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Research on the Development of Supply Chain Finance in the Digital Age

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Abstract: The widespread application of new-generation information technologies has driven the continuous development of supply chain finance in terms of expanding the credit base, precise risk control, and diversifying financing channels. In response to this trend, the government has successively introduced a number of policies aimed at regulating, guiding, and supporting the healthy and orderly operation of supply chain finance. These policies include improving public data open platforms, optimizing the regulatory system, strengthening risk governance, accelerating the construction of exchanges, improving the unified registration and information disclosure system, and introducing relevant supporting policies. To further promote the high-quality development of supply chain finance, it is necessary to continuously improve the risk-control system, ensure the stable operation of the financial market, enhance financial governance capabilities, adapt to dynamic market changes, and improve the information disclosure mechanism to provide institutional support for the construction of the data credit system.

Keywords: Digitalization; Supply chain finance; Development

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1. Introduction

Supply chain finance is an important tool connecting financial capital and the real economy, and it is of great significance for stabilizing the industrial chain and smoothing the economic cycle [1]. Since 2017, the state has successively introduced policies to encourage the establishment of supply-chain-finance service platforms. The 2021 Government Work Report also proposed "innovating the service model of supply chain finance", highlighting its strategic position. Driven by information technology, supply chain finance helps to alleviate corporate financing constraints, strengthen upstream-downstream collaboration, enhance the resilience and operation efficiency of the supply chain, and contribute to the sustainable development of enterprises [2]. In reality, enterprises such as State Grid Yingda, Shandong High-Speed Group, and NIO have achieved positive results in promoting green transformation through supply chain finance. However, some enterprises, such as Chengxing International and

Yijian Shares, carried out financing through false transactions, exposing problems such as weak risk control. In 2024, regulatory authorities issued documents emphasizing that supply chain finance should return to its essence of serving the real economy and cracking down on false transactions. Therefore, it is urgent to deeply study the actual impact of supply chain finance on the sustainable development of enterprises and promote its standardized and healthy development.

2. Overview of the supply chain

2.1. Overview of supply chain finance

2.1.1. The connotation of supply chain finance

Supply chain finance is an innovative financing model that relies on core enterprises and is carried out for small and medium-sized enterprises upstream and downstream of them. This model helps financial institutions reduce risks and improve capital efficiency by optimizing and controlling the overall cash flow of the supply chain. In practice, it requires core enterprises to establish stable cooperative relationships with small and medium-sized enterprises, strengthen the assessment of the latter's credit and operating conditions, and conduct scientific analysis and value assessment of the entire supply-chain system.

On this basis, financial institutions can set financing limits based on real transactions. The repayment methods are flexible, such as installment repayment and equal-principal-and-interest repayment, to meet the capital needs of different enterprises. In addition, core enterprises should also assume the responsibilities of guidance and support, help small and medium-sized enterprises solve problems in terms of capital, management, and technology, and provide comprehensive and professional services to promote the sustainable development of the industrial chain.

In modern commerce, supply chain finance has become an important part of corporate strategic management, relying on the leading role of core enterprises. These enterprises play a dominant position in the market and maintain frequent business contacts with numerous suppliers and distributors. With the expansion of transaction scales and the increase in the complexity of the supply chain, the accuracy and real-time nature of information flow are particularly crucial. Therefore, it is of great importance to establish an efficient information system. This system can integrate data from all links of the supply chain and use technologies such as cloud computing and big data for intelligent analysis. Relying on these technologies, supply chain finance can provide diversified financial services, such as financing plans, insurance products, and risk-control tools, to meet the capital-flow and risk-management needs of enterprises.

2.1.2. The systematic characteristics of supply chain finance

One of the core characteristics of supply chain finance is its systematic nature. That is, starting from the entire supply chain, it runs through all links from procurement, production, logistics to sales, achieving full-process, closed-loop management. Through system integration and optimization, it not only improves operational efficiency, reduces transaction and financing costs, but also enhances enterprises' market responsiveness and competitiveness.

In addition, supply chain finance creates more opportunities for small and medium-sized enterprises to participate in market competition. Facing difficulties such as capital shortages and insufficient credit, small and medium-sized enterprises can obtain convenient financing relying on the credit and financial support of core enterprises and achieve stable development. It can be seen that supply chain finance is not only an innovation of financial tools but also an important force in promoting industrial collaboration and improving economic

efficiency.

To sum up, the development of supply chain finance integrates technological progress, management updates, and business-model reconstruction. By strengthening the information-sharing and collaboration mechanisms between core enterprises and their upstream and downstream, supply chain finance is gradually becoming a new driving force and innovation engine for promoting the high-quality development of the real economy.

3. New trends in the development of supply chain finance in the digital age

Supply chain finance in China originally originated from trade finance and logistics finance [3]. With the increasingly complex and in-depth development of the supply-chain system, in the process of integrating with the digital economy, supply chain finance has gradually shown significant new trends, such as the expansion of the credit base, precise risk control, and diversified financing channels. In the early stage, supply chain finance was mainly dominated by commercial banks, providing financing support around core enterprises and their upstream and downstream and undertaking corresponding risk-control functions. With the refinement of the division of labor and the application of digital technologies, supply chain finance has gradually expanded from serving bilateral transactions to multi-level suppliers, distributors, and even the entire industrial chain. In this process, core enterprises, with their control over transaction data and good credit qualifications, have become the hubs and credit bases of supply chain finance. The widespread application of new-generation information technologies such as the Internet of Things, big data, and blockchain in the financial field has further expanded the credit base, improved risk-control efficiency, and broadened financing channels, providing technical support for the innovation and efficient operation of supply chain finance [4].

3.1. The expansion of the credit base

In the traditional financial system, the credit base was mainly established on real-estate mortgages. With the development of trade, movable property gradually became an acceptable collateral, especially highly liquid commodities such as bulk energy and grain. Subsequently, equity-based assets such as accounts receivable and letters of credit were also included in the scope of pledges, enriching the means of credit support. At present, digital technologies are promoting the transformation of the credit base from “physical assets” to “data”:

(1) The Internet of Things technology: It enables real-time monitoring of goods, improves the transparency and security of logistics, and allows financial institutions to extend their financing targets to assets that are traditionally difficult to pledge, such as semi-finished products and parts, without relying solely on the realizable value of movable property.

(2) Blockchain technology: It enhances the credibility of transaction data and promotes the extension of accounts-receivable financing to multi-level suppliers.

(3) Big-data technology: It promotes the evolution of credit assessment from “asset-based credit” to “data-based credit”, giving rise to “instant-approval” financing products based on platform data, such as Huabei, Jiebei, and order-based loans, improving the financing availability and efficiency of small and medium-sized enterprises.

3.2. Precise risk-control measures

New-generation information technologies endow supply chain finance with efficient and low-cost risk-control

capabilities, which are reflected in the following three aspects:

(1) More efficient risk identification: The combination of big data and the Internet of Things enables the real-time collection and analysis of transaction and logistics data, effectively distinguishing between real financing needs and speculative financing [5].

(2) Timely risk prevention: Through intelligent monitoring systems, financial institutions can keep abreast of the operating conditions of enterprises in real-time and dynamically adjust credit-granting strategies, which is significantly better than the information-lagged model relying on manual review in the past.

(3) Scientific risk resolution: Cross-verification and dynamic monitoring can accurately identify the causes of defaults. For defaults caused by short-term liquidity shortages, financial institutions can assist enterprises in overcoming difficulties by optimizing the financing structure and broadening the sources of funds, achieving risk mitigation and resource reallocation.

3.3. Diverse capital channels

China's financing system has long been dominated by indirect financing, with the lagging development of direct financing. Information technology is gradually breaking this pattern [6]:

(1) Promoting the development of direct financing: For example, the bill market uses blockchain technology to quickly verify credit information, providing support for building a safe, transparent, and sustainable short-term financing channel.

