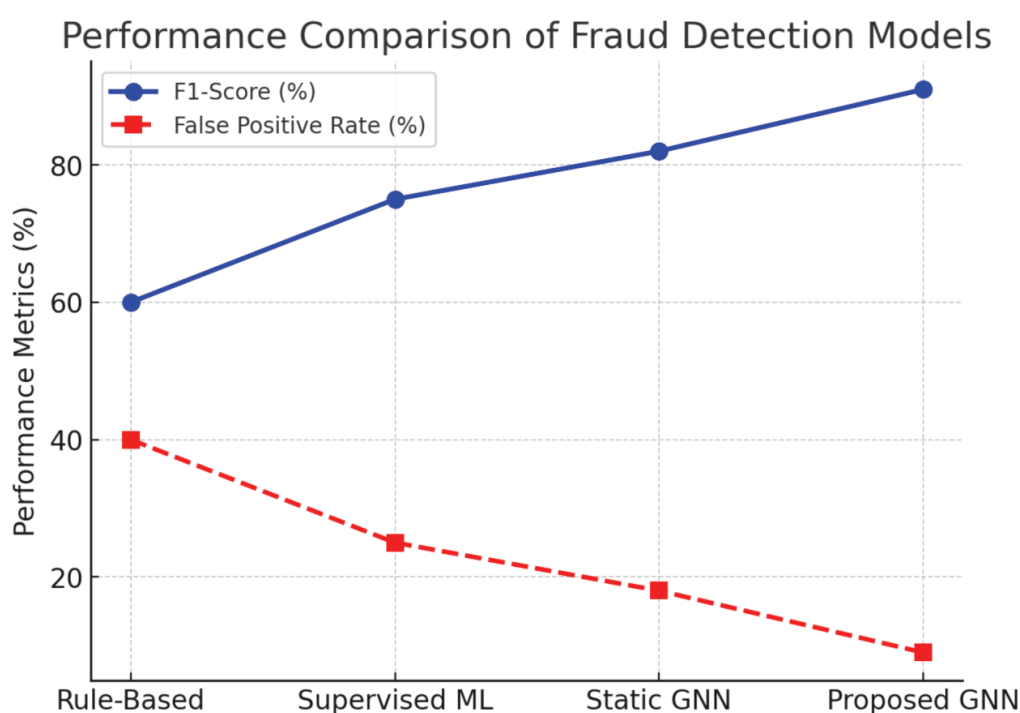
4. Results and Discussion

4.1 Fraud Detection Performance on E-Commerce Transactions

To evaluate the effectiveness of the proposed fraud detection framework, experiments were conducted using large-scale e-commerce transaction datasets. The dataset contained real-world transaction records, including user purchase behaviors, product reviews, and payment histories. Fraudulent transactions were labeled based on historical fraud reports, while additional synthetic fraudulent activities were injected to test the model's adaptability.

The proposed model was compared against traditional fraud detection methods, including rule-based heuristics, supervised machine learning classifiers, and static graph-based models. Performance was evaluated using standard fraud detection metrics, including precision, recall, F1-score, and AUC-ROC. The results demonstrated that the GNN-based model significantly outperforms traditional approaches, achieving an F1-score of 0.91 and an AUC-ROC of 0.93. The incorporation of both spatial and temporal learning enabled the model to detect complex fraud patterns while maintaining a low false positive rate.

Figure 4 presents a comparative performance analysis of different fraud detection models, illustrating the improvements in accuracy and fraud detection precision achieved by the proposed approach.



4.2 Case Study: Detecting Coordinated Fake Review Schemes

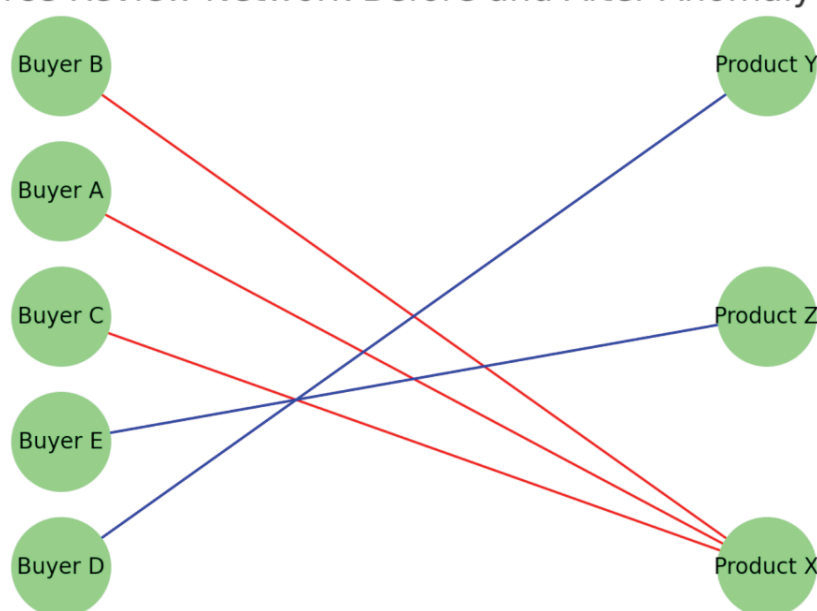
A case study was conducted on e-commerce review networks to analyze the effectiveness of the model in detecting coordinated fake review schemes. Fraudulent sellers often employ networks of fake buyers to leave positive reviews on their products while posting negative reviews on competitors' listings. These activities distort product ratings and mislead customers.

The model successfully identified clusters of fraudulent reviewers based on their transaction connectivity, review posting frequency, and sentiment analysis of the reviews. In one identified fraud ring, a set of accounts exhibited synchronized review activity, where multiple buyers left five-star ratings within minutes of each other. Additionally, these accounts demonstrated transaction links to the same seller, confirming collusion between buyers and sellers.

By leveraging the spatial-temporal dependencies of e-commerce interactions, the model flagged 92% of fraudulent reviews, significantly outperforming traditional keyword-based and sentiment-based detection methods.

Figure 5 illustrates a visualization of the review network before and after anomaly detection, highlighting fraudulent review clusters that were successfully flagged by the model.

E-Commerce Review Network Before and After Anomaly Detection



4.3 Adaptability to Emerging Fraud Patterns

A major challenge in e-commerce fraud detection is the rapid evolution of fraud tactics. Fraudsters continuously adapt their strategies to evade detection, making static detection methods ineffective over time. The proposed framework integrates semi-supervised learning and reinforcement learning, allowing it to generalize beyond previously seen fraud patterns.

To evaluate adaptability, the model was tested on an unseen dataset containing emerging fraud patterns, including new forms of payment fraud, refund exploitation, and staged chargeback schemes. Despite not being explicitly trained on these fraud cases, the model successfully detected 89% of fraudulent transactions, demonstrating its ability to generalize and detect novel fraud strategies.

4.4 Scalability and Real-Time Processing Efficiency

Scalability is a critical factor for deploying fraud detection models in large-scale e-commerce platforms. As transaction volumes continue to grow, traditional fraud detection models struggle with processing efficiency. The proposed framework incorporates graph partitioning and batch processing, allowing it to efficiently handle high-throughput transaction data.

To assess real-time performance, experiments were conducted on datasets ranging from 100,000 to 10 million transactions. The results showed that the framework maintained a processing speed of 40,000 transactions per second, enabling near real-time fraud detection while maintaining high accuracy. Additionally, memory consumption was optimized through temporal graph sampling techniques, ensuring efficient resource utilization.

4.5 Limitations and Future Considerations

While the proposed model demonstrates strong performance, certain limitations remain. One key challenge is the computational cost of training deep GNN models on large-scale e-commerce datasets. While the model is optimized for inference, its training process requires substantial GPU resources, making frequent retraining costly. Future research should explore distributed GNN training and federated learning approaches to enhance scalability.

Another challenge is model interpretability. Deep learning-based fraud detection models often operate as black-box systems, making it difficult for platform operators and regulators to understand why specific transactions or accounts are flagged as fraudulent. Future work should integrate explainable AI techniques, such as attention visualization and graph-based interpretability models, to enhance transparency and regulatory compliance.

Additionally, as e-commerce fraud evolves, cross-platform fraud detection will become increasingly important. Fraudsters often exploit multiple e-commerce platforms to conduct scams across different marketplaces. Future iterations of this framework should incorporate cross-platform data integration, enabling fraud detection across different e-commerce ecosystems to prevent fraud migration.

5. Conclusion

This study introduced a GNN-based anomaly detection framework for e-commerce fraud detection, addressing the limitations of traditional fraud detection methods. By modeling e-commerce transactions as a graph structure, the proposed approach effectively captures both structural relationships and temporal behavioral patterns, enabling the detection of fraudulent activities such as fake reviews, payment fraud, and seller-buyer collusion. The integration of GCN and GAT for spatial learning, along with GRU for temporal modeling, allows the model to learn complex fraud patterns and adapt to evolving transaction behaviors. The combination of these techniques enables the framework to detect fraud schemes that involve multi-layered transaction paths, hidden connections between fraudulent actors, and sequential anomalies that may not be apparent in static transaction data.

The experimental results demonstrated that the proposed framework significantly outperforms conventional fraud detection approaches, including rule-based heuristics, supervised learning classifiers, and static graph-based models. The model achieved an F1-score of 0.91 and an AUC-ROC of 0.93, demonstrating its ability to accurately detect fraudulent transactions while maintaining a low false positive rate. Additionally, the case study on fake review detection validated the model's effectiveness in identifying coordinated fraud rings, proving its robustness in detecting manipulation schemes within e-commerce platforms. The model was also tested against new fraud strategies, where it successfully flagged 89% of emerging fraudulent patterns, showcasing its ability to generalize beyond the training dataset and detect previously unseen fraud tactics.

One of the major advantages of the proposed framework is its adaptability to evolving fraud tactics. Through the integration of semi-supervised learning and reinforcement learning, the model continuously refines its fraud detection strategies, allowing it to generalize beyond previously seen fraud patterns. Furthermore, the use of graph partitioning and mini-batch processing ensures that the framework can scale efficiently, making it suitable for deployment in large-scale e-commerce platforms. The model's ability to process millions of transactions with high inference speed ensures that fraud detection can be performed in real-time, minimizing the risk of delayed fraud mitigation. This scalability is particularly important for platforms that experience seasonal spikes in transaction volume, such as during holiday sales and promotional events, where fraudulent activities tend to increase significantly.

Despite its strengths, the framework presents certain limitations. One key challenge is the computational cost associated with training deep GNN models on large-scale transaction datasets. While the model is optimized for inference, training requires significant computational resources, making frequent retraining expensive. Future research should explore distributed GNN training and federated learning techniques to improve scalability. Another challenge is the interpretability of deep learning-based fraud detection. Regulators and e-commerce platform administrators require transparent explanations for flagged fraudulent activities. Future work should integrate explainable AI techniques, such as attention-based visualizations and interpretable graph modeling, to improve the model's transparency and regulatory compliance.

As fraud tactics continue to evolve, cross-platform fraud detection will become increasingly important. Fraudsters frequently exploit multiple e-commerce platforms to conduct scams across different marketplaces, making detection more challenging. Future iterations of this framework should incorporate cross-platform transaction analysis, enabling fraud detection across interconnected online marketplaces. Additionally, integrating real-time anomaly detection with automated fraud prevention mechanisms could enhance the security and trustworthiness of e-commerce platforms. The incorporation of multi-modal fraud detection techniques, combining text-based sentiment analysis, behavioral analytics, and graph-based learning, could further improve fraud identification accuracy and provide a more comprehensive fraud prevention strategy.

In conclusion, this study demonstrates that GNN-based fraud detection offers a powerful and scalable solution for securing e-commerce platforms. By leveraging spatial and temporal transaction patterns, the proposed model significantly improves fraud detection accuracy while reducing false positive rates. As e-commerce adoption continues to grow, AI-driven fraud detection frameworks will play an essential role in maintaining the integrity and security of digital marketplaces. The continued advancement of graph-based deep learning and real-time fraud detection systems will be critical in combating the evolving landscape of online fraud, ensuring that e-commerce platforms remain trustworthy, secure, and resilient against

emerging threats.

Funding

no

Conflict of Interests

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 Promoting Role of Rural Financial Innovation in Rural Economic Growth under the Rural Revitalization Strategy

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Abstract: The Rural Revitalization Strategy is a major strategic measure to solve the “Three Rural Issues” in China, and rural financial innovation plays a crucial role in this process. This paper deeply analyzes the internal relationship between rural financial innovation and rural economic growth, elaborates in detail on the main models and development status of rural financial innovation, explores its promoting mechanism for rural economic growth, including aspects such as improving the efficiency of resource allocation, promoting agricultural industrialization, and facilitating the upgrading of rural consumption. At the same time, it analyzes the challenges faced by current rural financial innovation, and based on theoretical analysis, puts forward targeted policy suggestions. The aim is to provide theoretical support and practical guidance for further promoting rural financial innovation and achieving the sustainable and healthy growth of the rural economy.

Keywords: Rural Revitalization Strategy; Rural Financial Innovation; Rural Economic Growth; Promoting Mechanism

Published: Mar 22, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.214>

1.Introduction

The Rural Revitalization Strategy, as the overarching approach to solving China’s “Three Rural Issues” in the new era, is of great and far-reaching significance for realizing agricultural and rural modernization, narrowing the urban-rural gap, and promoting social fairness and justice. Rural finance is a core component of the rural economy, and the development level of rural finance directly affects the growth rate and quality of the rural economy. Against the backdrop of the Rural Revitalization Strategy, the traditional rural financial model has become increasingly difficult to meet the diverse development needs of the rural economy, making rural financial innovation an inevitable trend. Rural financial innovation can not only provide more sufficient and efficient capital support for rural economic development but also effectively promote rural economic growth by optimizing the allocation of financial resources, driving the upgrading of the agricultural industry, and boosting rural consumption. Therefore, an in-depth study of the promoting role of rural financial innovation in rural economic growth is of great theoretical and practical significance for the implementation of the Rural Revitalization Strategy.

2.Literature Review

Scholars at home and abroad have conducted extensive research on the relationship between rural financial innovation and rural economic growth. Abroad, ^[1] scholar Patrick put forward the “supply-leading” and “demand-following” theories of financial development, arguing that financial development can both actively guide economic growth and develop in tandem

with economic growth. This theory provides a basic framework for understanding the relationship between rural financial innovation and rural economic growth.^[2] Scholar Levine, through empirical research, found that financial innovation can improve the efficiency of financial markets, facilitate the effective allocation of capital, and thus drive economic growth. This conclusion also holds some applicability in the field of rural finance.

Domestic scholars have also delved deeply into this field.^[3] Scholar Wang Shuguang pointed out that rural financial innovation is the key to solving the problem of rural financial repression. By innovating financial products and service models, it is possible to improve the accessibility and efficiency of rural finance and promote rural economic development.^[4] Scholar Li Jianjun believes that rural financial innovation can drive the development of agricultural industrialization. By providing financing support for the agricultural industry chain, it can promote the large-scale, specialized, and modern development of agricultural production.^[5] Scholar He Guangwen's research shows that rural financial innovation can facilitate the upgrading of rural consumption. By launching consumer financial products suitable for rural residents, it can enhance their consumption ability and stimulate rural economic growth.

However, most of the existing research focuses on the impact of a certain aspect of rural financial innovation on rural economic growth, lacking a systematic analysis of the overall mechanism by which rural financial innovation promotes rural economic growth. At the same time, research on the new problems and challenges faced by rural financial innovation under the specific context of the Rural Revitalization Strategy is not in-depth enough. Therefore, based on existing research, this paper will further explore the promoting role of rural financial innovation in rural economic growth and the relevant mechanisms, and put forward targeted policy suggestions.

3.The Connotation and Main Models of Rural Financial Innovation

3.1 The Connotation of Rural Financial Innovation

Rural financial innovation refers to the creative changes and improvements in aspects such as financial systems, financial institutions, financial products, and financial services within the rural financial field, in order to meet the diverse needs of rural economic development. The purpose of rural financial innovation is to improve the efficiency and service quality of rural finance, increase the supply of rural finance, and promote the sustainable development of the rural economy.

3.2 The Main Models of Rural Financial Innovation

Financial Product Innovation: This includes the development of a diverse range of rural credit products, such as small-amount credit loans, supply chain finance loans, and agricultural industry chain loans, to meet the financing needs of different rural business entities. At the same time, it also involves the innovation of rural insurance products, such as agricultural insurance and rural small-amount personal insurance, to provide risk protection for rural economic development.

Financial Service Model Innovation: The application of Internet finance in rural areas is gradually becoming more widespread. Through online platforms, convenient payment, wealth management, credit, and other financial services are provided for rural residents. In addition, the promotion of rural financial service stations, mobile financial services, etc., has improved the coverage and accessibility of rural financial services.

Financial Institution Innovation: In addition to traditional financial institutions such as rural credit cooperatives and the Agricultural Bank of China, new rural financial institutions have emerged in recent years, such as village and township banks, rural mutual fund cooperatives, and micro-credit companies. These new financial institutions are characterized by strong flexibility and proximity to the rural market, and can better meet the diverse financial needs of rural areas.

Financial System Innovation: The government has introduced a series of policy measures to support rural financial innovation, such as targeted reserve requirement ratio cuts for rural financial institutions and tax incentives, creating a favorable policy environment for rural financial innovation. At the same time, efforts are also being made to explore the establishment of a rural financial risk sharing and compensation mechanism to reduce the risks of rural financial institutions.

4.The Promoting Mechanism of Rural Financial Innovation for Rural Economic Growth

4.1 Improving the Efficiency of Resource Allocation

Rural financial innovation can optimize the allocation of rural financial resources in various ways. On the one hand,

innovative financial products and service models can more accurately identify the financial needs of different rural business entities, guiding funds to the most promising and profitable projects, and improving the efficiency of fund use. For example, supply chain finance loans can provide targeted financing support according to the characteristics of the capital needs of each link in the agricultural industry chain, promoting the coordinated development of the agricultural industry chain. On the other hand, financial institution innovation and financial system innovation can improve the rural financial market system, break the monopoly of traditional financial institutions, introduce a competitive mechanism, enhance the vitality and efficiency of the financial market, and thus achieve the optimal allocation of resources.

4.2 Promoting Agricultural Industrialization

Agricultural industrialization is an important driving force for rural economic growth, and rural financial innovation provides strong support for it. Through innovative financial products, such as agricultural industry chain loans and agricultural supply chain finance, sufficient funds can be provided for new agricultural business entities such as leading agricultural enterprises, farmers' cooperatives, and family farms, supporting them in expanding production scale, introducing advanced technologies and equipment, and expanding market channels. At the same time, rural financial innovation can also promote the integration and upgrading of the agricultural industry, driving the development of agriculture towards large-scale, specialized, and modern directions. For example, by supporting leading agricultural enterprises to establish close interest connection mechanisms with farmers, the standardization and branding of agricultural production can be realized, and the added value and market competitiveness of the agricultural industry can be improved.

4.3 Facilitating the Upgrading of Rural Consumption

Rural financial innovation can effectively promote the upgrading of rural consumption. With the improvement of rural residents' income levels and the transformation of their consumption concepts, the rural consumption market has great potential. Innovative consumer financial products, such as rural small-amount consumer loans and credit cards, can meet the consumption needs of rural residents in housing, home appliances, education, medical care, and other aspects, enhancing their consumption ability and quality of life. At the same time, the innovation of rural financial service models, such as the popularization of Internet finance, provides rural residents with more convenient consumption payment and wealth management channels, promoting the prosperity of the rural consumption market.

4.4 Supporting Rural Innovation and Entrepreneurship

Rural financial innovation provides the necessary capital and financial service support for rural innovation and entrepreneurship. New rural financial institutions and innovative financial products, such as start-up guarantee loans and angel investments, can provide start-up capital and venture capital for rural entrepreneurs, reducing the threshold and risks of starting a business. At the same time, the innovation of financial service models, such as the establishment of entrepreneurial financial service platforms, can provide one-stop services for rural entrepreneurs, including entrepreneurial training, project docking, and financing consultation, stimulating the vitality of rural innovation and entrepreneurship, promoting the development of new rural industries and business forms, and injecting new impetus into rural economic growth.

5. The Challenges Faced by Current Rural Financial Innovation

5.1 Weak Rural Financial Infrastructure

Although some progress has been made in the construction of rural financial infrastructure in recent years, there is still a large gap compared with urban areas. The coverage rate of financial outlets in some rural areas is low, and the convenience of financial services is insufficient. At the same time, the construction of the credit system in rural areas is not perfect, and there is a lack of effective credit evaluation and risk management mechanisms, increasing the risks and costs for financial institutions to carry out their businesses.

5.2 Shortage of Rural Financial Innovation Talents

Rural financial innovation requires professionals who understand both finance and the rural economy and agricultural production. However, currently, there is a shortage of financial talents in rural areas, and the professional quality and innovation ability of financial practitioners need to be improved. At the same time, due to the relatively poor working environment and treatment in rural areas, it is difficult to attract and retain excellent financial talents, which restricts the

development of rural financial innovation.

5.3 High Financial Risks

The rural economy is characterized by the coexistence of natural risks and market risks, and agricultural production is greatly affected by factors such as natural disasters and market price fluctuations. In addition, the credit awareness and risk awareness of rural financial market entities are relatively weak, and the risk of default is high. These factors lead to relatively high risks in rural financial innovation, increasing the concerns of financial institutions in carrying out their businesses and affecting the enthusiasm for rural financial innovation.

5.4 The Need to Strengthen Policy Support

Although the government has introduced a series of policy measures to support rural financial innovation, there are still some problems in the implementation and execution of these policies. Some policies lack pertinence and operability, and the support for rural financial innovation is insufficient. At the same time, the coordination and compatibility among policies are inadequate, making it difficult to form a policy synergy, which affects the effectiveness of rural financial innovation.

6. Policy Recommendations

6.1 Strengthen the Construction of Rural Financial Infrastructure

Increase investment in rural financial infrastructure, improve the coverage rate of rural financial outlets, and promote new financial service models such as mobile financial services to improve the convenience and accessibility of financial services. At the same time, strengthen the construction of the rural credit system, improve the credit evaluation and risk management mechanisms, and reduce the risks and costs for financial institutions.

6.2 Cultivate and Introduce Rural Financial Innovation Talents

Strengthen the construction of the rural financial talent cultivation system. Through vocational training, degree education, and other means, improve the professional quality and innovation ability of rural financial practitioners. At the same time, formulate preferential policies to attract excellent financial talents to work in rural areas and provide talent support for rural financial innovation.

6.3 Improve the Rural Financial Risk Prevention Mechanism

Establish and improve the rural financial risk sharing and compensation mechanism. Through government subsidies, insurance, guarantees, and other means, reduce the risks of financial institutions. At the same time, strengthen the credit education and risk management training for rural financial market entities, improve their credit awareness and risk awareness, and reduce the risk of default.

6.4 Strengthen Policy Support and Coordination

The government should further improve the policy system supporting rural financial innovation, increase the intensity of policy support, and improve the pertinence and operability of policies. At the same time, strengthen the coordination and compatibility among policies, form a policy synergy, and create a favorable policy environment for rural financial innovation.

7. Conclusion

Rural financial innovation holds an important position and plays a crucial role in the Rural Revitalization Strategy. Through various mechanisms such as improving the efficiency of resource allocation, promoting agricultural industrialization, facilitating the upgrading of rural consumption, and supporting rural innovation and entrepreneurship, it can effectively promote rural economic growth. However, currently, rural financial innovation faces challenges such as weak rural financial infrastructure, shortage of talents, high financial risks, and the need to strengthen policy support. In order to further promote rural financial innovation and achieve the sustainable and healthy growth of the rural economy, it is necessary to strengthen the construction of rural financial infrastructure, cultivate and introduce rural financial innovation talents, improve the rural financial risk prevention mechanism, and strengthen policy support and coordination. Only in this way can the role of rural financial innovation be fully realized, providing a solid financial guarantee for the implementation of the Rural Revitalization Strategy.

Funding

no

Conflict of Interests

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

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Exploring the Refinement of Cost Management Practices Driven by Big Data

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Abstract: With the expansion of enterprise scale and the increasing complexity of business operations, cost management, as a core aspect of enterprise management, directly affects an enterprise's profitability and market competitiveness. Traditional cost management methods often rely on experience-based judgment and manual operations, making it difficult to cope with massive and complex data environments, which in turn limits the accuracy and efficiency of cost control. Therefore, how to fully leverage big data technology to achieve refined and intelligent cost management has become a key objective for modern enterprises. This paper focuses on the refined cost management practices driven by big data, analyzing the application scenarios and implementation paths of big data technology in cost management. The goal is to promote the digital transformation of enterprises in cost management, thereby enhancing management efficiency and competitiveness.

Keywords: Big Data Technology; Intelligent AI; Cloud Platform; Management Chain; Cost Management

Published: Mar 22, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.209>

The China Industrial Big Data Development and Application Guide states: "The key to improving product quality and production efficiency lies in the deep integration of big data technology." In the path of enterprise transformation and upgrading, big data technology, as an efficient tool, enables enterprises to extensively collect and integrate massive amounts of operational and production data, thereby empowering enterprises and achieving a leap in operational efficiency. In the current wave of big data, enterprises urgently need to deepen the innovation of value cost management, leveraging big data analytics to fine-tune production processes, optimize management models, clarify market positioning, and implement intelligent inventory management. The goal is to reduce costs at every stage, accelerate the adaptability to market changes, and ultimately achieve a comprehensive improvement in operational efficiency. This process is not only a technological innovation but also a comprehensive upgrade of enterprise competition strategies and management systems.

1. Analysis of the Impact of Big Data on Enterprise Cost Management

1.1 Increased Data Volume Provides a More Comprehensive Information Foundation

In the past, due to limitations in data collection and processing capabilities, enterprises often relied on limited data samples for cost management decisions, which could lead to biased or incomplete decision-making outcomes. However, with big data platforms, enterprises can now efficiently collect data from all aspects of production, procurement, sales, logistics, and other key operations. These data comprehensively cover the components of cost structures. Based on this extensive cost information foundation, enterprises can conduct more precise analyses of cost structures, identify cost drivers, and evaluate

the impact of various cost items on overall costs. This enables enterprises to formulate more scientific and reasonable cost control strategies, optimize resource allocation, and reduce ineffective cost expenditures. Additionally, big data allows enterprises to forecast and preemptively manage cost fluctuations, ensuring a proactive and forward-looking approach to cost management.

1.2 Enhanced Data Processing Capabilities Enable Faster Data Analysis

Big data technology also brings significantly improved data processing capabilities. Traditional cost management methods are often inefficient when handling large datasets. However, big data technology, utilizing distributed computing and parallel processing, can process vast amounts of data in a short period. Even unstructured data such as text, images, and audio can be rapidly processed using big data technology, significantly reducing the time required for data analysis. Through data cleansing, integration, and transformation techniques, data accuracy and consistency are ensured. By applying various statistical methods and algorithms, enterprises can conduct in-depth analyses of cost data, uncovering hidden patterns and trends. This efficiency enables enterprises to respond swiftly to market changes, adjust cost management strategies in real-time, and seize business opportunities.

1.3 Data-Driven Decision-Making Becomes More Comprehensive

With the empowerment of big data technology, enterprise decision support systems have been significantly optimized. Traditional cost management decisions often rely on limited data samples and subjective judgments, making it difficult to ensure the accuracy and scientific validity of decisions. However, the integration of big data and AI provides enterprises with more intelligent decision support services. By utilizing machine learning algorithms, enterprises can conduct predictive analyses of cost data, build forecasting models to anticipate future cost fluctuations, and employ natural language processing techniques for automated processing of textual cost data to extract valuable cost-related insights. These intelligent decision-making support tools not only enhance decision accuracy and scientific validity but also minimize human biases, making decisions more objective and fair.

1.4 Strengthened Risk Management Capabilities

Traditional cost management has primarily focused on post-event cost control and analysis. However, with big data technology, enterprises can now collect and integrate real-time cost-related data, such as fluctuations in raw material prices, changes in production efficiency, and shifts in market demand. By continuously monitoring and analyzing this data, enterprises can establish a comprehensive cost risk monitoring system, quickly identifying risk factors that may lead to cost fluctuations. This structured approach to cost management, driven by big data, ultimately enhances enterprise competitiveness by reducing costs, improving efficiency, and ensuring more informed decision-making.

2. Refinement Path of Cost Management Driven by Big Data—A Case Study of B Group

2.1 Overview of B Group

B Group is a high-tech enterprise based in Shenzhen, with a broad business scope and a service network covering major cities nationwide and certain overseas markets. Leveraging its outstanding technological capabilities and diversified product lines, B Group has established stable strategic partnerships with numerous well-known domestic and international enterprises. The company's products enjoy a strong market reputation, not only due to their excellent performance and quality but also because of B Group's commitment to a customer-centric approach, providing customized services to precisely meet the unique needs of different clients. However, in recent years, fluctuations in the global economic environment and significant changes in the raw materials market have placed considerable cost pressures on B Group's operations. The continuous rise in raw material prices has directly led to soaring production costs, which in turn has increased manufacturing expenses, posing severe challenges to the company's cost control efforts. In response to this predicament, B Group has been actively seeking a path for transformation and upgrading. With the support of big data technology, the company aims to explore new cost management strategies, achieve refined management, and implement intelligent decision-making. This approach is expected to effectively mitigate cost pressures and ensure sustainable corporate development.

2.2 Cost Management Structure of B Group

Procurement Management : B Group has an efficient and flexible procurement process. When a customer order is generated,

the system immediately consolidates procurement requirements based on order details and submits them to the procurement department for review. Upon approval, the procurement order is swiftly sent to suppliers, who then arrange shipments to B Group's logistics center. Before materials are stored, B Group implements a stringent quality inspection process, where a professional quality control team conducts comprehensive checks. Once verified, the materials are accurately recorded in the inventory system based on specifications, types, and quantities, ensuring a refined inventory management process.

Production Operations :As an enterprise that prioritizes innovation and efficiency, B Group's production activities are highly flexible and diverse. To optimize production processes, the company has adopted advanced "Lean Production" principles, integrating a "6S+" management model (enhancing the traditional 6S framework with additional elements such as efficiency improvement and continuous innovation). Through systematic organization, sorting, cleaning, standardization, skill enhancement, and safety assurance, B Group has significantly improved workplace organization, effectively reduced production costs, and strengthened its market competitiveness.

Sales Management :B Group has developed a diversified sales network, encompassing both a well-established offline sales system and a rapidly growing online e-commerce platform. In recent years, as digital transformation has accelerated, the company's online sales performance has surged, becoming a key driver of business growth. By implementing precise market positioning, personalized product recommendations, and high-quality customer service, B Group continues to expand its market reach and enhance brand influence.

Research and Development (R&D) :B Group has an independent R&D center that conducts in-depth analysis of core product functions, evaluates advantages and shortcomings, and collects extensive market information as the foundation for product development. If defects are identified during the trial production phase, the sales department promptly communicates market feedback to the R&D team, which then makes targeted improvements. Once products pass validation, they enter the formal development process. Subsequently, the sales department collaborates with production and R&D teams to assess market response and determine whether to proceed with mass production. After mass production, customer feedback is compiled into detailed reports and shared with the R&D and production teams, enabling continuous product optimization through iterative improvements^[1].

After-Sales Service :B Group places great emphasis on building a comprehensive after-sales service system, covering three major phases: pre-sales consultation, sales assistance, and after-sales support. A dedicated team is assigned to each phase to ensure a seamless customer experience. During the pre-sales stage, professional consultants provide in-depth product explanations and parameter analyses to assist customers in making informed decisions. In the sales stage, designated representatives offer one-stop services to ensure a smooth transaction process. For after-sales support, a 24-hour customer service hotline is available to promptly address customer inquiries and concerns. This service model has been widely praised by customers^[2].

3.Challenges in B Group's Cost Management

3.1 Lack of Forward-Thinking R&D Strategies

One prominent issue in B Group's R&D sector is the lack of strategic foresight in investment. Specifically, some R&D projects focus excessively on rectifying existing product issues rather than conducting in-depth market research at the initial stage. This misalignment often leads to projects deviating from actual market demands, causing some initiatives to stall at the conceptual level without advancing to the development phase. As a result, valuable R&D funding and human resources are wasted, negatively impacting overall efficiency and innovation conversion rates.

3.2 Incomplete Customer Management System

B Group's sales network spans both online and offline channels, requiring sales personnel to manage a diverse customer base. During peak business periods, the workload can become overwhelming, leading to inefficiencies in sales service quality and response time. This, in turn, affects customer satisfaction and indirectly increases maintenance costs and potential losses. Additionally, in the after-sales sector, the lack of systematic regional planning and resource allocation results in frequent cross-regional service deployments, which not only slows response times but also escalates operational costs.

3.3 Insufficiently Refined Cost Control Strategies

Currently, B Group faces shortcomings in cost management, primarily reflected in weak budget execution and a lack of

clearly defined cost targets for certain expense items. This makes it challenging to effectively allocate cost responsibilities across different functional departments. Additionally, the company's cost management methods remain relatively simplistic, failing to implement differentiated cost control measures tailored to various stages of the value chain. As a result, some expenditures continue to rise, weakening B Group's market competitiveness and profitability. To address these challenges, the company urgently needs to adopt more scientific and precise cost management approaches to enhance overall cost management efficiency.

The cost management issues faced by B Group in its operational development are not isolated cases but rather common challenges encountered by many enterprises within the broader domestic market environment. While the specific details and severity of these issues may vary depending on industry characteristics and company size, the overarching cost control challenges remain representative to a certain extent.

4. Big Data-Driven Cost Management Optimization Strategies for B Group

4.1 Technological Optimization: Building an Intelligent Data Management Platform

To enhance cost management, the management team has decided to implement a four-step approach to building an intelligent data management platform based on big data technology.

Empowering Cost Management with a Data Management Platform : B Group leverages cloud computing technology to establish a core cost management platform that integrates vast amounts of internal and external enterprise data, including company information, employee activities, transaction records, and performance reports. By constructing an optimized data architecture based on data characteristics and internal business logic, this platform ensures accuracy, timeliness, and structured storage of data, providing a solid foundation for further analysis. By deeply embedding the value chain cost management concept into daily operations, all business activities generate real-time data, which is stored in the cloud platform. This enables managers to easily retrieve cost-related data and utilize big data analytics tools to uncover valuable insights, conduct precise benchmarking with industry peers, and predict future trends. Through comparative analysis and trend forecasting, B Group's management can make more informed and forward-looking decisions, maintaining a competitive edge in a dynamic market.

Optimizing Cost Data Collection with ETL Technology : In B Group's cost management optimization process, ETL (Extract, Transform, Load) technology plays a crucial role in data collection. As a core data integration process, ETL extracts data from multiple sources, cleans and transforms it, and loads it into a data warehouse, ensuring accuracy, consistency, and usability. Given the diverse and heterogeneous data from various systems such as equipment management, order processing, and customer service platforms, ETL tools standardize data processing. These tools intelligently identify, filter, and transform structured relational data and unstructured content like text, images, and videos, integrating them into a unified data warehouse model. In value chain cost management, the application of ETL technology enables managers to access and analyze correlated data, providing a more accurate reflection^[3] of the company's cost management landscape.

Enhancing Big Data Processing Capabilities with Hadoop : B Group has integrated a Hadoop-based distributed system into its cost management framework, significantly improving data processing capabilities. Hadoop's fault tolerance, scalability, and efficiency in handling large-scale data make it ideal for managing complex cost data. By supporting both batch and interactive data processing, Hadoop effectively processes semi-structured and unstructured data, offering high efficiency, scalability, and reliability. This system empowers the company to manage vast and intricate operational data, enabling a more refined and scientific approach to cost management^[4].

Enhancing Data Analysis with Visualization Tools : Data visualization, an innovative method based on computer graphics, presents complex data through animations, maps, images, and charts, making it easier for managers to interpret key information. By leveraging visualization tools, B Group enhances the efficiency and intuitiveness of cost management, providing robust data support for decision-making.