(2) Breaking market barriers: Traditional financing markets are separated due to differences in risk preferences, sources of funds, and risk-control logics. With the popularization of big data, the risk-control logic is gradually shifting from "collateral-based" to "information-based", promoting market interconnection [7].

(3) Promoting the diversification of financing products: Information technology promotes the convergence of risk-control logics. Enterprises can flexibly select products that match their needs in a wider financing market, achieving the optimization of the financing structure and flexible management [8].

4. Suggestions for further improving supply chain finance policies

Supply chain finance policies revolve around "demand-supply-risk", aiming to standardize and promote its stable development by accelerating the construction of the financing market, improving the information-disclosure mechanism, and perfecting the risk-supervision system. The following are suggestions for further improving supply chain finance policies:

4.1. Improve the risk-control system to ensure the stable operation of the financial market

As the credit base extends from real estate and movable property to data credit, the financial boundaries become increasingly blurred, and the difficulty of risk control rises. To meet these challenges, the following suggestions are put forward:

(1) Diversify risk-control means: For different credit bases (such as real estate, movable property, and data), financial institutions are encouraged to adopt flexible and diverse risk-control mechanisms [9].

(2) Expand the scope of risk control: Shift the focus of risk control from a single market to multiple markets, and strengthen cross-market monitoring and data cross-verification.

(3) Improve the multi-party cooperation mechanism: Promote the construction of a cross-verification mechanism for business flow, logistics, and data flow to form a scientific and effective risk-control model.

4.2. Continuously enhance the governance ability of the financial market to adapt to market evolution

New technologies accelerate the transformation of financial institutions and also bring new changes in organizational models and risks. The government needs to enhance its governance capabilities:

(1) Adapt to the evolution trend of products: The boundaries of the financing market are becoming increasingly blurred, and traditional bank products are gradually moving closer to direct financing. Supervision needs to re-examine the "three-check" system and adjust the framework to adapt to the new business logic [10].

(2) Respond to the risks of new models: Supply-chain-finance platforms have given rise to new products. For example, although multi-level creditor's rights transfer based on blockchain technology improves efficiency, its potential risks emerge with a time lag. Regulatory authorities should pay close attention to the development of new businesses, promptly identify risks, and establish corresponding regulatory mechanisms.

4.3. Improve the information-disclosure mechanism to support the development of data credit

Effective information disclosure is the core support for promoting the development of supply chain finance. Therefore, the following suggestions are made:

(1) Promote the sharing of government data: In accordance with the Document, strengthen the information connection between the government, financial institutions, core enterprises, and third-party institutions, and clarify the scope and standards of information sharing [11].

(2) Improve the quality of information disclosure: Ensure the timely disclosure of information such as bill delinquencies and bond defaults to enhance the market's risk-warning ability [12].

(3) Promote the standardization of the bill market: Improve the interconnection level of platforms and market liquidity, improve the national capital-allocation efficiency, and enhance the risk-sharing ability.

To sum up, improving the risk-control system, strengthening market governance, and improving the information-disclosure mechanism will help supply chain finance achieve compliant innovation and high-quality development in the context of the digital economy [13]. The government should continue to promote policy improvement to support the steady progress of this field.

5. Conclusion

The integration of next-generation information technologies has become a key driver in the evolution of supply chain finance, contributing to the expansion of credit foundations, refinement of risk control mechanisms, and diversification of financing channels [14]. In response, the Chinese government has implemented a series of targeted policies aimed at fostering a regulated and sustainable development environment [15]. These measures—ranging from the establishment of public data platforms and optimization of regulatory frameworks to the enhancement of unified registration and disclosure systems—constitute a comprehensive institutional support system.

Despite these advancements, the pursuit of high-quality development in supply chain finance remains contingent upon addressing several structural challenges. It is imperative to strengthen risk management frameworks, improve financial market resilience, and enhance governance capabilities to better respond to an increasingly complex and dynamic market landscape. Furthermore, the development of a robust and transparent information disclosure mechanism is essential to underpin the construction of a credible data-based credit system.

Ultimately, the synergistic integration of technological innovation and institutional reform will be critical to unlocking the full potential of supply chain finance. Such coordinated efforts are expected to enable the sector to more effectively support the real economy, particularly by improving access to finance for small and medium-sized enterprises.

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The Role of Investor Protection on Corporate R&D

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Abstract: This study investigates the impact of investor protection on corporate R&D investment using panel data from Chinese A-share listed companies spanning 2015 to 2022. By employing OLS regression, mediation, and moderation analyses, the results demonstrate that robust investor protection mechanisms significantly enhance corporate R&D expenditures. The mediation analysis reveals that investor protection alleviates financing constraints and improves information disclosure quality, both of which serve as key channels for fostering R&D investment. Furthermore, internal control systems and media attention are identified as positive moderators, amplifying the beneficial effects of investor protection on R&D. In contrast, the equity Herfindahl index (HHI) does not exhibit a significant moderating role. The study also highlights that financial leverage, profitability, and equity concentration negatively influence R&D, while revenue growth exerts a positive effect. These findings underscore the critical role of investor protection in driving corporate innovation and sustainable growth, offering valuable insights for policymakers and corporate managers aiming to optimize R&D strategies through improved governance frameworks.

Keywords: Investor protection, Corporate R&D, Financing constraints, Information disclosure, Mediation effect, Moderating effect

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1. Introduction

In China's A-share market, investor protection mechanisms have multiple impacts on corporate R&D investment. As investor protection efforts increase, investors' confidence in the market grows, making them willing to provide funds to enterprises [1]. This broadens the financing channels for corporate R&D investment and solves the problem of R&D funding shortages. A sound investor protection mechanism can stabilize enterprises' expectations, prompting them to focus on long-term development strategies and increase R&D investment to enhance their core competitiveness. When enterprises know that their operations are properly supervised and investors' rights and interests are protected, it will be a strong motivation to invest in R&D innovation [2].

However, due to the characteristics of R&D activities, such as a long R&D cycle, high risk of failure, and results may not be presented in the current financial year, short-term focused indicators will be dragged down.

To cater to them, enterprises may cut R&D investment as R&D activities will negatively affect performance indicators in the short term. In addition, the compliance requirements related to investor protection have increased, and enterprises need to invest more resources in information disclosure, corporate governance improvement, etc., which increases operating costs and, to a certain extent, squeezes R&D funds. But in the long run, positive factors still dominate [3].

Based on these influences, this research plans to deeply explore the differences in the impact of different investor protection mechanisms on corporate R&D investment, to accurately optimize the investor protection system; study how to balance the short-term interests of investors and the long-term R&D investment needs of enterprises, build a reasonable incentive mechanism, guide investors to pay attention to the long-term development of enterprises, and encourage enterprises to increase R&D investment; analyze the relationship between investor protection mechanisms and corporate R&D investment in different industries, enterprise sizes, and development stages, to provide a basis for formulating differentiated policies.

2. Methods

2.1. Basic regression model

Based on the article's hypothesis 1, the investor protection role has a positive effect on the impact of corporate R&D, to test this hypothesis, this paper constructs the benchmark regression model as follows:

$$RDRatio\_ic_{it} = \alpha_0 + \alpha_1 \mathrm{InvProt}_{it} + \alpha_2 + \beta_2 Controls_{i,t} + Year_t + Ind_i + \varepsilon_{i,t} \quad (1)$$

Where, $RDRatio\_ic_{it}$ is the explanatory variable of this paper, and its meaning represents the ratio of R&D expenditures to current operating income. InvProt is the explanatory variable of this paper, which stands for the investor protection index. Meanwhile, the model selected in this paper is a two-way fixed effect model, *Year* represents year fixed effect, and *Ind* represents the industry fixed effect. $\varepsilon_{i,t}$ denotes the random perturbation term.

2.2. Mediation effects model

Based on the article's hypothesis 2, the investor protection index can alleviate the cost of debt financing, improve the quality of information disclosure, and then promote corporate R&D. This paper uses the three-step regression method of mediation effect, and constructs the mediation effect model as follows:

$$\mathrm{SA\ kv\_r}_{i,t} = \alpha_0 + \alpha_1 \mathrm{InvProt}_{it} + \alpha_2 + \beta_2 Controls_{i,t} + Year_t + Ind_i + \varepsilon_{i,t}\# \quad (2)$$

$$RDRatio\_ic_{it} = \alpha_0 + \alpha_1 \mathrm{InvProt}_{it} + \alpha_2 + \beta_2 Controls_{i,t} + + \beta_3 \mathrm{SA\ kv\_r}_{i,t_{i,t}} + Year_t + Ind_i + \varepsilon_{i,t}\# \quad (3)$$

Where, *SA,kv_r* denotes the degree of financing constraints and the quality of disclosure, respectively, is the mechanism variable of this paper indicates that the smaller the firm's financing constraints indicator, the weaker the financing constraints.

2.3. Moderated effects model

Moderating effects are changes in the relationship between the independent and dependent variables in a regression model due to the presence of one or more moderating variables [4]. When there is a moderating effect, the moderating variable changes the strength or direction of the relationship between the independent and dependent variables. Specifically, if the moderating variable has a significant effect on the relationship between

the independent and dependent variables, we call this a positive moderating effect or a negative moderating effect, depending on the direction in which the moderating variable affects the relationship.

When there is a moderating effect of the moderating variable, the coefficient estimation in the regression model should not only take into account the direct effect of the independent variable on the dependent variable, but also take into account the moderating effect of the moderating variable on this relationship. Therefore, this paper constructs the moderating effect model as follows:

$$RDRatio\_ic_{it} = \alpha_0 + \alpha_1 \mathrm{InvProt}_{it} + \alpha_2 + \beta_2 Controls_{i,t} + + \beta_3 \mathrm{W}_{i,t_{i,t}} + Year_t + Ind_i + \varepsilon_{i,t} \quad (4)$$

Where, W is the moderating variable, which in this paper is the internal control index (NK), media attention (Media), and the equity Herfindahl index (HHI).

3. Results

3.1. Variable selection and data sources

Table 1 shows description of variables in the research paper. It categorizes variables into Explanatory, Intermediary, Moderator, and Control types. It offers a logical structure that simplifies understanding the research framework. The use of consistent formatting enhances readability, ensuring even complex concepts are accessible.

Table 1. Description of variables

	VarName		
Explanatory variable	RDRatio_ic	R&D as a percentage	Ratio of R&D expenditures to current operating revenues
	InvProt		Investor Protection Index
Intermediary variable	SA	SA index	The larger the absolute value, the more severe the degree of financing constraints.
	kv_r	Quality of disclosure	KV index
Moderator variable	NK	internal control	Natural logarithm of the Dibble internal control index
	Media	Media attention	Total media coverage, plus one in natural logarithms)
	HHI	Equity Herfindahl Index	The sum of the squares of the shareholdings of the company's top 10 largest shareholders
Control variable	Size	Company size	Natural logarithm of total assets for the year
	Lev	financial leverage	Total liabilities at year-end divided by total assets at year-end
	ROA	Net profit margin on total assets	Net profit/average balance of total assets
	Cashflow	Cash flow levels	Net cash flows from operating activities divided by total assets
	FIXED	Fixed assets as a percentage	Ratio of net fixed assets to total assets
	Growth	Revenue growth rate	Current year's operating income/previous year's operating income - 1
	Indep	Proportion of independent directors	Independent directors divided by number of directors
	TOP1	Shareholding ratio of the largest shareholder	Number of shares held by the largest shareholder/total number of shares

In this paper, the listed companies selected from 2015–2022 as the initial sample data, and made three treatments: (1) exclude the financial category; (2) exclude ST and *ST companies; (3) exclude companies with more missing values. All company data in this paper comes from the Cathay Pacific (CSMAR) database and WIND data, and the basic characteristics of all variables are in **Table 2**.

Table 2. Descriptive statistical analysis of variables

Variable	N	Mean	SD	Min	p25	p50	p75	Max.
RDRatio ic	18300	0.0549	0.111	0	0.0206	0.0388	0.0616	8.954
RDRatio sz	18300	0.0259	0.0268	0	0.0103	0.0213	0.0336	1.455
InvProt	28400	55.68	4.530	31.48	52.86	55.78	58.68	74.43
SA	20100	3.900	0.259	2.094	3.745	3.905	4.070	5.690
kv r	20200	0.0951	0.160	0	0.0187	0.0441	0.106	3.513
NK	19500	6.458	0.162	4.749	6.421	6.488	6.537	6.847
Media	19300	4.979	0.994	1.386	4.331	4.820	5.451	11.85
HHI	20200	0.147	0.112	0.000900	0.0648	0.116	0.201	0.810
Size	20200	22.37	1.307	20.06	21.43	22.18	23.11	26.41
Lev	20200	0.424	0.200	0.0640	0.267	0.417	0.567	0.907
ROA	20200	0.0349	0.0734	-0.283	0.0118	0.0370	0.0700	0.228
Cashflow	20200	0.0492	0.0669	-0.149	0.0110	0.0475	0.0871	0.248
FIXED	20200	0.197	0.150	0.00180	0.0793	0.165	0.281	0.666
Growth	20200	0.151	0.367	-0.590	-0.0330	0.101	0.261	2.068
Indep	20200	0.379	0.0562	0.143	0.333	0.364	0.429	0.800
TOP1	20200	0.328	0.145	0.0826	0.216	0.303	0.421	0.726

3.2. Return to baseline

As shown in **Table 3**, this paper tests the effect of the role of investor protection on firms' R&D, with columns (1) and (2) showing the regression results controlling for year and industry fixed effects and control variables. Column (1), the explanatory variable is RDRatio_ic, and column (2), the explanatory variable is RDRatio_sz.

Table 3. Benchmark regression

	(1) RDRatio_ic	(2) RDRatio_sz
InvProt	0.0007***	0.0008***
	(0.000)	(0.000)
Size	-0.0001	-0.0023***
	(0.001)	(0.000)
Lev	-0.0812***	-0.0024**
	(0.007)	(0.001)
ROA	-0.1833***	0.0075

Table 3 (Continued)

	(1) RDRatio_ic	(2) RDRatio_sz
	(0.035)	(0.005)
Cashflow	-0.0678***	0.0105***
	(0.015)	(0.003)
FIXED	-0.0320***	-0.0118***
	(0.007)	(0.001)
Growth	0.0086	0.0032***
	(0.008)	(0.001)
Indep	-0.0022	-0.0031
	(0.012)	(0.003)
TOP1	-0.0080	-0.0020
	(0.008)	(0.001)
_cons	0.0709***	0.0358***
	(0.017)	(0.004)
Ind FE	Yes	Yes
Year FE	Yes	Yes
N	18341	18341
Adj. R^2	0.122	0.293

In both column (1) and column (2), the coefficient of ESG is significantly positive, indicating that the role of investor protection can promote corporate R&D, which verifies the hypothesis of this paper.1 From the point of view of the control variables, the financial leverage (LEV), the profitability of total assets (ROA), the level of cash flow (Cashflow), the level of fixed assets, and the level of fixed assets are the most important variables in this paper. level (Cashflow), fixed asset ratio (FIXED), and equity concentration (TOP) have a significant negative impact on corporate R&D investment, and the growth rate of operating income (GROWTH) has a significant positive impact.