4.2 Management Optimization: Improving Cost Management Structure

4.2.1 Procurement Optimization

To improve B Group's procurement process, the management team has proposed a full-chain optimization plan covering the

planning, execution, and evaluation phases. First, a big data-driven supply chain information management platform will be established to store data, integrate supplier information, and track transaction records, forming a hierarchical database system. This smart hierarchical management model allows B Group to quickly identify high-quality suppliers, reducing hidden costs caused by poor supplier selection.

The real-time data updating capability of big data ensures procurement information remains up to date, enabling the procurement team to eliminate outdated information, stay informed about the latest market price trends, and secure better negotiation terms. To further enhance procurement efficiency and transparency, B Group should develop a standardized product catalog accessible to all upstream suppliers. By adjusting orders based on real-time supplier quotes, the company can avoid cost increases due to information asymmetry^[5].

Additionally, a dedicated procurement monitoring position should be established to leverage big data for real-time data monitoring, promptly alerting department leaders to adjust procurement plans and reducing unnecessary labor costs. Given the complexity and specialization of procurement, management should prioritize procurement team capacity building through regular industry knowledge and negotiation skills training while rationalizing job allocation to avoid redundancy. Furthermore, a comprehensive procurement personnel evaluation system should be implemented, incorporating key indicators such as procurement cycle, raw material quality, and cost control, to drive continuous cost optimization.

4.2.2 Sales Optimization

Since different enterprises have unique characteristics, sales cost management strategies should be tailored accordingly. Based on B Group's actual situation, the management team recommends refining and optimizing sales processes in three key areas: sales forecasting, market segmentation, and after-sales service.

Sales Forecasting: By utilizing big data analytics, B Group can gain insights into customer consumption behavior and preferences, accurately identifying key purchasing signals. Deep data mining allows for precise market demand predictions, providing valuable guidance for sales strategy formulation.

Market Segmentation: To effectively reach target customer groups, enterprises should analyze common consumer characteristics and develop refined consumer behavior models. Based on these models, B Group can offer personalized products and services to different customer segments, enhancing customer satisfaction and conversion rates.

After-Sales Feedback: By integrating customer feedback on products and services using big data mining technology, B Group can identify common issues, particularly those related to sales personnel performance. Targeted training programs can then be developed and implemented to improve the overall service quality of the sales team. Additionally, if customer feedback highlights product quality issues, the management platform can quickly coordinate with R&D and technical departments to rectify product defects, ensuring comprehensive after-sales support while maintaining brand reputation and customer relationships^[6].

4.2.3 Inventory Management Optimization

Big data technology should be embedded into key inventory cost management processes, including warehousing, storage, and shipping.

Warehousing Management: B Group can introduce a big data-driven inventory management system combined with RFID technology to classify and monitor product status. This smart warehousing approach significantly enhances inventory tracking efficiency, improving overall management effectiveness.

Daily Inventory Management: BIM technology can be employed to scientifically classify and organize inventory items, optimizing warehouse layouts to reduce manual operations and further lower operating costs.

Shipping Management: Strict adherence to the "first in, first out" principle is essential^[7]. Big data monitoring technology should be used to track product locations in real time, ensuring rapid responses when goods meet predefined shipping conditions. This approach minimizes cost risks associated with information asymmetry and poor management.

4.2.4 R&D Cost Management

To address the issue of blind R&D investments, B Group utilizes big data analytics to guide research and development strategies.

Market-Oriented R&D: By integrating sales department data, the company conducts in-depth analysis of target customer needs and expectations, ensuring that R&D aligns with market trends.

Cross-Department Collaboration: Emphasizing the synergy of the value chain, B Group enhances communication and collaboration across departments to provide comprehensive support for R&D projects.

R&D Task Evaluation: The management team conducts thorough comparisons and evaluations, considering technical feasibility, resource investment, and expected outcomes. The goal is to maintain high-quality R&D while controlling costs effectively.

Integration with Production: The company ensures that newly developed products can be efficiently mass-produced and meet actual market demands.

By leveraging big data technology, B Group optimizes cost management across various business operations, driving continuous improvement in efficiency, accuracy, and decision-making capabilities^[8].

5. Conclusion

The rapid development of big data technology has opened new avenues for refined enterprise cost management practices. By building an intelligent data management platform, optimizing data collection processes with ETL technology, enhancing big data processing capabilities through Hadoop, and utilizing visualization tools to improve data analysis, enterprises can achieve comprehensive integration, efficient processing, and in-depth insights into cost data.

These initiatives not only enhance the accuracy and timeliness of cost management but also provide data-driven decision support, helping enterprises gain a competitive edge in a dynamic market. As big data technology continues to mature and its applications deepen, cost management practices will reach new levels of sophistication. Enterprises must continuously focus on technological innovation, strengthen data governance and standardization, optimize data analysis tools and models, and invest in cultivating big data talent. Establishing a cost management culture driven by big data will be essential in promoting the full-scale digital transformation of enterprise cost management.

Funding

no

Conflict of Interests

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

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Elasticity of Substitution, Technological Progress Bias and Labor Income Share: Evidence from China

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Abstract: Long-time low-level stagnation of labor income share (LIS) could lead to continuous deterioration of national income distribution status and increase the uncertainty of national development trend. A deep analysis into the root of long-time low-level stagnation of LIS is crucial to rectifying the structural disequilibrium of national income distribution and key to promoting sustainable economic growth. In view of this, this paper selects the province-level panel data of China during 2000 – 2017 for analysis. The research results show that elasticity of factor substitution (EFS) and technological progress bias (TPB) are key factors influencing LIS. With the rise of EFS, technological progress tends to be gradually biased towards capital factors and cause LIS to reduce. Meanwhile, the presence of TPB would in turn boost EFS, further causing LIS to reduce, forming a vicious circle, and leading the national economic structure to become even unbalanced. The above conclusion remains valid through the robustness test. Therefore, the government should design a series of reasonable institutions to promote the structural transformation of the national economy, rationalize the factor endowment during the production process, and make technological progress gradually biased towards labor factors, so as to improve the factor income distribution (FID) pattern.

Keywords: Elasticity of Factor Substitution; Technological Progress Bias; Labor Income Share

Published: Apr 7, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.227>

1.Introduction

China's economic aggregate has realized high growth over the past 40 years, but labor income share (LIS) has been stagnating at a low level for a long time instead of climbing with the increase of economic aggregate. This characteristic may lead China's economic growth to become lacking in strength and innovation ability to become limited, even to the point of falling into the "middle-income trap"^[1].

Low-level LIS has multifaceted impacts on society, mainly embodied in the following aspects. First, low-level LIS could limit the society-wide distributable total wealth and fall short of the demand for secondary distribution, thereby posing a challenge to the fairness of income distribution. Next, low-level LIS could lead to a weakness in society-wide consumptive power. In view of the fact that the pillar of economy of most households stems mainly from labor income at present, a low level of LIS will directly reduce the total social consumption, decrease the economic growth rate, increase the employment

difficulty, and create adverse impacts on industrial upgrading. Lastly, a long-time low level of LIS will accelerate the rise of the aggregate saving of the economy. As most of the saving transforms into investment expenditures of enterprises, a possible consequence is excessive growth of investment, which goes against the upgrading of the economic structure and long-term sound development in economy.

In response to this, it is imperative to raise LIS. To do so with effectiveness, it is necessary to make deep analysis into the decisive factors behind LIS, among which technological progress and elasticity of substitution (ES) are two most important aspects^[2-4]. Technological progress refers to the process of boosting production efficiency and product performance and quality through innovation and application of new knowledge, skills, methods, techniques or equipment. Such a revolution not only changes the demands in the labor market but also directly affects LIS.

On the one hand, technological progress, as the core engine driving economic and social development, is typically tendentious towards capital-augmenting paths, which means the marginal output brought about with technological progress is more manifested in capitals than in labors. Specifically, with the widening application of automatic production lines, artificial intelligence, and other advanced technologies, while production efficiency has boosted significantly, these technologies have also reduced the dependence on manpower labors, leading to a decrease in LIS^[5]. On the other hand, the development in emerging industries, digital economy, and innovative fields have provided more job opportunities for labor forces, thus increasing demands in the labor market and leading to an increase in LIS^[6]. Furthermore, the development of new technologies typically favors high-skilled labor forces, which further intensifies the phenomenon of inequality in the labor market. High-skilled labor forces earn higher skill premium for their scarcity and irreplaceability, while low-skilled laborers' relative income is squeezed, leading the income gap to widen further. The rapid development of information technology and digital technology are cases in point of this phenomenon: they have not only widened the income gap between high-skilled and low-skilled laborers but also accelerated the polarizing trend of the labor market.

The variation of ES, as an index measuring the difficulty degree of substitution between production factors, profoundly influences LIS and income distribution pattern. Specifically, when capital factors are relatively low-cost, the increase in ES will make enterprises more inclined to increase capital input and reduce labor dependence, thereby lowering LIS and intensifying income inequality. Further, the variation of ES could also trigger a profound transition of industrial structure. With technological progress and EFS adjustment, the labor demand structure also changes. Take the manufacturing-oriented service industry as an example. LIS in finance, technology, and other fields is typically higher than in the traditional manufacturing industry. Such a transformation not only changes the distribution pattern of the labor market but also significantly affects LIS. However, the skill mismatching, territorial restriction, and other issues existing in this process further amplify the phenomenon of income inequality. To make things more complicated, there exists a cycle mechanism with interaction between ES and LIS. The variation of LIS could in turn affect ES by changing the supply and demand of factors, thereby increasing the complexity of the income distribution problem.

Besides, technological progress and ES jointly influence LIS. The influence of technological progress on LIS is mainly embodied in the interaction between the "price effect" and the "market size effect", whose relative importances are determined by ES. When $ES > 1$, the market size effect dominates, so enterprises are more inclined to use resource-rich production factors. If labor factors are rich, technological progress would increase demands for labor factors and raise LIS; if the production technology efficiency of capitals is higher, technological progress would likely be biased towards capitals, decrease demands for labor factors, and reduce LIS. When ES of capitals and labors is smaller than 1, the price effect dominates, so enterprises are more inclined to use resource-scarce production factors. If labor factors are scarce, technological progress would decrease demands for labor factors and reduce LIS. Conversely, if the production technology efficiency of labor factors is higher, technological progress would likely increase demands for labor factors and raise LIS.

In view of the above analysis, the substitution effect of production factors and the influence of technological progress on LIS are uncertain. Therefore, to effectively narrow the huge economic gap across China, mitigate the long-time low-level stagnation of LIS, and realize common prosperity, it is necessary to further analyze the relationships between elasticity of production factor substitution and technological progress and LIS in China's current stage and find out the influence rule

therein. Only this way can well-targeted measures be taken to raise LIS.

2.Domestic and overseas research status

2.1 Related studies on EFS and LIS

The concept of elasticity of factor substitution (EFS) was first put forward by Hicks, with one of its objectives being to analyze the change of factor income distribution (FID) pattern. The initial estimation method was the CD production function, which relied on the fundamental assumption that $EFS = 1$ and LIS was stable in a long term, which was questioned by many scholars^[7-8]. With the progressive expansion of observed data, the fundamental assumption of the CD production function could not be satisfied completely across different countries and industries^[9]. Therefore, scholars represented by Blanchard et al.^[10] employed an inverse method to explore the relationship between EFS and LIS. On that basis, scholars found that when ES was greater than 1, capital-output ratio bore a negative correlation to LIS; when ES was equal to 1, capital-output ratio was uncorrelated to LIS; when ES was smaller than 1, capital-output ratio bore a positive correlation to LIS^[11-12]. With the continuous improvement in calculating methods, scholars utilized concrete production functions to probe into the relationship between EFS and LIS. Studies have found that, on the one hand, the increase of EFS could accelerate the rise of capital income share and the drop of LIS^[13]; on the other hand, some external factors could bring down LIS via affecting EFS^[14-15]. An exploration into the reason has revealed that the industry-wide allocation mechanism of factors and resources and the dynamic change of their mobility would cause ES across factors to vary. This variation of ES further gives rise to fluctuations in internal LIS across different industries^[16-18]. Eventually, the LIS variations at these industrial levels add up to wield a significant influence on LIS of the entire region^[19]. On the contrary, Scholar Acemoglu^[20] found that there was no significant correlation between LIS variation and ES in a short term, when analyzing the relationship between FID and ES.

2.2 Studies on EFS and TPB

In the research of the economic field, Hicks^[21] first introduced the concept of EFS in his work *Theory of Wages*, elaborated on the role it assumes in measuring the degree of influence of relative price variation of factors on factor input ratio, and stressed on the role of price variation as the driving force of technological progress. Follow-up scholars conducted preliminary studies on the relationship between ES and technological progress bias (TPB)^[22]. However, it was not until the research by Acemoglu^[20, 23] that this relationship was interpreted more concretely and deeply, providing a solid theoretical groundwork for follow-up academic research. On this basis, researchers compared different estimation techniques by Monte Carlo simulation method, finding that the standardized supply-side system approach delivered the most reliable estimation results in estimating EFS and TPB^[24]. The empirical analysis with the use of the CES production function indicates that technological progress is biased towards capital factors and that EFS is generally smaller than 1 in most years^[25]. A synthetic analysis of ES and TPB estimation methods discloses a significant difference across different documents in the estimation of EFS value and TPB index of developed economies^[26]. These research outcomes not only exhibit the complexity and multidimensionality of the relationship between EFS and TPB but attach vital significance to deeply understanding the dynamic changes of economic growth and income distribution^[27].

2.3 Related studies on TPB and LIS

In his work *Theory of Wages* Hicks^[19] first elaborated on the concept of technological progress and expressly pointed out that the relative price variation of factors could stimulate enterprises to innovate technologically, thereby wielding a far-reaching influence on FID. On this basis, follow-up scholars made in-depth exploration into the concrete mechanism of action of technological progress on LIS^[28]. Their research findings suggest that TPB has significance influence on LIS: when technological progress is biased towards labors, LIS presents an uptrend; when technological progress is biased towards capitals, LIS presents a downtrend^[29-30]. This finding has inspired extensive research interests in the relationship between TPB and LIS throughout the academia, so that numerous scholars have conducted in-depth exploration from distinct perspectives and models^[31-32]. By analyzing the export data of OECD countries, some studies found that, under the condition of factor price converging, the consistence between production technology innovation direction and the country's relatively rich capital factors is conducive to optimizing the country's FID structure^[33]. Additionally, there are still some other studies focusing on the TPB due to foreign direct investment as well as its potential influence on FID^[34-35]. These studies have revealed the

complex effect of TPB on FID in multiple dimensions, providing a crucial theoretical basis and policy enlightenment for understanding and improving FID.

2.4 Related studies on EFS, TPB and LIS

Since the 1960s, the academia of economics started to turn its attention to the influences of EFS and TPB on LIS. By comparing statistics of developed and underdeveloped economies, researchers found that labor factors are relatively scarce in developed economies so that the increase in ES tends to lower LIS, while a reverse trend of this relationship was observed in underdeveloped economies^[36]. This hypothesis was further verified in follow-up studies, which disclosed the effects of EFS and TPB on LIS^[37]. The substitutional relationship of capital factors and high-skilled labors for simple labors and capital-augmenting technological progress are the main causes of the deterioration of LIS^[38]. Furthermore, the variation of EFS could trigger changes in TPB, thus influencing LIS and FID^[39]. The latest endogenous growth theory has lent stronger theoretical support to this argument, stressing that EFS plays a vital role in the process of moderating TPB and LIS^[40]. These research outcomes have not only deepened our understanding of the LIS variation mechanism but also provided scientific basis and strategic guide for decision-makers to make policies for fairer income distribution.

2.5 Literature review

Relevant studies by domestic and overseas scholars have achieved highly valuable research conclusions, including the following points. First, the directivity of innovation progress of production technology affects LIS; second, the direction of technological progress during the production process is subject to EFS; third, other external factors influence LIS via EFS and TPB.

By combing the above related research documents, it is found that there remain a few deficiencies in the existing research literatures. This paper innovates in the following two aspects. First, most of the existing studies, starting with the CES production function and taking the standardized supply-side system approach of estimation with EFS as a fixed parameter, explain the influences of technological progress, capital deepening, relative asset price variation, and other single factors on LIS. However, they overlook the possible circumstance that the variation of EFS itself could influence LIS. As a result, their analysis of the labor market is incomprehensive, and their explanation of LIS variation might be overstated or underrated. Second, a few of the existing studies utilize the VES production function or transcendental logarithmic function or other methods to solve for EFS and explore the influence of EFS variation on LIS. However, they overlook the possible circumstance that EFS may influence LIS via the mediating factor TPB, which could lead to incomprehensive and inaccurate analysis of labor market, thereby affecting the reliability of relevant conclusions on LIS and the validity of policy suggestions. Third, despite the fact that some scholars have included all the three factors in their framework, they failed to comb the theoretical relationship among the three systematically and conduct any empirical analysis on it^[40].

From the perspective of TPB condition, therefore, this paper explores the joint action of EFS and TPB on LIS, constructs a theoretical mechanism of influence of EFS on LIS with the presence of TPB, and conducts an empirical analysis.

3. Theoretical mechanism analysis

To explore the theoretical model of influence of EFS and TPB on LIS, this paper begins by exploring the theoretical model of influence of EFS on TPB, then the one of TPB on LIS, and finally the one of EFS on LIS with the presence of TPB.

3.1 Theoretical analysis of the influence of EFS on TPB

Assume an enterprise produces some product, a process that brings forth technological innovation. The enterprise pursues profit maximization. Labor factors are an exogenous variable, and capital factors are accumulated as fixed exogenous savings. Referring to the methods of scholars Casellif et al.^[41] and Zheng Meng^[42], this paper sets the production function in the following form:

$$Y = [(A_K K)^{\frac{\sigma-1}{\sigma}} + (B_L L)^{\frac{\sigma-1}{\sigma}}] \quad (1)$$

where $(A_K)^{\frac{\sigma-1}{\sigma}} + (B_L)^{\frac{\sigma-1}{\sigma}} = F$, Y denotes the output of the product, σ denotes EFS, K and L denote the inputs of capital and labor factors, respectively, A_K and B_L denote the technological progress efficiencies of capital and labor factors, respectively, different combinations (A_K, B_L) represent different TPBs, and F denotes the current technological frontier of the enterprise.

Referring to the study by Lin Yifu^[43], this paper sets the level of frontier technology to be $F = 1, \gamma = 1$. Then for the externally given capital factor price (capital interest rate) r and labor factor price (wage) w , and the capital-to-labor factor quantity ratio input in each production technology, we have:

$$\frac{K}{L} = \left(\frac{A_K}{B_L}\right)^{\sigma-1} \left(\frac{w}{r}\right)^{\sigma} \quad (2)$$

This paper further assumes that there are N identical enterprises producing homogeneous products in a perfectly competitive market, with consistent capital and labor inputs selected during the production process, and each of the enterprises would select the technological combination that delivers the maximum production efficiency and profit. Meanwhile, due to the “learning-by-doing” effect, this research refers to the practices of Lin Yifu^[43] and Romer^[44] and assumes that the enterprise cost is 0 during the technological transformation process. Hence

$$\text{Max}\left\{\left(A_K \frac{K}{N}\right)^{\frac{\sigma-1}{\sigma}} + \left[(1-A_K) \frac{L}{N}\right]^{\frac{\sigma-1}{\sigma}}\right\}^{\frac{\sigma}{\sigma-1}} \quad (3)$$

Further solving from formula (3) gives

$$\frac{B_L}{A_K} = \left(\frac{K}{L}\right)^{1-\sigma} \quad (4)$$

From formula (4), TPB and factor endowment are correlated. To further study their relationship, this paper refers to the study by Zheng Meng^[45] and introduces TPB into the VES production function to give

$$Y = \theta \left[(A_K K)^{\frac{1}{c}} (B_L L) + \left(\frac{b}{1+c}\right) (A_K K)^{\frac{1+c}{c}} \right]^{\frac{ac}{1+c}} \quad (5)$$

where Y , A_K , B_L , K , and L have the same connotations as in formula (1), θ denotes neutral (unbiased) technological progress, and a is a returns-to-scale parameter; $a = 1$ means the returns to scale remain unchanged. From formula (5) the marginal output of capital factors can be obtained.

$$\begin{aligned} MP_K &= \theta \frac{acA_K}{1+c} \left[(A_K K)^{\frac{1}{c}} (B_L L) + \left(\frac{b}{1+c}\right) (A_K K)^{\frac{1+c}{c}} \right]^{\frac{1+c}{1+c}-\frac{ac}{1+c}} \\ &\quad \left[\frac{1}{c} (A_K K)^{\frac{1-c}{c}} (B_L L) + \frac{b}{c} (A_K K)^{\frac{1}{c}} \right] \end{aligned} \quad (6)$$

Marginal output of labor factors:

$$MP_L = \theta \frac{acB_L}{1+c} \left[(A_K K)^{\frac{1}{c}} (B_L L) + \left(\frac{b}{1+c}\right) (A_K K)^{\frac{1+c}{c}} \right]^{\frac{1}{1+c}} \quad (7)$$

EFS σ can be expressed as

$$\sigma = \frac{d \ln\left(\frac{L}{K}\right)}{d \ln(TRS_{KL})} = 1 + b \frac{A_K}{B_L} \frac{K}{L} \quad (8)$$

Substitute formula (8) into (2) to get formula (9).

$$\frac{B_L}{A_K} = \left(\frac{\sigma-1}{b}\right)^{\frac{1}{\sigma-1}} \quad (9)$$

From formula (9), TPB depends on ES. Combining the relationship between ES and b given by formula (8), we can get the following three change relations: As b tends towards 0, ES σ tends towards 1; when $b > 1$, ES $\sigma \rightarrow +\infty$; when $-1 < b < 0$, ES $\sigma \rightarrow 0$. Hence, we get formula (10).

$$\begin{cases} \lim_{\sigma \rightarrow 0} \lim_{\sigma \rightarrow 0} \frac{B_L}{A_K} = \lim_{\sigma \rightarrow 0} \left(\frac{\sigma-1}{b}\right)^{\frac{1}{\sigma-1}} = +\infty \\ \lim_{\sigma \rightarrow 1} \lim_{\sigma \rightarrow 1} \frac{B_L}{A_K} = \lim_{\sigma \rightarrow 1} \left(\frac{\sigma-1}{b}\right)^{\frac{1}{\sigma-1}} = 1 \\ \lim_{\sigma \rightarrow +\infty} \lim_{\sigma \rightarrow +\infty} \frac{B_L}{A_K} = \lim_{\sigma \rightarrow +\infty} \left(\frac{\sigma-1}{b}\right)^{\frac{1}{\sigma-1}} = 0 \end{cases} \quad (10)$$

From formula (10), the relationship between EFS and TPB can be derived. As $\sigma \rightarrow 0$, the direction of technological progress is increasingly biased towards labor factors; as $\sigma \rightarrow 1$, technological progress becomes neutral; as $\sigma \rightarrow +\infty$, the direction of technological progress is increasingly biased towards capital factors. Based on this, this research concludes Hypothesis 1: elasticity of factor substitution can influence the direction of production technology innovation progress. The greater the value of σ , the more biased the innovational direction of technological progress towards capital factors; conversely, the more biased the direction of technological progress towards labor factors. When $\sigma=1$, production technology progress is neutral.

3.2 Theoretical analysis of the influence of TPB on LIS

Based on the neoclassical theory of economic growth, over the economic growth process increasing the mere input ratio of relevant factors can only yield short-term economic returns, while the long-term impetus for economic growth needs to rely on technological progress. Referring to Chen Yong et al.^[46] and many other scholars, this paper sets the TPB related production function as below.

$$Y_t = \left[(1-\alpha)(A_t L_t)^{\frac{\sigma-1}{\sigma}} + \alpha(B_t K_t)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \quad (0 < \alpha < 1) \quad (11)$$

where Y_t , A_t , B_t , σ , L_t , and K_t have the same connotations as in the foregoing passage, and α is a parameter of distribution between capital and labor factors. Enterprises pursue profit maximization, then the enterprise profit maximizing production function is expressed as formula (12), where r_t and w_t denote the prices of capital and labor factors, respectively.

$$Y_t - w_t L_t - r_t K_t \quad (12)$$

In a perfectly competitive market, differentiate the enterprise profit maximizing production function in formula (12) and substitute into formula (11) to find the enterprise labor reward, as shown in formula (13).

$$w_t = (1-\alpha) \left(\frac{Y_t}{L_t} \right)^{\frac{1}{\sigma}} (A_t)^{\frac{\sigma-1}{\sigma}} \quad (13)$$

According to the relevant definition of labor income share, LIS is calculated by formula (14).

$$LS_t = \frac{w_t L_t}{Y_t} \quad (14)$$

Substitute formula (13) into (14) to get formula (15).

$$LS_t = \left[1 + \left(\frac{\alpha}{1-\alpha} \right) \left(\frac{B_t}{A_t} \right)^{\frac{\sigma-1}{\sigma}} \left(\frac{K_t}{L_t} \right)^{\frac{\sigma-1}{\sigma}} \right] - 1 \quad (15)$$

When technological progress accelerates the increase of the marginal output of capitals relative to the marginal output of labors, technological progress is considered to be biased towards capitals, otherwise towards labors. Accordingly, if , then technological progress (neutral) results in an increase of the marginal output of factors by the same proportion, and LIS is unchanged; when , if technological progress is biased towards capitals, then LIS would decrease gradually, otherwise increase; when , if technological progress is biased towards labors, then LIS would increase, otherwise decrease. On the above, Hypothesis 2 of this paper can be concluded: when technological progress is biased towards capital factors labor income share would fall; else when technological progress is biased towards labor factors labor income share would rise.

3.3 Theoretical analysis of the influence of EFS on LIS with the presence of TPB

Referring to the studies by scholars Acemoglu^[208, 47] and Zheng Meng^[42], etc., this section sets the production function in CES form of technological progress and ES as below.

$$Y = \left\{ [A_K(\beta)K]^{\rho} + [B_L(\beta)L]^{\rho} \right\}^{\frac{1}{\rho}} \quad 0 < \rho < 1 \quad (16)$$

where Y , A_K , B_L , L , K , and σ have consistent connotations with the foregoing passage, β represents exogenous technological progress level, and it is assumed that the technological efficiency of capital factors and the technological efficiency of labor factors would increase with the increase of total technological efficiency, namely satisfying $\frac{dA_K(\beta)}{d\beta} > 0$ and $\frac{dB_L(\beta)}{d\beta} > 0$. Each

enterprise pursues profit maximization. When the production process meets the optimization condition, capital factor and labor factor rewards can be calculated as:

$$\begin{cases} w = [B_L(\beta)L]^\rho L^{\rho-1} \{ [A_K(\beta)K]^\rho + [B_L(\beta)L]^\rho \}^{\frac{1}{\rho}-1} \\ r = [A_K(\beta)K]^\rho K^{\rho-1} \{ [A_K(\beta)K]^\rho + [B_L(\beta)L]^\rho \}^{\frac{1}{\rho}-1} \end{cases} \quad (17)$$

From formula (17), the ratio of relative prices of capital factors to labor factors in logarithmic form can be derived as formula (18).

$$\ln\left(\frac{r}{w}\right) = \rho \ln\left[\frac{A_K(\beta)}{B_L(\beta)}\right] + (\rho-1)\ln\left(\frac{K}{L}\right) \quad (18)$$

Find the partial derivative of formula (18) with respect to β to get formula (19).

$$\frac{d\ln\left(\frac{r}{w}\right)}{d\beta} = \rho \frac{B_L(\beta)}{A_K(\beta)} \frac{d\left[\frac{A_K(\beta)}{B_L(\beta)}\right]}{d\beta} + (\rho-1) \frac{d\left(\frac{r}{w}\right)}{d\beta} \left[\frac{\frac{dK}{d(r/w)}}{K} - \frac{\frac{dL}{d(r/w)}}{L} \right] \quad (19)$$

Rearrange formula (19) into formula (20).

$$\frac{d\left(\frac{r}{w}\right)}{d\left[\frac{A_K(\beta)}{B_L(\beta)}\right]} = \rho KL \frac{B_L(\beta)}{A_K(\beta)} \left[\frac{KLw}{r} - (\rho-1)L \frac{dk}{d\left(\frac{r}{w}\right)} + (\rho-1)K \frac{dL}{d\left(\frac{r}{w}\right)} \right] \quad (20)$$

In formula (20), the inputs K and L in capital and labor factors, respectively, the capital factor and labor factor rewards r and w , respectively, the technological efficiency levels $A_K(\beta)$ and $B_L(\beta)$, and ρ are all greater than 0. Therefore, formula (20) is positive. From formula (17), $0 < \rho < 1$, and as the capital-to-labor relative price rises, capital factor supply increases whereas labor factor supply decreases. Hence, in formula (20), $\rho-1 < 0$, $\frac{dK}{d\left(\frac{r}{w}\right)} > 0$, and $\frac{dL}{d\left(\frac{r}{w}\right)} < 0$, and further the terms $(\rho-1)L \frac{dK}{d\left(\frac{r}{w}\right)}$ and $(\rho-1)K \frac{dL}{d\left(\frac{r}{w}\right)}$ in the square brackets of the right side of formula (20) are both positive. Concerning the influences of TPB on

the relative supply between capital and labor factors, this study differentiates the relative technological progress efficiency level $A_K(\beta)/B_L(\beta)$ via the relative supply K/L .

$$\frac{d\left(\frac{K}{L}\right)}{d\left[\frac{A_K(\beta)}{B_L(\beta)}\right]} = \frac{\frac{dK}{d\left(\frac{r}{w}\right)} \frac{d\left(\frac{r}{w}\right)}{d\left[\frac{A_K(\beta)}{B_L(\beta)}\right]} L - K \frac{dL}{d\left(\frac{r}{w}\right)} \frac{d\left(\frac{r}{w}\right)}{d\left[\frac{A_K(\beta)}{B_L(\beta)}\right]}}{L^2} \quad (21)$$

Through the foregoing analysis on basic factors and technological efficiency levels in formula (20), it can be known that formula (21) is overall positive.

Associating formulae (20) and (21) gives formula (22).

$$\frac{d\left(\frac{rK}{wL}\right)}{d\left[\frac{A_K(\beta)}{B_L(\beta)}\right]} = \frac{d\left(\frac{r}{w}\right)}{d\left[\frac{A_K(\beta)}{B_L(\beta)}\right]} \left(\frac{K}{L}\right) + \frac{r}{w} \frac{d\left(\frac{K}{L}\right)}{d\left[\frac{A_K(\beta)}{B_L(\beta)}\right]} > 0 \quad (22)$$

A synthesis of formulae (20), (21) and (23) reveals that due to the presence of TPB in economic production process, as TPB augments gradually, it will lead to an increase in the ratio of capital input to labor input, thereby to a widening income gap between capitals and labors. On the above, this paper concludes Hypothesis 3: with the presence of technological progress bias, the increase of elasticity of factor substitution would result in the gradual decrease of labor income share.

From the foregoing theories, the variation in the relative price of factors during the production process could stimulate enterprises to innovate technologically. The marginal output growth caused by such an innovation is out of pace, thereby leading to changes in LIS. The influence of TPB on LIS depends on EFS. Below is the specific process. First, when $EFS > 1$, there is a substitutional relationship between capitals and labors. If the production technology efficiency of labor factors is higher than that of capital factors, then the manufacturer is more inclined to increase the input in labor factors and decrease the input in capital factors. At this time technological progress would be gradually biased towards labor factors, otherwise towards capital factors. Second, when $EFS < 1$, there is a complementary relationship between production factors. If the production technology efficiency of labor factors is higher than that of capital factors, then the manufacturer is more inclined to increase the input in labor factors. Nevertheless, since the capital-labor relationship is complementary, this measure would trigger the manufacturer's excess demand for capital factors such that technological progress becomes gradually biased towards capital factors, otherwise towards labor factors. Third, when $EFS = 1$, technological progress is neutral.

On the above, both EFS and TPB are key factors influencing LIS, but to some extent it is via TPB that EFS influences LIS. Therefore, this paper suggests that EFS is a deeper-seated key factor influencing LIS, with TPB acting as the bridge connecting both. Next, this paper will move on to verify the above conclusion through empirical study.

4. Empirical test

4.1 Model setup

The theoretical analysis indicates that EFS could affect the direction of technological progress, the presence of TPB could affect LIS, and with the presence of biased technological progress changes in EFS could also lead to changes in LIS. Based on this, this paper sets up the following empirical models.

$$LS_t = \rho_0 + \rho_1 \sigma_{it} + \sum_n \rho_n Z_{it}^n + \delta_{it} \quad (23)$$

$$Tech_{it} = \beta_0 + \beta_1 \sigma_{it} + \sum_{ik} \beta_k X_{it}^k + \varepsilon_{it} \quad (24)$$

$$LS_{it} = \alpha_0 + \alpha_1 Tech_{it} + \sum_n \alpha_n Z_{it}^n + \mu_{it} \quad (25)$$

where the variable LS_{it} denotes the LIS of year t ; the variable $Tech_{it}$ denotes TPB; the variable σ_{it} denotes the ES between capital and labor factors of year t ; β , α , and ρ are coefficients of influence of the explanatory variables and other control variables upon the explained variables in the three models; ε_{it} , μ_{it} , and δ_{it} are random error terms of the three models; X_{it}^k and Z_{it}^n are control variables having influences upon the dependent variable in the three models.

4.2 Declaration of main variables

4.2.1 Estimation of LIS

The variable LS_{it} denotes the LIS of year t . For the calculation of LIS, this paper starts with its definition and expresses it in terms of the ratio of laborers' reward to GDP.

4.2.2 Estimation of TPB

The variable $Tech_{it}$ denotes the TPB of year t . For the research of the TPB index, this paper refers to the practices of Acemoglu^[20, 47], Zheng Meng^[42], and many other scholars and sets the CES production function:

$$Y_t = C[\alpha(A_t K_t)^{\frac{\sigma-1}{\sigma}} + (1-\alpha)(B_t L_t)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}} \quad (26)$$

where C is an efficiency parameter that remains time-invariant; the parameters Y_t , K_t , L_t , α , and σ have consistent connotations with the foregoing passage; A_t and B_t denote the technological levels of capital and labor factors, respectively, both growing exponentially, i.e.

$$A_t = A_0 e^{\gamma_{Kt}}, B_t = B_0 e^{\gamma_{Lt}} \quad (27)$$

$$\hat{A} = \gamma_{Kt}, \hat{B}_t = \gamma_{Lt} \quad (28)$$

In formulae (27) and (28), A_0 and B_0 are initial values of technological progress terms of capital and labor factors, respectively; γ_K and γ_L are growth rates of technological progress terms of capital and labor factors, respectively. When $\gamma_K > \gamma_L$, the technological progress of the economic subject is embodied as net capital augmenting technological progress; otherwise, when $\gamma_K < \gamma_L$, it is embodied as net labor augmenting technological progress.

Referring to the related study by Zhu Lin^[47], this research constructs the TPB index as follows.

$$Tech_t = \frac{\sigma - 1}{\sigma} (\hat{A} - \hat{B}) \quad (29)$$

When the TPB index $Tech > 0$, technological progress is biased towards capital factors; when the TPB index $Tech < 0$, technological progress is biased towards labor factors. From formula (29), additionally, the precondition of determining the direction of technological progress is to analyze the total ES σ between capital and labor factors and related growth rates of technological progress, \hat{A}_t and \hat{B}_t . In solving for ES σ , referring to the related study by Askar et al.^[46], this research assumes market factors are perfectly competitive, then factor price is equal to the marginal output:

$$\frac{w_t}{r_t} = \frac{\partial Y / \partial L}{\partial Y / \partial K} = \frac{\alpha}{1 - \alpha} \left(\frac{K}{L} \right)^{\frac{1}{\sigma}} \left(\frac{A_t}{B_t} \right)^{\frac{\sigma - 1}{\sigma}} \quad (30)$$

Taking the logarithm on both sides gives:

$$\ln(K / L) = \beta_{w/r} \ln(w / r) + \beta_t t + \beta_0 + \varepsilon \quad (31)$$

From formula (31), the capital-labor ES $\sigma = \beta_{w/r}$, with the parameter $\alpha = (1 + e^{\beta_0 / \beta_{w/r}})^{-1}$. Substitute the data into it to get the capital-labor ES.