3.3. Mechanism testing

3.3.1. Mediation effects analysis

As shown in **Table 4**, the investor protection role on improving the quality of disclosure, corporate R&D is significantly positively correlated at 1% level with positive 0.0456 and 0.0069, respectively. indicating that the quality of disclosure plays a mediating role. And corporate financing cost is significantly negatively correlated at 1% level with -0.0277 and -0.0062, respectively, indicating that the investor protection role effectively mitigates corporate debt financing cost verifying hypothesis 2 of this paper.

Table 4. Intermediation effects

	(1) SA kv_r	(2) RDRatio_ic	(3) RDRatio_sz
InvProt	0.0007***	0.0007***	0.0008***
	(0.000)	(0.000)	(0.000)
SA		-0.0277***	-0.0062***
		(0.005)	(0.001)
kv_r		0.0456***	0.0069***
		(0.008)	(0.001)
Size	-0.0001	0.0007	-0.0022***
	(0.001)	(0.001)	(0.000)
Lev	-0.0812***	-0.0762***	-0.0014
	(0.007)	(0.007)	(0.001)
ROA	-0.1833***	-0.1937***	0.0060
	(0.035)	(0.037)	(0.005)
Cashflow	-0.0678***	-0.0668***	0.0107***
	(0.015)	(0.015)	(0.003)
FIXED	-0.0320***	-0.0288***	-0.0114***
	(0.007)	(0.008)	(0.001)
Growth	0.0086	0.0069	0.0029***
	(0.008)	(0.008)	(0.001)
Indep	-0.0022	-0.0123	-0.0052*
	(0.012)	(0.013)	(0.003)
TOP1	-0.0080	-0.0182**	-0.0039***
	(0.008)	(0.007)	(0.001)
_cons	0.0709***	0.1581***	0.0582***
	(0.017)	(0.031)	(0.006)
Ind FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
N	18341	18333	18333
Adj. R^2	0.122	0.130	0.298

3.3.2. Moderating effects analysis

As shown in **Table 5** and **Figure 1**, the coefficients of the independent variables are all significantly positive at the 5% level and consistent with the sign of the main hypothesis, indicating that there is a significant moderating effect of the internal control index (NK) and media attention (Media).

Table 5. Regulatory effects

	(1) RDRatio_ic	(2) RDRatio_sz
InvProt	0.0017***	0.0011***
	(0.000)	(0.000)
NK	0.0573*	0.0221**
	(0.032)	(0.009)
Media	0.0803*	0.0286**
	(0.043)	(0.012)
HHI	0.9645	0.2709
	(0.787)	(0.256)
NK_Media	-0.0100	-0.0036*
	(0.007)	(0.002)
NK_HHI	-0.1233	-0.0334
	(0.119)	(0.039)
Media_HHI	-0.1552	-0.0562
	(0.166)	(0.052)
NK_Media_HHI	0.0186	0.0070
	(0.025)	(0.008)
SA	-0.0258***	-0.0073***
	(0.004)	(0.001)
kv_r	0.0482***	0.0060***
	(0.009)	(0.002)
Size	-0.0065***	-0.0052***
	(0.001)	(0.000)
Lev	-0.1014***	-0.0097***
	(0.007)	(0.001)
ROA	-0.2438***	-0.0031
	(0.045)	(0.006)
Cashflow	-0.0756***	0.0029
	(0.015)	(0.004)
FIXED	-0.0639***	-0.0229***
	(0.006)	(0.001)
Growth	0.0100	0.0036***
	(0.009)	(0.001)
Indep	-0.0032	0.0011
	(0.015)	(0.003)
TOP1	-0.0430***	-0.0183***
	(0.013)	(0.004)
_cons	-0.1636	-0.0435
	(0.214)	(0.061)
Ind FE	Yes	Yes
Year FE	Yes	Yes
N	17093	17093
Adj. R^2	0.079	0.119

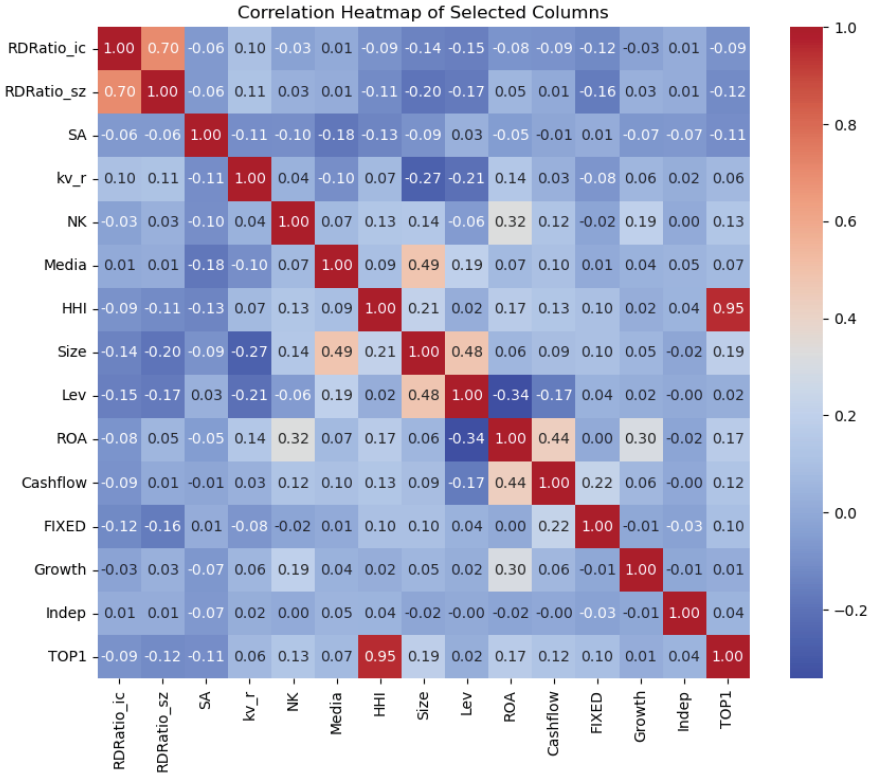

Figure 1. Correlation analysis

3.4. Correlation analysis

This paper carries out a simple correlation analysis of the data of the investor protection index, enterprise R & D, SA index, disclosure quality and other variables, the results are shown below, from which we can see the correlation coefficient between the variables, the larger the absolute value of this correlation coefficient indicates that the relationship between the two variables is closer, that is to say, the variables have a relatively high degree of correlation [6]. As a whole, the correlation coefficient of each variable is not close to -1 or 1, and the whole is within the range of -0.5 to 0.5, which indicates that the independence of each variable is good, and the possibility of negative impact on the subsequent regression analysis is small [7]. It shows that the data selected in this paper are reliable overall.

4. Discussion

Based on the data of all A-share listed companies in China from 2015 to 2022, this paper analyzes the impact of investor protection on corporate R&D by using the OLS method, and further explores its mediating and moderating effects [8]. The findings show that investor protection has a significant positive impact on corporate R&D and can effectively promote corporate R&D investment. This conclusion remains highly robust after considering various robustness tests, such as replacing the explanatory variables.

From the mechanism test, investor protection significantly enhances the R&D expenditure capacity of enterprises by reducing their financing constraints and improving the quality of information disclosure. Specifically, the mediation effect analysis of investor protection index and corporate financing constraints shows that the alleviation of financing constraints is significantly negatively correlated at the 1% level, indicating that

investor protection can effectively reduce the cost of debt financing for enterprises [9]. Meanwhile, the mediation effect analysis of disclosure quality shows that investor protection is significantly and positively correlated with disclosure quality at the 1% level, further validating the mediating role of disclosure quality between investor protection and corporate R&D.