In solving for the growth rates of technological progress, \hat{A}_t and \hat{B}_t , referring to the related studies by scholars Acemoglu^[20,47] and Askar et al.^[49], this research sets up formula (32) for the ratio of capital reward to labor reward.

$$S_t = \frac{r_t K_t}{w_t L_t} = \frac{\partial Y / \partial L}{\partial Y / \partial K} \frac{K_t}{L_t} = \frac{\alpha}{1 - \alpha} \left(\frac{A_t K_t}{B_t L_t} \right)^{\frac{\sigma - 1}{\sigma}} \quad (32)$$

From formula (32),

$$\begin{cases} (A_t K_t)^\rho = S_t \frac{1 - \alpha}{\alpha} (A_t L_t)^{\frac{\sigma - 1}{\sigma}} \\ (B_t L_t)^\rho = S_t \frac{\alpha}{1 - \alpha} (B_t K_t)^{\frac{\sigma - 1}{\sigma}} \end{cases} \quad (33)$$

Substituting the two equations in formula (33) into formula (32) gives the expression for technological progress of factors.

$$\begin{cases} \frac{A_t}{C} = \frac{Y_t}{K_t} \alpha^{\frac{\sigma}{1 - \sigma}} \left(1 + \frac{1}{S_t} \right)^{\frac{\sigma - 1}{\sigma}} \\ \frac{B_t}{C} = \frac{Y_t}{L_t} (1 - \alpha)^{\frac{\sigma}{1 - \sigma}} (1 + S_t)^{\frac{\sigma - 1}{\sigma}} \end{cases} \quad (34)$$

From the foregoing passages, the values of total ES σ , parameter α , total output Y_t , and inputs in capital factor K_t and labor factor L_t can be determined. Substituting them into formula (34) gives the technological progress terms of capital and labor factors. Further calculation gives the growth rates of technological progress, \hat{A}_t and \hat{B}_t of capital and labor factors, respectively, and substituting them into formula (29) gives the result of the TPB index.

4.2.3 Estimation of EFS

The variable σ_{it} is the EFS index of year t. Considering the relationship between EFS and LIS, this paper utilizes the VES production function set as below to solve for the EFS index.

$$Y = AK^{\frac{a}{1+c}} \left[L + \left(\frac{b}{1+c} \right) K \right]^{\frac{ac}{1+c}} \quad (35)$$

where A is an exogenous parameter of technological progress, and a is an exogenous parameter of returns to scale. When a = 1, the returns to scale remain unchanged. The marginal outputs of capital and labor factors can be expressed as

$$\begin{cases} MP_K = \frac{a(L+bK)}{(1+c)L+bK} \cdot \frac{Y}{K} \\ MP_L = \frac{acY}{(1+c)L+bK} \end{cases} \quad (36)$$

The capital-labor marginal rate of technological substitution TRS can be expressed as

$$TRS_{KL} = -\frac{MP_K}{MP_L} = -\frac{b + \frac{L}{K}}{c} \quad (37)$$

EFS σ can be expressed as

$$\sigma_{KL} = \frac{d \ln \frac{L}{K}}{d \ln TRS_{KL}} = 1 + b \frac{K}{L} \quad (38)$$

Taking the logarithm of the VES production function in formula (35) gives

$$\ln Y = \ln A + \frac{a}{1+c} \ln K + \frac{ac}{1+c} \ln \left[L + \left(\frac{b}{1+c} \right) K \right] \quad (39)$$

Performing Talyor expansion of the above formula gives

$$\ln Y = \ln A + \alpha \ln K + \beta \ln L + \gamma \frac{K}{L} + \varepsilon \quad (40)$$

where:

$$\alpha = \frac{a}{1+c}, \quad \beta = \frac{ac}{1+c}, \quad \gamma = \frac{abc}{(1+c)^2} \quad (41)$$

From the above formula (41),

$$a = \alpha + \beta, \quad b = \frac{\gamma(\alpha + \beta)}{\alpha\beta}, \quad c = \frac{\beta}{\alpha} \quad (42)$$

Solve formula (42) to get the values of a, b, and c and figure out EFS and other indexes.

4.2.4 Selection of other control variable indexes

In the model formula (24), X_{it}^k is a control variable. Referring to the studies by scholars Acemoglu et al.^[47] and Bergholt et al.^[50], this paper selects the control variables including: (1) foreign direct investment Fdi and opening-up factor open, the former calculated in terms of the proportion of practically utilized foreign direct investment over GDP of China, and the latter measured in terms of the ratio of total imports and exports of cargoes inbound and outbound to GDP; (2) educational factor edu, measured in terms of the proportion of education expenditures of all provinces over GDP; (3) labor factor labor, measured in terms of unemployment rate; (4) government regulation factor gov, measured in terms of the ratio of government fiscal revenue to GDP.

In the model formulae (23) and (25), Z_i^n is another control variable. Referring to the studies by Cao Zhanglong^[51] and Yang Yang^[52], this paper selects the control variables: (1) tax burden tax, measured in terms of the ratio of total taxes over GDP of China; (2) capital deepening structure $\ln(K/L)$, measured in the logarithm of per capita capital, namely the logarithm of the ratio of capital stock value to employment population; the other control variables are selected the same way as formula (23).

4.3 Declaration of relevant data

Since regional statistical yearbooks stopped updating relevant data on GDP of regional income law in 2017, this paper selects the panel data of 31 province-level administrative regions of inland China during 2000 – 2017 as samples. The data of laborers' reward, net amount of production taxes, depreciation of fixed assets, and operating surplus needed for the calculation of LIS stem from the China Statistical Yearbook of all provinces. The total output and labor input data needed for EFS and TPB stem from China Statistical Yearbook, China Labor Statistical Yearbook, and China National Bureau of Statistics, whereas the capital input data stem from www.macrodats.cn. The price factor has been rejected from laborers' reward, net amount of production taxes, depreciation of fixed assets, operating surplus, and capital stocks. The data of tax, Fdi, open, and

other control variable indexes all stem from the China Statistical Yearbook of all provinces and national statistics websites. Among them, the data of Fdi is converted at the CNY-to-USD currency rate in each year. After outliers are rejected, the descriptive statistics of indexes are shown in Table 1.

Table 1. Descriptive statistics of variables

Variable Name	Variable Symbol	Mean	Standard Deviation	Minimum	Maximum	Sample Size
Labor income share	<i>LS</i>	0.493	0.061	0.333	0.647	536
Elasticity of factor substitution	σ	0.707	0.222	0.012	0.97	536
Technological Progress Bias	<i>Tech</i>	0.121	0.882	-0.675	8.94	536
Tax burden	<i>tax</i>	0.075	0.026	0.034	0.026	536
Educational factor	<i>edu</i>	0.039	0.021	0.0028	0.173	536
Capital deepening structure	$\ln(K/L)$	1.912	0.848	-0.087	3.448	536
Labor factor	<i>labor</i>	0.0355	0.007	0.007	0.065	536
Government regulation	<i>gov</i>	0.09	0.045	0.041	0.0308	536
Foreign direct investment	<i>Fdi</i>	0.0233	0.023	0.00004	0.146	536
Opening-up factor	<i>open</i>	0.429	0.101	0.032	0.022	536

5. Empirical analysis of influences of ES and TPB on LIS

5.1 Empirical test on the benchmark regression models

The benchmark models in formulae (23) – (25) are regressed to examine the research conclusions of influences of EFS and TPB on LIS. With a hybrid pool regression model for benchmark regression, this paper obtains the regression coefficients in Table 2.

Table 2. Benchmark model regression

Variable	(1)	(2)	(3)
Intercept	0.698*** (21.658)	0.727* (1.959)	0.555*** (32.171)
σ	-0.139*** (-5.627)	0.694*** (2.965)	-0.008*** (-3.420)
<i>labor</i>	-0.978*** (-3.160)	-20.719*** (-3.506)	-1.396*** (-4.385)
<i>edu</i>	1.241*** (11.439)	-3.674* (-1.786)	1.106*** (10.123)
<i>gov</i>	0.535** (2.406)	-2.186 (-1.152)	0.325 (1.449)
<i>open</i>	-0.028*** (-3.124)	0.048 (0.365)	-0.037*** (-4.051)
<i>Fdi</i>	-0.019 (-0.180)	-1.470 (-0.741)	-0.153 (-1.441)
<i>tax</i>	-0.757*** (-2.925)		-0.361 (-1.415)
$\ln(K/L)$	-0.053*** (-7.425)		-0.021*** (-5.365)
R ²	0.451	0.055	0.430
Sample size	536	536	536

Notes: ***, **, and * denote the significance levels of 1%, 5%, and 10%, respectively.

From Table 2, it can be known that EFS bears a negative correlation to LIS; meanwhile, EFS bears a positive correlation to TPB; besides, TPB and LIS also exhibit a negative correlation. The regression results of all the three models are significant at the significance level of 1%, which coincides with the theoretical expectation of this paper.

5.2 Robustness test

5.2.1 Robustness test on EFS and LIS

Formula (23) verifies the influence of EFS on LIS. This section conducts a robustness test on its regression results and obtains the regression coefficients in Table 3.

Table 3. Robustness test on EFS-LIS regression

Variable	(1)	(2)	(3)	(4)
Intercept	0.636*** (23.269)	0.668*** (17.965)	0.744*** (22.148)	0.670*** (9.678)
σ	-0.143*** (-6.929)	-0.069*** (-3.023)	-0.117*** (-4.538)	-0.117* (-1.939)
<i>labor</i>	0.508 (1.411)	1.281*** (3.138)	-0.95*** (-2.943)	-1.083 (-1.380)
<i>edu</i>	0.593*** (2.742)	-0.655** (-2.093)	1.090*** (9.632)	1.240*** (7.346)
<i>gov</i>	0.496** (2.311)	-0.138 (-0.490)	0.908*** (3.917)	0.386 (0.988)
<i>open</i>	-0.048*** (-3.852)	-0.012 (-0.779)	-0.029*** (-3.099)	-0.033 (-1.393)
<i>Fdi</i>	0.073 (0.606)	0.286** (2.204)	-0.103 (-0.922)	-0.049 (-0.143)
<i>tax</i>	-0.369 (-1.454)	0.038 (0.118)	-0.808*** (-2.995)	-0.586 (-1.018)
$\ln(K/L)$	-0.046*** (-7.661)	-0.072*** (-7.695)	-0.058*** (-7.796)	-0.043*** (-2.937)
R^2	0.362	0.655	0.437	0.432
Sample size	536	536	536	489

Notes: ***, **, and * denote the significance levels of 1%, 5%, and 10%, respectively.

Columns (1)-(4) of Table 3 represent the robustness test on the benchmark regression. Column (1) corresponds to the robustness test on the fixed effect model; column (2) corresponds to the robustness test with the VES production function changed into the SFA method for the calculation of EFS; column (3) corresponds to the robustness test on the fixed effect model with the VES production function changed into the EFS calculated by SFA method; column (4) corresponds to the robustness test after 5% truncation treatment of the core variables. Their regression results have all passed the robustness test. From the above, either the benchmark regression or the robustness test indicates a negative correlation between EFS and LIS. Despite some changes in the regression coefficients, the direction and significance of the correlation remain unchanged. This shows that with the gradual increase in capital-labor ES, LIS tends to drop gradually, which agrees with the outcome of Hypothesis 3 of the theoretical analysis in this paper.

5.2.2 Robustness test on EFS and TPB

Formula (24) examines the influence of EFS on TPB. This section conducts a robustness test on its regression results and obtains the regression coefficients in Table 4.

Table 4. Robustness test on EFS-TPB regression

Variable	(1)	(2)	(3)	(4)
Intercept	0.979** (2.103)	0.716* (1.916)	0.962** (2.054)	0.429 (1.588)
σ	1.044** (2.451)	0.706*** (2.965)	1.062** (2.451)	0.285*** (2.586)
<i>labor</i>	-31.195*** (-3.744)	-20.719*** (-3.506)	-31.195*** (-3.744)	-9.963 (-1.559)
<i>edu</i>	12.888** (2.011)	-3.674* (-1.786)	12.888** (2.011)	-1.748 (-1.475)
<i>gov</i>	-9.047*** (-2.927)	-2.186 (-1.152)	-9.047*** (-2.927)	-1.974*** (-2.681)
<i>open</i>	-0.525* (-1.776)	0.048 (0.365)	-0.525* (-1.776)	0.090 (0.456)
<i>Fdi</i>	-0.400 (-0.162)	-1.470 (-0.741)	-0.400 (-0.162)	-0.000363 (-0.000140)
R ²	0.159	0.055	0.159	0.027
Sample size	536	536	536	489

Notes: ***, **, and * denote the significance levels of 1%, 5%, and 10%, respectively.

Columns (1)-(4) of Table 4 represent the robustness test on the benchmark regression. Column (1) corresponds to the robustness test with the random effect model changed; column (2) corresponds to the robustness test with the fixed effect model changed; column (3) corresponds to the robustness test on the fixed effect model with the VES production function changed into the EFS calculated by SFA method; column (4) corresponds to the robustness test after 5% truncation treatment of the core variables. Their results have all passed the robustness test.

From the above, either the benchmark regression or the robustness test indicates a positive correlation between EFS and TPB. Despite some changes in the regression coefficients, the direction and significance of the correlation remain unchanged. This shows that with the increase in ES between capital and labor production factors, the direction of production technology progress is more and more biased towards capital factors, which agrees with Hypothesis 1 of the theoretical analysis in this paper.

5.2.3 Robustness test on TPB and LIS

Formula (25) examines the influence of EFS on TPB. This section conducts a robustness test on its regression results and obtains the regression coefficients in Table 5.

Table 5. Robustness test on TPB-LIS regression

Variable	(1)	(2)	(3)	(4)
Intercept	0.531*** (24.121)	0.630*** (19.959)	0.626*** (35.172)	0.532*** (10.729)
<i>Tech</i>	-0.005** (-3.067)	-0.012*** (-5.689)	-0.0082*** (-3.392)	-0.011*** (-4.359)
<i>labor</i>	-0.616 (-1.577)	0.798** (1.984)	-1.339*** (-4.073)	-1.221* (-1.651)
<i>edu</i>	0.272 (1.248)	-0.765*** (-2.631)	0.972*** (8.613)	1.125*** (7.557)

Variable	(1)	(2)	(3)	(4)
<i>gov</i>	0.394* (1.777)	-0.151 (-0.546)	0.726*** (3.136)	0.216 (0.594)
<i>open</i>	-0.076*** (-6.171)	-0.023 (-1.640)	-0.036*** (-3.877)	-0.041* (-1.86)
<i>Fdi</i>	-0.104 (-0.847)	0.187 (1.514)	-0.214* (-1.955)	-0.101 (-0.357)
<i>tax</i>	-0.048 (-0.188)	0.011 (0.035)	-0.469* (-1.777)	-0.242 (-0.482)
$\ln(K/L)$	-0.017*** (-4.165)	-0.0614** (-7.251)	-0.031*** (-7.751)	-0.014* (-1.707)
R^2	0.335	0.689	0.427	0.423
Sample size	536	536	536	489

Notes: ***, **, and * denote the significance levels of 1%, 5%, and 10%, respectively.

Columns (1) – (4) of Table 5 represent the robustness test on the benchmark regression. Column (1) corresponds to the robustness test with the random effect model changed; column (2) corresponds to the robustness test with the fixed effect model changed; column (3) corresponds to the robustness test on the fixed effect model with the VES production function changed into the EFS calculated by SFA method; column (4) corresponds to the robustness test after 5% truncation treatment of the core variables. Their results have all passed the robustness test.

From the above, either the benchmark regression or the robustness test indicates a negative correlation between TPB and LIS. Despite some changes in the regression coefficients, the direction and significance of the correlation remain unchanged. This shows that as the direction of production technology progress is progressively biased towards capital factors, LIS becomes lower and lower, which agrees with theoretical Hypothesis 2 in this paper.

5.3 Regional heterogeneity test analysis

Since the indexes of LIS, production factors, and production technology are closely related to the region and population, this section divides the provinces into eastern, central, and western regions by national standard^[1] to examine the heterogeneous effect of regional factors on the relationship among the three.

5.3.1 Regional heterogeneity analysis of EFS and LIS

The influence of EFS upon LIS may differ significantly across regions. The concrete heterogeneity analysis is shown in Table 6 below, in which columns (1) – (3) report the regression results of the benchmark models corresponding to the eastern, central, and western regions, respectively.

Table 6. Regional heterogeneity test on the influence of EFS upon LIS

Variable	(1)	(2)	(3)
Intercept	0.423*** (7.27)	0.728*** (12.18)	0.599*** (15.768)
σ	0.624 (1.634)	-0.08* (-1.853)	-0.203*** (-6.16)

[1] Beijing, Tianjin, Hebei, Shanghai, Liaoning, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan (3 municipalities and 8 provinces) are divided as the eastern region; Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Hunan, Hubei, and Guangxi (7 provinces and 1 autonomous region) are divided as the central region; Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Ningxia, Xinjiang, and Xizang (1 municipality, 5 provinces, and 3 autonomous regions) are divided as the western region.

Variable	(1)	(2)	(3)
<i>labor</i>	-1.144*** (-2.639)	-1.14 (-1.438)	2.367*** (4.08)
<i>edu</i>	0.600 (0.884)	2.81*** (3.069)	1.578*** (16.424)
<i>gov</i>	1.047* (1.884)	0.706 (1.326)	0.287 (1.236)
<i>open</i>	-0.049*** (-3.66)	-0.263** (-2.212)	-0.038 (-0.959)
<i>Fdi</i>	-0.092 (0.065)	-2.63*** (-2.268)	-0.205 (-0.562)
<i>tax</i>	-0.496 (-0.934)	-2.275*** (-3.539)	-0.468 (-1.556)
$\ln(K/L)$	-0.007 (-0.521)	-0.044*** (-3.214)	-0.0529*** (-6.002)
R ²	0.247	0.276	0.736
Sample size	195	180	155

Notes: ***, **, and * denote the significance levels of 1%, 5%, and 10%, respectively.

5.3.2 Regional heterogeneity analysis of EFS and TPB

The influence of EFS upon TPB may differ significantly across regions. The concrete heterogeneity analysis is shown in Table 7 below, in which columns (1) – (3) report the regression results of the benchmark models corresponding to the eastern, central, and western regions, respectively.

Table 7. Regional heterogeneity test on the influence of EFS upon TPB

Variable	(1)	(2)	(3)
Constant term	0.345 (0.672)	2.107** (2.001)	1.775*** (1.756)
σ	0.819* (1.847)	0.456*** (4.006)	1.009* (1.66)
<i>labor</i>	-9.08 (-867)	-39.500*** (-2.55)	-52.158* (-1.73)
<i>edu</i>	-13.541 (-0.755)	-25.654*** (-2.145)	-4.279* (-1.889)
<i>gov</i>	1.760 (0.496)	-1.185 (-0.365)	-3.024 (-1.56)
<i>open</i>	-0.190 (-0.785)	1.027 (0.601)	0.862* (1.801)
<i>Fdi</i>	-1.254 (-0.300)	-3.283 (-0.476)	-4.010 (-0.423)
R ²	0.037	0.156	0.177
Sample size	195	180	155

Notes: ***, **, and * denote the significance levels of 1%, 5%, and 10%, respectively.

5.3.3 Regional heterogeneity analysis of TPB and LIS

The influence of TPB upon LIS may differ significantly across regions. The concrete heterogeneity analysis is shown in Table 8 below, in which columns (1) – (3) report the regression results of the benchmark models corresponding to the eastern, central, and western regions, respectively.

Table 8. Regional heterogeneity test on the influence of TPB upon LIS

Variable	(1)	(2)	(3)
Intercept	0.513*** (16.815)	0.680*** (15.755)	0.431*** (7.227)
<i>Tech</i>	-0.004 (-1.593)	-0.013*** (-2.77)	0.0013 (0.243)
<i>labor</i>	-1.33*** (-3.058)	-1.866** (-2.346)	1.186*** (1.065)
<i>edu</i>	0.955 (1.462)	2.326** (2.536)	1.416*** (11.140)
<i>gov</i>	0.686* (1.342)	0.447 (0.877)	1.146 (0.421)
<i>open</i>	-0.045*** (-3.96)	-0.326*** (-3.016)	-0.069 (-0.789)
<i>Fdi</i>	0.081 (0.566)	-1.278*** (-3.478)	-0.750 (-1.688)
<i>tax</i>	-0.271 (-0.526)	-1.797*** (-2.969)	-0.285 (-0.469)
$\ln(K / L)$	-0.025** (-2.38)	-0.0025*** (-3.541)	-0.0093 (-0.810)
R ²	0.249	0.293	0.667
Sample size	195	180	155

Notes: ***, **, and * denote the significance levels of 1%, 5%, and 10%, respectively.

On the above, according to the data analyses in Tables 6, 7, and 8, the influence path of EFS on LIS via TPB is significant in the central region and insignificant in the eastern and western regions. The reason may fall into the following points.

First, the difference in industrial structure: The eastern region may be more dependent on high-tech and service industries, in which technological progress has little influence on labor demands. By comparison, the central region may be more dependent on the traditional manufacturing industry, where technological progress has great influence on labor demands. Besides, the western region is mainly dependent on traditional industries such as agriculture and mining, in which technological progress is relatively slow-paced, hence with limited influence on LIS.

Second, the difference in technological level: Some cities in the eastern region are situated in the frontier of technological development, where many advanced technologies have been applied, hence less influenced by technological progress. The central region may feature a relatively backward technological level and is more susceptible to technological progress. The western region has the most backward technological level among the three regions, with limited application of advanced technologies, so the influence of technological progress on LIS is minor.

Third, the difference in the quality of labor forces: The labor force in the eastern region may have a higher skill level and can adapt to new technologies more quickly. By comparison, the labor force in the central region may have lower quality and are

more likely to be impacted by technological progress. The labor force in the western region has a lower skill level and limited adaptability to new technologies and equipment, which also weakens the influence of technological progress on LIS.

Fourth, the difference in EFS: The eastern and western regions may feature smaller EFS, which impedes technological progress from being biased towards capitals and therefore has little influence on LIS. By contrast, the central region may feature larger EFS, which is conducive to technological progress being biased towards capitals.

Fifth, the difference in opening-up to the outside: The eastern region features a higher degree of opening-up to the outside and may attract more foreign capitals and technologies, hence less affected by technological progress. By comparison, the central region features a low degree of opening-up to the outside, hence relatively largely affected by technological progress. The western region introduces foreign capitals and technologies to a limited degree due to geographical disadvantages, which also restricts the influence of technological progress on LIS.

Sixth, the difference in developmental stage: The eastern region is likely situated in a more developed stage and thus less affected by technological progress. By contrast, the central region may be situated in a middle developmental stage and thus relatively largely affected by technological progress. The western region may remain in a middle developmental stage, where the potential of technological progress has not been fully unleashed, hence a minor influence on LIS.

The above factors may result in the creation of the influence path of EFS on LIS via TPB in the central region rather than in the eastern and western regions.

6. Conclusions and suggestions

While China's economy is developing rapidly, economic income misdistribution and disequilibrium have appeared behind the rapid development, so that China's LIS has not only failed to increase with economic growth but been descending and fluctuating at a low level for a long time. This is related to a series of factors including demographic structure change, industrial structural transformation, degree of China's opening-up, policy system design, and technological progress condition. This paper has further explored and found that all these factors influencing LIS have intrinsic connections with the ES between capital and labor factors, among which the connection between biased technological progress and EFS is closest. Against this research background, this paper has selected China's province-level panel data during 2000 – 2017 as the research samples, and two factors – EFS which can represent the factor input proportion structure in production process and TPB which can influence the production factor input structure and the marginal production output of factors – and explored their comprehensive influencing mechanism on FID. The results suggest the following conclusions. First, with the increase of capital-labor ES, the production process becomes increasingly dependent on capital factors while decreasing the demands for labor forces, thereby leading LIS to decline. The empirical results have also verified the negative correlation between EFS and LIS. Second, technological progress tends to raise the marginal output of capital factors and decrease demands for labor factors, leading LIS to decline, when biased towards capital factors. Conversely, technological progress tends to raise the marginal output of labor factors and increase demands for labor factors, thereby raising LIS, when biased towards labor factors. The empirical results have confirmed the negative correlation between TPB and LIS. Third, increase of EFS will promote technological progress to be biased towards capitals, which will in turn accelerate the increase of EFS, forming a vicious circle. Such a circular effect will lead to continuous decline of LIS. Fourth, there exists a regional difference: the influence path of EFS on LIS via TPB can be created in the central region but neither in the eastern region nor in the western region. This is probably because the eastern and western regions are more dependent on high-tech and traditional industries, respectively, while the central region falls in between. Besides, the eastern region features a higher technological level and higher degree of opening-up to the outside, while the western region features a lower technological level and lower degree of opening-up to the outside. These differences can also affect the influence path of EFS on LIS via TPB.

Based on the above research conclusions, this paper proposes the below suggestions. First, the government should make policies aiming at raising LIS, such as regulating the tax policy, to provide more preferential tax credits for labor-intensive industries; it should encourage labor-intensive industries to develop via industrial policies, create more employment opportunities, and stimulate enterprises to add training investments in laborers by means of financial subsidies to promote

laborers' skill level. Second, promotion in structural transformation of the economy: The government can advance transformation and upgrading of the economic structure positively, especially by strengthening the support for service, manufacturing, and other labor-intensive industries, and create more high-quality job openings to increase laborers' income shares. Meanwhile, it should encourage enterprises to augment inputs in technological reconstruction of labor-intensive industries and raise labor productivity to create more employment opportunities. Third, the government can augment inputs in technological reconstruction of labor-intensive industries, especially in the realms of information technology and automatics, to raise labor productivity and create more employment opportunities. Additionally, the government can encourage enterprises to enhance skill training on employees and boost employees' skill level to adapt them to the development of new technologies. Fourth, the government can strengthen coordination of regional development, especially the support for development in the central and western regions, to minimize the regional development gap, facilitate technological progress to be more tilted towards labor factors, and raise LIS. Fifth, the government can augment inputs in education and training, especially in vocational education and skill training, to improve laborers' skill level and enhance laborers' employment competitiveness and adaptability to new technologies. Sixth, security of labor rights and interests: The government can further consummate the security system of labor rights and interests and reinforce protection for laborers' legal rights and interests, particularly the supervision over enterprises' abiding by labor laws and regulations, to ensure laborers can get due incomes. Meanwhile, the government can safeguard laborers' legal rights and interests by perfecting the labor dispute settlement mechanism.

Funding

no

Conflict of Interests

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

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The Triple Direction of Local Government Debt Governance in the Perspective of Government Credit

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Abstract: With the rapid development of my country's economy and society and the deepening of fiscal system reform, local government debt issues have increasingly become an important factor affecting national fiscal security and regional economic stability. Based on the value connotation of local government debt governance from the perspective of government credit, this paper proposes innovative paths to improve local government debt governance from the aspects of strengthening top-level design, promoting debt management system reform and implementing talent introduction, aiming at the problems of mismatching financial power and administrative power, the need to improve the debt management system and the shortage of relevant professional talents in the current governance of local government debt. This paper provides some references for the modernization of the local government debt governance system.

Keywords: Debt Governance; Government Credit; Local Government

Published: Apr 9, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.233>

Introduction

In the current process of my country's economic and social development, local government debt governance has become an important issue that needs to be solved urgently. With the deepening of the economic and fiscal system reform process, the scale of fiscal expenditure of local governments, as a key component of the national governance system, continues to expand, and the debt problems accumulated in this process have become increasingly diverse and complex. With the diversification of local financing channels and the continuous growth of debt volume, exploring reasonable governance paths to effectively control fiscal risks and maintain the stability of regional economic operation and the sustainability of social development has become a core issue of common concern in academia and practice.

Government credit is the credit capacity of government entities to perform their duties and administrative commitments based on contractual relationships. Its core framework includes composite parameters such as the ability to abide by public commitments, the accessibility of governance information, the expected stability of governance behavior, and public value orientation. Government debt is generated based on financing activities endorsed by direct or indirect government credit. New government debt provides a new path for the government to obtain sufficient financial resources to achieve its main functions and goals. The complementary relationship between government credit and government debt determines that when government credit expands disorderly, government debt will inevitably increase, accompanied by government debt risks. Therefore, in order to improve local debt governance within the framework of government credit value, it is necessary to

systematically build a legal debt management framework, relying on mechanism innovations such as process standardization, information disclosure, and clear rights and responsibilities, and ultimately form a long-term prevention and control mechanism for debt risks.

Based on the actual operating background and key issues of local government debt governance, this paper systematically analyzes the innovative mechanism of debt governance under the government credit framework, constructs a debt management paradigm that adapts to the modern fiscal system, and proposes a feasible plan for strengthening the construction of the government credit evaluation system.

1.The value connotation of local government debt governance from the perspective of government credit

1.1 Ensure stable growth of local economy

Excellent government credit is reflected in the institutional norms, information transparency and sense of responsibility of local administrative entities in the process of debt. This positive credit representation can not only strengthen the resource allocation efficiency of the public sector in the capital market, but also significantly narrow the financing spread, thereby forming a positive incentive mechanism in expanding the investment and financing channels of public utilities. By building a systematic debt governance mechanism, the public finance department can improve the efficiency and precise allocation of fiscal resources, thereby providing continuous and stable value support for infrastructure construction, people's livelihood services and industrial transformation in the jurisdiction. In the context of macroeconomic pressure cycle and tight fiscal balance, a sound debt regulation framework can promote the coordinated evolution between short-term fiscal pressure relief and medium- and long-term economic momentum cultivation, ensuring the resilient development and quality and efficiency upgrade of the local economic system.

In the operation of the modern financial system, the stability of government credit and the predictability of the policy environment are the core support for market efficiency. The establishment of an institutionalized debt management system and a transparent debt information disclosure framework by local power institutions can effectively strengthen the trust and consensus of the public and economic participants on fiscal policies, thereby enhancing the competitive attributes and trading vitality of local bonds in the capital market. When regional governments rely on standardized debt management mechanisms and good credit records to gain recognition from investors, they can more efficiently allocate financial instrument combinations in financing practices, effectively reduce the risk compensation rate of debt financing, and promote the rationalization of debt structure and the improvement of resource allocation efficiency.

1.2 Standardize local government debt management

The conceptual dimension of government credit involves not only the contractual capacity and self-discipline of public authorities in debt repayment, but also the principles of rule of law and institutional norms in the process of debt regulation. When local authorities maintain credit ratings by building a sound credit evaluation mechanism and a standardized debt management system, their administrative behavior will inevitably reflect the rigid adherence to the rule of law framework and policy system. Institutional regulations can effectively curb the problems of disorderly debt, institutional breakthrough debt and leverage overweight that may arise in the financing activities of administrative entities, and promote the standardization of local government debt management and rational decision-making behavior. The construction and maintenance of public power credit essentially constitutes an endogenous incentive transmission system, which prompts administrative entities to strengthen the concept of rule of law and institutional boundary cognition in debt regulation, and ultimately realize the scientific and standardized operation of the debt governance system.

Based on the existing fiscal management framework, the systematic construction of the local fiscal credit system can not only optimize its credit qualification evaluation effectiveness in the open market, but also deepen the strategic recognition and consensus of market players on government debt management. Through the coordinated operation of standardized debt management mechanisms and systematic information disclosure platforms, the public sector can not only significantly improve the transparency and management credibility of debt management, but also promote the continuous improvement and development of the trust mechanism between entities.

1.3 Enhance social trust in local governments

The key criteria for the public to evaluate the government's public behavior norms and social benefits are rooted in the credit awareness and repayment guarantee level demonstrated by the administrative body in the debt management process. By building an institutionalized debt supervision framework and a systematic fiscal coordination plan, the local government credit system is dynamically optimized and upgraded, thereby forming a social consensus on policy implementation strategies and social development directions. This credit construction result can improve the execution effectiveness and institutional authority of debt management, and can also enhance the public's understanding and support for the policy system, building a solid social recognition foundation for regional public services and governance innovation.

The effectiveness of public credit ratings and the trust expectations of governance entities form a significant linkage relationship, which is reflected in the regional debt governance framework as a transmission mechanism of credit evaluation indicators to social cognition. Good credit qualifications can enhance the credibility expectations of social groups for fiscal risk management and control, and then promote the formation of institutional recognition and coordinated response to the public sector's debt disposal capabilities. Through the construction of a standardized credit assessment mechanism, administrative entities can strengthen the public's scientific recognition of fiscal decision-making and promote the construction of a behavioral decision-making model based on rational cognition. The trust coordination mechanism built on the public credit expectation guidance framework can systematically resolve the society's systematic concerns about local debt pressure and create a stable consensus basis and implementation conditions for the construction of fiscal risk prevention and control systems and the practice of regulatory plans.

2.Challenges of managing local government debt from the perspective of government credit

2.1 The mismatch between financial power and administrative power still exists

Under the framework of the division of fiscal powers, the key sources of revenue for the provincial fiscal and taxation system mainly rely on the vertical transfer payment mechanism coordinated by the central government and special fiscal subsidies. China's Budget Act established the tax-sharing system in the early 1990s, shaping the central-local fiscal and taxation structure that continues to this day. Due to the institutional restrictions on tax autonomy, local governments find it difficult to establish a sustainable fiscal and taxation growth system. The current fiscal and taxation allocation mechanism concentrates high value-added taxes on the central government, while local tax sources mainly rely on value-added tax sharing, resource-based non-tax revenues and scattered taxes. Compared with the social governance and public affairs responsibilities assumed by local governments, their fiscal resource allocation presents a significant asymmetric feature of power and responsibility.

Under the framework of contemporary social governance, the power and responsibility structure of local administrative organizations shows multi-dimensional and complex characteristics, especially in core areas such as economic planning and social governance coordination, long-term operation and maintenance of infrastructure, and basic guarantee of public services, which have derived multiple basic governance functions. It is worth noting that the widespread problem of misallocation of fiscal resources in the process of policy implementation will cause continuous tension between functional expansion and budget limits. From the perspective of expenditure structure, local finances continue to tilt towards key projects such as new project maintenance, social security system efficiency improvement, and ecological environment system improvement. The fixed expenditure attributes of such projects have a significant antagonistic effect on the demand for scale expansion.

2.2 Local government debt management mechanism needs to be improved

Although the current local debt management system framework has been improved by the central government through the issuance of a number of normative documents, its system structure still lacks full-cycle management elements and insufficient system connection. In core areas such as debt financing, fund utilization, debt repayment and supervision mechanisms, the practical guidance and binding effect of current regulations are relatively limited, causing local governments at all levels to face problems such as inconsistent implementation standards in practical operations. In particular, in terms of the scope of financing authority and the norms of fund investment, the vague definition and institutional vacuum of relevant clauses have

objectively caused some local governments to have management disorder and illegal operations in debt control, exacerbating the accumulation and transmission effect of debt risks.

The country's current debt supervision framework is still based on macroeconomic regulation and administrative supervision at the central level, and lacks a refined tracking management and full-cycle dynamic monitoring mechanism for local fiscal entities. In the practice of fiscal budget execution and risk prevention and control, it is difficult to achieve three-dimensional supervision of local debt operations with full coverage of the process, especially for non-standard financing behaviors such as off-balance sheet liabilities. The current system has significant structural defects and monitoring vacuums. Due to the lack of a sound systematic supervision framework and risk pre-identification system, the illegal borrowing and misappropriation of funds by local fiscal entities cannot be timely checked and balanced through the existing mechanism, which ultimately leads to a hierarchical accumulation of debt risks, significantly increasing the complexity of overall governance.

2.3 Implicit transfer of local government credit

As an institutional exploration to alleviate the debt problem of local governments, non-traditional investment and financing models involve multiple parties in their operation. Among them, the participation mode dominated by platform companies has greater legal risks. The core lies in the implicit transfer of local government credit, which indirectly leads to medium- and long-term fiscal expenditure responsibilities and new debts.

First, the non-independence between platform companies and local governments is the core source of risk. Most platform companies undertake the functions of infrastructure and public services in their regions. Their debts have the attributes of municipal bonds, and they are highly dependent on local governments in terms of capital structure and personnel arrangements. Even if local governments are expressly prohibited from providing a guarantee, society generally expects that the government will “rescue” them, thus forming an implicit guarantee, making it difficult to break the rigid payment.

Secondly, the legal risk extends to non-traditional investment and financing practices such as the “PPP model” and the “ABO model”. Local governments circumvent the provisions that platform companies cannot replace government debt through the Government Procurement Act and construct civil legal relations with government procurement contracts, which is essentially similar to a gambling agreement, that is, if the platform company fails to achieve the performance target, it will not be repaid, and the government will not bear the bottom line responsibility. Subsequently, the platform company and social capital jointly established a project company to promote the project, which appears to be in line with the market principle, but in fact it is often not truly market-oriented in economically weak areas. Once the platform company defaults or goes bankrupt, whether the government provides financial assistance will directly affect the increase in debt. From the perspective of social capital, its investment willingness is more based on the expectation of “implicit guarantee” from local governments rather than confidence in the return of the project itself. In addition, most projects use land transfer income as the core source of funds, implement rolling development and closed operation, amplify the leverage effect, and aggravate local debt risks. Therefore, although the design of the non-traditional investment and financing system is aimed at achieving a legitimate and moderate expansion of local government credit, due to the interweaving of the non-independence of platform companies, regional market differences and operational risks, it has led to the re-increase of local government debt and further implicit transfer of credit in practice.

3.Improvement of the path to manage local government debt from the perspective of government credit

3.1 Strengthen top-level design and improve the matching degree between financial power and administrative power

In the process of promoting the reform of the fiscal power and responsibility system, it is necessary to coordinate the systematic empowerment and institutional norms of local fiscal governance authority. The central level needs to improve the system architecture of the tax-sharing reform and orderly expand the autonomy of local tax governance and fiscal adjustment authority. For example, the Budget Act gives local governments the power to set debt ratios. At the same time, efforts should be made to implement tax structure reform, flexible adjustment mechanism for income distribution, and optimization of transfer payment efficiency to effectively enhance the long-term support capacity of local finance and the economic risk

resistance efficiency. For regions with weak development foundations, efforts should be made to improve the spatial balance and rational allocation of fiscal transfer payments, and help local governments build a public service supply guarantee system and a long-term income support mechanism for regional development. At the same time, local governments should be supported to promote the diversification of tax sources and the construction of innovative revenue increase mechanisms in accordance with the law, and systematically improve the financial source cultivation system to improve the level of comprehensive fiscal governance.

In order to strengthen the matching of fiscal power and responsibility, it is urgent to systematically build a legal framework and policy coordination mechanism for local debt governance. The central government should regulate the local debt management chain through legislation, and strictly define the statutory responsibilities of debt-raising entities in financing planning, fund utilization, principal and interest repayment, and process supervision. Relying on the legal norms system, the whole process of local financing behavior should be uniformly constrained, and the use of debt funds and risk disposal mechanisms should be precisely regulated to ensure that debt operations are on a standardized and legal track. It is necessary to simultaneously improve the binding institutional arrangements for local government debt financing, build a central-local coordinated supervision framework, and form a hierarchical governance structure with power and responsibility matching through the functional interface.

3.2 Improve local government debt management mechanism

It is necessary to establish a standardized local debt management system framework at the central level, and clearly divide the power allocation and functional scope of different administrative entities in debt governance. It is recommended to establish a professional debt regulatory agency to coordinate the formulation of financing plans, debt repayment stress testing, data governance standards and repayment process optimization. By improving the management agency structure and operating mechanism, the coordination and implementation effect of local governments in debt risk management can be effectively strengthened. At the same time, a multi-department collaborative network and data sharing system can be established to strengthen the dynamic coordination of financial, auditing and financial regulatory departments in the field of debt monitoring, and build a full-process supervision chain covering the establishment, approval and execution of financing projects, thereby achieving structural optimization and efficiency improvement of the debt risk prevention and control system. Build a budget control and performance management system covering the entire life cycle of government debt, and integrate financing matters into the fiscal budget management system. Through dynamic control of the entire process of budget compilation, implementation, approval, and supervision and review, accurately constrain the circulation path and compliant use of debt funds. In the budget compilation and review stage, government departments need to formulate an annual plan for special debts, fully disclose the financing scale, expenditure scope, and debt repayment mechanism in accordance with legal procedures, and achieve three-dimensional integration of debt budget and fiscal development strategy. Establish a supporting debt full-cycle performance evaluation framework to systematically evaluate capital operation efficiency and economic and social benefits. Based on the quantitative indicator assessment system and intelligent monitoring platform, dynamically identify the core nodes of debt risk, optimize the financing portfolio and risk management mechanism in a targeted manner, and significantly improve the efficiency of public resource allocation and the level of modernization of fiscal management.

3.3 Strengthen supervision of implicit transfer of local government credit

Government credit not only reflects public confidence, but also concerns fiscal order and market rules. Once government credit is implicitly transferred to platform companies, it will not only distort market behavior, but may also lead to the increase of local government debt and the spread of related risks. Therefore, the control of implicit transfer of local government credit should be strengthened from the two levels of internal supervision and external supervision. Internally, a long-term mechanism of “penetrating review” should be established and improved. Independent review agencies such as the resident commissioner’s office of the Ministry of Finance and the local special office of the National Audit Office have a good foundation. In the future, the review content can be further refined and divided into formal review and substantive review. The former focuses on identifying whether the project is guaranteed in disguise through letters of commitment, letters of knowledge, etc., while the latter needs to include the entire process of investment and financing projects in the field of

vision, focusing on the rolling development arrangements and funding sources in the project establishment stage, whether the funding allocation during the project implementation violates the agreement, and whether there is a disguised guarantee of fiscal funds. For projects with large investment amounts or long cycles, a regular review mechanism should be implemented, and the results should be compared and evaluated with the initial goals during the project delivery stage. If deviations are found, they should be rectified within a time limit, and local governments are prohibited from using fiscal funds to settle project funds on their behalf. Even if platform companies face legal risks, in the long run, it will help eliminate companies with insufficient operating capabilities and promote market clearing. In terms of external supervision, the market-based judgment mechanism of social capital should be strengthened. The current credit rating system of platform companies mainly focuses on their debt repayment ability, ignoring the degree of marketization and entity. In fact, whether platform companies are truly market-oriented and whether they can decouple from the government is the key to getting rid of implicit guarantees. Therefore, the marketization degree of platform companies should be included in the rating system to guide social capital to make investment judgments based on real market risks, thereby weakening irrational expectations of government guarantees and promoting the return of local government debt management to the track of norms and the rule of law.

4.Conclusion

Promoting the modernization and transformation of the local government debt governance system is a multi-dimensional system project, covering the continuous optimization of institutional frameworks and policy tools, and also involving the coordinated innovation of governance capabilities and technical means. From the perspective of government credit construction, establishing a scientific, standardized and efficient local government debt management mechanism is considered to be the core support for ensuring the steady development of the regional economy, building a solid financial security barrier and improving the government credit ecology. It is necessary to adhere to the dual-wheel drive of institutional innovation and governance capacity improvement, continuously improve the new governance model that fits the actual national conditions, and promote the modernization of the local government debt governance system to achieve a qualitative leap.

Funding

no

Conflict of Interests

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

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The Impact of Regional Digital Trade Rules on Global Value Chains

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Abstract: Based on bilateral trade data from 62 exporting and importing countries (regions) between 2007 and 2021, this study employs the ADB database to measure the global value chain (GVC) participation of exporting countries (regions) and the TAPED database to calculate the depth index of digital trade rules. It explores the mechanisms through which regional digital trade rules influence GVC participation. The findings are as follows: First, digital trade rules in regional trade agreements (RTA) significantly enhance the GVC participation of exporting countries (regions). Second, heterogeneity analysis reveals two key insights: (1) From the perspective of different types of digital trade rules, the depth indices of e-commerce clauses, data flow clauses, new data clauses, cross-cutting issues clauses, and digital intellectual property clauses all promote GVC participation among signatory countries (regions), with new data clauses having the most pronounced effect. (2) From the perspective of heterogeneity in country-pair types among RTA signatories, deeper digital trade rules in RTAs between developing-developing country pairs and developed-developed country pairs positively promote GVC participation of exporting countries (regions). Therefore, exploring the impact of regional digital trade rules on global value chain (GVC) participation holds significant theoretical and practical importance for China in formulating digital trade policies and enhancing its position within the global value chain.

Keywords: Regional Trade Agreements; Digital Trade Rules; GVC Participation

Published: Apr 15, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.215>

1.Introduction

The rapid advancement of digital technologies is reshaping the global economic landscape. As an emerging form of trade, digital trade has become a crucial engine driving global economic growth. Against this backdrop, digital trade rules within Regional Trade Agreements (hereinafter referred to as “RTAs”) have emerged and gradually become essential tools for countries to formulate digital trade policies and participate in global digital governance. By the end of 2024, the number of RTAs in force globally has reached 374, with their digital trade rules covering various domains such as e-commerce, data-specific provisions, new data economy issues, cross-cutting issues between e-commerce and data-specific regulations, and intellectual property rights. Global Value Chains (GVC), as the primary form of international division of labor, directly influence a country’s income distribution and industrial competitiveness in international trade.

In recent years, regional digital trade rules have witnessed vigorous development. From the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) to the Regional Comprehensive Economic Partnership (RCEP) and the

Digital Economy Partnership Agreement (DEPA), the content of digital trade rules has been continuously deepening, while their scope of coverage has been expanding. These rules not only address traditional issues such as cross-border data flows, electronic signatures, and consumer protection but also encompass emerging areas like artificial intelligence and digital currencies. This evolution has provided institutional safeguards for the healthy development of digital trade.

GVC participation serves as a critical indicator of a country's depth and breadth of involvement in international division of labor. With the widespread adoption and application of digital technologies, GVC is undergoing a digital transformation, wherein digital trade has become a pivotal link connecting various segments of global value chains. Digital trade rules exert a profound influence on GVC participation through several mechanisms, including the reduction of transaction costs and digital trade barriers, enhancement of transaction efficiency, and facilitation of knowledge and technology spillovers.

2. Research Design

2.1 Model Design

Based on the basic specification of the trade gravity model, this paper selects control variables by drawing on the approaches of Donglin Li and Chunding Li (2024), as well as Yuhong Sun (2022). To examine the impact of digital trade rules on global value - chain participation, the following econometric model is specified in this paper:

$$\text{Lngvc}_{ijt} = \beta_0 + \beta_1 \text{Index_total}_{ijt} + \beta_2 \text{Lngdp}_{ijt} + \beta_3 \text{Ec_fr}_{ijt} + \beta_4 \text{Dist_w}_{ijt} + \beta_5 \text{Pgdp}_{ijt} + \beta_6 \text{Free}_{ijt} + \beta_7 \text{Gdpsim}_{ijt} + \lambda_{ij} + \lambda_{it} + \lambda_{jt} + \varepsilon_{ijt}$$

Among them, i , j , and t represent the exporting country (region), importing country (region), and time respectively. Lngvc_{ijt} is the explained variable, representing the global value chain participation index; Index_total_{ijt} is the explanatory variable, used to measure the depth index of RTA digital trade rules; Lngdp_{ijt} , Ec_fr_{ijt} , Dist_w_{ijt} , Pgdp_{ijt} , Free_{ijt} , Gdpsim_{ijt} are a series of control variables, representing the differences in economic scale, economic freedom, geographical distance, factor endowment, trade openness, and economic similarity between the exporting country (region) and the importing country (region) in period t respectively. The data sources are the WDI database, The Heritage Foundation, the CEPII database, the CEPII database, the WDI database, and the WDI database respectively; λ_{ij} , λ_{it} , λ_{jt} are fixed effects, including country - pair fixed effects and country - time fixed effects; ε_{ijt} is the random disturbance term.

2.2 Data Sources

2.2.1 Explained variable (Lngvc)

The global value chain participation index calculated by the method of Borin and Mancini (2019) and based on the ADB database is selected, and a logarithmic transformation is performed. The explained variable in this paper is the sum of the forward participation and backward participation decomposed from the bilateral export volume of 62 countries (regions) globally from 2007 to 2021, that is, the total global value chain participation. It is sourced from the Asian Development Bank (ADB) database.

2.2.2 Explanatory variable (Index_total)

The explanatory variable in this paper is the depth index of digital trade rules calculated based on the RTAs signed by countries (regions) around the world from 2007 to 2021. The data is sourced from the TAPED database. The measurement method draws on the approach of Jiang Gao and Bin Sheng (2018), which standardizes the depth of each clause in regional trade agreements to analyze the position of the integration degree of the digital trade rule depth of the agreement in the overall sample.

Table 1 Descriptive Statistics

Variable	Meaning	Obs	Mean	Std. Dev.	Min	Max
Lngvc	global value chain participation index	56730	4.535	2.811	0	12.037
Index_total	the depth index of RTA digital trade rules	56730	0.131	0.229	0	1
Lngdp	economic scale	55278	2.287	1.685	0	9.401
Ec_fr	economic freedom	56730	15.245	17.121	0	90.2
Dist_w	geographical distance	56730	6110.166	4293.834	55	18312
Pgdp	factor endowment	55278	28.72	28.178	0.002	193.414
Free	trade openness	55278	14.092	43.955	0	524.706
Gdpsim	economic similarity	55278	0.118	0.087	0	0.25

According to the descriptive statistics of each variable in Table 1, it can be seen that there are a total of 56,730 observations for the core variables in the sample data. The average value of the global value chain participation (Lngvc) is 4.535, and the standard deviation is 2.811. There is a certain degree of difference in the global value chain participation of various countries. Moreover, the minimum value is 0 and the maximum value is 12.037, indicating that in the research sample, the global value chain participation of some countries (regions) is relatively high. The average value of the digital trade rule depth index (Index_total) is 0.131, and the standard deviation is 0.229. Among the RTAs signed by countries (regions), the emphasis on digital trade rules varies. The maximum value of the digital trade rule depth index is 1, while the average value is 0.131, indicating that the depth of most RTA digital trade rules still remains at a relatively low level.

3. Empirical Test

3.1 Baseline Regression

Table 2 presents the regression results of the depth index of digital trade rules on the global value chain participation. From the regression results, it can be seen that at the 1% significance level, the coefficient of the depth index of digital trade rules is 0.1454. The depth index of digital trade rules can significantly affect the global value chain participation of the signatory countries (regions) and has a positive promoting effect. The main reason for this is that the digital trade rules in RTAs can effectively reduce transaction costs, simplify the trading process, and lower trade barriers. As a result, they promote more frequent trade exchanges among countries (regions) and enhance their own global value chain participation.

Table 2 Results of the Baseline Regression

VARIABLES	(1)	(2)
	lngvc	lngvc
Index_total	0.1454*** (0.0280)	0.1347*** (0.0281)
Lngdp		-0.2602*** (0.0217)
Economic_freedom		0.0001 (0.0007)
Dist_w		0.0013*** (0.0005)
Pgdp		-0.0018*** (0.0006)
Free		-0.0000 (0.0002)
Gdpsim		-2.6360*** (0.3064)
Constant	4.5161*** (0.0040)	-2.1318 (2.8705)
Observations	55,278	55,278
Adjusted R-squared	0.979	0.979
ij FE	YES	YES
it FE	YES	YES
jt FE	YES	YES

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

The same applies to the following tables.

3.2 Robustness Test

According to the results of the baseline regression, it can be preliminarily determined that the depth of digital trade rules

has a promoting effect on global value chain participation. To ensure the robustness of the results, this paper will conduct robustness tests from three aspects: replacing the explanatory variables, dividing the research sample period, and performing endogeneity tests.

3.2.1 Replace the explanatory variables

The scoring method for digital trade rules remains the same as before, but the calculation method for the digital trade rule depth index has changed. The depth (di) represents the degree of legal protection that the digital trade rules covered by the RTA receive during the implementation process (Hofmann et al., 2017). This paper draws on the method of Yu Peng et al. (2021) and constructs the total RTA digital trade rule depth index by using the ratio of the total score of digital trade provisions in RTAs signed by a country to the number of provisions. The specific calculation formula is as follows:

$$di_{it} = \text{depth}_{it} / n_{it}$$

According to the regression results of the robustness test in Table 3, the depth index of digital trade rules can still promote the participation of the signatory countries (regions) in the global value chain. Meanwhile, it indirectly indicates that changing the measurement method of the digital trade rule depth index has not altered the conclusion of the baseline regression, reflecting the robustness of the regression results.

Table 3 Robustness Test I

VARIABLES	(1)	(2)
	lnlgvc	lnlgvc
Di_total	0.1768*** (0.0352)	0.1592*** (0.0354)
Lngdp		-0.2597*** (0.0217)
Economic_freedom		0.0001 (0.0007)
Distw		0.0013*** (0.0005)
Pgdp		-0.0018*** (0.0006)
Free		-0.0000 (0.0002)
Gdpsim		-2.6295*** (0.3065)
Constant	4.5166*** (0.0041)	-2.2179 (2.8698)
Observations	56,730	55,278
Adjusted R-squared	0.979	0.979
ij FE	YES	YES
it FE	YES	YES
jt FE	YES	YES

3.2.2 Divide the research sample interval

After countries (regions) sign RTAs, there is an obvious time - lag in the effectiveness. That is, the signed RTAs cannot have an effective impact on the local trade in the year of entry into force, and the obvious effects can only be seen in subsequent

years. To improve the utilization rate of the research sample, this paper draws on the method of Lin Xi et al. (2018) and divides the research interval with a two - year gap. That is, the research years are 2007, 2009, 2011, 2013, 2015, 2017, 2019, and 2021. The data for the above years are re - regressed, and the regression results are shown in Table 4.

As can be seen from Table 4, this testing method also produces results similar to those of the baseline regression. Moreover, when dividing the research sample interval, the magnitude of the regression coefficient of the explanatory variable even increases. This indicates that the way of dividing the research sample interval can also reflect the promoting effect of the digital trade rule depth index on the global value chain participation of the signatory countries (regions), which proves the robustness of the baseline regression results.

Table 4 Robustness Test II

VARIABLES	(1)	(2)
	lngvc	lngvc
Index_total	0.1849*** (0.0375)	0.1682*** (0.0378)
Lngdp		-0.2703*** (0.0295)
Economic_freedom		0.0001 (0.0009)
Dist_w		0.0010 (0.0007)
Pgdp		-0.0017** (0.0009)
Free		0.0002 (0.0003)
Gdpsim		-2.8353*** (0.4129)
Constant	4.5213*** (0.0054)	-0.7435 (4.5070)
Observations	30,256	29,532
Adjusted R-squared	0.978	0.978
ij FE	YES	YES
it FE	YES	YES
jt FE	YES	YES

3.2.3 Endogeneity test

Although the use of joint fixed effects of economies and economy-year fixed effects in the previous text can address the endogeneity problem to a certain extent, there still exists the issue of reverse causality in the study of the impact of the depth of digital trade rules on global value chain participation. This paper will solve the endogeneity problem from the following two aspects.

First, in order to deal with the reverse causality, this paper follows the approach of Xi Lin and Xiaohua Bao (2018). It removes the depth index of digital trade rules in bilateral RTAs while retaining the depth index of digital trade rules in multilateral RTAs, and then conducts a re-regression after merging the data. The reason for this is that the data on global value chain participation decomposed from bilateral trade will affect bilateral RTAs, but has a relatively small impact on

multilateral RTAs. The results of the re-regression are shown in Table 5. After removing the depth index of digital trade rules in bilateral RTAs, the original regression results have not undergone any substantial changes. Moreover, compared with the coefficient of the digital trade rule depth index in Table 2, this regression coefficient is larger, indicating that the depth of digital trade rules in multilateral RTAs has a more significant impact on global value chain participation.

Table 5 Endogeneity Test I

VARIABLES	(1)	(2)
	lngvc	lngvc
Index_total	0.3256*** (0.0466)	0.3085*** (0.0466)
Lngdp		-0.3474*** (0.0549)
Economic_freedom		-0.0022 (0.0014)
Dist_w		0.0006 (0.0010)
Pgdp		-0.0025** (0.0011)
Free		-0.0014 (0.0018)
Gdpsim		-3.9710*** (0.7316)
Constant	5.6358*** (0.0159)	4.7106 (3.4345)
Observations	21,690	21,482
Adjusted R-squared	0.977	0.978
ij FE	YES	YES
it FE	YES	YES
jt FE	YES	YES

Second, introduce instrumental variables to alleviate the endogeneity problem. Referring to the widely recognized approach in the academic community, this paper takes the average value of the depth indices of digital trade rules among all pairs of countries other than a specific country as the instrumental variable. The specific calculation formula is as follows:

$$\text{Index_total}_{ijt}^{\text{iv}} = \sum_{k \neq i} \text{index_total}_{kjt} / N_{kjt}$$

$\text{Index_total}_{ijt}^{\text{iv}}$ refers to the instrumental variable,

$\sum_{k \neq i} \text{index_total}_{kjt}$ represents the sum of the depth indices of digital trade rules for all country pairs other than country i in year t , and N_{kjt} refers to the number of pairs of all other countries except country i in the same year. The results of the two-stage regression using the instrumental variable method are shown in Table 6. According to the regression results of the first stage,

it can be seen that the correlation between the selected instrumental variable and the core explanatory variable is significant. The regression results of the second stage are significantly positive at the 1% statistical level, which is consistent with the results of the baseline regression, proving the robustness of the results.

Table 6 Endogeneity Test II

VARIABLES	The first stage	The second stage
	index_total	lngvc
index_total		4.3960*** (0.2362)
iv	-1,890.0004*** (0.0008)	
lngdp	0.0000 (0.0000)	-0.1533*** (0.0155)
Economic_freedom	-0.0000** (0.0000)	-0.0052*** (0.0007)
Dist_w	0.0000*** (0.0000)	0.0000 (0.0000)
pgdp	0.0000 (0.0000)	0.0011** (0.0004)
free	0.0000 (0.0000)	-0.0143*** (0.0004)
gdpsim	-0.0000** (0.0000)	3.5334*** (0.3114)
Constant	246.8875*** (0.0001)	4.1739*** (0.1150)
Observations	55,278	55,278
Adjusted R-squared	1.000	0.212
ij FE	YES	YES
it FE	YES	YES
jt FE	YES	YES

4. Conclusion and Implications

This paper is based on the bilateral trade data of 62 exporting countries (regions) and importing countries (regions) from 2007 to 2021. It measures the global value chain participation of exporting countries (regions) using the ADB database, calculates the depth index of digital trade rules through the TAPED database, explores the mechanism of interaction between regional digital trade rules and global value chain participation, and conducts robustness tests, endogeneity tests and index replacements. The research conclusions are as follows: First, the digital trade rules in regional trade agreements can significantly promote the improvement of the global value chain participation of exporting countries (regions). Second, from the perspective of heterogeneity, it can be divided into two categories: (1) from the perspective of different types of digital

trade rules, the depth indices of five types of digital trade rules, namely e-commerce provisions, data flow provisions, new data provisions, cross-cutting issue provisions and digital intellectual property provisions, can all promote the global value chain participation of signatory countries (regions) at the 1% significance level. Among them, the new data provisions have the most obvious promoting effect. (2) from the perspective of the heterogeneity of the types of country pairs among RTA signatory countries (regions), for the types of country pairs between developing countries-developing countries and developed countries-developed countries, the deeper the digital trade rules involved in the RTAs they sign, the more it can promote the global value chain participation of exporting countries (regions). However, the digital trade rules in RTAs signed by the type of country pairs between developed countries and developing countries have a negative impact on the global value chain participation of exporting countries (regions).

At present, the international situation is complex and trade exchanges among countries are frequent. Promoting the construction of a digital trade rule system has become the core content of the new international trade rules. As the second largest economy in the world, China occupies an important position in global digital trade. In the process of moving towards a powerful digital trade country, under the multilateral and regional frameworks such as the WTO, RCEP and CPTPP, China should actively participate in digital trade rule negotiations, enhance its international discourse power in digital governance, and promote the construction of an open, inclusive and inclusive digital trade rule system. In the process of formulating digital trade rules, fully consider the interests and demands of developing countries. Under multilateral frameworks such as the United Nations and the G20, promote the establishment of digital cooperation platforms, and facilitate exchanges and cooperation among countries in the fields of digital technology and digital trade, so as to promote the construction of a more fair and reasonable international digital trade order.

Funding

no

Conflict of Interests

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

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Green Transformation in Agricultural Supply Chains: A Case Study of Jinhuai Q Enterprises' Transition Towards Carbon Neutrality

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Abstract: This paper examines the current state of supply chain operations at Jinhuai Q Enterprises, a leading company in the Jinhuai industry, and explores its transition towards a green, carbon-neutral supply chain. Given the growing importance of addressing climate change and the need for sustainable agricultural practices, this study investigates how Jinhuai Q Enterprises is adapting to the challenges of integrating green logistics and carbon neutrality in its supply chain. By conducting a detailed survey of the company's upstream, midstream, and downstream supply chain segments, we identify critical issues such as fragmented planting distribution, low mechanization in processing, and the need for better sustainability in downstream sales channels. Furthermore, we propose strategic recommendations to enhance supply chain management, including the implementation of a carbon-neutral supply chain, improvements in deep processing technology, and optimizing collaboration across different sectors. This study provides valuable insights for both Jinhuai Q Enterprises and other agricultural businesses aiming to achieve sustainable growth and contribute to national carbon neutrality goals.

Keywords: Agricultural Supply Chain; Green Transformation; Agricultural Logistics; Sustainability; Supply Chain Optimization

Published: Apr 15, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.229>

1. Introduction

With the escalating severity of global climate change and environmental challenges, the green transformation and sustainable development of the agricultural industry have become urgent global priorities (Zhu et al., 2023). In China, the introduction of the "dual carbon goals" policy has made it imperative to focus on achieving carbon neutrality across various sectors, including agricultural supply chains (Zhuang & Wang, 2023). As a key component of agricultural supply chains, agricultural logistics plays a critical role in the efficient allocation and circulation of resources (He et al., 2023). Its importance is growing, particularly in driving the green transformation of agriculture and achieving carbon neutrality targets (Qi et al., 2023).

In the context of specialized sectors like the Jinhuai industry, agricultural logistics management faces numerous challenges, including upstream and downstream supply chain coordination, product quality control, and green development (Shao & Hu, 2021; Li & Ouyang, 2024). Specifically, Jinhuai Q Enterprises, as a leading representative in China's Jinhuai industry, has established a relatively complete industrial chain across upstream planting, processing, and downstream consumption (Zhang, 2024). However, the company faces several challenges in its development. For example, the distribution of Jinhuai planting is fragmented, mechanical processing technology is underdeveloped, and the sustainability of its supply chain is lacking (Ni et

al., 2024). These issues significantly impact the company's competitiveness in both domestic and international markets (Jiang, 2024). The root causes of these problems are often closely tied to the traditional agricultural supply chain management model, especially in areas such as the digitalization of agricultural logistics, supply chain coordination, and technological innovation (Wang et al., 2024; Li, 2024).

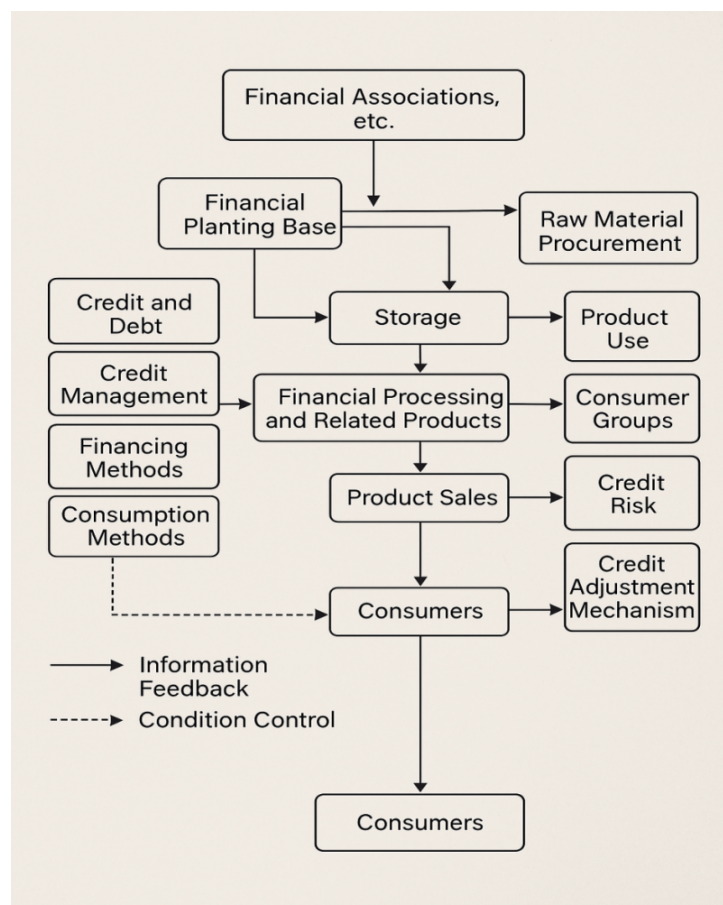
Therefore, this paper aims to provide an in-depth analysis of the operational status of Jinhuai Q Enterprises' supply chain, exploring pathways for promoting green logistics, carbon-neutral supply chains, and product quality improvements (Guo & Yao, 2023). By conducting a detailed survey of the Jinhuai industry supply chain, the paper proposes strategies to strengthen supply chain management, enhance deep processing capabilities, and optimize collaboration across supply chain segments (Zhang & Wen, 2023). Furthermore, through the integration of digital transformation and strategic alignment with carbon neutrality goals, this paper offers practical solutions that not only have significant implications for Jinhuai Q Enterprises' sustainable development but also provide valuable insights and recommendations for the green transformation of other agricultural enterprises' supply chains (Zhao, 2012; Jiang, 2024).

2. Research on the current status of enterprise supply chain

2.1 Survey of Supply Chain Operations of Jinhuai Q Enterprises

Based on a comprehensive survey of Jinhuai Q Enterprises, the current operational status of the company's supply chain has been assessed. The company's goal is to create new markets, new formats, and new energy sources. In the upstream segment of the supply chain, most of the production is managed internally by the company. Currently, the company benefits from a relatively abundant supply of raw materials, with six "Jinhuai" planting demonstration bases and 40,000 acres of high-quality "Jinhuai" cultivation land. With an estimated yield of approximately 157 kg per acre, the annual production of locust seed is about 6,280 tons. This has facilitated the development of a relatively complete product system downstream, including products such as pharmaceuticals, tea, traditional Chinese medicine, health supplements, and cosmetics, all of which are directed at consumers.

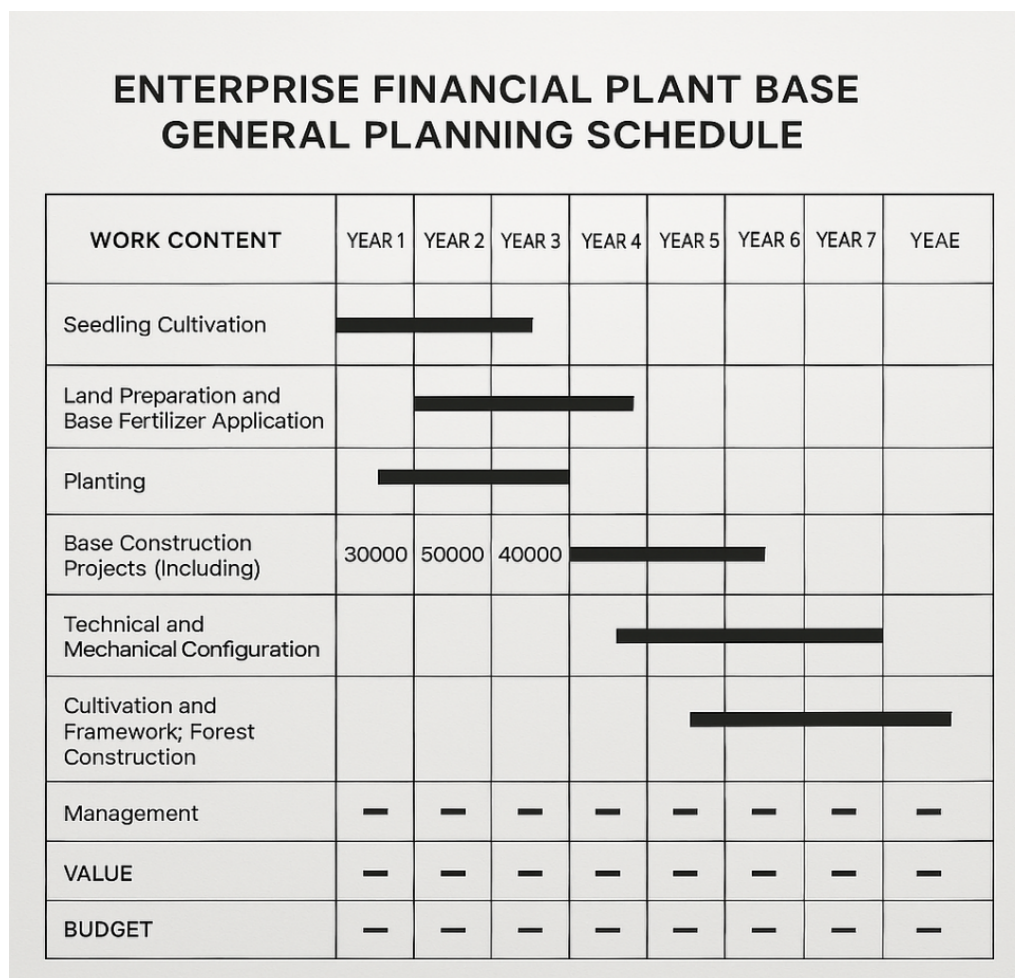
Fig. 1. Supply Chain Operation Diagram of Jinhuai Q Enterprises



(1) Upstream Supply Chain: Jinhuai Planting

According to the “Jinhuai Planting Base Construction Master Plan,” Jinhuai Q Company has established six “Jinhuai” planting demonstration bases. Additionally, three towns have developed approximately 40,000 acres of high-quality locust seed production bases, yielding around 6,280 tons of locust seed annually. The average yield can reach up to 157 kg per acre, indicating a relatively stable and sufficient supply of locust raw materials.

Fig. 2. Progress Arrangement of the Overall Planning for the Construction of Acacia Planting Bases of Jinhuai Q Enterprises



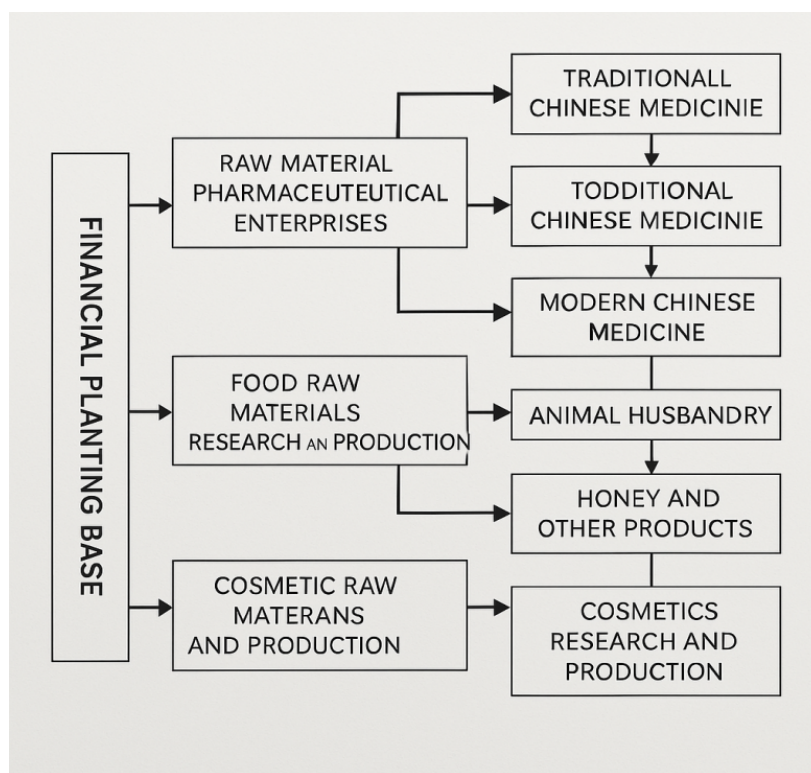
(2) Midstream Supply Chain: Jinhuai Processing

According to the survey, the company has multiple industrial chains for the deep processing of Jinhuai locust (as shown in Fig. 3) and has mastered advanced techniques for the deep processing of locust seeds. With an annual production of 6,280 tons, it is projected that the value of the deep-processed locust seeds will reach approximately 37.68 million RMB annually. Currently, Jinhuai Q Enterprises operates several deep-processing industry chains and has mastered a range of advanced processing techniques, including rutin extraction and locust seed processing.