The moderating effect analysis shows that internal control (NK) and media attention (Media) have a significant moderating effect on the relationship between investor protection and corporate R&D. Among them, the moderating effects of internal control index and media attention are significantly positive at the 5% level, indicating that investor protection promotes corporate R&D more significantly when internal control and media attention are high. However, the moderating effect of the equity Herfindahl index (HHI) is not significant, suggesting that the effect of equity concentration on corporate R&D may be more complex and requires further research.

In addition, this paper finds that financial leverage, profitability of total assets, cash flow level, fixed asset ratio, and equity concentration have a significant negative impact on a firm's R&D investment, while the growth rate of operating income has a significant positive impact [10]. These results indicate that a firm's financial position and governance structure have a significant impact on its R&D decisions.

5. Conclusion

In summary, the findings of this paper provide strong empirical support for investor protection in promoting corporate innovation and sustainable development. Strengthening investor protection not only enhances corporate governance but also strengthens firms' R&D capabilities by optimizing the financing environment and improving the quality of information disclosure. This finding has important implications for policymakers and corporate managers, and suggests that the investor protection system should be further improved in order to promote innovative investment and high-quality development of enterprises.

Disclosure statement

The authors declare no conflict of interest.

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Digital Transformation-Digital Economy and Business Innovation

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Abstract: The digital intelligence economy, driven by the dual wheels of digital industrialization and industrial digitalization, reconfigures the industrial ecosystem through intelligent technologies and data resources. Business innovation specifically relies on four types of practices: product intelligence, service wisdom, model ecology, and management intelligence, to revolutionize the value creation model. The two form a virtuous cycle of technology supply and innovative application, driving enterprises to complete digital transformation through the integration of intelligent technologies, process reengineering, precise marketing, and the construction of ecological platforms. However, they also face challenges such as data security, traffic barriers, and talent shortages, requiring the establishment of governance systems and training mechanisms to achieve sustainable development.

Keywords: Digital intelligence economy; Business innovation; Digital transformation

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1. Introduction

Recently, the "Digital China Development Report (2024)" was released at the 8th Digital China Summit, revealing the trend of coordinated advancement of digital industrialization and industrial digitalization [1]. The report indicates that in 2024, the added value of China's core digital economy industries will account for about 10% of the GDP, marking the digital economy as a significant pillar of the national economy. Against this backdrop, exploring the intrinsic connection and transformation paths between the digital intelligence economy and business innovation is of great significance for understanding the reconstruction of business models driven by technology.

2. Theoretical connotations and connections between digital intelligence economy and business innovation

2.1. The concept and characteristics of digital intelligence economy

The digital intelligence economy is an advanced form of the digital economy. On the basis of the digital economy,

which takes data as the core element, it emphasizes the deep integration of intelligent technologies such as artificial intelligence with the economic system. The digital economy framework consists of two core components (**Table 1**), which form a deeply integrated situation in the national economic system, demonstrating the internal driving logic of the penetration of technological elements into the industrial system-digital industrialization provides technical tools and infrastructure, while industrial digitalization realizes the application and value transformation of technology, jointly building a new economic form with data as the key production element and intelligent technology as the core driving force [2].

Table 1. Two core components of the digital economy framework

Core sector	Definition	Specific fields/ Manifestations	Role
Digital industrialization	Focuses on the development of the information industry itself	Basic telecommunications services, electronic manufacturing industry, software research and development and information technology services, internet economy, etc.	Constitutes the technical foundation and innovation source of the digital economy
Industrial digitalization	Uses information and communication technology (ICT) to empower and transform agriculture, industry, and service industries	Efficiency improvement and value creation generated by information and communication technology investment in various industrial fields (such as intelligent agriculture, industrial internet, smart service industry, etc.)	Realizes technology application and value transformation

2.2. The essence and types of business innovation

In the context of the digital intelligence economy, the core of business innovation lies in enterprises' systematic reconstruction of value creation mechanisms, value transmission paths, and value acquisition methods through the integration of intelligent technology systems and data resources, thereby building a differentiated competitive advantage. From a practical perspective, it can be divided into four types of innovation:

2.2.1. Intelligent product innovation

This is specifically manifested in the technological empowerment and functional iteration of physical products. For instance, Apple's Apple Watch, by integrating biosensors, wireless communication modules, and self-developed chips, has expanded the traditional watch's timekeeping function to health monitoring, sports management, mobile payment, and other diverse scenarios. Through real-time analysis of user physiological data by algorithm models, it achieves functional value addition, reconstructing the product definition and user experience paradigm of consumer electronics [3].

2.2.2. Intelligent service innovation

This is reflected in the transformation of service supply towards precision and personalization. For example, the online education platform Coursera uses machine learning technology to build a user learning behavior model, generating personalized learning paths based on data such as course browsing history and assignment completion status. Through an intelligent Q&A system and adaptive question banks, it realizes the dynamic matching of "teaching" and "learning", breaking the limitations of traditional standardized courses and forming a service innovation model oriented towards user needs.

2.2.3. Ecological innovation of business models

A typical representative of ecological innovation in business models is the construction of value networks by sharing economy platforms. Take Uber as an example. By integrating global driver and passenger resources and using location data and real-time supply and demand algorithms to build a two-sided market platform, it not only meets users' convenient travel needs but also provides income channels for idle transportation capacity. By integrating third-party resources such as map services, payment systems, and car rental, it forms a cross-domain collaborative business ecosystem, achieving value co-creation and co-evolution among multiple participants.

2.2.4. Intelligent management innovation

This innovation focuses on enhancing the operational efficiency of enterprises and organizational transformation. For instance, the intelligent management system developed by SAP integrates enterprise resource planning, supply chain management, and human resource management modules. It uses blockchain technology to achieve data traceability and process automation, and employs natural language processing technology to analyze business documents and generate decision-making suggestions. This promotes the transformation of enterprises from experience-driven hierarchical management to data-driven flat operation, demonstrating significant efficiency improvement effects in areas such as inventory optimization and supply chain collaboration [4].

2.3. The intrinsic link between digital intelligence economy and business innovation

The digital intelligence economy provides a multi-dimensional support system for business innovation: intelligent technologies such as cloud computing and the Internet of Things form the technological foundation for innovation, enabling enterprises to break through physical space limitations and achieve resource integration and real-time interaction; big data analysis technology endows enterprises with the ability to deeply understand user needs, market trends, and competitive landscapes, converting data assets into the basis for innovative decision-making; an open and collaborative digital ecosystem reduces innovation costs and trial-and-error risks, promoting the efficient flow of technology, capital, and talent. Meanwhile, business innovation practices serve as a significant driving force for the development of the digital intelligence economy: the demand for sensor accuracy and computing efficiency in the process of product intelligence drives research and development in areas such as chip manufacturing and edge computing; the massive application data generated in the process of service intelligence innovation provides training materials for the optimization of artificial intelligence algorithms, promoting the iterative upgrade of technologies such as natural language processing and computer vision; the demand for industrial integration brought about by the ecological innovation of business models prompts the improvement of infrastructure such as 5G and digital twins and the formulation of cross-industry standards.

3. The path and challenges of driving business innovation through digitalization and intelligence transformation

3.1. The core path of digitalization and intelligence transformation

3.1.1. Deep integration and application of intelligent technologies

Artificial intelligence, big data, the Internet of Things, and other technologies are deeply integrated into various operational links of enterprises, presenting multi-dimensional collaborative characteristics. In the manufacturing field, IoT sensors collect real-time equipment operation parameters, which are pre-processed through edge computing and then transmitted to the cloud data center via 5G networks. Combined with digital twin technology,

a virtual mirror of the production line is constructed to support dynamic optimization of process parameters and predictive maintenance of equipment. The big data analysis engine models historical production data to identify quality defect correlation factors, driving the upgrade of intelligent quality inspection systems. In supply chain management, blockchain technology is used to record logistics node data, and smart contracts automatically execute order settlements. Combined with demand forecasting models, safety stock levels are dynamically adjusted to shorten order fulfillment cycles. In customer service scenarios, natural language processing technology parses customer service dialogue texts, builds a knowledge base of customer intentions, and optimizes the multi-round dialogue logic of the intelligent customer service system. At the same time, service process data is fed back to the product design stage to form a closed loop of demand insight [5].