One of its core technologies—the molecular transformation method for producing high-purity rutin—is a domestic first and has been awarded a national invention patent. This method leverages the molecular characteristics of flavonoid glycosides, which consist of 2-phenylchromone with a planar structure, small intermolecular spacing, and strong attractive forces. The application of molecular transformation enables the production of rutin with a purity exceeding 99%, fully meeting the requirements for export. Compared to traditional methods, this technique improves the yield by 10%.

All products manufactured by the company conform to the German Pharmacopoeia, currently considered one of the most rigorous pharmaceutical references globally. In terms of quality, these products surpass those of similar Japanese imports and offer a significant cost-performance advantage. Consequently, Jinhuai Q Enterprises has broken China’s historical reliance on imported rutin and disrupted Japan’s dominance in refined rutin products.

Fig. 3. Deep Processing Industry Chain of Jinhuai Q Enterprises



(3) Downstream Supply Chain: Jinhuai Consumption

At present, the downstream segment of Jinhuai Q Enterprises has developed into a relatively complete industrial chain. The extracted rutin is used in pharmaceutical development and production and is further processed into tea, traditional Chinese medicine, and health products. Additionally, processed locust seeds are used for the development of functional foods and beverages, while refined rutin serves as a key ingredient in the production and R&D of cosmetics.

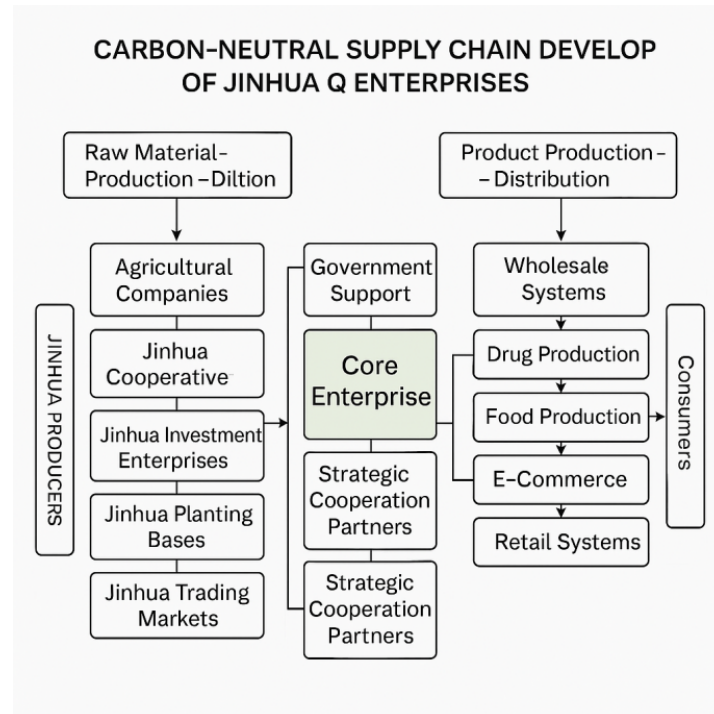
The company has developed more than 20 types of Jinhuai-based products, which have significantly stimulated the growth of the broader Jinhuai industry in the region, forming a solid foundation for integrated industrial development.

2.2 Carbon-Neutral Supply Chain Development of Jinhuai Q Enterprises

Global climate change is one of the major issues humanity faces in the 21st century. Its impact not only affects the living environment of humans but also has significant consequences on the global economy and geopolitics. In 2023, global carbon dioxide emissions from energy production reached 3.74 billion tons, setting a historical record. With the worsening climate and environmental challenges, there is an urgent need to implement proactive measures to achieve “net-zero emissions.” On September 22, 2020, President Xi Jinping presented China’s “dual carbon goals” for 2030 and 2060 at the 75th United Nations General Assembly, marking a major step toward global efforts to address climate change and accelerating the pace of global emission reduction.

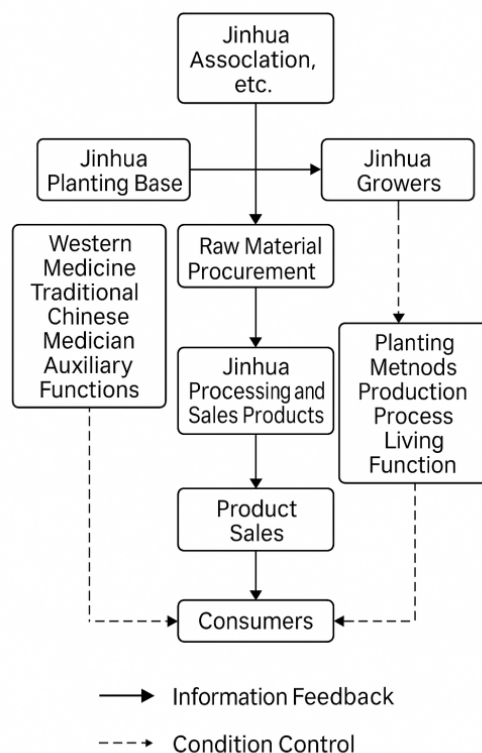
In the process of formulating the “carbon-neutral” strategy, reinforcing the green and carbon-neutral supply chains of enterprises is a critical component. Currently, Jinhuai Q Enterprises is progressing towards the development of a “carbon-neutral supply chain.” The aim is to establish a unique carbon sink economic model, promote industrial transformation towards low-carbon, green, and environmentally-friendly practices, and adapt to the trends of “low-carbon” and “zero-carbon” development. By focusing on “soft technologies” such as locust tree planting, energy conservation, emission reduction, and strengthening the carbon-neutral supply chain system, Jinhuai Q Enterprises is responding to the demands of the current era, seizing opportunities, and contributing to the realization of the “dual carbon goals.” The company is establishing a comprehensive carbon-neutral supply chain system, making significant contributions to China’s sustainable development and the construction of a global community with a shared future for humanity.

Fig. 4. Schematic Diagram of the Development of the Carbon-Neutral Supply Chain of Jinhua Q Enterprises



The construction of a carbon-neutral supply chain requires smooth material and information flows, supported by robust infrastructure and modern logistics systems. It represents a more efficient, agile supply chain that can quickly respond to market and user demand changes within a dynamic market environment, involving multiple suppliers and customers. Through scientific management practices, the carbon-neutral supply chain requires high quality in every stage of the manufacturing process, establishing strong cooperative relationships with suppliers, and accurately forecasting the needs of end-users to achieve Just-In-Time (JIT) production. Compared to traditional production and material management, this system enhances operational efficiency, streamlines business practices, and results in substantial cost savings for the company.

Fig. 5. Schematic Diagram of the Supply Chain Development Model of Jinhua Q Enterprises

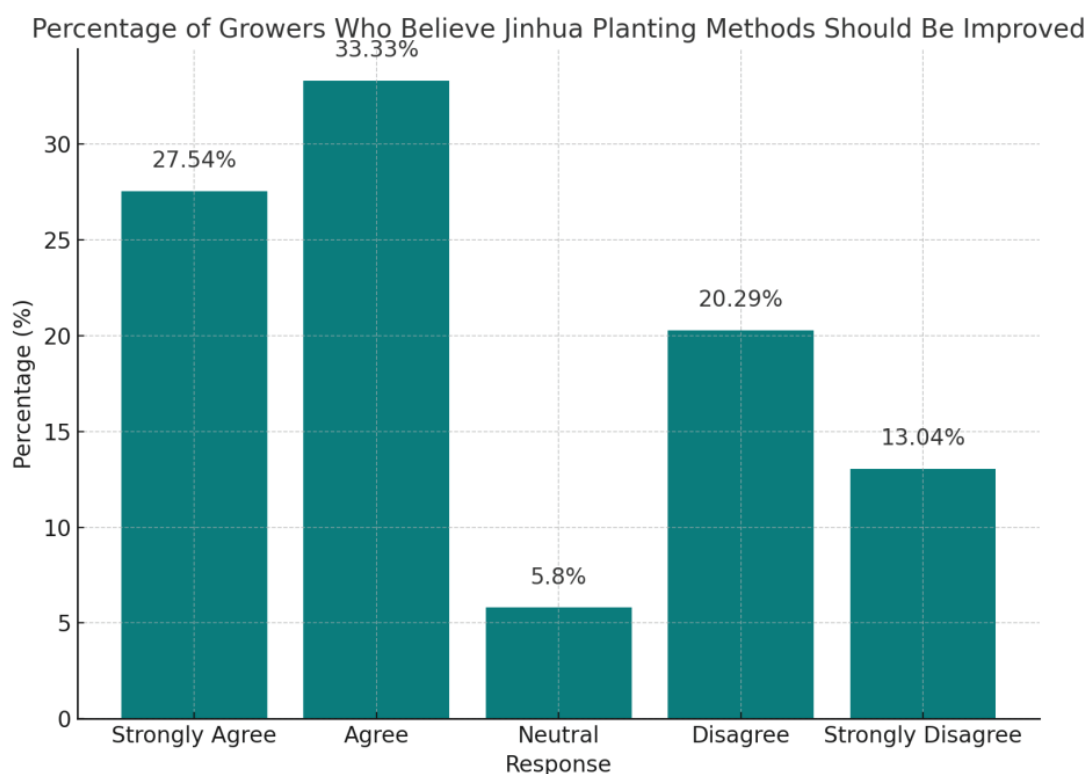


3. Issues in Jinhuai Q Enterprises' Supply Chain

3.1 Upstream Supply Chain – Characteristics of Small, Scattered, and Disorganized Planting Distribution

The planting distribution of Jinhuai is characterized by being “small,” “scattered,” and “disorganized,” leading to significant market influence on small-scale farmers and instability in supply. We distributed questionnaires to growers, processing enterprises, consumers, and product sales consumers. By combining the survey results with the characteristics of Jinhuai planting distribution, we concluded that the “Jinhuai growers” in the supply chain need to accelerate the transition to large-scale and intensive planting methods. More than 60% of the growers believe that there should be a shift towards large-scale and intensive cultivation. Currently, scattered planting operations are highly susceptible to market fluctuations, resulting in instability in supply.

Fig. 6. Percentage of Growers Who Think that Jinhuai Planting Should Be Improved in Terms of Planting Methods



3.2 Midstream Supply Chain – Low Technological Content in Jinhuai Processing Equipment

Jinhuai Q Enterprises possesses a full range of tea processing equipment (such as rolling machines, dryers, screening machines, and air classifiers), but most of these are single-machine operations requiring manual supervision. The level of electromechanical integration is low, leading to inefficient production processes. While some automation has been introduced in the initial processing stages, many processes, especially drying and grinding in the pulp production process, are still manually operated. As a result, the overall mechanization of Jinhuai's initial processing is low. This slow pace of mechanization in initial processing has hindered the company's development.

3.3 Downstream Supply Chain – Weak Sustainability, Limited Sales Channels, and Insufficient Promotion Efforts

Currently, Jinhuai Q Enterprises has established both online and offline sales channels for its Jinhuai tea, but both remain at a small scale. The offline stores are limited to the county, which hinders consumer awareness and product experience. Our in-depth interviews with company leaders revealed that the downstream supply chain lacks sustainability, with limited sales channels and insufficient promotional efforts. Despite previous attempts to expand sales to other regions and through micro-commerce, results were underwhelming. For example, online marketing efforts through WeChat were discontinued due to low effectiveness, and the company also struggled with low profit margins when attempting to cooperate with tourism companies and restaurants.

4. In-depth micro-analysis of Samuel Kim Q Enterprises

4.1 Micro Analysis 1----Inadequate Training for Supply Chain Management Personnel at Jinhuai Q Enterprises

Table 1 Changes in purchasing staff at Gold Samuel Q.

Date	2019	2020	2021	2022	2023
Number of purchases	8	10	12	10	10
Number of new entrants	4	3	4	2	2
Number of withdrawals	2	1	6	2	3

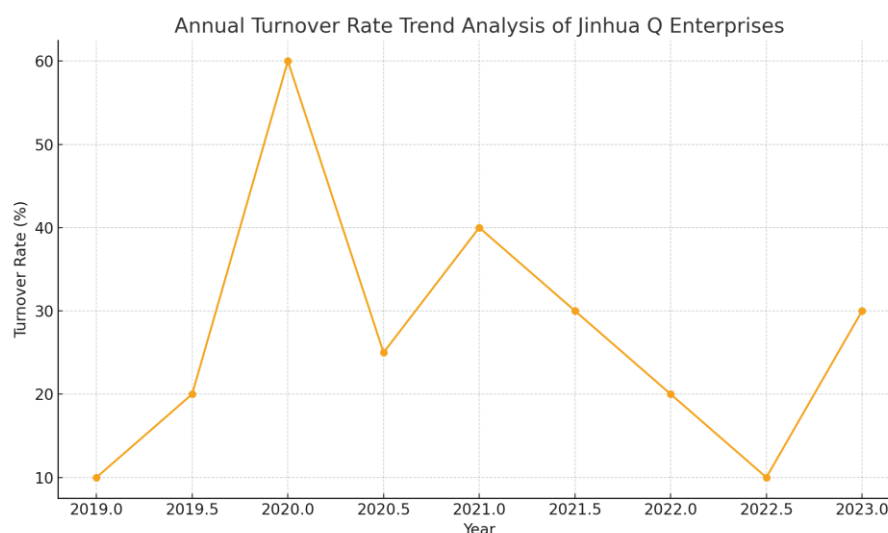


Fig. 7 Trend analysis of annual turnover rate changes in Samuel Gold Q enterprises

Year	Project	1st quarter	2nd quarter	3rd quarter	4th quarter
2022	Inventory amount	20	21	22.7	19.2
2023	Inventory Amount	18.2	19.4	20	17.3
2022	Inventory Turnover Days	42.2	50	48.3	47
2023	Inventory Turnover Days	47	45.9	44.2	49.2

As shown in Table 1 and Fig. 7, the personnel changes in the purchasing department of Jinhuai Q Enterprises are significant. The rapid expansion of the company's business has led to an increasing demand for purchasing talent. New employees, lacking systematic training, are often pressured to handle responsibilities without adequate preparation, which causes many to leave the company, particularly when they cannot cope with the fast-paced development of the company. In many cases, these new recruits leave within a year. In 2021, the turnover rate reached 60%, which is notably higher than the normal range of 10-15%. This situation is indicative of management issues within the company, leading to low job satisfaction among purchasing staff. Furthermore, the cost of turnover is low, and employees tend to leave Jinhuai Q Enterprises more quickly compared to other companies. The impact of the COVID-19 pandemic also contributed to this situation.

4.2 Micro Analysis 2----Inventory Issues at Jinhuai Q Enterprises

Table 2 Company's inventory amount and inventory turnover days

Unit: Millions of RMB

Based on a review of relevant data from the Chinese MBA business management database, inventory management in procurement can be classified as successful or unsuccessful in three main aspects:

1. Inventory Value = Inventory Volume \times Unit Price

2. Raw Material Turnover Days = $[(\text{Current raw material inventory} - \text{Previous period's inventory}) / \text{Current total raw material inventory}] \times 30$ days

3. Excess Inventory = Quantity of inventory that has not been used for over 60 days \times Unit Price of raw material

After reviewing the 2023 Chinese Enterprise Accounting Standards and related accounting subjects, it was found that Jinhuai Q Enterprises has a higher inventory amount compared to its industry peers. Typically, the inventory value for similar companies is around 10 million RMB, with a turnover rate of around 30 days. In contrast, Jinhuai Q's inventory amount ranges between 180,000 and 220,000 RMB, with turnover days ranging from 42 to 50 days. This indicates that Jinhuai Q Enterprises is experiencing significant inventory management issues.

I have identified several issues with Jinhuai Q Enterprises' inventory management. The company faces problems such as high inventory volume and long inventory turnover cycles. These issues lead to a series of challenges, primarily including: large land area usage, impact on cash flow, and increased handling costs. The main reasons for Jinhuai Q Enterprises' large inventory volume include: The reasons for Jinhuai Q's large inventory and extended turnover period are as follows:

(1) Lack of Procurement Strategy in SCM: Purchases are made based on production volume, and inventory is replenished periodically until exceeding critical thresholds.

(2) Imbalance in Supply and Demand: The company's procurement strategy is rigid, and there is no market research conducted to analyze product sales, resulting in inaccurate forecasts of market demand.

(3) Absence of Effective Inventory Strategy and Management: The purchasing department has not categorized products and materials, leading to unorganized inventory management.

4.3 Micro Analysis 3 – Supplier Management Issues at Jinhuai Q Enterprises

(1) Lack of a Rational Supplier Evaluation System

Jinhuai Q Enterprises holds the purchasing rights for suppliers but tends to prioritize cost control, with the primary consideration being the unit price of suppliers. As a result, the company may cooperate with suppliers offering low prices but unable to ensure high-quality products. This can lead to significant losses for the company, highlighting the scientific shortcomings in Jinhuai Q's supplier selection process.

(2) Lack of Strategic Cooperation with Key Suppliers

Currently, the relationship between Jinhuai Q and most suppliers is transactional, and cooperation with large agricultural production bases is limited. The company has not yet developed long-term strategic cooperation with suppliers, which hinders the establishment of a stable and mutually beneficial partnership. Procurement is a vital part of the overall supply chain, and the management of suppliers should shift from being solely based on negotiations to strategic cooperation.

(3) Limited Information Sharing

Jinhuai Q Enterprises does not provide transparent announcements regarding the procurement of key agricultural products on its website. Occasionally, procurement plans are made casually in an effort to save costs, leading to short-term product shortages, especially for key raw materials. This has resulted in financial losses and frustration within the company, damaging mutual trust and preventing long-term cooperation.

(4) Excessive Number of Suppliers

To reduce costs, Jinhuai Q Enterprises tends to partner with multiple suppliers, which can lead to significant losses if a supplier fails to deliver sufficient raw materials due to factors like delayed payments or natural disasters. It is recommended that the company select only two or three strategic suppliers based on its specific needs.

5. Countermeasures and Suggestions for Supply Chain Optimization

5.1 Evolutionary Game Analysis of Growers, Purchasers, and Jinhuai Association

(1) Government Promotion Through Policy: The government can use policies to promote long-term cooperation between Jinhuai-related enterprises and factor institutions, extending the industrial chain and weaving a complete supply chain. After reaching a certain scale, these industrial chains should be evaluated by professionals to identify key nodes, which can be developed into an "industrial tree," creating a distinctive and scaled industry.

- (2) Establishment of Jinhuai Industrial Union: By mutual shareholding, signing long-term cooperation agreements, and establishing non-profit coordinating bodies, Jinhuai enterprises can expand their business scope and create value collectively.
- (3) Creation of Innovative Jinhuai Industrial Organizations: Industrial innovation clusters gather talent, knowledge, and technology along the same value chain. Establishing a Jinhuai industrial innovation alliance

5.2 Supply Chain Management Personnel

(1) Management Personnel

Jinhuai Q Enterprises should provide more opportunities for supply chain management personnel to enhance their training and knowledge, including attending academic courses at agricultural universities like Zhongkai University of Agricultural Engineering and engaging in online learning about supply chain management.

(2) Establishing Mechanisms

Implementing a reasonable system of rewards and penalties can effectively motivate employees and reduce incidents in the procurement process, ultimately lowering procurement costs.

(3) Company Culture

It is important to establish a strong corporate culture and a unique corporate style that emphasizes performance evaluation and budget management.

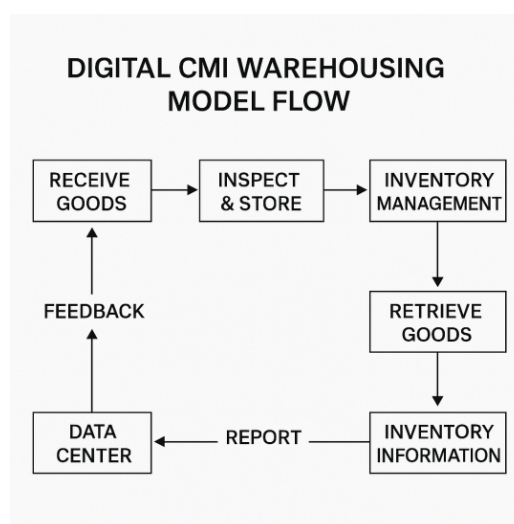
(4) Information Technology

Introducing an information management system will digitize procurement management, greatly reducing information blockages and human error rates during the procurement process.

5.3 Optimization of Inventory Management in the Supply Chain

The introduction of the CMI (Customer Managed Inventory) warehousing model focuses on managing inventory within the customer's internal warehouse, allowing the customer to handle the management independently. This approach ensures that the inventory holder (the customer) can forecast demand and match it with actual needs. Furthermore, based on this model, suppliers can use inventory data provided by the information center to make optimal adjustments to purchased products, reducing discrepancies between procurement volume and production requirements. Jinhuai Q Enterprises also categorizes its inventory into strategic materials, key materials, and leverage materials, applying different management methods to each category. This approach enables more efficient inventory management and ensures better control over material usage. As shown in Figure 8 informational CMI (Customer Managed Inventory) warehousing model flowchart.

Fig. 8. Flowchart of Informative CMI (Customer Managed Inventory) Warehousing Model



5.4 Optimization of Supplier Management in the Supply Chain

(1) Strengthening Cooperation with Suppliers

1. Direct Participation in Supplier Development

Jinhuai Q Enterprises regularly dispatches technical personnel to assist suppliers in solving technical challenges, thereby

improving their product quality. An incentive mechanism is employed to reward outstanding suppliers each season or year.

2.Multi-Channel Information Collection During Supplier Evaluation

To enhance the supplier evaluation process, Jinhuai Q Enterprises has increased the use of surveys and on-site visits to suppliers. This helps to gather more comprehensive and accurate data, reflecting the true condition of suppliers.

(2) Optimizing the Supplier Evaluation and Selection System

1.Supplier Evaluation System Change

Supplier evaluations were previously conducted by individual procurement departments. Now, the procurement department takes the lead, and all production departments are included in the evaluation and review process. Specific steps for supplier evaluation are outlined in Table 3 and Table 4, which illustrate the evaluation criteria and weightings.

2.Refinement and Classification of Suppliers

Jinhuai Q Enterprises has further refined and categorized suppliers, ensuring that evaluations are tailored to the needs of different supplier categories.

3.Optimization of Supplier Evaluation Elements

The elements of supplier evaluations have been optimized to focus primarily on a weighted scoring method, ensuring that evaluations are both fair and objective.

Table 3 Supplier evaluation weights

Item	Weighting
Quality	30%
Price	20%
Delivery on time	15%
Sales Service	15%
Location	10%

Table 4 Classification of suppliers

Classification	Materials supplied
Category A suppliers	Major or critical components required for production
Category B suppliers	Minor components required for production
Category C suppliers	Auxiliary materials for production

6.Conclusion and Outlook

6.1 Conclusion

This study examines the current state of the supply chain operations at Jinhuai Q Enterprises, identifying both opportunities and challenges in the company's path towards sustainable development and carbon neutrality. Through an in-depth analysis of the company's upstream planting, midstream processing, and downstream consumption operations, several critical issues have been highlighted, such as the fragmented distribution of planting bases, low mechanization in processing, and insufficient sustainability in downstream sales channels. Additionally, the company faces challenges in inventory management, supplier coordination, and employee turnover. These challenges significantly impact the efficiency, stability, and sustainability of the supply chain.

In response, several strategies have been proposed, including the promotion of large-scale and intensive planting, the adoption of more advanced processing technologies, the optimization of supplier management, and the development of a carbon-neutral supply chain. These measures aim not only to strengthen Jinhuai Q Enterprises' competitive position but also to align the company with China's "dual carbon" goals and contribute to sustainable agricultural practices. Through improved

supply chain management and technological innovation, Jinhuai Q Enterprises can enhance its operational efficiency, reduce environmental impact, and achieve long-term growth.

6.2 Outlook

Looking ahead, Jinhuai Q Enterprises has a unique opportunity to further strengthen its supply chain by adopting digital technologies and green logistics practices. The integration of advanced information management systems and the optimization of logistics networks will be critical in enhancing real-time inventory tracking, improving demand forecasting, and reducing inefficiencies. Furthermore, greater collaboration with key suppliers, along with the establishment of strategic partnerships, will play a crucial role in ensuring a stable supply of raw materials and fostering innovation.

The company should also continue to focus on product diversification, expanding its range of Jinhuai-based products, and exploring new market segments, particularly in health and wellness industries. By enhancing its market presence and leveraging its strong product offerings, Jinhuai Q Enterprises can better capitalize on the growing consumer demand for sustainable and eco-friendly products.

In the longer term, as global climate policies continue to evolve and consumer preferences shift towards sustainable products, Jinhuai Q Enterprises is well-positioned to become a leader in the green agricultural supply chain sector. However, achieving these goals will require continuous investment in innovation, effective management practices, and proactive engagement with stakeholders across the supply chain.

Funding

This research was supported by the Zhong Kai College of Agricultural Engineering Graduate Student Science and Technology Innovation Fund Grant (KJCX2024031) and General Program of the National Social Science Foundation (21BSH104). The funding institutions had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Conflict of Interests

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

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A Case Study on the Efficiency of Medical Insurance Cost Accounting in Public Hospitals under DRG Policy — Taking XX Hospital as an Example

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Abstract: This study focuses on a tertiary public hospital in XX, employing Data Envelopment Analysis (DEA) and cost accounting methods for specific diseases to systematically evaluate its cost efficiency performance and optimization paths in DRG payment reform. By constructing a dual-dimensional model of “internal time series analysis + external benchmark comparison,” combined with the BCC model and Malmquist index, the study analyzes the dynamic changes in hospital efficiency from 2019 to 2023. The findings are as follows: (1) The overall technical efficiency (TE) of the hospital is 0.82, indicating an efficiency loss of 18%, primarily due to redundant drugs and medical supplies (15.2%) and the case mix index (CMI) gap (5.6%); (2) High-weight DRG diseases (such as interventional treatment for acute myocardial infarction) have a cost overrun of 16.3%, significantly dragging down overall efficiency; (3) Standardizing clinical pathways and collaborating with regional resources can improve efficiency to industry benchmark levels. This case provides a theoretical and operational framework for detailed cost management in individual hospitals.

Keywords: DRG Payment; Data Envelopment Analysis; Disease Cost Accounting; Case Study

Published: Apr 16, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.243>

1. Introduction

1.1 Research background and significance

The DRG (Diagnosis Related Groups) payment method is a way to set fixed reimbursement costs for medical insurance using a unified disease diagnosis classification, which is currently recognized as one of the more advanced methods of medical insurance payment^[1]. It charges per disease, with the health insurance bureau planning out the budget in advance. Any excess cost is borne by the hospital, which, to reduce costs and cut budgets, will prescribe relatively cheaper medications^[12]. The DRG payment method reconstructs the medical expense settlement mechanism through “prepayment + standardized diseases,” compelling public hospitals to shift from “scale expansion” to “cost control”^[7]. However, individual hospitals lack horizontal efficiency benchmarking tools, making it difficult to accurately identify cost loopholes. This study uses XX Hospital as a sample to explore efficiency evaluation and optimization paths applicable to single hospitals, providing micro-empirical support for the implementation of DRG policies^[13].

1.2 Significance of the study

Shifting the pricing power of medical services from providers (hospitals) to payers (health insurance). Since the launch of

DRG pilots in 2019, over 200 cities in our country have been included in the reform scope^[2]. However, public hospitals have long relied on the crude model of “relying on drug sales to fund healthcare” and “paying per service,” which faces two major contradictions under the DRG payment system: first, the pressure to control costs has sharply increased, with hospitals needing to cover all treatment costs within a fixed payment amount; second, the lack of efficiency evaluation tools makes it difficult for managers to quantify the impact of DRG on resource allocation^[16]. Now, with the reform of China’s health insurance policy, ordinary citizens pay different monthly premiums, which are collectively incorporated into the health insurance fund, commonly referred to as the national health insurance pool. Timely payments by ordinary residents also ensure they can access the health insurance fund when facing major illnesses, making each insured resident a beneficiary of the health insurance fund^[3]. From the perspective of ordinary residents, they are both payers and beneficiaries. From the national perspective, how the government can effectively use the funds and maximize the efficiency of the health insurance fund is not just the responsibility of the government. Ensuring adequate benefits for urban and rural residents, reasonable distribution, and efficient allocation are also social responsibilities shared by the National Health Insurance Administration and public hospitals^[4].

2. Research objectives and innovations

2.1 Research Objectives:

To build a cost efficiency evaluation model of DRG for a single hospital;

Put forward an operable efficiency optimization strategy.

The current DRG grouping rules and the implementation of DGR charges pose a significant challenge to China’s healthcare system, which includes all public and private hospitals. The introduction of DGR will alter the profit model of domestic hospitals, inevitably compelling them and their doctors to reduce unnecessary examinations and treatments, maximizing the pooling effect of medical insurance funds and rationalizing medical resources. Initially, the aim was to prevent over-treatment and leverage the economic regulatory role of medical insurance funds^[5]. The government’s medical insurance bureau aggregates all data through information systems, categorizing them by region, category, and disease group under the DRG system. The medical insurance payment standards are based on the cost expenditures of different hospitals within the same pooling area, balancing fairness and efficiency^{[15][17]}. The DGR reform aims to return hospitals to their public welfare nature, ensuring that everyone can afford healthcare. By analyzing the characteristics of different DRG groups and the actual conditions of medical services, the goal is to more accurately reflect the costs and quality of medical services. Expanding universal health coverage is just the beginning, not the end, as once this is achieved, costs still need to be controlled and quality improved. Adjustments to the medical insurance payment ratio are necessary to better align with the latest cost structures of each treatment group^[8]. For high-cost, high-risk disease groups, the medical insurance should appropriately increase the payment ratio. Special attention must be paid to establishing a payment system. Once problems arise, this will have an opposite stimulating effect, leading to many incorrect medical services, ultimately weakening the overall quality of health services. For low-cost, low-risk disease groups, the payment ratio should be moderately reduced. This will ultimately achieve the dual optimization goals of controlling medical costs and optimizing medical resource allocation^[6].

Hospitals that have implemented the DRG payment system primarily use the average medical cost of cases to set up the DRG payment system, without paying more attention to the actual medical resources consumed during the treatment process^[9]. This approach lacks a corresponding cost budget and cannot effectively control resource consumption. For example, within the same case group, individual differences among patients lead to variations in the medical resources used^{[10][18]}. If the average cost under the DRG payment model is blindly adopted as the standard for cost accounting, it may result in unnecessary losses of medical resources^[19].

2.2 Innovation points:

Integrating DEA efficiency decomposition and activity-based costing (ABC) to break through the limitations of single hospital data;

The virtual reference set (national hospital mean) is introduced to solve the problem of missing efficiency frontier.

3. Application of DEA in medical efficiency evaluation

Advantages of the model: suitable for nonparametric efficiency analysis with multiple inputs and outputs (Charnes et al., 1978);

Medical field: mainly used in hospital bed, operating room and other resource allocation research (Hollingsworth, 2008).

3.1 Research positioning

It breaks through the limitation of “horizontal comparison” of traditional DEA, and reveals the internal mechanism of efficiency change through time series analysis and disease cost decomposition.

4. Research methods and data

4.1 DEA model construction

4.1.1 Model selection and mathematical expression

Using the BCC model (variable returns to scale) and the Malmquist index:

$$\left\{ \begin{array}{l} \min \theta \\ \text{s.t. } \sum \lambda_j x_{ij} \leq \theta x_{i0}, \\ \sum \lambda_j y_{rj} \geq y_{r0}, \\ \sum \lambda_j = 1, \lambda_j \geq 0 \end{array} \right\}$$

θ : Comprehensive technical efficiency (TE), decomposed into pure technical efficiency (PTE) and scale efficiency (SE)

Malmquist Index:

$$\text{Malmquist} = \sqrt{\frac{D^t(x^{t+1}, y^{t+1})}{D^t(x^t, y^t)} \times \frac{D^{t+1}(x^{t+1}, y^{t+1})}{D^{t+1}(x^t, y^t)}}$$

Divided into technical efficiency change (EFFCH) and technological progress (TECHCH)

4.1.2 reference set construction

Virtual DMU: The input-output mean of 200 tertiary hospitals nationwide was introduced as the benchmark of efficiency frontier;

Data processing: The data of XX Hospital and virtual DMU were standardized (Z-score) to eliminate the dimensional difference.

4.2 Cost accounting method by disease type

Disease screening: select high-value diseases with DRG weight greater than or equal to 1.2 (such as interventional treatment of acute myocardial infarction) and low-value diseases with DRG weight less than or equal to 1.0 (such as community-acquired pneumonia);

Cost aggregation:

Direct cost: drugs, consumables, examination and inspection fees (extracted from the first page of the medical record);

Indirect costs: management, energy costs (based on clinical pathway hours).

4.3 Data sources and processing

data type	metric	source
Input indicators	Number of medical staff (X1)	Hospital human resources system
	Net value of equipment (X2)	Financial statement of assets
	Expenditure on pharmaceuticals and consumables (X3)	Medical insurance settlement system
Output indicators	Number of DRG groups (Y1)	Medical Insurance Bureau DRG grouping platform
	Medicare settlement cases (Y2)	Statistics on the first page of the medical record
	CMI value (Y3)	DRG platform calculation
External data	Mean of tertiary hospitals at national level	National Health Commission (2023)

Data cleaning:

Missing values: linear interpolation of net equipment value data in 2019;

Abnormal value: drug and material expenditure Winsorize truncated processing (1% percentile).

5. Empirical analysis

5.1 DEA Static Efficiency Analysis (2023)

DMU	TE	PTE	SE	return of scale	Redundancy input rate (X3)	CMI breach
XX hospital	0.82	0.88	0.93	IRS*	15.2%	-5.6%
invented DMU	1.00	1.00	1.00	-	0%	0%

conclusion:

The main causes of efficiency loss were redundant drug consumables (15.2%) and insufficient CMI value (too high proportion of low difficulty cases);

Returns to scale: In the stage of increasing returns to scale, the service volume needs to be expanded to the optimal scale.

5.2 Malmquist Dynamic efficiency (2019-2023)

period	EFFCH	TECHCH	TFP
2019–2021	1.05	1.10	1.16
2021–2023	0.98	1.15	1.13

explain:

TFP growth: 13% per year after the implementation of DRG, with technological progress (such as intelligent coding system) as the main driving force;

Efficiency decline: After 2021, the management efficiency (EFFCH) declined, reflecting the weakening of the initial cost control dividend.

5.3 Cost accounting by disease type

Case 1: DRG-123 (interventional treatment of acute myocardial infarction, weight 1.45)

Cost item	XX Hospital (former)	Industry benchmark (yuan)	Overhead rate	Root cause analysis
Drug costs	9,800	8,200	+19.5%	Antibiotics are used beyond guidelines
high-value consumable	52,000	45,000	+15.6%	Imported brackets account for 70%
total cost	66,300	57,000	+16.3%	The payment standard is 65,000 yuan

Quantitative impact: cost overruns for this disease resulted in an overall decrease in efficiency of about 0.12 ($p < 0.05$).

Case 2: DRG-456 (community-acquired pneumonia, weight 0.92)

Cost item	XX Hospital (former)	Industry benchmark (yuan)	Balance rate	successful experiences
Drug costs	1,200	1,500	-20%	Strictly follow the antibiotic guidelines
total cost	2,000	2,500	-20%	The payment standard is 2,300 yuan

6. Discussion and policy recommendations

6.1 Problems existing in cost management of public hospitals:

The cost management system is inadequate. The actual treatment costs of hospitals are disconnected from the calculated costs, increasing the operational costs of public hospitals and leading to severe waste of medical resources, making the effectiveness of cost management less than satisfactory. Moreover, in some hospitals, the specific aspects of cost management are poorly organized, with responsibilities not clearly defined for personnel at different levels. This results in a lack of close cooperation and efficient communication among staff, posing potential risks to the hospital's cost management work.

Cost analysis and evaluation lack detail. Cost analyses in public hospitals mostly rely on basic data from various departments, with low requirements for data authenticity and completeness. There is no in-depth analysis of the issues reflected by the data, which hinders cost control. For example, within the same case group, individual differences among patients lead to variations in the medical resources used^[20].

Taking XX Hospital as an example, after the full implementation of DRG in 2021, its CMI (case combination index) value dropped from 1.12 to 1.08, reflecting the decrease in the difficulty of treating cases, while the expenditure on drugs and materials increased by 9.5% during the same period. Such behavior will exacerbate the mismatch of medical resources and damage the long-term sustainability of the medical insurance fund.

6.2 Efficiency optimization path

Under the DRG framework, hospital cost optimization involves using information technology to dynamically monitor medical practices. First, in conjunction with DRG cost accounting results, standardize charging standards for each department and develop detailed cost management rules based on the requirements of medical services, avoiding systems that become mere formalities. Promptly remind and record any unreasonable medical expenses that have occurred in the knowledge base to prevent recurrence. Focus on monitoring changes in controllable costs and timely collect cost accounting data.

Members of the cost accounting team should maintain close contact with clinical departments and communicate promptly. In conjunction with resource consumption in medical business processes, they must strictly adhere to cost accounting principles. Public hospitals should estimate the procurement volume for the month based on actual surgical consumption in each department, reasonably design procurement volumes, and ensure timely supply to formulate a rational procurement cycle, effectively reducing procurement costs. Additionally, the National Medical Security Administration continuously introduces new agency procurement policies. After the issuance of new volume-based documents, hospitals should promptly halt in-house procurement execution plans and implement national volume-based material policies. Meanwhile, the medical supplies market is constantly evolving, requiring procurement personnel to stay updated with market changes and timely grasp the supply status and price information of various medical supplies.

Cost Management of Disease Types: Mandatory use of centrally procured consumables for high-value DRG groups (such as DRG-123), with penalties for non-compliance. Strengthen the management and control of controllable costs, promptly alerting to excess expenses to prevent overruns. Adopt a scientific performance distribution method, shifting from a coarse allocation approach to one that strongly links performance evaluations with cost management. Enhance the integration and analysis of patient settlement fees, delving into the factors that constitute medical expenses to identify controllable points in cost management, continuously refining the management of medical expenses. The fundamental purpose of performance distribution is to reflect fairness in management; a scientific performance distribution method can effectively motivate healthcare workers, guide their work direction, and improve management efficiency. Personal income for healthcare workers should not be tied to drug and consumable costs; instead, emphasis should be placed on cost factors, focusing on medical efficiency and quality. Additionally, it is necessary to adjust performance distribution rules, formulating targeted performance distribution methods, refining income distribution mechanisms, reducing the proportion of cost items, and increasing the share of income from medical service projects and medical quality assessments. A scientific performance distribution method can continuously motivate employees and enhance medical efficiency.

The DRG grouping rules implemented are based on the “law of large numbers,” aiming to leverage the economic regulatory role of health insurance funds in a fair environment. The personal income of healthcare providers should not be tied to drug and consumable costs; instead, emphasis should be placed on cost factors, focusing on medical efficiency and quality. Case-specific characteristics are reflected through variables such as primary diagnosis, surgery, and other diagnoses listed on the first page of medical records.

6.3 Research limitations and prospects

Limitations: the sample is from a single hospital, and the conclusion should be promoted with caution;

Outlook: Optimize resource allocation by integrating AI prediction models and explore the linkage mechanism between DRGs and performance-based compensation. Hospital efficiency optimization should follow a three-tier path: prioritize

controlling high-weight disease costs, then reduce indirect costs through inter-departmental collaboration, ultimately achieving Pareto improvement of hospital-wide resources.

Funding

no

Conflict of Interests

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

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Application and Challenge of Artificial Intelligence in Stock Investment

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Abstract: This paper examines the application and challenges of AI in stock investing. AI is transforming stock investing through data mining, predictive modeling, and trading decisions. It processes multi-source data, captures real-time market sentiment, and identifies investment opportunities using deep learning models. The widespread use of automated trading systems and intelligent advisors has enhanced trading efficiency and returns. However, AI also faces challenges such as algorithmic “black boxes,” model failures, and system issues. Through case studies, this paper analyzes the practical impact of AI in data mining, predictive modeling, and automated trading, and discusses the constraints of technology application. It proposes a technology optimization path combining data enhancement and cross-validation, and designs an auditable, transparent decision-making mechanism. Additionally, the paper explores the potential of quantum computing and blockchain in finance, offering theoretical insights and practical guidance for the industry to navigate the opportunities and challenges of intelligent investing.

Keywords: Artificial Intelligence; Stock Investing; Market Volatility

Published: Apr 23, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.288>

1. Introduction

1.1 Research background

In recent years, artificial intelligence (AI) technology, relying on computing power improvement, big data accumulation and algorithm breakthroughs, is profoundly reshaping the field of stock investment. Its applications cover the entire chain of data processing, predictive modeling and trading decisions, demonstrating revolutionary potential. At the information processing level, AI analyzes multi-source heterogeneous data such as news, financial reports, and social media through natural language processing technology to capture market sentiment fluctuations in real time. With the deep learning model, the system can complete massive data cleaning and risk and return assessment at the millisecond level, and accurately identify potential investment opportunities. Automated trading system, as a typical application of AI landing, executes algorithmic trading with a microsecond response speed and becomes the standard equipment of institutions. Smart advisors show their advantage in the balance of return and risk by dynamically optimizing asset allocation. However, technology dependence also creates new challenges: opaque decision-making caused by algorithmic “black boxes”, the risk of model failure in extreme markets, and the chain reaction that system failures may trigger need to be addressed through regulatory upgrading and technological innovation.

1.2 The purpose and significance of the study

This study focuses on the application effectiveness and existing challenges of artificial intelligence in the field of stock investment, aiming to provide a systematic reference for theory and practice. The core objectives include: empirical analysis of the landing effect of AI in data mining, predictive modeling and automated trading; In-depth analysis of the practical constraints of technology application; Building a multi-dimensional solution system; Look forward to the new trend of technological development. This study has both theoretical value and practical significance, provides decision-making basis for fintech innovation, and explores feasible paths for protecting investors' rights and interests and maintaining market stability.

2.Literature review

2.1 Overview of traditional stock investment theory

The traditional stock investment theory is built on three pillars: the Efficient Market Hypothesis (EMH), technical analysis, and fundamental analysis. EMH, proposed by Fama (1970)^[1], asserts that stock prices reflect all available information. Markets are categorized into weak, semi-strong, and strong forms based on the degree of information absorption, supporting passive investment strategies like index funds. However, this hypothesis assumes “perfectly rational people” and “frictionless markets,” which are unrealistic. Behavioral finance shows that investor biases (e.g., overreaction, herding) can cause prices to deviate from fundamentals.

Technical analysis uses historical price and trading volume data to predict trends, based on the logic that “history repeats itself” (Dow Theory). Tools like moving averages (MA) and Relative Strength Indicator (RSI) are commonly used (Murphy, 1999)^[2]. Yet, in strongly efficient markets, technical indicators' predictive power is limited, and strategies like “head-and-shoulders” patterns become less effective as market efficiency improves.

2.2 Progress in the application of artificial intelligence in the financial field

Artificial intelligence (AI) is transforming investment decision-making in the financial sector. Machine learning has demonstrated notable success in stock price forecasting, enhancing prediction accuracy. Research indicates that combining multiple machine learning algorithms can further improve results (Atsalakis & Valavanis, 2009^[3]; Huang et al., 2005^[4]). Deep learning, particularly LSTM networks, is also widely used for stock market prediction due to its ability to process time series data (Fischer & Krauss, 2018)^[5]. NLP has broken through barriers in analyzing unstructured text. Transformer-based models like BERT excel in social media sentiment analysis. For example, the Twitter sentiment index developed by Li et al. (2020)^[6] can predict the next day's Nasdaq movements with 68.5% accuracy. RL is driving the evolution of high-frequency trading algorithms. The Deep Q Network (DQN) achieves statistical arbitrage through dynamic order book simulation, with a Sharpe ratio of up to 3.2 in the Eurozone market (Biais et al., 2015)^[7]. However, data sensitivity and the risk of overfitting to historical fluctuations are concerns (Dixon et al., 2020)^[8].

3.The application of artificial intelligence in stock investment

3.1 Data mining and analysis

In modern financial markets, data is a key resource for investors, with vast amounts generated from news, social media, company earnings, and macroeconomic indicators. Extracting valuable insights from this complex data is challenging, but AI technologies, especially machine learning and NLP, provide powerful solutions.

AI enables large-scale data collection through web crawlers and APIs, capturing real-time content from financial news sites, social media platforms, and government data, as well as structured data from providers like Bloomberg and Reuters. These diverse sources ensure comprehensive and timely information.

Data cleansing is crucial for quality and reliability. AI, particularly deep learning, can correct errors, fill missing values, and standardize data. NLP converts unstructured text into structured data and captures semantic relationships to enhance analysis accuracy. In the analysis phase, AI models identify investment opportunities by learning patterns from historical data and predicting future trends. Cluster analysis groups similar stocks or industries for asset allocation, association rule mining reveals event correlations, and sentiment analysis detects market sentiment shifts to aid short-term trading decisions.

Automated Trading Systems (ATS) execute trades based on preset rules, responding to market changes within milliseconds. Building an efficient ATS involves integrating data processing, strategy development, and risk management.

3.2 System architecture design

Automated trading systems (ATS) use computer programs to automatically execute buy and sell orders according to preset rules, and can respond to market changes within milliseconds, greatly improving trading efficiency and accuracy. Building an efficient and reliable automated trading system requires comprehensive consideration of many aspects, including data processing, strategy development, risk management, etc.

4. Case study

4.1 Analysis of successful cases

Two Sigma's AI-driven advisory platform Euclid, managing \$42 billion, offers personalized asset allocation. Table 1 compares Euclid's performance with traditional manual customers across three key metrics: annualized return, volatility, and user satisfaction. Euclid's annualized return of 12.1% significantly outperforms traditional customers' 8.6%, demonstrating superior market opportunity capture and higher returns. In terms of volatility, Euclid's 9.4% is much lower than traditional customers' 13.7%, indicating better risk control. User satisfaction also favors Euclid at 94%, compared to traditional customers' 76%, highlighting its strong user experience. Through data-driven decisions, personalized services, and dynamic risk management, Euclid enhances investment returns, risk control, and user experience.

Table 1 Performance comparison.

Index	AI high frequency strategy	Traditional regression strategy
Annual return	12.1	8.6
Volatility	9.4	13.7
User satisfaction	94	76

4.2 Failure case reflection

During the US stock market circuit break in March 2020, Wealthfront's portfolio fell 34% in a single day due to concentrated user redemptions, highlighting liquidity management weaknesses. Table 2 compares AI advisory platforms with traditional portfolios on three metrics: current asset ratio, maximum one-day retracements, and redemption policies. The AI advisory platform holds 64% of current assets, focusing on liquidity management, while the traditional portfolio holds 86%, prioritizing long-term investment and higher returns. In terms of risk control, the AI platform's maximum one-day retracement was 34% under extreme market conditions, compared to 21% for the traditional portfolio, indicating higher market risk exposure but lower risk resistance. Regarding redemptions, the AI platform sets a 72-hour processing time to balance liquidity and risk control, whereas the traditional portfolio allows immediate redemptions, prioritizing user flexibility. Moving forward, AI platforms need to optimize liquidity strategies, enhance risk control, and balance risk management with user experience to improve service quality and competitiveness.

Table 2 Risk exposure comparison.

Index	AI consulting	Traditional combination
Proportion of current assets	64	86
Maximum single-day retracement	34	21
Redemption prescription	72h	Immediately

5. Conclusion

This paper systematically analyzes the application and challenges of artificial intelligence (AI) in stock investment, aiming to provide systematic reference for theory and practice. Through natural language processing and deep learning models, AI technology can efficiently process massive amounts of data, capture market sentiment fluctuations in real time, and accurately identify investment opportunities. The wide application of automated trading systems and intelligent advisors

has significantly improved trading efficiency and investment returns. However, AI technology also faces challenges such as algorithmic “black boxes,” model failures, and system failures. Through case studies, this paper analyzes the landing effect of AI in data mining, predictive modeling and automated trading, and discusses the practical constraints of technology application. The study proposes a technology optimization path that combines data enhancement with cross-validation, and designs an auditable transparent decision-making mechanism to balance regulatory requirements. At the same time, this paper looks forward to the application prospects of quantum computing and blockchain technology in the financial field, and provides theoretical basis and practical guidance for the industry to cope with the opportunities and challenges in the era of intelligent investment. Future research directions include further optimizing AI algorithms, improving prediction accuracy and transaction efficiency, strengthening data security and privacy protection, ensuring regulatory compliance, and exploring the application of AI technology in more financial fields.

Funding

no

Conflict of Interests

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

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Innovative Application of the 3D-IDPT Theory in Integrated Marketing Communications: A Case Study of Tianlala's New Honeysuckle Herbal Tea

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Abstract: This study explores the innovative application of the 3D-IDPT theoretical model in integrated marketing communications (IMC) through a detailed case analysis of Tianlala's new honeysuckle herbal tea. Given the intense competition in China's burgeoning new tea beverage market, this research identifies existing challenges within Tianlala's IMC strategy and proposes practical improvements guided by information resource management theories. By leveraging the 3D-IDPT model—which emphasizes the multi-dimensional flow of information (individual and collective, instant and synchronic, and construct dimension)—the study provides an analytical framework for systematically enhancing Tianlala's IMC effectiveness. It integrates traditional marketing tools with modern digital platforms and strategic resource management practices. This comprehensive approach aims to strengthen Tianlala's market competitiveness, ensuring sustainable brand growth and consumer loyalty in a dynamic market environment.

Keywords: Integrated Marketing Communications; 3D-IDPT Model; Tianlala; Honeysuckle Herbal Tea; Information Resource Management; Digital Marketing; Brand Strategy

Published: Apr 24, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.248>

1.Introduction

Marketing is a systematic process of promoting and selling products/services in target markets to fulfill consumer needs. It extends beyond mere transactions, emphasizing deep understanding of market demands and expectations to design strategies that create customer value while achieving organizational goals. Centered around four core elements—product design, pricing strategy, distribution channels, and promotional tactics—these components work cohesively to form a comprehensive system. For instance, companies must develop products addressing consumer pain points, set prices reflecting product value, establish efficient online/offline distribution networks, and employ diverse promotional methods (advertising, PR) to deliver value and capture market share.

Information Dissemination Theory, this theory examines how information flows from senders to receivers, focusing on its creation, transmission, reception, and interpretation. Whether through face-to-face interactions or mass media, the essence lies in encoding ideas into recognizable signals (text, visuals), transmitting them via appropriate channels (social media, TV ads),

and enabling receivers to decode messages based on their context. Environmental “noise” (e.g., information overload, cultural gaps) may disrupt this process, necessitating feedback mechanisms (surveys, sales data) to verify accurate delivery. Effective communication reduces information asymmetry, empowering consumers to make informed decisions.

Integrated Marketing Communications (IMC) emphasizes unifying fragmented channels by coordinating tools like advertising, PR, and social media under a consistent strategy. Its core lies in ensuring brands deliver coherent messages across all touchpoints (in-store experiences, online ads, membership emails) to strengthen consumer perception. For example, a beverage brand highlighting “natural ingredients” in TV ads could simultaneously launch live-streamed farm tours on social media and print QR codes linking to sourcing stories on packaging. Implementing IMC involves four stages: market analysis, strategy formulation, cross-department collaboration, and dynamic evaluation. As technology evolves, IMC integrates innovations like big-data targeting and VR experiences to adapt to consumers’ fragmented, cross-screen information habits in the digital age.

In the overall market environment of our country, with the increase in disposable income of Chinese residents, consumers have more diverse demands for products and services, considering more quality and brand factors when purchasing products. As an alternative to ordinary drinking water, new tea beverages, in the context of the new era of “consumption upgrade,” with the gradual improvement of the economic environment, further explore the beverage consumption potential of residents as consumption scenarios.

The competition in the current Chinese new tea beverage market is becoming increasingly fierce, with annual sales reaching 1.2 billion cups in 2021, and the market size reaching over 140 billion yuan. New tea beverages are increasingly present in the daily work and family life of young people, gradually becoming a lifestyle and social need for the youth.

In the current media era, with the continuous popularity of short video new media and the national popularization of live streaming for sales, a rich variety of content forms have constructed a new marketing communication environment. The technological upgrade of new media has triggered progress from community to traffic dominance, causing many changes in the environment of various marketing communication channels. Brands are beginning to madly compete for limited traffic resources, therefore, through detailed analysis of specific categories of Fast-Moving Consumer Goods (FMCG), especially the analysis of marketing strategies, it helps to understand the thinking changes and specific behavior patterns of many stakeholders, including consumers, markets, supply chains, distributors, governments, non-profit organizations, etc. This research also helps market operators - brand companies to adapt more actively to changing living environments, operate more resiliently, and activate the economy

2.Introduction to Tianlala Brand

The Tianlala brand was established in 2015 in Bengbu, Anhui Province. It is primarily a national chain tea beverage brand, specializing in the production of fresh fruit tea and milk tea. That same year, Tianlala opened up franchising and expanded to 92 stores by the end of the year.

In 2016, a supporting production base was established, and the number of stores increased to 296 by the end of the year.

In 2018, planning and construction of the upstream and downstream beverage industry chain layout began. That same year, the Changsha warehouse opened, and the number of stores grew to 1,000.

In 2019, the layout of information industry construction planning began, and the online operational business sector was established. That same year, the Tianjin warehouse opened, and the number of stores increased to 1,800.

In 2020, the number of stores in Zhengzhou increased to 3,000, annual sales reached 463 million yuan, and tax revenue reached 20 million yuan.

In 2021, the company reached corporate-university cooperation with several universities, providing high-quality talent for business development and receiving the “Anhui Food Safety” brand. That same year, stores opened in Changchun and Shijiazhuang, and the number of stores increased to 4,500, annual sales reached 1.173 billion yuan, and tax revenue reached 70.433 million yuan.

In 2022, Tianlala’s fresh fruit tea sales, certified by Euromonitor, led the nation.

In just eight years, Tianlala has grown to over 6,000 franchised stores and 106 direct stores, covering 27 provinces and

autonomous regions, 4 municipalities directly under the central government, 261 prefecture-level cities, 563 counties, and county-level cities. In the tea beverage industry, it is one of the few brands that have reached 6,000 stores.

Tianlala is a latecomer to the industry, but it has been rated as one of the “Top 10 Tea Beverage Brands in China” for three consecutive years, and has achieved this without external financing, relying solely on its own development and financing. In August 2021, certified by Euromonitor, the national fresh fruit tea sales volume reached 110 million cups, ranking second in the nation with a market share of 9.17%.

Against this backdrop, this article conducts an integrated marketing communication study on Tianlala’s new product “Honeysuckle Tea”. Through this study, we attempt to identify problems and deficiencies in Tianlala’s marketing, especially in integrated marketing communication (IMC), and propose corresponding improvement measures based on actual conditions. We aim to formulate a more viable “Honeysuckle Tea” IMC plan, using integrated marketing communication theory to support Tianlala’s long-term healthy development.

3. Theory and Method Expanded

3. Theory and Method Expanded

3.1 Related Theories

3.1.1 Theoretical Expansion of Marketing Frameworks: The 7PS Paradigm

The 7PS Marketing Theory advances the classical 4PS model (Product, Price, Place, Promotion) through the integration of three service-centric dimensions: People, Process, and Physical Evidence, as conceptualized by Bums and Bitina (1981). This paradigm shift addresses the inherent complexities of service industries—such as food and beverage—where human-centric interactions and experiential quality supersede purely transactional dynamics.

Human Capital Integration (People) prioritizes frontline employees as value co-creators, recognizing their role in shaping service encounters through expertise, empathy, and relational engagement. Operational Architecture (Process) systematizes service delivery protocols to ensure consistency across customer touchpoints, transforming chaotic workflows into replicable excellence. Tangible-Intangible Dyad (Physical Evidence) bridges sensory perception and brand credibility, leveraging environmental cues (e.g., ambiance, packaging) as silent communicators of service quality^[1].

While the traditional 4PS framework anchored marketing in product-centric metrics—supply chain logistics, pricing elasticity, and promotional ROI—the 7PS model reorients strategy toward service-dominant logic. This evolution acknowledges the inseparability of production and consumption in service ecosystems, where customer satisfaction hinges on ephemeral interactions rather than static outputs. By formalizing intangible variables (e.g., employee-customer rapport, service blueprinting) as strategic levers, organizations cultivate holistic consumer journeys that align with experiential expectations^[1].

The 7PS framework’s analytical power lies in its multidimensional calibration:

Product/Service Hybridity: Reconceptualizing offerings as bundled solutions (goods + service interactions)

Price-Value Synchronicity: Aligning cost structures with perceived experiential worth

Place-Accessibility Optimization: Redefining distribution channels as moments of service accessibility

Promotional Dialogue: Transitioning from monologic advertising to participatory storytelling

People-Driven Branding: Embedding organizational culture into customer-facing interactions

Process Standardization: Mitigating service variability through procedural codification

Physical Evidence Curation: Engineering multisensory touchpoints to reinforce brand narratives

This theoretical expansion not only enriches marketing strategy formulation but also redefines competitive differentiation in service economies, positioning human-centric factors and environmental semiotics as critical drivers of market success.

3.1.2 Theoretical Framework of Communication Studies

As a foundational discipline for investigating the laws of information exchange, communication theory establishes a cognitive cornerstone for research in the information society. This field constructs three core research dimensions through progressive theoretical models—ranging from unidirectional transmission to cyclical interaction—encompassing interpersonal communication mechanisms, mass communication effects, and symbolic communication paradigms.

Interpersonal Communication Mechanisms focus on micro-level interactive patterns, including both traditional face-to-face

exchanges and digitally-mediated remote dialogues. This dimension dissects the synergistic operation of verbal systems (lexical choices, tonal variations) and nonverbal systems (gestures, micro-expressions), emphasizing the intrinsic logic of trust-building, cognitive synchronization, and the dynamic maintenance of social relational networks ^[2].

Mass Communication Effects investigate the shaping role of media technologies on societal cognition, systematically analyzing information diffusion patterns across newspapers, broadcast media, and digital platforms. This domain highlights the steering mechanisms of agenda-setting in directing public attention allocation, the unique influence of the spiral of silence on opinion formation ^[3], and evaluates media content's intervention pathways in shaping collective attitudes ^[4].

Symbolic Communication Paradigms deconstruct the socialized processes of meaning production, centering on symbolic interaction theory to explain how linguistic systems construct societal cognitive frameworks. This theory underscores the cultural-context dependency in symbolic encoding/decoding, revealing the structural role of symbolic systems in forging social consensus, preserving cultural traditions, and influencing collective behavioral decisions ^[5].

The theoretical framework of communication studies prioritizes the impact of information entropy (communication interference) on transmission efficacy. By optimizing encoding strategies (enhancing signal discernibility) and refining decoding mechanisms (improving contextual adaptability), it drives continuous innovation to elevate the precision and effectiveness of cross-cultural, transmedial communication.

3.1.3 Paradigm Evolution of Integrated Marketing Communications (IMC) Theory

Emerging in the early 1990s, Integrated Marketing Communications (IMC) represents a transformative shift in marketing strategy, moving from fragmented tactics to a systematic, holistic approach. Its foundational premise lies in achieving strategic synergy across marketing elements, unifying diverse tools—such as advertising, public relations, direct marketing, and digital outreach—within a cohesive framework to balance maximal communication efficacy with cost efficiency ^{[6][7]}. This theory redefines traditional marketing's one-way messaging by fostering a closed-loop communication ecosystem centered on consumer value co-creation.

The Strategic Synergy Framework emphasizes deep integration of omnichannel communication networks, ensuring brand messaging maintains consistency across temporal (campaign cycles) and spatial (media touchpoints) dimensions. This synergy extends beyond standardized visual identities and linguistic styles to align consumer cognitive schemas with brand value propositions, thereby mitigating communication entropy caused by fragmented information ^[8].

Relationship-Centric Communication, as IMC's theoretical core, prioritizes the sustained cultivation of consumer lifetime value. By leveraging dynamic customer databases and real-time feedback mechanisms, organizations deploy precision-targeted content and context-driven interactions, transforming transactional exchanges into long-term brand equity ^[9]. This relational approach transcends traditional marketing's zero-sum dynamics, relying instead on emotional resonance and shared values to amplify user engagement.

The construction of Multimodal Communication Systems highlights IMC's interdisciplinary nature, encompassing:

Creative symbol encoding and media mix optimization in advertising;

Issue management and social capital accumulation in public relations;

Behavioral data mining and algorithmic recommendation refinement in digital marketing;

Sensory stimulus design and situational memory reinforcement in experiential marketing;

The orchestration of these tools forms an integrated impact chain spanning cognition, attitude, and behavior ^[7].

IMC offers dual implications for marketing practice: Operationally, it necessitates a "centralized content hub" for cross-departmental collaboration; strategically, it shifts performance metrics from mere exposure metrics to composite indices evaluating brand equity growth and consumer relationship quality. This evolution from instrumental rationality to value rationality positions IMC as a cornerstone theory for reconstructing marketing ecosystems in the digital age.

3.2 Strategic Analytical Frameworks

3.2.1 Structural Industry Diagnostics: Porter's Five Forces Model

Porter's Five Forces Model constitutes a systematic framework for evaluating competitive dynamics within industrial ecosystems. By analyzing five critical vectors—buyer/supplier bargaining leverage, market entry barriers, substitution threats,

and incumbent rivalry intensity—organizations gain granular insights into competitive positioning. This diagnostic instrument enables enterprises to deconstruct sectoral power structures, identify strategic vulnerabilities, and architect countermeasures to optimize market influence ^[10].

3.2.2 Macro-Environmental Scanning: PEST Analysis

The PEST framework (Political, Economic, Sociocultural, Technological) serves as a macro-environmental scanning tool for decoding exogenous variables impacting organizational strategy. Through structured assessment of regulatory climates, macroeconomic cycles, demographic shifts, and disruptive innovations, businesses cultivate anticipatory capabilities to navigate volatility and align operations with emergent megatrends. This methodology transforms environmental uncertainty into strategic foresight, enabling proactive resource allocation ^[11].

3.2.3 Dual-Axis Organizational Auditing: SWOT Analysis

SWOT analysis provides a dual-axis diagnostic framework, juxtaposing endogenous capabilities (Strengths/Weaknesses) against exogenous conditions (Opportunities/Threats). By mapping internal competencies (e.g., operational efficiency, brand equity) against external market realities (e.g., regulatory changes, technological disruptions), organizations achieve strategic coherence—leveraging core advantages while instituting risk mitigation protocols. This matrix functions as a cognitive bridge between organizational potential and market actualization.

3.2.4 Consumer Journey Architecture: AIDA Model

The AIDA model (Attention → Interest → Desire → Action) articulates the psychographic progression driving consumer decision-making. Originating in late 19th-century sales theory, this cognitive funnel informs modern engagement strategies by systematizing touchpoint design:

Attention: Disrupting perceptual filters through sensory stimuli.

Interest: Building relevance through personalized narratives.

Desire: Activating latent needs via aspirational storytelling.

Action: Reducing friction in transactional pathways.

Its cyclical application in omnichannel campaigns demonstrates enduring utility in synchronizing messaging with buyer psychology.

3.3 Synthesis of Methodological Value

These frameworks collectively form a multidimensional analytical matrix for strategic decision-making. Porter's Five Forces deciphers industry tectonics, PEST contextualizes macro-environmental pressures, SWOT calibrates organizational readiness, and AIDA engineers behavioral pathways. When integrated, they enable enterprises to:

Anticipate sectoral shifts through cross-matrix scenario modeling;

Optimize resource deployment via risk-reward stratification;

Orchestrate market interventions with psychographic precision;

Sustain competitive advantage through iterative environmental adaptation.

This strategic ecosystem empowers organizations to transform raw market data into actionable intelligence, fostering resilience in hypercompetitive landscapes while aligning operational DNA with evolving consumer expectations.

4.IMC Status and Problems Analysis

4.1 Industry Environment Analysis

Supplier Bargaining Power

Dependence on raw material suppliers (e.g., water, honeysuckle) creates vulnerabilities in cost control and supply stability. Rising demand for premium ingredients intensifies price pressures, requiring strategic supplier partnerships or vertical integration to mitigate risks.

Buyer Bargaining Power

High buyer influence stems from intense competition (e.g., Honey Snow City, tea brands). To counterbalance, the company must differentiate through localized flavor innovation and premium product positioning to reduce substitutability.

Competitive Rivalry

Established brands dominate with superior resources and market penetration. Survival hinges on leveraging niche markets, digital-first engagement strategies, and agile product iterations to avoid direct clashes.

Threat of New Entrants

Low entry barriers invite disruptors. Defensive measures include rapid product innovation cycles (e.g., seasonal limited editions), loyalty program enhancements, and exclusive ingredient sourcing to deter competitors.

Substitute Products

Shifting consumer preferences toward health-focused alternatives demand continuous portfolio renewal. Strategies involve modular product designs for quick adaptation and cross-category collaborations to expand usage scenarios.

4.2 IMC Environmental Analysis

the PEST model:

Political Environment

Government policies like the 14th Five-Year Plan incentivize innovation and digital consumption, supporting cross-sector integration and fostering immersive, experiential consumption scenarios. This creates opportunities for brands to diversify integrated marketing channels and upgrade strategies.

Economic Environment

China's new tea beverage market reached ¥290 billion in 2022, serving 250M+ consumers across 450K stores. Projected to grow to ¥340 billion by 2025, rising urban incomes and food expenditure signal sustained market expansion ^[12].

Social Environment

Gen Z (post-95s/00s), the core consumer group, prioritizes product quality and digital engagement. Their preference for online media, particularly in second-tier cities and southern China, enables targeted digital marketing strategies.

Technological Environment

Adoption of cold extraction and flavor enhancement technologies differentiates product offerings. Digital transformation accelerates shifts from offline to integrated online media strategies, aligning marketing goals with consumer engagement via tech-driven channels.

4.3 Brand Management Analysis

the SWOT model:

Strengths

Mature R&D capabilities for trend-responsive product iterations

Strong supplier partnerships ensuring raw material dominance

Self-built infrastructure enhancing operational efficiency

Weaknesses

Limited premium branding in high-tier cities

Inconsistent cross-regional brand image weakening loyalty

Frequent brand identity changes confusing consumers

Opportunities

Gen Z's growing purchasing power and digital savviness

Post-pandemic digital acceleration and 5G infrastructure growth

Untapped potential in first/second-tier urban markets ^[13]

Threats

Price wars with established tea brands eroding margins

Low entry barriers increasing market saturation

Substitution threats from coffee and functional beverages

Strategic Imperatives: Tianlala must innovate products, stabilize brand identity, and leverage digital channels to enhance loyalty while monitoring competitive and consumer trends for sustainable growth.

4.4 Current IMC Status

Resource Analysis: Tianlala has a strong online influence on platforms such as Weibo, Xiaohongshu, and TikTok, with millions of followers and interactions. However, platforms like Kuaishou and Bilibili need further development to fully utilize their potential in integrated marketing communication ^[14].

Communication Channels: The brand adopts a combination of online and offline marketing strategies, with some notable activities generating a significant amount of online interaction. Initiatives like the “Bear Black Egg” brand image IP and the “Take Your Bucket to Tianlala” campaign have attracted widespread attention. However, brand inconsistency and a lack of targeted communication strategies pose challenges to the brand image and market positioning.

Challenges: Insufficient brand integration and segmentation hinder effective communication with current and potential customers. Compared to leading tea brands with complex membership marketing systems, Tianlala’s approach lacks personalized incentives and integration with new media platforms. Achieving a coherent and strategic approach to integrated marketing communication is crucial for enhancing brand recognition, customer loyalty, and market competitiveness.

5. Tianlala Integrated marketing and communication strategy of Honeysuckle Cool tea beverage

5.1 The application of the AIDA model

AIDA Framework Implementation for Thorn Flower

A - Attention Capture

Deploy brand signature assets (unified logo system, chromatic branding) across multi-channel touchpoints. Utilize sensory triggers through short-form video content showcasing product aesthetics (e.g., layered beverages, dessert texture close-ups) on Douyin/WeChat. Launch seasonal teasers with countdown mechanics to amplify anticipation for limited editions ^[15].

I - Interest Cultivation

Implement narrative immersion via behind-the-scenes content:

Ingredient provenance documentaries (organic farms, extraction processes)

Barista skill showcases (craftsmanship storytelling)

“Day in the Life” consumer testimonials

Introduce experiential marketing through pop-up DIY workshops (customizable drink stations) and AR filter games mimicking drink creation ^[16].

D - Desire Activation

Develop social proof ecosystems:

UGC campaigns with branded hashtags (#MyThornFlowerMoment)

Tiered influencer partnerships (micro to KOL) demonstrating daypart consumption (morning energizers, afternoon treats)

Limited “Early Bird” bundles (pre-release access for loyalty members)

A - Action Facilitation

Optimize frictionless conversion pathways:

WeChat Mini Program integration (scan-to-order in stores)

Geo-targeted flash sales (30% off within 1km radius)

Membership tiers with progressive rewards (free 5th drink, birthday doubles)

Embed urgency CTAs in digital interfaces:

“Claim Your Summer Chill - 50% OFF First Mobile Order”;

“Reserve Limited Pineapple Mint Cooler - Stock Alert: 23 Left”

This structured AIDA application enables systematic conversion from awareness to transaction while aligning with Gen Z’s preference for interactive, authenticity-driven brand engagement.

5.2 Implementation of IMC

5.2.1 Integrating Communication Image to Achieve “Unified Image, Consistent Voice”

Brand positioning must identify its unique characteristics and then concentrate and repeat them. In the internet era, consumers are faced with an explosion of information and distracting messages. Brands need to find their unique value proposition,

integrate relevant communication channels, unify external image dissemination, and convey a consistent external voice, aiming to accurately communicate advertising messages to the target audience ^[17].

Suggestion: In the integrated marketing communication activities for promoting honeysuckle herbal tea, incorporate the unified Tianlala brand concept to enhance its position in marketing communication strategies; increase long-term fixed hanging advertising materials in physical stores to promote Tianlala herbal tea; and increase unified and coordinated publicity online on new media platforms.

5.2.2 Integrating Consumer Data to Develop Targeted Incentive Policies

The official WeChat mini-program has approximately 6.9 million members, which is a substantial number. However, currently, there are no targeted promotion strategies for these existing customers, i.e., members.

The optimization plan is implemented in four steps:

Firstly, the 6.9 million members need to be segmented to further refine consumer behavior information and create a consumer database. This includes gender, geographical distribution area, cumulative consumption frequency, consumption frequency, average customer spending per purchase, frequently purchased products, etc., forming different segments for various types of members, and “inserting” “Honeysuckle Herbal Tea” based on these characteristics.

Secondly, for members of different levels, we can adopt a consumption points system, dividing members into different levels based on the number of points, and implementing different levels of cashback and discount offers for members accordingly.

For customers who have not yet registered as Tianlala members, a membership registration incentive can be offered, such as a discount on the first purchase, to encourage potential customers to become members.