3.1.2. Intelligent redesign of business processes

Enterprises rely on intelligent technologies to deconstruct and reconstruct business processes, breaking down information silos in traditional hierarchical organizations. In the R&D and design stage, the collaborative platform integrates CAD design data, bill of materials, and process routes, and uses knowledge graph technology to establish parameter correlation models, enabling the automatic generation and compliance verification of design schemes. The production planning module accesses real-time production capacity data, order priority rules, and material inventory status, and uses heuristic algorithms to generate multi-objective optimization schedules, dynamically adjusting task allocation for each production line. The supply chain collaboration system synchronizes supplier production capacity, in-transit logistics information, and customer order changes in real time through API interfaces, triggering intelligent replenishment strategies and logistics route re-planning. In the financial settlement process, RPA robots automatically capture invoice images, and after key information is recognized by OCR technology, it is matched with purchase orders. Abnormal data is pushed to financial personnel for manual verification, forming an automated process system that is mainly handled by machines with human intervention as a supplement.

3.2. Implementation methods of business innovation in digital and intelligent transformation

3.2.1. Precise marketing and service based on intelligent data

The data-driven demand insight system realizes value transformation through a multi-level technical architecture. The bottom-level data collection layer integrates online mall browsing logs, offline store traffic sensor data, customer service work order texts, and third-party industry reports. After being cleaned by ETL tools, the data is stored in a data lake. The middle-level analysis layer uses machine learning algorithms to build user segmentation models, calculates customer lifetime value by combining implicit feedback (such as clickstream data) and explicit feedback (such as product ratings), and identifies high-potential market segments. The application layer develops a personalized recommendation engine based on collaborative filtering algorithms and content matching models, dynamically generating product combinations on user touchpoints. At the same time, a predictive maintenance system is used to push component replacement suggestions to equipment users, transforming passive services into active value output. The marketing activity management platform connects to real-time public opinion data, uses sentiment analysis technology to monitor the popularity of social media topics, and automatically adjusts advertising placement strategies and content creativity, achieving precise allocation of marketing resources [6].

3.2.2. Business model innovation of ecological platform

Enterprises build value co-creation networks by establishing intelligent digital platforms. A typical example is

the difference in the traffic ecosystem operation logic between WeChat and Douyin (**Table 2**). WeChat takes the social relationship chain as the core, integrating multiple carriers to form a closed ecosystem of private and public domain traffic interaction. Douyin, on the other hand, relies on its algorithmic advantages to create a content-driven commercial monetization system. Both attract third-party developers by opening data capabilities and expanding the boundaries of ecological services.

Table 2. Comparison of traffic ecosystem operation logics between WeChat and Douyin

Comparison dimension	WeChat	Douyin
Core logic	Centered on social relationship chains to build a private domain traffic precipitation system	Relying on algorithmic advantages to achieve precise content distribution and efficient traffic conversion
Ecological closed-loop path	Social drainage → content reach → transaction conversion → user retention	Content production → traffic distribution → commercial realization
Key functions/ Platforms	Open platform interfaces integrate Official Accounts, Video Accounts, and Mini Programs; Search function realizes public domain traffic diversion; Data permission management supports precision marketing	ByteDance Marketing Services integrates advertising, live streaming, and influencer resources; Douyin Shop connects with supply chains; Data-driven content recommendation model optimization
Third-party cooperation models	Open data capabilities through API interfaces to attract developers to access	Open data capabilities to encourage developers to enrich platform functions and services

3.3. Challenges and countermeasures in the process of digital and intelligent transformation

3.3.1. Challenges faced

Data security and privacy protection issues present new dimensions as the value of data assets rises. In the heterogeneous network environment created by distributed architectures, the complexity of compliance reviews for cross-domain data flows increases. Traditional security architectures face dual pressures of technical iteration costs and business adaptability when implementing zero-trust systems. New data leakage risks impose higher requirements on the dynamic and precise nature of protection mechanisms, while traditional boundary defense methods show capability gaps in dealing with distributed attacks and API vulnerabilities. At the same time, the supply and demand contradiction of digital and intelligent composite talents is manifested as a connection gap between technology application and business scenarios. There is a shortage of talents who understand industry business logic and master complex algorithm engineering capabilities. The existing professional training system in universities is restricted by disciplinary divisions, leading to a knowledge structure biased towards a single technical field or theoretical research, which is difficult to meet the actual needs of cross-domain problem-solving capabilities required by the integration and innovation of multiple technology stacks in enterprises.

3.3.2. Countermeasures

The construction of a data security governance system needs to break through the traditional protection framework and form a three-dimensional architecture of technical protection, institutional norms, and process control. By adopting technologies such as federated learning and privacy computing, distributed collaboration can be achieved where data is “usable but not visible”. Through the establishment of a data classification and grading standard system, the boundaries of data access, flow, and storage permissions in different business scenarios can be clearly defined. A data security risk assessment mechanism and multi-level emergency response plans should be implemented to enhance the full life cycle management capabilities of data. At the same time, the talent cultivation

and introduction mechanism for digital intelligence needs to be restructured to transform knowledge. At the level of industry-education integration, it is necessary to promote the in-depth connection between enterprise business scenarios and university research resources, develop customized course systems that include core technology modules, industry application scenarios, and engineering practice cases, and build a knowledge sharing platform through cross-departmental joint projects to improve the efficiency of converting technical theories into commercial solutions. In the talent introduction process, focus on the dual ability matrix of "technology commercialization" and "commercial technologization", design a competitive salary incentive system, and attract compound talents with industry experience and technological foresight through high-end talent plans. For internal talent cultivation, a mechanism combining job rotation and mentorship should be established to accelerate the integration of technical capabilities and business insights in real business scenarios, and build a hierarchical and sustainable talent team.

4. Conclusion

In summary, the deep integration of digital intelligence and business innovation is manifested in the empowerment of industrial efficiency by intelligent technologies and the reconstruction of value creation models by data resources. Through technology integration, process optimization, and ecosystem construction, enterprises can achieve innovative breakthroughs in digital transformation, while data governance and talent cultivation become key supports for sustainable development. This collaborative process will continue to promote the deep integration of the digital economy and the real economy, injecting new impetus into high-quality development.

Disclosure statement

The author declares no conflict of interest.

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Application Analysis of Growth Strategies for Industrial Automation Enterprises in the Automotive Manufacturing Sector

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Abstract: As the demand for intelligent and flexible production in the automotive manufacturing industry continues to intensify, industrial automation enterprises are gaining ever-greater market opportunities and competitive advantages in this field. Based on a literature review and representative case studies, this paper constructs a theoretical framework for growth strategies and systematically analyzes the current application status and growth paths of automation enterprises in both complete vehicle and component production. The research finds that different growth strategies (such as vertical integration, horizontal diversification, and digital service transformation) exhibit varying applicability across upstream and downstream segments of automotive manufacturing, while simultaneously facing challenges related to technology integration, business models, and organizational change. In response to these issues, this paper proposes countermeasures such as optimizing R&D and customer relationship management, improving branding and after-sales service systems, and strengthening policy and industry environment support, thereby offering guidance for sustainable growth of industrial automation enterprises in the automotive manufacturing sector.

Keywords: Industrial automation; Growth strategy; Automotive manufacturing; Smart manufacturing; Case analysis

Online publication: September 10, 2025

1. Introduction

In recent years, driven by the global trend toward intelligent and digital transformation in manufacturing, the automotive industry—an essential pillar of national economies—has accelerated its transition from traditional labor-intensive operations to high-end automation. Under China's "dual circulation" development framework and its goals of "carbon neutrality and carbon peak," demand for automation solutions—such as flexible production lines, intelligent robots, and big data analytics—has risen exponentially in both complete vehicle and component production. Against this backdrop, industrial automation enterprises face enormous market opportunities, yet must continuously enhance their technological R&D capabilities, offer customized services, and innovate their

business models to achieve sustained growth amid fierce competition. Relying solely on traditional product sales can no longer satisfy customer-driven value chain requirements; instead, enterprises must adopt diversified growth strategies—such as vertical integration, horizontal diversification, or digital service transformation—to gain advantages in resource integration, ecosystem collaboration, and sustainable profitability. Therefore, examining the growth strategies adopted by industrial automation enterprises in the automotive manufacturing field holds significant theoretical value and practical guidance.

Through in-depth analysis of representative cases and empirical data, this study aims to clarify growth paths, optimize resource allocation, and support the intelligent upgrading and high-quality development of the automotive manufacturing industry. Based on this background, the primary objective of this research is to construct a theoretical framework of growth strategies tailored to industrial automation enterprises, using the automotive manufacturing sector as an application scenario, and to systematically explore the applicability and implementation effects of various growth strategies in both complete vehicle and component production. Specifically, on one hand, this paper synthesizes the core content and mainstream models of growth strategies for industrial automation enterprises through a literature review, and identifies development trends in automotive manufacturing automation. On the other hand, by conducting case studies and comparing financial indicators of representative vehicle manufacturers and component suppliers, the paper deeply analyzes the practical paths and challenges that automation enterprises face in market expansion, technological innovation, and service extension.

To accomplish these goals, this study employs a combination of literature analysis, case research, and empirical investigation. In the literature analysis phase, relevant academic findings and industry reports—both domestic and international—are systematically organized to provide theoretical support for constructing the growth strategy framework. In the case research phase, first-hand empirical data are gathered through interviews and data collection with multiple automotive manufacturers and automation solution providers. In the empirical investigation phase, SWOT analysis and financial data comparisons are used to evaluate the performance and risks of various growth strategies in real-world applications. Finally, based on the research findings, the paper proposes optimization measures and policy recommendations directed at industrial automation enterprises and industry regulators, with the aim of supporting the intelligent upgrading of the automotive manufacturing industry and the sustainable development of automation enterprises.

2. Literature review

2.1. Current research on growth strategies for industrial automation enterprises

Research on growth strategies for industrial automation firms has evolved from straightforward market- and product-expansion models toward more complex, service-oriented, and ecosystem-based approaches. Early work classified growth modes into four basic types: deepening presence in existing markets, entering new markets, developing new products for current customers, and diversifying into adjacent or unrelated sectors. In relatively stable supply-chain environments, simply increasing market share or introducing incremental product variants can deliver short-term gains. However, the pace of technological change and the blurring of industry boundaries have rendered these tactics insufficient for long-term competitiveness [1]. More recent studies emphasize the rise of servitization, in which equipment vendors expand their offerings to include software platforms, remote diagnostics, preventative maintenance, and outcome-based contracts. By transforming one-time hardware sales into ongoing “product-plus-service” relationships, companies build stronger customer loyalty and generate recurring revenue streams.

Case analyses of leading integrators show that cloud-enabled monitoring dashboards, predictive analytics engines, and on-demand consulting services can shorten delivery cycles and enhance profitability without heavy new-product investments. At the strategic level, the focus has shifted toward building digital ecosystems through partnerships and open platforms. Manufacturers that share data with suppliers, clients, and research institutions are better positioned to co-innovate, accelerate time-to-market, and spread the cost of R&D. Multi-tier growth frameworks now incorporate factors such as platform governance, data-sharing protocols, and collaborative innovation networks. Empirical comparisons of different integrator models suggest a three-stage progression: establishing technical leadership, developing platform-based service offerings, and ultimately engaging in broader ecosystem collaboration. Despite these advances, gaps remain in understanding how small and medium-sized enterprises can navigate the costs and organizational changes required by servitization and digital-ecosystem participation. There is also limited cross-industry benchmarking to reveal which combination of product, service, partnership, and platform strategies yields the best risk-adjusted returns. Addressing these unanswered questions will be key to guiding automation firms of all sizes toward sustainable, high-value growth paths [2].

2.2. Current research on automation applications in automotive manufacturing

With the industry's shift toward highly flexible, data-driven production, recent work has moved beyond single-process optimization to integrated, intelligent automation across the entire vehicle lifecycle. In stamping operations, researchers have explored closed-loop control strategies that adjust press parameters in real time based on force and displacement feedback, enabling consistently high-quality forming of both traditional steel and advanced lightweight alloys. Simulation-driven parameter tuning—combined with adaptive die-clearance adjustment—has been shown to reduce defect rates and tooling wear, while modular quick-die-change systems shorten setup times for new model runs. Welding technology has likewise advanced through the integration of real-time sensing and machine-learning-based path planning. Vision-guided seam tracking, using laser or structured-light scanners, enables robots to dynamically correct trajectory deviations, improving joint consistency for mixed-material body structures.

At the same time, data-driven weld-parameter optimization frameworks analyze historical process data to recommend optimal current, speed, and torch-angle settings for varying material thicknesses, reducing under- or over-fusion defects without manual retuning. In paint shops, dynamic spray-pattern algorithms now adapt robot motion profiles and spray-gun flow rates according to local part geometry and ambient conditions. Closed-loop thickness control—using infrared or ultrasonic sensors—maintains uniform coating even on highly contoured surfaces, while automated solvent-recovery and airflow-management systems capture overspray and accelerate drying, cutting both energy use and VOC emissions. Final assembly has seen rapid growth in collaborative robots (Cobot) applications and digital guidance systems. Lightweight, sensor-equipped Cobots assist human workers with torque-sensitive fastening, part presentation, and ergonomic lifting, balancing flexibility and throughput without extensive safety guarding. Augmented-reality work instructions and force-feedback tools guide technicians through complex multi-step assemblies, reducing errors and accelerating operator learning curves. Supporting all production stages, factory-wide digital platforms unify MES, PLM, and equipment-health data via industrial-edge nodes and high-bandwidth networks. Digital-twin models mirror physical assets and process flows, enabling virtual commissioning, "what-if" scenario analysis, and predictive maintenance scheduling.

In-process quality inspection leverages multi-sensor fusion—combining 2D/3D vision, laser scanning, and acoustic emission—to detect surface scratches, dimensional deviations, and feature defects on the fly. Logistics

and material handling have been transformed by autonomous guided vehicles (AGVs) and smart conveyors coordinated through centralized traffic-management software. AGVs equipped with LiDAR and simultaneous localization and mapping (SLAM) navigate dynamic shop floors, delivering parts just-in-time to workstations and returning waste containers without human intervention. Despite these advances, challenges remain in seamless data integration across heterogeneous equipment, ensuring cybersecurity in connected production lines, and scaling AI-based controls in legacy facilities. Future research is focusing on end-to-end digital-twin ecosystems, federated learning for on-device AI model updates, and multimodal human–machine interfaces that combine vision, touch, and voice to further enhance efficiency, quality, and workforce collaboration [3].