Lastly, during special holidays, incentives can be offered through coupons or other forms of discount activities to encourage customers to make purchases in-store.

By doing so, not only can consumer stickiness be increased, but it can also help businesses segment customer preferences, optimize product structures, and form more favorable marketing methods ^[18].

5.2.3 Integrating Diverse New Media Resources and Utilizing Opinion Leaders

Brand communication needs precise positioning, selecting opinion leaders consistent with the brand’s tone to promote “Honeysuckle Herbal Tea,” and paying attention to the variable characteristics of opinion leaders. At the same time, leveraging the advantages of different media channels, integrating marketing communication, forming a closed-loop marketing communication process, and enhancing communication effectiveness. Tianlala should improve and build accounts on each mainstream new media platform, develop different communication content, integrate online and offline media channels, and form a virtuous cycle to enhance brand awareness and sales [19].

5.2.4 Utilizing Charitable Activities to Fulfill Social Responsibility and Maintain Public Relations

Combine corporate mission with charitable projects or social responsibility activities consistent with corporate values and brand image. By participating in social responsibility activities, improve brand image, enhance public image and brand reputation. Increase customer engagement by encouraging customers to participate in charitable activities. For example, for every cup of “Honeysuckle Herbal Tea” purchased, the enterprise can donate one yuan to relevant activities. Ensure transparency and certification of charitable activities to gain relevant social responsibility certifications to enhance credibility. Establish good media communication relationships, build good relationships with third-party media to ensure positive reporting of brand information. Event sponsorship, by hosting or sponsoring events to increase brand exposure and interaction with the target audience ^[20].

5.3 Implementation Safeguards for Integrated Marketing Communication Strategies Optimization Plan

5.3.1 Marketing Talent Echelon Construction

Tianlala has established a branch in Shanghai to attract outstanding talents from first-tier cities. In addition to recruitment, we also need to motivate internal talents. We should select talents with forward-looking and advanced qualities and improve the recruitment process. At the same time, an internal talent echelon and incentive policies should be established. Some marketing projects can be outsourced to external advertising companies, utilizing their professional skills and experience ^[21].

5.3.2 Budget Planning

An integrated marketing plan requires a reasonable budget. Tianlala has not yet received funding, and capital injection is needed to implement safety strategies. After going public, cash flow will support the rapid growth of the enterprise. The financing cost in the secondary market is lower, and more capital means that a more comprehensive and thorough marketing plan can be implemented ^[22].

5.3.3 Completeness of Consumer Database

Understanding the target consumer group is crucial. Consumer data generated after each marketing activity should be incorporated into the database to more accurately target the audience and develop incentive plans. Digital construction helps maintain the connection between the brand and consumers, which is the foundation of customer relationship marketing.

5.3.4 Perfection of Marketing Team System

The performance evaluation system should be improved to ensure its high relevance to the marketing communication plan. Strengthen coordination between departments to ensure that all departments work towards a common goal. Empower each department with the appropriate authority to ensure the effective and smooth implementation of the integrated marketing communication plan ^[23].

5.3.5 Intellectual Support from External Teams

Leverage professional market knowledge and rich experience to provide new perspectives and ideas for the company's market opportunities, helping it explore underutilized market opportunities. Flexible and scalable, using advanced marketing tools and technologies to improve the efficiency of activities. Provide various references to help internal teams share risks and reduce failures.

6. Analysis of Tianlala Honeysuckle Herbal Tea Integrated Marketing Communication Strategy Based on the 3D-IDPT Model

6.1 Introduction to the 3D-IDPT Theoretical Model

The 3D-IDPT model is an analytical framework within information resource management theory, emphasizing information's essential property—its shareability and continuous flow. Information is placed at the origin of a three-dimensional model, divided into four quadrants by two axes: the horizontal axis (space: Individual & Collective), and the vertical axis (time: Instant & Synchronic). Additionally, a third dimension (Z-axis: construction) represents the process of information construction, reflecting continuous improvements driven by technology advancements, value orientation, and user demands.

Specifically, the model identifies four quadrants:

Individual-Instant: immediate information needs of individuals.

Individual-Synchronic: sustainable and repeated utilization of information by individuals over time.

Collective-Instant: immediate information demands shared by groups at specific moments.

Collective-Synchronic: long-term and stable information sharing among user groups.

The 3D-IDPT model illustrates how information construction evolves comprehensively by overcoming various barriers, matching values with user demands, and leveraging technological progress, ultimately enhancing information resource effectiveness ^[24].

6.2 Applicability of the 3D-IDPT Theory in This Study

Integrated Marketing Communications (IMC) is essentially a comprehensive process of information management, with the core objective of achieving consistency, effectiveness, and coordination in corporate marketing communications. Information science and information management theory provide solid theoretical support and methodological guidance for IMC from the perspectives of information flow, information resource management, and communication and communication.

The main manifestations are: enhance the efficiency and accuracy of information flow in the marketing communication process; promote the strategic integration and systematic management of marketing information resources; optimize communication channels, media, and feedback mechanisms to achieve continuous improvement in marketing communication effectiveness.

6.2.1 The Applicability of Information Flow and Communication Theory in IMC

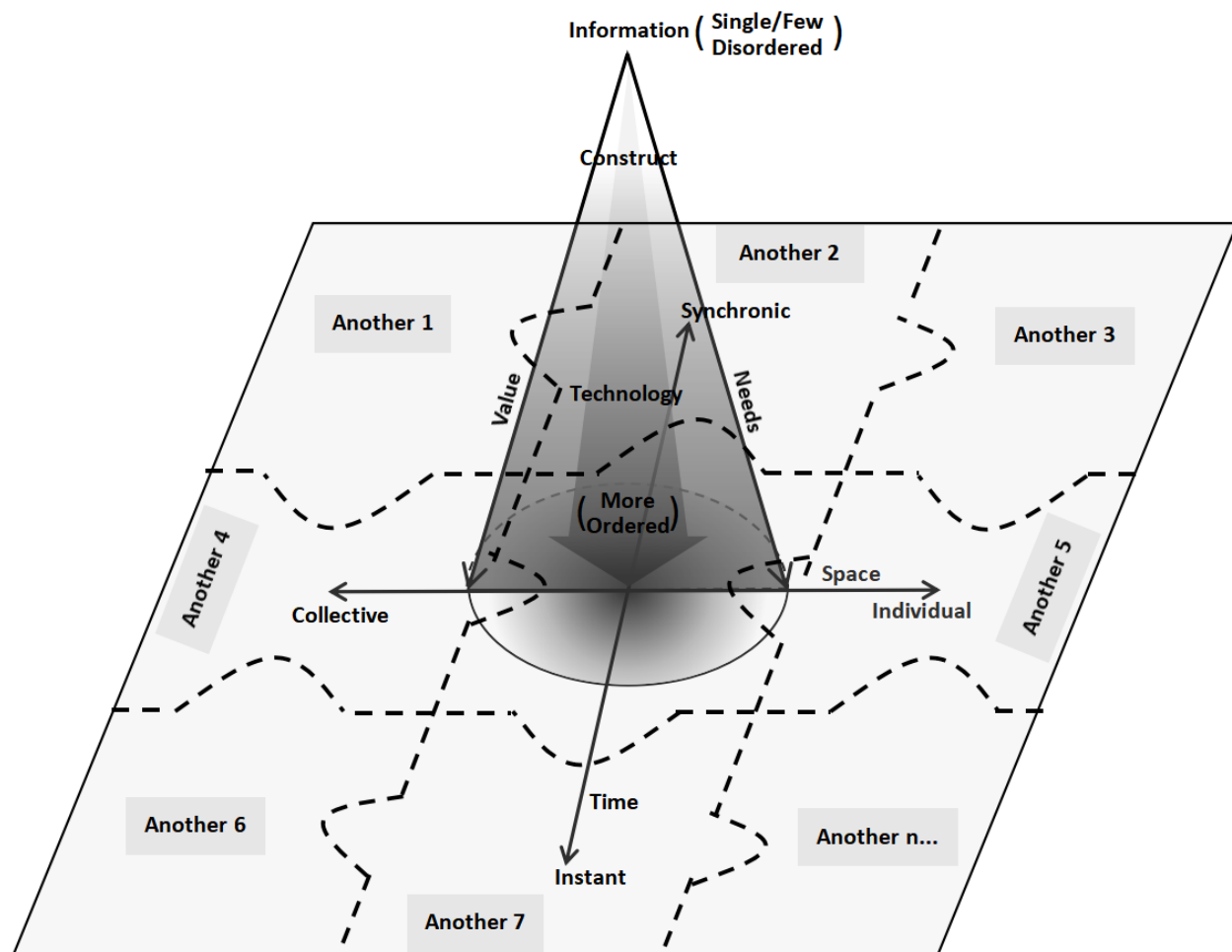
Information science theory emphasizes the process of information dissemination, which is the efficient flow of information from the sender to the recipient. This is highly consistent with the requirement of “precisely conveying marketing information” in IMC. Specifically, this is reflected in:

Improving Information Delivery Efficiency: information flow theory emphasizes the timeliness, accuracy, and completeness of information transfer, helping enterprises scientifically design their communication content and methods, thereby reducing information distortion and ensuring unified audience perception of core brand messages.

Optimizing Information Feedback Mechanisms: informatics stresses the importance of feedback loops in communication processes, closely aligning with IMC’s emphasis on customer feedback, brand interactions, and communication effectiveness assessment. This alignment enables enterprises to timely adjust their communication strategies and dynamically optimize information dissemination.

Enhancing Media Matching in Communication: the media richness theory in informatics guides enterprises in selecting the optimal communication channels (such as social media, traditional media, or face-to-face communication) according to information characteristics, audience attributes, and communication contexts, thereby improving communication effectiveness.

Figure1: 3D-IDPT(Integrate Discipline Puzzle Theory) Model



6.2.2 The Applicability of Information Resource Management Theory in IMC

Information Resource Management Theory considers information as a strategic resource for enterprises, emphasizing the unified organization and efficient utilization of information resources. This provides a theoretical basis for the information integration and resource collaboration in IMC. It is mainly manifested as follows:

Strategic Integration of Marketing Information Resources: information Resource Management Theory provides methodological support for enterprises to establish a unified information resource management platform, enabling the efficient

integration and sharing of brand, product, channel, and customer data in marketing communication. This avoids information silos and ensures the consistency and coordination of communication strategies.

Construction of Information Resource Sharing Mechanisms: information Resource Management Theory helps enterprises design cross-departmental information sharing and collaboration mechanisms. For example, through CRM (Customer Relationship Management System) and marketing automation tools, it achieves smooth information flow between different departments, strengthening the high synergy of brand information dissemination during the IMC process.

Systematic Management of Marketing Information Dissemination: information Resource Management Theory also guides enterprises in establishing clear information communication and authority management norms. This ensures the security of information, the efficiency of information transmission, and the standardization of the marketing information dissemination process, maintaining the consistency of the brand image.

6.2.3 Dimension Specification

Space Dimension (Horizontal Axis)

Individual: Tianlala Company

Collective: Consumers, market competitors, supply chain partners, government, and the public

Time Dimension (Vertical Axis)

Instant: Product launch, short-term marketing activities

Synchronic: Long-term brand building, changes in market environment, and trends in consumer behavior

Construct Dimension (Z Axis):

Technology: Marketing communication channel technologies (new media, short videos), product manufacturing technologies

Value and Needs: Changes in consumer demand, company brand values, and social responsibilities

6.3 Detailed Analysis Framework Based on the 3D-IDPT Model

6.3.1 Space Dimension Analysis (Horizontal Axis)

Individual Dimension: Tianlala Company achieves consistency in brand voice and visual identity across different media platforms through a unified brand communication strategy. For instance, when launching honeysuckle herbal tea, the company adopts a unified brand logo, communication slogan, and precise product positioning and feature description, effectively clarifying the brand's unique positioning. At the same time, based on the AIDA model, by integrating resources and carefully designing communication strategies, the company guides individual consumers from attention (Attention), generating interest (Interest), thereby stimulating the desire to purchase (Desire), and ultimately facilitating the purchase behavior (Action), ensuring the brand message achieves a "consistent voice" across different channels.

Collective Dimension: Tianlala Company deeply analyzes the consumption habits and value orientations of the younger generation (Generation Z), precisely capturing their interest points in health and novel tea drinks. Through social media and new media KOLs, the company effectively strengthens interaction with the target group. At the same time, the company closely monitors changes in consumer group needs, market strategies of competitive brands, supply chain and government requirements for product safety and quality, as well as the public's focus on the brand's social responsibility. The company dynamically adjusts marketing communication strategies to ensure that the brand always meets the needs of young consumers and the market development trends.

6.3.2 Time Dimension Analysis (Vertical Axis)

Instant Dimension: Tianlala implemented an effective and efficient instant marketing strategy during the initial launch of the new product (Honeysuckle Herbal Tea). Through diverse forms such as short videos and live streaming, they quickly attracted widespread consumer attention and stimulated immediate purchasing behavior. In addition, well-crafted promotional activities for holidays and hot events also served as a key component of the instant strategy, aiming to rapidly increase brand exposure and drive short-term sales growth. This series of initiatives formed an organic integration, ensuring the logical coherence of the overall promotion plan. Particularly, the unique advantages of short video KOL marketing were leveraged to play a significant role in rapidly increasing product popularity and immediate sales.

Synchronic Dimension: Tianlala Company focuses on long-term brand strategy construction, shaping a systematic brand story

and continuously spreading brand culture to stabilize and enhance consumer loyalty and identification with the brand. For instance, the company has long been engaged in charitable public welfare activities, actively establishing and maintaining a good brand social image; at the same time, it has established a complete consumer database to implement long-term precise marketing strategies. Through long-term cultivation of consumer groups, brand loyalty building, and the continuous dissemination of brand values, a solid brand identity is gradually formed, ensuring that brand communication strategies are highly aligned with market trends.

6.3.3 Construct Dimension Analysis (Z Axis)

Technology Dimension: Tianlala Company actively adopts digital marketing technologies, conducting precise and personalized communication through platforms such as Douyin(Tiktok), Xiaohongshu, Weibo, and WeChat Mini Programs. Additionally, leveraging big data platforms, the company deeply analyzes consumer behavior and preferences to achieve precise marketing. In terms of product technology innovation, the company applies cold-brew technology to develop novel flavor products, continuously enhancing product competitiveness and consumer experience.

Value and Needs Dimension: Tianlala Company closely integrates its brand core value with consumer demands, precisely meeting the market's need for a healthy lifestyle through the distinctive features of healthy and low-sugar products; at the same time, by engaging in charitable public welfare activities, the company combines the dissemination of brand value with the practice of social responsibility, further enhancing consumers' emotional identification and value resonance with the brand, continuously strengthening the brand's social responsibility image, and reflecting the brand value.

6.4 Comprehensive Application of 3D-IDPT Analysis in Tianlala Marketing Strategy

Figure2: Comprehensive Application of 3D-IDPT Analysis in Tianlala Marketing Strategy

Quadrant Dimension	Specific Marketing Communication Strategies	Examples from Original Content	Supporting Foundations
Individual-Instant Quadrant	New product short video promotion, real-time promotional events	Application of AIDA model, KOL marketing strategies	<p>Technology: Integrating the latest technological information to ensure research outcomes are promptly applied in the company's marketing strategies and daily operations.</p> <p>Needs: Always remembering that Tianlala is essentially a fast-moving consumer goods (FMCG) company; only by meeting consumers' needs for better quality, taste, price, and novelty can it achieve rational and sustainable development.</p> <p>Value: Emphasizing the voice of every participant in the consumption process to achieve a shared and sustainable value orientation.</p>
Individual-Synchronic Quadrant	Long-term brand image promotion, user loyalty building	Brand consistent voice strategy, long-term brand management analysis	
Group-Instant Quadrant	Trending topic marketing, short-term promotional campaigns	Holiday promotions, real-time user interaction	
Group-Synchronic Quadrant	Long-term public welfare activities, communication of brand social responsibility	Charity strategy, long-term consumer trend analysis	

7. Conclusion

Anhui's Tianlala Company stands as a leading private enterprise and ranks among the top ten brands in China's innovative tea beverage sector. Its success is rooted in the consistent evolution of its brand communication strategies, particularly its IMC approach, which has set a benchmark for the industry. While Tianlala's IMC framework demonstrates notable strengths—such as cohesive cross-channel messaging and agile product development—it faces challenges that require refinement. Gaps in premium market penetration, fragmented digital engagement tactics, and delayed responses to emerging beverage trends highlight areas for strategic adjustment. Addressing these weaknesses proactively is critical for the company to sustain its competitive edge, capture greater market share, and align with the rapid evolution of consumer preferences and industry dynamics.

Looking ahead, Tianlala must prioritize a holistic analysis of its IMC strategy to fortify its marketing ecosystem. This

involves deepening its understanding of high-tier urban markets, enhancing digital personalization through advanced technologies like AI-driven analytics, and fostering innovation to counter substitutes such as coffee culture. By streamlining brand narratives across regions and platforms, investing in premium product lines, and leveraging real-time consumer feedback loops, the company can solidify its domestic leadership while laying the groundwork for global expansion. The long-term vision centers on transforming Tianlala into an internationally recognized brand, capitalizing on its core strengths in ingredient innovation and cultural storytelling. Sustained growth will depend on balancing operational agility with strategic foresight, ensuring the brand remains synonymous with quality, adaptability, and consumer-centric innovation in an increasingly crowded and dynamic market.

Funding

no

Conflict of Interests

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

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A Study on the Mechanism of User Co-creation on LEGO Brand Loyalty: the Moderating Role of Mind-Flow Experience and the Mediating Role of Community Affiliation

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Abstract: Taking LEGO brand as a case study, this study constructs a chain model of “user value co-creation→community belonging→brand loyalty” based on the value co-creation theory, the mind-flow theory and the brand community theory, and explores the moderating role of the mind-flow experience in it. We collected questionnaire data from LEGO’s core user group (N=310), and used structural equation modeling (SEM) and Bootstrap method to conduct empirical tests. The study found that: value co-creation significantly and positively affects brand loyalty, indicating that users’ participation in product design, content generation and other co-creation behaviors directly strengthens brand identity and repeat purchase intention; community belongingness plays a partially mediating role, revealing that users’ sense of belonging to LEGO’s fan community is strengthened through co-creation behaviors, which is then transformed into brand loyalty; mind-flow experience has a significant effect on the above paths; heart-flow experience has a significant effect on the above paths. The co-creation behavior of the users’ community of LEGO fans enhances their sense of belonging to the community, which is then transformed into brand loyalty. This study is the first to integrate the multi-stage mechanism of “behavior-emotion-loyalty” in a physical product scene, verifying the gain effect of mind-flow experience on value co-creation, and expanding the boundaries of the application of the theory of consumer engagement. In practice, companies such as LEGO are suggested to systematically enhance user loyalty through step-by-step task design (to stimulate heart flow), community belonging cultivation (e.g., offline fan festivals), and open co-creation platforms (e.g., LEGO Ideas). This study provides a theoretical basis and operational framework for user operations of high-engagement brands.

Keywords: User Value Co-creation; Heart Flow Experience; Brand Community Belonging; Brand Loyalty; Consumer Psychology

Published: Apr 24, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.245>

1.Introduction

At a time when Web 4.0 and experience economy are intertwined, the role of consumers has evolved from passive receivers to value co-creators^[1]. Brands empower users to participate in product design, content production and even marketing communication through open innovation platforms, forming a unique “co-creation-symbiosis” relationship. LEGO, as a model of global user co-creation, has received tens of thousands of user design proposals on its LEGO Ideas platform, which has directly driven the revenue growth of related products. This phenomenon reveals that user co-creation is reconfiguring the

logic of brand loyalty generation - the traditional loyalty driving mechanism centered on product quality or price is gradually giving way to the deep psychological connection of emotional immersion and social recognition.

However, there is a significant paradox in corporate practice: although most multinational companies have already laid out user co-creation, only a small number of them have been able to effectively transform it into long-term loyalty. For example, LEGO's competitor Mattel's "Design by Me" program has a retention rate of less than 1/3 of LEGO's similar platforms due to a lack of community interaction and immediate feedback, suggesting that technology alone is not enough to activate loyalty behaviors, and that in-depth analysis of the psychological mechanisms of the user is needed. It is necessary to deeply analyze the psychological mechanism of users.

Based on the above background, this study will investigate the impact of user co-creation on LEGO brand loyalty and focus on testing the mediating effects of mindstream experience and community belonging in this process.

2. Preliminaries

2.1 User value co-creation and brand loyalty

Value Co-Creation Theory (VCT) advocates that value is not created unilaterally by the enterprise, but by the enterprise, consumers and other stakeholders through interaction. The core of the theory breaks through the traditional "enterprise-centered theory" and emphasizes that consumers are transformed from passive recipients to active participants, and that they collaborate with enterprises to create value in research and development, design, consumption and other aspects. In the 19th century, service economics proposed that "production and consumption need to cooperate", and in the 20th century, the consumer production theory was further expanded to consider that consumers participate in value creation through knowledge and skills. In the beginning of the 21st century, Schneider, P.A (2005) suggested that in order to improve customer satisfaction, value should be co-created by consumers and consumers should be involved in the design stage of products/services^[2]. Through empirical analysis, Jia Shuainan (2024) concluded that the practice of value co-creation is an important foundation for the formation of brand loyalty, i.e., high-quality value co-creation behaviors can have a positive impact on consumer brand loyalty^[3]. For example, LEGO through the LEGO Ideas platform to build an open ecology of co-creation, users can submit creative designs and participate in the voting, the excellent works of eventual commercialization, this "participatory design" to give the user "This kind of "participatory design" gives users the identity of "creators" and stimulates their sense of belonging and responsibility, which may directly enhance the recognition and loyalty to the brand. Therefore, this study proposes the hypothesis

H1: User value co-creation influences brand loyalty.

2.2 User value co-creation, mindstream experience and brand loyalty

The concept of mindstream experience was first proposed by psychologist Csikszentmihalyi (1975), who emphasized that when individuals are attracted by the activities they are engaged in, they will forget about the passage of time and not be affected by the things around them, and they will be fully immersed in the current affairs, and enter a kind of mindstream state. According to Xu Jianing (2023), the mindstream experience is widely used in online environments, where consumers are able to generate pleasurable positive emotions in the state of mindstream, which are externalized into user's will and behaviors through the mechanism of psychological transformation^[4]. User behavior is further manifested as an autonomous expectation to co-create value with merchants, and empirical analysis confirms that the mind-flow experience can promote consumers' willingness to co-create value. Guo Shu (2024) in the field of tourism argued that the mindstream experience as a psychological state in which users feel happy and satisfied will stimulate value co-creation behaviors such as sharing and commenting, i.e., the mindstream experience has a positive impact on value co-creation^[5].

Therefore, this study proposes the following hypothesis:

H2: Heartstream experience plays a mediating role in the influence of users' value co-creation on brand loyalty.

2.3 User value co-creation, brand community belonging and brand loyalty

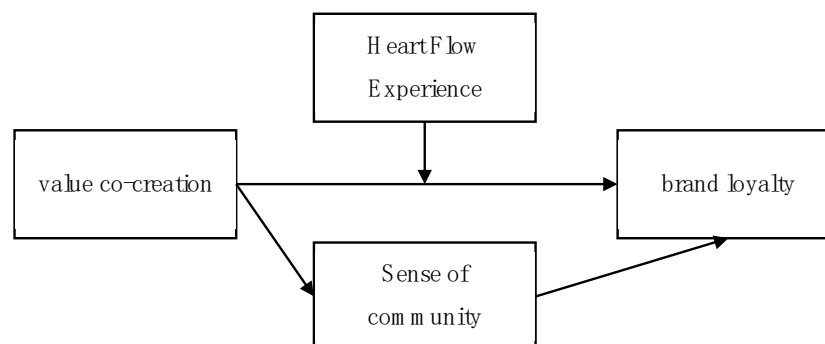
The concept of brand community was first proposed by Muniz and O'Guinn (2001), and defined it as a specialized community that breaks through geographic constraints based on a network of social relationships for co-branded consumption, where members are linked through a sense of sharing, ritual traditions and moral responsibility, and whose

core features are brand-centered, through social interactions (online or offline) The core features are brand-focused, through social interaction (online or offline), establishing member relationships and emphasizing identity and group belonging, for example, the Lululemon brand strengthens users' sense of belonging through the operation of yoga community to drive repurchase and word-of-mouth communication ^[6]. Scholars such as Algesheimer (2005) define brand community belonging as a state of psychological belonging formed by consumers in a brand community, which manifests itself as recognition of the identity of the community, emotional dependence and active participation behavior ^[7]. active participation behavior ^[7]. Through his research, Xu Mangmang found that the sense of belonging of virtual brand community members positively affects their brand loyalty, brand trust and brand commitment, i.e., the higher the sense of belonging of brand community members, the higher the loyalty to the brand ^[8]. According to Zhou Jianling (2020), users' participation in value co-creation (e.g., product feedback, content creation) significantly enhances brand cognitive preference and brand affective preference, i.e., the more a user participates in value co-creation actions, the higher the cognitive preference and affective preference for that brand ^[9]. Wu Si proposed that the behavior of user value co-creation, such as information exchange and social interaction, can significantly affect the user's willingness to publish and browse opinions through perceived ease of use and cognitive and emotional trust, i.e., it can add the user's understanding of the brand and, thus, generate cognitive and emotional preferences [10]. In the case of Xiaomi brand in China, we can see more that users through the Xiaomi online community user interaction (such as product improvement discussion, and get the recognition of Xiaomi company, according to the user's co-creation to improve the product) through the accumulation of trust, improve the community activity and the user's sense of belonging.

In summary, this study proposes the hypothesis,

H3: Community belonging plays a moderating role in the effect of user co-creation on brand loyalty

Fig 1. research model



3.The Proposed Scheme

3.1 Research Data

This study was conducted in April 2025 using the Chinese Internet questionnaire “Questionnaire Star”, targeting respondents who are interested in the topic of LEGO. 314 responses were collected. A total of 314 responses were collected, and after removing the 4 invalid samples that indicated they had no experience with LEGO, there were 310 valid samples remaining. 310 respondents were evenly balanced between males (150, 45.4%) and females (160, 51.6%). In terms of age, the largest number of respondents were aged 18-30 (125, 40.3%) and 31-45 (128, 41.3%). In terms of monthly income, \$3001-6000 was the most numerous, hitting 145 (46.8%). And the largest number of respondents indicated that they had recently followed LEGO-related content 2-5 times (149, 48.1%). The details are shown in Table 1.

Table 1. Demographics

		frequency	%	Effective percentage	Total percentage
genders	man	150	48.4	48.4	48.4
	women	160	51.6	51.6	100.0
age	18~30	125	40.3	40.3	40.3
	31~45	128	41.3	41.3	81.6
	46+	57	18.4	18.4	100.0

		frequency	%	Effective percentage	Total percentage
monthly salary	0-3000	67	21.6	21.6	21.6
	3001-6000	145	46.8	46.8	68.4
	6001-10000	68	21.9	21.9	90.3
	10000+	30	9.7	9.7	100.0
Number of Con- cerns	0-2	81	26.1	26.1	26.1
	2-5	149	48.1	48.1	74.2
	6-9	60	19.4	19.4	93.5
	10+	20	6.5	6.5	100.0

3.2 Operational Definition of Variables

The variables used in this study were reconstructed to suit the purpose of this study by reconstructing the criteria used in the previous study to suit the purpose of this study using a 5-point Likert scale (1 = Strongly Disagree, 3 = Moderately, and 5 = Strongly Agree), with the measurements for each of the components shown in Table 2 below.

Table 2. Variable definitions

Variable	Item	Source
User value co-creation	I would like to make suggestions for the development of LEGO's design etc. through online or offline platforms.	M.M. YAN. (2024) ^[11]
	I'll work with the LEGO design publisher.	
	I'll be responding to and helping other users with LEGO-related questions on all platforms.	
	I will post or participate in comments on various platforms to show my understanding of the staff's flawed service (poor service, etc.) due to certain reasons.	
	I will use various platforms to get the information I need to design Lego.	
	I will share my LEGO designs through various platforms, or encourage friends around me to participate in LEGO creation and share their experiences	
	I'll be watching for information on LEGO designs, ways to put LEGO together, etc. in various platforms.	
	I will respond to my needs through various platforms to LEGO staff, or publishers of information.	
Heart Flow Experience	I've been feeling suitably challenged by playing with Lego lately.	C.C. XU. (2023) ^[12]
	My mind/activity runs in a very flow and smooth way when I play with Lego lately.	
	I haven't noticed the passage of time while playing with Lego lately.	
	I haven't had trouble concentrating when playing with Lego lately.	
	Lately I've been playing with Lego's with my mind completely clear.	
	Lately when I play with Lego I'm completely focused on what I'm doing.	
	While playing with Lego lately I've been naturally having thoughts/actions about.	
	I know what to do every step of the way when I'm playing with Legos these days.	
	I was able to get the hang of it while playing with Lego recently.	
	I've been in deep thought lately while playing with Lego.	
Brand Community Belonging	I feel part of the LEGO community.	M.M. XU. (2012) ^[8]
	I'm honored to be a part of the LEGO Brand community.	
	I hope to always be able to communicate in the LEGO community.	
	I don't miss the opportunity to interact with other members if there's nothing special going on.	
	I would like to be actively involved in the LEGO community organization.	
	Members of the LEGO community often take my opinions seriously.	

Variable	Item	Source
brand loyalty	Next time I buy, I'll go for the LEGO brand.	M.M. XU. (2012) ^[8]
	I will buy other products or services from the LEGO brand if needed.	
	I would highly recommend the LEGO brand to others.	
	Even if the price of LEGO products goes up, I'm still willing to buy the brand.	
	I'm willing to pay a higher price for the Lego brand compared to other brands.	
	Members of the LEGO community will join me in discussing negative feelings about other competing brands' products.	
	I would express negative things to others about other competing brands' products.	

4. Results

4.1 Reliability of Measurements

In this study, exploratory factor analysis (EFA) was conducted using SPSS to validate the factor validity. The reliability of the questionnaire scales of User Value Co-creation, Heart Flow Experience, Brand Community Belonging and Brand Loyalty was measured by internal consistency. Table 3 shows the results of reliability analysis using Cronbach's alpha. According to the structure of the correlation theory, there are 31 entries consisting of 4 factors, and the total variance explained by these factors is 60.720%. The results of the reliability analysis of Cronbach's alpha: user value co-creation ($\alpha=.895$), mindstream experience ($\alpha=.913$), brand community belonging ($\alpha=.863$), interactivity ($\alpha=.886$), and brand loyalty ($\alpha=.928$). All constructs had Cronbach alpha values of 0.5 or higher, demonstrating high reliability.

Table 3. Factor Analysis Results

	Component				Communality
	1	2	3	4	
					.557
G1	.728				.587
G2	.749				.605
G3	.742				.595
G4	.743				.592
G5	.721				.583
G6	.734				.570
G7	.725				.574
G8	.734				.604
X1		.732			.518
X2		.677			.632
X3		.770			.607
X4		.759			.582
X5		.721			.545
X6		.697			.561
X7		.709			.575
X8		.720			.506
X9		.673			.550
X10		.699			.549
P1			.713		.600
P2			.735		.614

	Component				Communality
P3			.762		.633
P4			.769		.607
P5			.745		.577
P6			.722		.724
Z1				.777	.738
Z2				.756	.657
Z3				.720	.702
Z4				.759	.674
Z5				.722	.701
Z6				.731	.700
Z7				.719	.557
Dispersion rate(%)	18.728	15.450	14.486	12.056	
Accumulation rate(%)	18.728	34.178	48.664	60.720	
Cronbach's Alpha	.895	.913	.863	.928	
KMO(kaiser-Meyer-Olkin)=0.946 Bartlett's Test of Sphericity=5264.933 Degrees of Freedom =465 Significance Probability = 0.000					

4.2 Hypothesis test

In order to test the hypotheses, a regression model was constructed by setting the dependent variable as brand loyalty and the independent variable as user value co-creation. As shown in Table 4, the t-value of user value co-creation on brand loyalty is 9.300 ($p=.000$), which is statistically significant, therefore, the main effect of this study, i.e., hypothesis 1 is valid. In the regression model, the F-value is 86.489, $p=.000$, which is statistically significant. The r-squared coefficient of the regression equation was .219, which explained 21.9% of the total variation. This study confirms that user value co-creation has a positive and significant effect on brand loyalty.

Table 4. Main effects test

Model B		Unstandardized Coefficient		Standardized Coefficient	t	p-value
		Standard Error	β			
1	constant	1.269	.258		4.925	.000
	G	.598	.064	.468	9.300	.000
R=.468 R-Squared (R^2)=.219 Modified R-squared=.217 Durbin-Watson=2.190 F=86.489 $p=0.000$						

implicit variable: brand loyalty

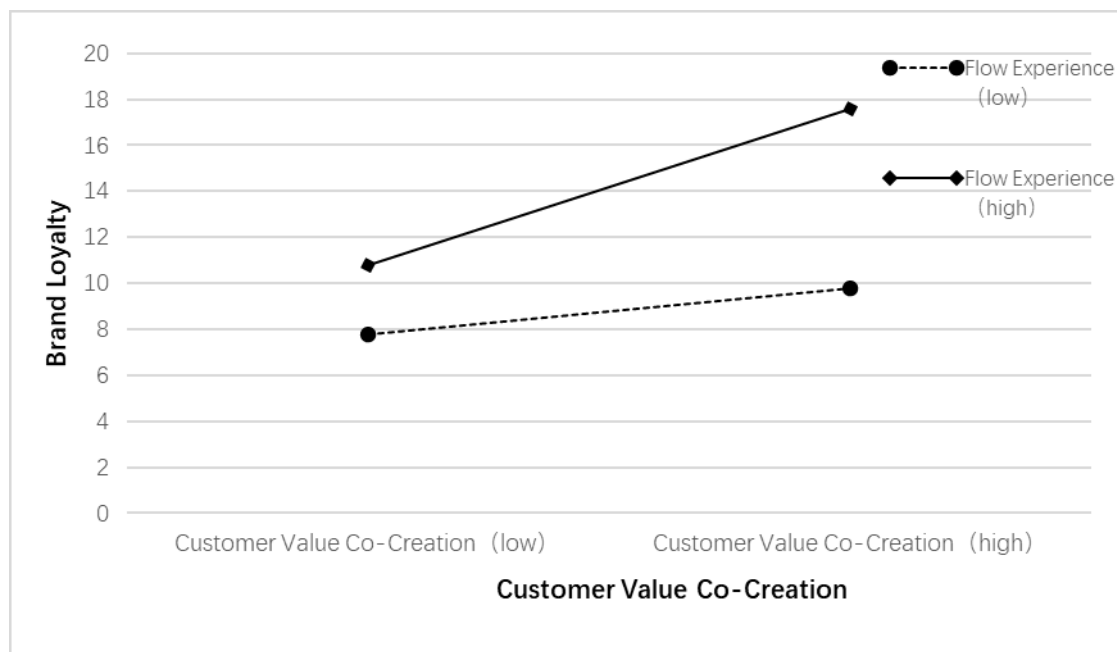
Next, in order to explore the moderating effect of heartflow experience, SPSS Process Macro (Model 1) was used for the analysis. As shown in Table 5, the results of the analysis show that the heartflow experience plays a moderating role in the effect of user value co-creation on brand loyalty, and Hypothesis 2 is adopted. As shown in Fig.2, user value co-creation can increase brand loyalty more significantly at high levels of heartflow experience.

Table 5. A test of the moderating effect of the mind-flow experience

Variable	B	β	t-value
User value co-creation	.598	.468	4.925***
Heart Flow Experience	.768	.565	12.017***
User Value Co-Creation* Heart Flow Experience	.134	.641	14.659***

<.05, *<.01

Fig 2. Moderating effects of the heart flow experience



In order to verify how community belonging mediates the effect of user value co-creation on brand loyalty, this study analyzed the relevant data using SPSS Process Macro (Model 4). The results are shown in Table 6. The results show that the [LLCI, ULCI] of the direct, mediated, and total effects do not contain zero, i.e., brand community belonging plays a partially mediating role in the influence of user value co-creation on brand loyalty, which is statistically significant.

Table 5. A test of the mediating effect of brand community belonging

Effect	B	SE	95%CI		Effect in %
			LLCI	ULCI	
Direct effect	.4808	.0603	.3622	.5994	80.43
Indirect effect	.1170	.0341	.0539	.1865	19.57
Total effect	.5978	.0643	.4713	.7243	100.00

5. Conclusions

Taking LEGO brand as the empirical object, this study systematically explores the mechanism of user value co-creation on brand loyalty, and reveals the moderating role of mind-flow experience and the mediating path of community belonging. The main findings are as follows:

5.1 The direct drive of user value co-creation on brand loyalty

The data analysis shows that LEGO users' participation in value co-creation (e.g., product design, content generation, etc.) significantly enhances their loyalty to the brand, which verifies the applicability of the theory of value co-creation in the field of physical products. This result is consistent with the "co-creation of value" proposed by Prahalad and Ramaswamy (2004),

which suggests that user participation not only enhances brand identity, but also strengthens long-term loyalty behaviors through emotional connection ^[13].

5.2 The moderating role of mindstream experience: the reinforcing effect of immersive participation

Mindstream experience plays a significant positive moderating role between value co-creation and brand loyalty. When users enter a “mindstream state” during the co-creation process (e.g., building challenges and skill matching, instant feedback mechanisms), their engagement and enjoyment will further amplify the effect of brand loyalty. This finding extends Csikszentmihalyi’s (1990) theory of mindstream, which emphasizes that companies need to optimize the user immersion experience through task design and interaction mechanisms ^[14].

5.3 The mediating path of community belonging: an emotional bond from co-creation to loyalty

Community belonging assumes a partially mediating role between value co-creation and brand loyalty, suggesting that users strengthen their sense of belonging to the LEGO fan community through co-creation behaviors, which translates into loyalty to the brand. This echoes McAlexander et al.’s (2002) brand community theory, which reveals the transmission logic of the “user-community-brand” triad ^[15].

Through the analysis of the results, LEGO and other companies can enhance user loyalty by opening up co-creation platforms (e.g., LEGO Ideas), designing step-by-step challenge tasks (to stimulate the flow of mind), and strengthening community interactions (e.g., offline fan festivals). It is recommended that brand managers incorporate “mindstream experience design” into the user co-creation process, e.g., through gamification mechanisms to balance the difficulty of the tasks with the ability of the users.

This study focuses on the adult population, and there is a selective bias in the sample coverage. In the future, we can compare the differences between regular consumers and heavy users, or include LEGO communities from other cultures (e.g., Asian markets). Brand loyalty may be influenced by product scarcity (e.g., LEGO limited edition models) or premium prices in the secondary market. It is recommended that subsequent studies introduce control variables (e.g., collecting motivation, resale behavior) to strip away the purely emotional loyalty effect.

Funding

no

Conflict of Interests

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 Tolerance of Privacy Leakage Among Consumers in Offline Retail Shopping Scenarios

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Abstract: With the continuous combination of artificial intelligence technology and the field of security, intelligent security is gradually popularized in offline retail scenes. While helping merchants to obtain and analyze consumer data and bringing certain consumption convenience to consumers, it also brings practical problems of privacy leakage. The CCTV 315 gala revealed the use of AI technology to obtain users' privacy information, helping consumers truly realize that they still need to protect their privacy information in the offline retail scene. By investigating the tolerance of privacy leakage in consumers' offline retail shopping scenarios, this paper hopes to explore how to better build a shopping environment between consumers and offline retail stores. After integrating the sensitivity of consumers' information type, the sensitivity of information receiving, information use sensitivity and related privacy theory, this paper developed and designed a third-order seventh scale. We collected data through questionnaire survey method, a total of 237 questionnaires were collected, and used to analyze the data and reliability test with SPSS software. The analysis proves that most consumers do not have a high tolerance for privacy leakage. Although there are differences between personalities, there is a centralized trend. Finally, this paper further reflects on how to build a better shopping environment and consumer experience of offline stores.

Keywords: Privacy Leakage; Consumer; Artificial Intelligence; Attitude Measurement

Published: Apr 24, 2025

DOI: <https://doi.org/10.62177/apemr.v2i2.246>

1.Introduction

1.1 Research Background

With the increasing popularity of artificial intelligence technology in the field of intelligent security, video surveillance has successfully broken through the boundaries of basic security functions, and more visual management and applications will become a reality. Traditional security focus on “see, see clearly”, and has artificial intelligence technology blessing intelligence security, video monitoring positioning in how differentiation on the application, embodied in the matter, to advance analysis, these a series of intelligent security application of the ground, in increase convenience and commercial interests at the same time, also brought some privacy problems.3152021 party revealed Kohler bathroom, good shop, the morning stationery offline retailers for installed the Suzhou store palm network technology co., LTD., for information technology co., LTD., on the premise of consumers unaware, captured more than 3 million customer face information, and

add labels to these consumers, in order to achieve the purpose of accurate marketing. Wandian palm “stealing” customers’ facial information, location information and other privacy behavior exposure, caused great panic and anger from all walks of life, as well as concerns about the security of personal privacy information. A group of offline retailers, led by Miniso and Xicha, were found to use such “cameras” to steal customers’ privacy information, such as facial information and location information, and the use is very common.

At present, there are many studies on the privacy protection of online Internet shopping, Volkswagen seems to think that online shopping involves information technology, In this, businesses and other personnel to obtain facial privacy information and other data; But in fact, in the offline retail scenario, Businesses are also using cameras like Wan, Constantly use AI technology to obtain people’s facial information, location information and other privacy during offline shopping, This paper hopes to discuss the issue of “tolerance of privacy leakage” in the attitude level of privacy concerns in the offline retail shopping scenario, To explore how to better build a better consumption environment between consumers and offline retail stores.

1.2 Research Questions and Significance

Current market demand oriented sales model, make enterprises pay more attention to consumer actual needs, at the same time with the increasingly widespread application of artificial intelligence technology, the improvement of cloud computing and the popularization of application, and the mature data mining technology, are related to obtain and analyze user data, understand the user preferences provides possible. For enterprises, collecting and analyzing user data can be used to analyze the market and study consumers, so as to fully tap the needs of consumers and obtain greater profits. However, the amount of information and data collected by users is not the better, on the one hand, when analyzing the huge amount of data, there may be insufficient analysis and high cost of daily maintenance; on the other hand, it also brings the risk of consumer satisfaction, moral and legal risks. Once the behavior of obtaining consumer privacy information is exposed, the trust of consumers in the corresponding enterprises will be greatly reduced. Faced with such a complex situation, the author tries to explore how to better build a shopping environment between consumers and offline retail stores by understanding the attitude of consumers about the tolerance of privacy leakage in the offline physical shopping scene.

For consumers, providing private information can be a double-edged sword. On the one hand, consumers may unknowingly disclose the privacy information they care about, causing the loss of their property or reputation; On the other hand, consumers may be willing to obtain some convenience through some privacy that individuals think is less important. But then it will bring new problems. For most consumers, which privacy information can be obtained by merchants in exchange for a certain extent of convenience, which privacy is their intention and is not allowed to be obtained by merchants, the author needs to explore this boundary, so as to build a harmonious and win-win shopping environment.

1.3 Study Methods

In order to solve the problems described above, the author tries to integrate quantitative analysis and qualitative analysis. Through sorting out relevant literature and the method of issuing questionnaires, the research is conducted according to the following methods and steps:

- (1) Define the research objectives. By clarifying the privacy leakage incidents, understanding the public’s concerns about privacy, and sorting out relevant literature, we can understand the current situation of privacy leakage in the offline physical shopping scene, as well as people’s views on AI’s behavior of obtaining face privacy, and then determine the research target and build the corresponding framework.
- (2) Determine the research methods. In view of the empirical research ideas and research risk tolerance methods, the author determines the methods of sorting out documents and issuing questionnaires.
- (3) Refer to theoretical models, develop scales, and design questionnaires. Through sorting out the relevant literature, the author decided to draw on Adams ‘theory, and developed a scale and designed a questionnaire according to the author’s practical research problems.
- (4) Questionnaire “probe trap” setting. The author considering the respondents may not patience to fill in the questionnaire, and research time urgent cannot test the actual situation of the questionnaire, the author designed the basic logical idea in the

questionnaire, namely “probe trap” problem, later by screening the two questions, and screen out the effective questionnaire.

(5) Issuing questionnaires. The author generated the questionnaire through the questionnaire star, and distributed the questionnaire through the online social media. After screening out the invalid questionnaire, the valid questionnaire was analyzed and processed.

(6) Data analysis. After receiving the valid questionnaire, after the basic chart analysis of the questionnaire, the author used SPSS to further analyze the correlation and significance of the data, and verified the quality of the questionnaire by checking the reliability.

(7) Research conclusions and reflection. By discussing the analysis results, we speculate the causes behind the results, and combine the analysis results with how to build a good offline shopping platform.

2.literature review

What is privacy? Everyone has a very different understanding of privacy. The discussion of privacy is involved in law, sociology and other disciplines (Chiung-wen (Julia) Hsu, 2006). At the legal level, privacy is vary (Lior Jacob Strahilevitz, 2005). Therefore, in the vast majority of cases, the law is not important to those who infringe. Sociology, however, believes that privacy is determined by the accidental law in the functional differentiation of the social communication system (Katayoun Baghai, 2012). In addition, many scholars have produced different views. For example, privacy is the theory of personal space or area that invades others and invades them (Herman T. Tavani, 2007). Privacy is your “right to be alone” (Warren and Brandeis, 1890). Privacy is the “reservation” (Westin, 1968) and so on. As a result, there has not been a unified concept of privacy.

However, with the advent of the Internet era, the amount of information suddenly increased and people’s information communication became more frequent. The attention to personal privacy has also become an increasing topic of discussion. Many people consider it necessary to sacrifice their privacy for the convenience of living in the Internet age (Gandy, 1993). Therefore, it can be considered that in the Internet era, due to people’s different understanding of information and the diversification of information presentation methods, people’s attention to privacy in the Internet era is different from the privacy in the traditional sense (Kim Bartel Sheehan, 2002). Alan Westin Under the theoretical system based on traditional privacy concerns, people’s concerns about privacy in the Internet era are divided into three categories (FTC, 1996). One is the behavior that affects their privacy in the Internet age, the other is not concerned about it, and the last one depends on the circumstances. In this study, the difference factors of people’s attention to privacy are respectively explained through four aspects: personal belief, attitude, behavior intention and actual behavior.

2.1Personal Beliefs

In terms of personal beliefs, Tamara Dinev concerns that there will be some differences in personal beliefs about government monitoring. Some people think that the government needs more opportunities to obtain relevant information, while some people are worried about government monitoring (Tamara Dinev, Paul Harta & Michael R. Mullen, 2008). Yuan Li Found that the tendency of personal beliefs on privacy has a positive impact on both online privacy concerns and website privacy concerns, and focusing on website privacy concerns is an important indicator to predict the personal disclosure of relevant personal information on the Internet (YuanLi, 2014).

2.2 Attitude

On the level of privacy attitudes, Prashanth Rajiva found that discussions to protect privacy raised concerns when choosing mobile apps (Prashanth Rajivan & Jean Camp, 2016). Govani In users’ attitudes towards Facebook services and privacy settings, it is found that even though people understand Facebook-related privacy issues and available privacy settings, most users have not changed their attitudes towards Facebook (Govani & Pashley, 2005).

2.3 Behavioral intention

In the behavioral intention about privacy, the Hongwei Yang online survey of American college students shows that those whose privacy is somehow violated on the Internet will enhance their intention to forge personal information or refuse to provide personal information (Hongwei Yang, 2012). However, in the research on the privacy concerns of chatbots and mobile advertising, it is found that people’s attitude towards mobile advertising does not directly affect the behavior intention

of using chatbots, which is determined by people's attitude towards chatbots (Lucrezia Maria de Cosmo, Luigi Piper & Arianna Di Vittorio, 2021).

2.4 Actual behavior

In the study of people's privacy preferences and actual behavior of shopping robots, it is found that even if they pay attention to their privacy in the communication of shopping robots, they will not take practical action (Sarah Spiekermann, Jens Grossklags & Bettina Berendt, 2001). In addition, other studies have found that even if people know the importance of privacy, when they start to interact online, they often ignore their privacy and do not regulate their actual behavior (Bettina Berendt, Oliver Gunther & Sarah Spiekermann, 2005).

Today, the concept of risk tolerance, used in business, has gradually been introduced as a perspective to measure individual attitudes towards privacy. Hallahan T et al. believe that the evaluation criteria of privacy leakage tolerance are similar to the risk tolerance (Hallahan T.A, Faff R.W & McKenzie M.D, 2004), and that the measurement in the form of questionnaire scale is completely effective. Liang used risk tolerance in information behavior research (Liang H & Xue Y, 2009), which found that users' tolerance of information security risks and their perception of information threat had negative effects. Taken together the results suggest that the applicability of the questionnaire scale of tolerance for relevant measures of privacy attitudes.

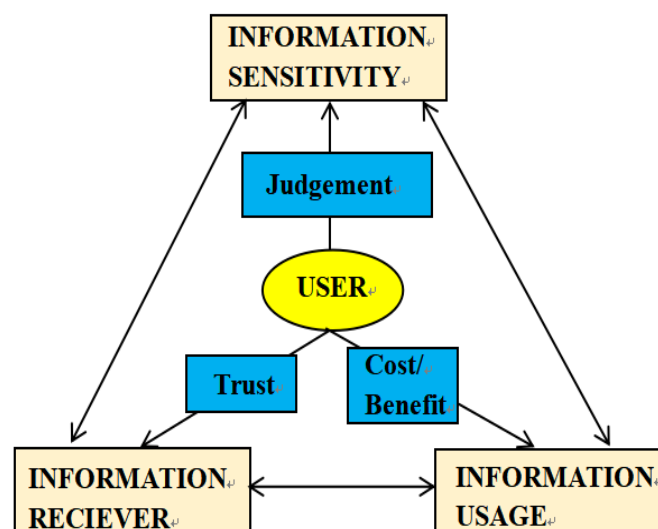
3.Theoretical principle

3.1 Theoretical framework

In fact, as early as the beginning of the 21st century, Adamas, Berrotti, Davis and other scholars have explored and studied the privacy protection under the background of multimedia communication, while Admas has proposed a specific privacy model based on multimedia communication. She points out that the core concept of the privacy model is that the plot of privacy invasion and privacy invasion (the conceptualization of the descriptive narrative of privacy invasion) is actually a privacy invasion cycle. When most privacy violations occur when the user is aware of them, the user's cognition and the reality are not matched and not coordinated.

Based on the above core views, Admas proposed a privacy model framework from the perspective of three privacy factors, namely, information sensitivity (ISS), receiver sensitivity (ICS) and use sensitivity (IUS). These three factors interact to make users form their overall perception of privacy. Therefore, in different research backgrounds, the relationship of the three factors is specific, and researchers need to weigh these factors and make some assumptions appropriately, such as assuming that users can accept some privacy risks. Then the specific privacy framework is shown in Figure 1 below:

Figure 1 The Adams privacy model framework



3.2 Study model

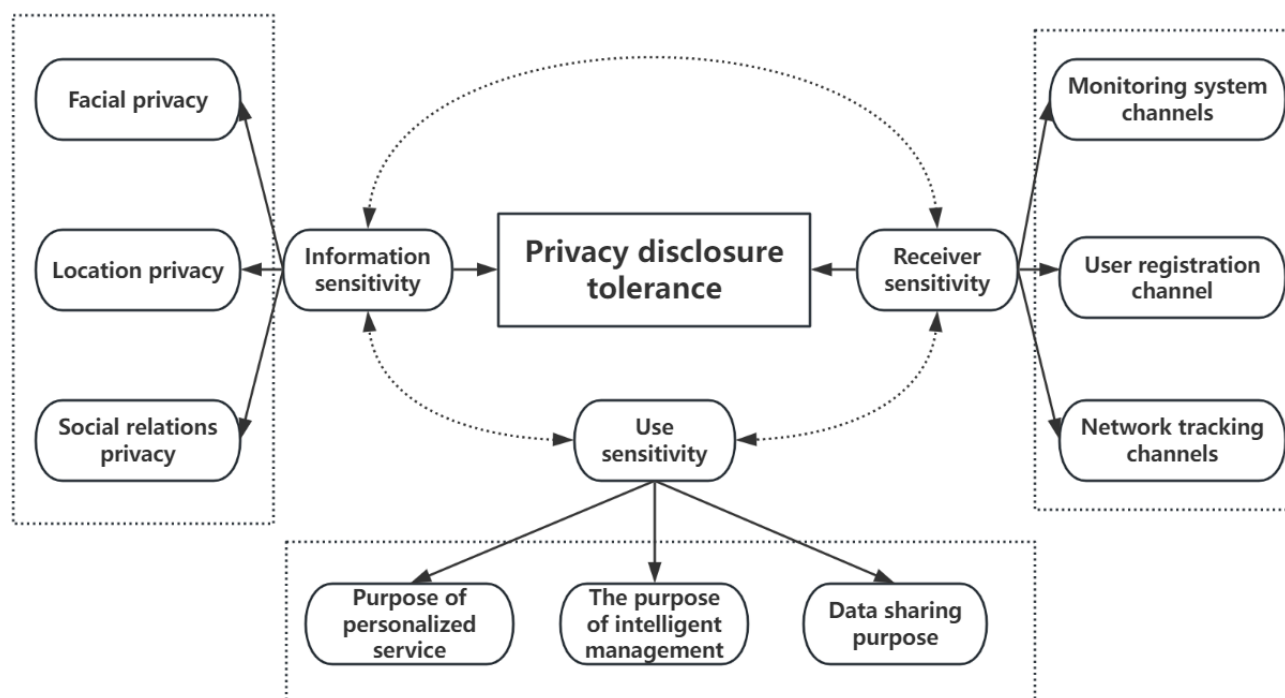
With the continuous popularization and application of Adams' theoretical framework on multimedia privacy in the field of privacy research, Li Rui and other scholars proposed a research model based on Admas theoretical framework in their own

related privacy research papers. For example, Li Rui introduced his own model in the empirical investigation of the tolerance of privacy leakage of big data in libraries. The model framework is determined from three aspects: information sensitivity (ISS), receiver sensitivity (ICS), and the use of sensitivity (IUS). Li Rui regards these three aspects as three dimensions, and then in the dimension perspective, he designed the research structure model of “second order, third factors, first order and 12 factors” for the tolerance of library big data privacy leakage.

The author’s privacy leakage tolerance investigation model for the offline retail scene is based on the library big data model proposed by Li Rui, and designed as a model specifically for the offline retail scene. The author also starts from the three dimensions of information sensitivity (ISS), receiver sensitivity (ICS) and use sensitivity (IUS), and each specific dimension is subdivided into three indicators. Information type sensitivity refers to the perception and judgment of individual sensitivity to different types of information, which is used to define the content and type of personal privacy that the user allows to disclose; the information reception sensitivity refers to the perception of individual sensitivity to the information collection channel and the tolerance of the information collection channel and method; the information sensitivity refers to the perception of the individual’s sensitivity to how the privacy and the acceptable purpose, scope and degree of the use of personal privacy information.

In this way, the author generates the privacy leakage tolerance investigation model of offline retail scenarios with exclusive “second order and third dimension, first order and ninth index”. The model diagram is shown in Figure 2 below:

Figure 2 Research model of offline retail scenario



After clarifying the theoretical framework and research model of the author’s research, the nine questions in the model are subdivided into four questions for each index, and the specific privacy leakage tolerance questionnaire question is designed.

3.3 Variables and scales

For the questionnaire design, the relevant scales must be needed as the support of the questionnaire design. Therefore, starting from the research model, the author designs the corresponding questionnaire questions under the nine indicators to form the questionnaire measurement scale. As a questionnaire variable, in the first part, the variables were the demographic indicators. That is, the gender, age, education level and occupation of the respondent. The second part is based on nine indicators under three dimensions, including facial privacy (FP) under information sensitivity (ISS), Location privacy (LP), Social relations privacy (SP); monitoring system channel (MSC) under receiver sensitivity (ICS), user registration channel (URC), network tracking channel (NTC); personalized service purpose (PSP) under using sensitivity (IUS), intelligent management purpose (IMP), and data sharing purpose (DSP). The specific scale is shown in Table 1 below :

Table 1 Privacy leakage tolerance questionnaire scale in offline retail scenarios

Research topic	Second order	First order	Measure the project	Contents of a project
Research on the tolerance of consumer privacy leakage in the offline retail shopping scenario	Information-type sensitivity(ISS)	facial privacy (FP)	FP1	I can accept the offline retail stores to take my avatar
			FP2	I can accept the offline retail store records and analyze my facial information
			FP3	I can accept offline retail stores disclosing my facial features
		Location privacy (LP)	LP1	I think the offline retail store can record my visits
			LP2	I can tolerate offline retail stores leaking the areas I often to in the store
			LP3	I can accept offline retail stores storing my phone or WeChat ID
		Social relations privacy(SP)	SP1	I can accept offline retail store users to know my family staff when registering
			SP2	I can tolerate offline retail stores leaking my personal real social relationship information
			SP3	I can accept the offline retail stores to browse and analyze my online friends circle
	under receiver sensitivity(ICS)	monitoring system channel (MSC)	MSC1	I can accept the installation of multiple monitoring devices in the offline retail stores
			MSC2	I can accept recording and viewing my activity in the offline retail store
			MSC3	I can tolerate offline retail stores to monitor my shopping behavior through access control sensing devices
		user registration channel (URC)	URC1	I can accept offline retail stores to collect personal information through user registration
			URC2	I can accept offline retail stores to analyze user registration information for certain purposes
			URC3	I can accept the offline retail stores to disclose my registration information
		network tracking channel (NTC)	NTC1	I can accept the offline retail stores to collect my online browsing information through the background
			NTC2	I can accept the offline retail stores to get the purchase records of my online purchases
	under using sensitivity (IUS)	personalized service purpose (PSP)	PSP1	I can accept offline retail stores to analyze my browsing records to develop personalized product recommendation services
			PSP2	I can tolerate offline retail stores sending messages through wechat official accounts or SMS in order to achieve personalized services
		intelligent management purpose (IMP)	IMP1	I can accept offline retail stores to store and analyze consumers' personal shopping information to realize intelligent management
			IMP2	I can accept offline retail stores to improve their shopping efficiency by monitoring consumer activities
			IMP3	I can tolerate offline retail stores to disclose consumers' personal information for the sake of daily business convenience
		data sharing purpose (DSP)	DSP1	I can accept offline retail stores sharing each other's consumer purchase records or purchase habits
			DSP2	I can accept offline retail stores to provide consumer information to third parties such as database providers for free or for compensation
			DSP3	I can accept offline retail stores to analyze and publish consumer information for product promotion

4.Data analysis

This section mainly describes the process of issuing the questionnaire, the planning and interpretation of the sample, and presents the results of demographic variables; and checks the reliability of the scale, which objectively evaluates the scale reliability by calculating Cronbach's Alpha. In terms of results, the scale has good reliability; and according to the situation, the data content obtained through the questionnaire generated by the scale can be returned to the research topic of "privacy leakage tolerance survey in offline retail shopping scenarios" and suitable for the measurement of privacy leakage tolerance in the topic.

4.1 Data collection and preprocessing

4.1.1 data collection

This analysis mainly adopts the way of network questionnaire data collection, mainly through the Internet social media tools to obtain convenient samples, such as QQ space, WeChat circle of friends and weibo and other social media tools on the questionnaire, relative to the traditional network questionnaire, through the Internet social media tools to collect data in sample randomness and sample source range has certain limitations, but through the channels of questionnaire collection due to social

The addition of the lines, It has relatively obvious advantages in terms of collection rate; And also retains the basic advantages of the network questionnaire survey — objective voluntary and anonymous protection; As the questionnaire was delivered through the social media, Therefore, the participants filled out the questionnaire based on voluntary reasons, There is no coercion or other reasons; Secondly, according to the relevant theory of the anonymous effect of P. C. Zimberdo, an American psychologist, When measured by the online questionnaire, As the subjects were in an anonymous state, In an "anonymous uniform," Can make the individual independence, autonomy is fully reflected, Therefore, the participants' views and attitudes are more similar to the real attitudes, The results avoid the interference of other external pressure or factors, Make the results more objective.

Due to time problem, the duration of the questionnaire survey from May 23,2021,17 points to May 25,2021,17, lasted 3 days, a total of 237 questionnaires, the overall collection efficiency is higher, it also thanks to the author using public social media tools to questionnaires, in social relations and social expectations, in social group people more active and voluntary fill in the questionnaire, and even willing to help further forward and share, sample size can snowball rapidly, so as to achieve the expectations of the sample size.

4.2.2 data preprocessing

Although the total amount recovered reached the author's expectation, the author excluded 57 invalid questionnaires after questionnaire screening, and the final number of questionnaires was 180. In addition to the obvious perfunctory filling in, the most important basis is the "probe" problem designed by the author in the questionnaire. At the beginning of the questionnaire design, the author considered the possibility that the questionnaire was filled due to the lack of patience. Therefore, in order to test whether everyone was "consistent" and "not changing the original intention", the author set questions 23 and 32 of the questionnaire to test the probe. The 23rd question of the questionnaire is " I can accept the offline retail stores to analyze my browsing records to (AI technology) to carry out personalized product recommendation service.", And the 32nd question of the questionnaire is " I can accept merchants through my past browsing records to use AI technology to provide personalized services such as product customization and product recommendation.", It can be seen from the above statement that the two problems are actually expressing the same meaning, so for the subjects, the attitude towards the problem based on the same scenario should be the same or the gap is not large. The scale adopted by the author is 7-point Likert scale, so the author believes that if the difference between the measurement conclusion of the above two questions is greater than 2 points, then the author thinks that the questionnaire is invalid or low-quality questionnaire and should be excluded. Therefore, according to 180 valid questionnaires, the author described and analyzed the sample attributes of demographic variables, as shown in Table 2 below:

Table 2 Sample attribute distribution table

Survey indicators		Quantity	Frequency (%)
Gender	man	92	51.1
	woman	88	48.9
Age	Under the age of 18	7	3.9
	18-24 Years old	117	65.0
	25-34 Years old	38	21.1
	35-44 Years old	4	2.2
	Over 45 years old	14	7.8
Education level	High school and below	11	6.1
	junior college education	20	11.1
	undergraduate course	93	51.7
	Master / doctor	56	31.1
Occupation	Personnel of state government organs and public institutions	23	12.8
	Doctors, teachers and other professional technicians	18	10.0
	Private sector or self-employed labor company employees	45	25.0
	Business and services industry personnel	12	6.7
	soldier	2	1.1
	student	80	44.4
Monthly income	Below 3K	77	42.8
	3K-5K	35	19.4
	5K-8K	28	15.6
	8K-12K	21	11.7
	More than 12K	19	10.6

From table 2, the ratio of men and women to close to 1:1, basic, and the questionnaire subjects 86.1% is from 18-24 or 25-34 young adults, and the part is the mainstay of the current social line retail store consumer population today, so the distribution of the sample has certain representative, accord with the research needs and subject content.

4.2 Scale reliability check

In the above according to the relevant research model and theory form belongs to the author research topic research scale, the author also want to check and judge the indicators of the scale (item) can fit in the research topic, in other words, also hope that through reliability check to see if the questionnaire topic can accurately measure to the author wants to measure the variables. Therefore, the reliability check method is to observe the α -value size of Cronbach's Alpha to conduct the reliability

evaluation. Clone Bach coefficient is a commonly used reliability evaluation index in the social science research field, which overcomes the disadvantage of partial halving and measures the internal consistency of the scale by calculating the coefficient (α value); the larger α value, the higher the scale; since the deleted α value can be obtained by SPSS software, the author can update the scale according to the change of α value to improve the credibility of the scale. As shown in Table 3 below.

Table 3 reliability adjusted scale

Second order	First order	Measure the project	The correction was total correlated	α price	
Information-type sensitivity(ISS)	facial privacy (FP)	FP1	0.678	0.816	
		FP2	0.817		
		FP3	0.613		
	Location privacy (LP)	LP1	0.519	0.678	
		LP2	0.480		
		LP3	0.516		
	Social relations privacy(SP)	SP1	0.866	0.917	
		SP2	0.848		
		SP3	0.822		
under receiver sensitivity(ICS)	monitoring system channel (MSC)	MSC1	0.681	0.862	
		MSC2	0.770		
		MSC3	0.770		
	user registration channel (URC)	URC1	0.657	0.764	
		URC2	0.716		
		URC3	0.515		
	network tracking channel (NTC)	NTC1	0.738	0.843	
		NTC2	0.738		
under using sensitivity (IUS)	personalized service purpose (PSP)	0.672		0.804	
	intelligent management purpose (IMP)	0.672			
	data sharing purpose (DSP)	0.745		0.813	
Information-type sensitivity(ISS)	facial privacy (FP)	IMP3	0.788		
		IMP2	0.526		
	Location privacy (LP)	DSP1	0.658		0.860
		DSP2	0.833		
		DSP3	0.737		

As can be seen from Table 3, the total correction correlation of each measurement item of the scale is above 0.5, and the clonal Bach coefficient (α value) can reach about 0.8 in the second order dimension, and the general standard of social science research (α value above 0.7).

4.3 Data presentation

After the scale reliability test, the issuance and recovery of questionnaires, and the data pretreatment, The author presents the mean value and standard deviation of each dimension and index through SPSS software, We hope to find out the causes and practical significance behind it through data comparison, And outside of the scale, Measurement questions of consumer “behavioral variables” were added at the end of the questionnaire, And Pearson correlation between the behavioral variables and the dimensions, Observed with a significant positive correlation, The specific data contents are shown in Tables 4 and and 5 below, The analysis of the outliers observed in the data and the causes and practical significance will be further discussed in the subsequent subsections.

Table 4 Mean value, standard deviation

Second order	First order	Measure the project	Mean value	Standard deviation
ISS (1.89)	FP (1.88)	FP1	2.36	1.806
		FP2	1.87	1.364
		FP3	1.41	1.066
	LP (2.36)	LP1	3.04	2.065
		LP2	1.69	1.309
		LP3	2.37	1.560
	SP (1.42)	SP1	1.45	1.032
		SP2	1.29	0.887
		SP3	1.52	1.179
ICS (2.23)	MSC (2.87)	MSC1	3.61	2.155
		MSC2	2.25	1.880
		MSC3	2.76	1.962
	URC (1.96)	URC1	2.28	1.607
		URC2	2.24	1.623
		URC3	1.37	0.933
	NTC (1.86)	NTC1	1.71	1.331
		NTC2	2.00	1.575
IUS(2.17)	PSP (2.56)	PSP1	2.53	1.804
		PSP2	2.58	1.756
	IMP (2.27)	IMP1	2.71	1.844
		IMP2	2.52	1.735
		IMP3	1.58	1.228
	DSP (1.69)	DSP1	1.91	1.462
		DSP2	1.53	1.207
		DSP3	1.62	1.283

Table 5 Correlation measures of the behavioral variables

Second order	First order	Behavioral variables
ISS	FP	0.496**
	LP	0.600**
	SP	0.371**
ICS	MSC	0.645**
	URC	0.633**
	NTC	0.537**
IUS	PSP	0.612**
	IMP	0.647**
	DSP	0.508**

5. Results of discussion and reflection

5.1 Results for discussion

According to the overall analysis results, the author shows that consumers' tolerance of privacy leakage in offline retail scenes is relatively low. In fact, this is also in line with the phenomenon that people pay more attention to personal information privacy in today's society, which is within the expected range of the author. According to the figure above, the average value of the data is basically below 3 (disagree) in terms of dimension (ISS, ICS, IUS) or specific indicators (respectively), which shows that the overall attitude is a negative attitude.

From the ISS dimension, consumer tolerance for different information types are collected from low to high for social relations privacy, facial privacy, location privacy, and the gap between the indicators span is larger, so I know that consumers in offline shopping, for location privacy tolerance than other types of information, of course it also exists because the author of the preset scene itself is based on the "offline".

In terms of ICS dimension, the overall data of this dimension is higher than that measured in the other two dimensions, that is, compared with what channel the information is obtained, consumers are more concerned about what information it is obtained and how it is used by merchants. ICS dimension monitoring system channel (MSC) has a high mean in the questionnaire, find the reason, because consumers for indicators "receive offline installation monitoring system" high tolerance, also for businesses using the monitoring system record behavior tolerance is higher, it also shows that consumers can actually stand in the position of the businessman, in order to prevent theft or other reasons, even if may cause privacy, but due to certain legitimacy, also tolerate merchants put cameras for information.

In the measurement of the IUS dimension, very interesting phenomena are found. There are certain "double standards" for consumers about the use of information. Since the author adopts the method of seven measures, and the overall measurement is within 3, the author believes that in the data recovered this time, the mean value greater than 2.5 can be regarded as high, while the degree of about 1.5 is low. In IUS, from the above perspective, it can be found that the index PSP1.PSP2.IMP1.IMP2. has an obvious gap with IMP3.DSP2.DSP3; through reviewing the problems, it is not difficult to find that the use method with high consumer tolerance is nothing more than "personalized recommendation, improving shopping efficiency and intelligent management", and if the merchants use the information for sharing and analysis, the attitude of consumers will plummet. It also proves that consumers for privacy information use "double standard", consumers are willing to sacrifice some privacy information to improve their shopping experience and convenient degree, but not willing to merchants for merchants own sharing and management, embodies the "information collected from me this can only be used to serve me, not for" conservative attitude.

In addition, in addition to measuring the tolerance of consumer privacy leakage, in order to get more enlightenment, the

author designed the question of consumer behavior variables in the questionnaire in addition to the scale. Consumers are open to shopping after obtaining personal information, and the author also tries to ask some of the subjects

5.2 Reflection

Through the analysis of the above results, it is not difficult to find that consumers now have a negative attitude towards offline retail stores to obtain personal information, but it is not irrational “brainless unwilling”, just as the consumers have the tolerance of “monitoring system acquisition” generally, consumers sometimes think from the perspective of the business; from the perspective of beneficial or beneficial, so they are willing to sacrifice some personal information for greater benefit. Therefore, we can have the following reflections on how to build a good offline shopping environment.

5.2.1 For the consumers

(1) Improve consumers' tolerance for information acquisition. From the conclusion, the author learned that consumers' aversion to the monitoring system channel is not so strong, and they can obtain information through the monitoring system channel, and the author studied the original Background The “Wandian Palm” incident is also the use of AI camera to capture information, but it is still necessary to inform consumers in advance, so that consumers can feel respected and have the right to independent choice, so as to improve the perception of consumers.

(2) Let consumers feel that they have gained their dividends after collecting their own information, which will greatly improve the shopping experience. For example, consumers can only recommend and customize customized services, so that consumers can feel that their information is “profitable” after it is obtained, so that consumers will gradually relax the control of their own information, forming a virtuous cycle.

5.2.2 For businesses

In order to build a good shopping environment, merchants also want to do, remove the optimization, more is in the aspect of information use can have good norms, wanton use shall not be allowed and leak, according to the study, consumers most hate information use is personal information in the way to paid or free, so if businesses can do consumer personal information protection, consumers to have trust for merchants, thus forming merchants can obtain profits, consumers can enjoy more quality service of good cycle, help each other to build a good offline shopping environment.

Funding

no

Conflict of Interests

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

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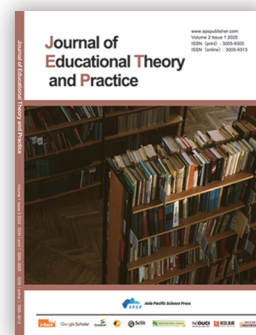
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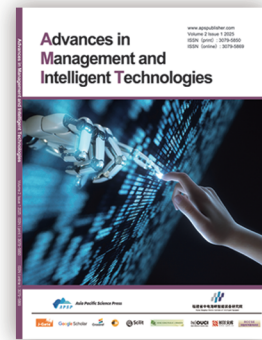
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