3. Theoretical framework and research methods

This study uses a mixed-method approach of literature analysis, case studies, in-depth interviews, and empirical data comparison. In the literature phase, databases (e.g., CNKI, Web of Science) and industry reports are searched to review growth strategies, servitization, and digital transformation research in industrial automation and automotive manufacturing. White papers and market research summarize technology trends and market size, guiding case selection and metric definitions. In the case study phase, two automation solution providers and two automotive manufacturers are chosen. The automation firms have extensive automotive experience with projects like complete-vehicle welding lines, stamping lines, and painting upgrades. The manufacturers include a leading domestic brand and a joint-venture factory, illustrating diverse scales and technology levels. Interviews with senior managers and project leaders yield first-hand details on project backgrounds, technological plans, investment scales, and implementation challenges [4]. Public financial statements, annual reports, and industry analyses provide financial indicators (revenue growth, profit margin, R&D ratio) and capacity utilization rates, allowing quantitative evaluation of performance before and after upgrades.

In the data analysis phase, SWOT and PEST tools assess internal resources and external environments of each growth strategy. Comparing financial and performance metrics before and after implementation reveals actual outcomes and risks. To bolster reliability, questionnaires are designed for both automation buyers (manufacturers) and providers, covering technology satisfaction, service experience, and return expectations. This collection of methods and data ensures theoretical depth and practical relevance, offering comprehensive guidance to optimize growth strategies for industrial automation enterprises in automotive manufacturing [5].

4. Current status of industrial automation applications in the automotive manufacturing sector

4.1. Technological evolution and application scenarios

Driven by smart manufacturing and Industry 4.0, automotive automation has evolved from standalone CNC machines to flexible, intelligent systems. Initially, stamping, welding, and painting relied on CNC tools and traditional manipulators, supporting high-volume, single-model lines with limited automation. As demand for lightweight materials and model variety increased, stamping adopted high-speed servo presses, closed-loop control, and quick-die changes, enabling high-quality forming of complex parts [6]. In welding, spot-welding robots were enhanced with vision guidance and laser distance sensors for online seam tracking, while laser and hot-forming welding produced higher-strength body structures.

In the intelligent phase, paint shops implemented robot-based painting—using genetic algorithms or path

planning plus electrostatic atomization—to improve coating uniformity. Automatic air curtains, online inspection, and drying systems ensured consistent curing and thickness. Final assembly shifted to human–robot collaboration (Cobots), combining human flexibility with robotic precision to reduce labor intensity and quality risks. Concurrently, MES, PLM, and industrial-internet platforms were deployed shopwide. Equipment now connects via industrial Ethernet and edge computing, providing real-time data on status, productivity, and quality. Digital twins simulate physical assets for mixed-model production and flexible changeovers. Quality inspection uses machine vision, 3D laser scanning, and deep learning to detect surface defects online and guide rework.

Moreover, intelligent logistics and AGV systems—using multi-sensor navigation—replace manual handling, efficiently delivering parts in complex, mixed-model workshops. Overall, automotive automation has progressed from "single-machine, single-line" to a three-tiered "equipment → systems → digital platforms" structure, enhancing flexibility, efficiency, and responsiveness to market and customer demands [7].

4.2. Status of typical case enterprises

This study examines two Chinese automotive plants: a domestic independent OEM (Plant A) and a joint-venture OEM (Plant B). Plant A, founded in 2005 and focused on new-energy passenger vehicles, has staged automation upgrades across stamping, welding, painting, and final assembly. In 2019, its stamping shop added closed-loop high-speed servo presses, quick-die change systems, and online pressure monitoring to handle lightweight part production. By late 2020, its welding shop deployed a vision-guided laser-welding line—compatible with steel and aluminum—using image-recognition algorithms for real-time quality checks [8].

In 2021, Plant A upgraded electrostatic paint robots and installed an online thickness-measurement and adjustment system, boosting its paint pass rate from 85 percent to over 95 percent. Its final assembly area now pilots Cobot-assisted trim installation, reducing labor intensity by 20 percent and improving precision to ± 0.2 mm. Plant B, operating since 1998, launched a "smart factory" initiative in 2020 aimed at digital workshop construction. Its stamping area employs a digital twin platform to map equipment to virtual models, predict die wear, and improve uptime. In welding, it introduced North China's first hybrid laser-plus-six-axis robot line, enabling flexible, small-batch switching through trajectory simulation and collision detection. Plant B's paint shop uses a closed-loop system integrating electrostatic robots, an automatic drying tunnel, and paint-fume recovery to ensure coating uniformity and meet strict environmental standards.

In final assembly, Plant B partnered with technology firms to implement an MES-centric scheduling system that synchronizes materials, equipment, and personnel, and added a robot-vision inspection station to check exterior and panel gaps, reducing defect feedback time by 30 percent. Both plants share three traits: (1) phased, tailored upgrade plans; (2) simultaneous integration of advanced equipment, intelligent algorithms, and digital platforms in stamping, welding, painting, and final assembly; (3) emphasis on human–robot collaboration via vision guidance, digital twins, and Cobots to reduce labor intensity and increase flexibility. They also confront common challenges: high costs for premium robots and sensors, complex technology integration, and the need to reskill employees—factors that shape subsequent growth strategy research [9].

5. Analysis of growth strategy applications for industrial automation enterprises

5.1. Evaluation of growth strategy applicability

To systematically evaluate the applicability of different growth strategies in automotive manufacturing, this study compares them across multiple dimensions: financial investment, technical fit, market risk, expected return,

and organizational readiness. **Table 1** shows the ratings and characteristic descriptions for four typical growth strategies (market penetration, market development, product development, and diversification) in these five dimensions, providing an intuitive overview of each strategy's advantages and limitations.

Table 1. Comparison of main growth strategies across key dimensions

Dimension	Market penetration (MP)	Market development (MD)	Product development (PD)	Diversification (DV)	Note: Ratings are on a scale of 1 (lowest) to 5 (highest)
Financial investment	Moderate (2)	Moderately high (3)	High (4)	Very high (5)	Cost level required for implementation
Technical fit	Good (4)	Average (3)	Best (5)	Poor (2)	Degree of alignment between existing technology and strategy requirements
Market risk	Low (2)	Medium (3)	Relatively high (4)	High (5)	Risk level (industry barriers, customer acceptance, etc.)
Expected return	Moderate (3)	Moderately high (4)	High (5)	Uncertain (2)	Based on industry trends and case analyses
Organizational readiness	Best (5)	Good (4)	Average (3)	Poor (2)	Alignment of internal resources and team capabilities with strategy execution

From **Table 1**, it can be observed that market penetration scores well in technical fit and organizational readiness, but its expected return is only moderate, making it suitable for automation enterprises with stable customer bases seeking steady short-term expansion. Market development requires higher investment and carries moderate risk but offers solid expected returns and organizational alignment; it is suited for companies leveraging brand reputation to expand into new regions or downstream component suppliers. Product development scores highest in technical fit and expected return, but demands substantial R&D and equipment investments and carries relatively high risk—making it appropriate for firms with strong R&D capabilities that wish to create differentiated offerings with higher added value. Diversification is the most demanding: it involves cross-industry operations, high complexity, and high uncertainty. Although diversification can yield new profit streams, it requires an extensive technical foundation and organizational change, so it is generally recommended only for large enterprises with ample resources and mature management.

In summary, industrial automation enterprises of different sizes and resource endowments should select growth strategies based on their own circumstances and market conditions, prioritizing those with strong technical fit, organizational readiness, and manageable risk. For example, small- to medium-sized automation firms might first pursue market penetration and market development by optimizing product performance and service quality to deepen presence in existing or adjacent markets. Large enterprises, on the other hand, can build on these approaches by increasing R&D investment and exploring product development or even diversification—provided they carefully manage risk and prepare in advance by training talent and fostering cross-department collaboration to ensure stable implementation and sustained benefit [10].

5.2. Implementation challenges and countermeasures

When implementing growth strategies in the automotive manufacturing sector, industrial automation enterprises face multiple challenges: technical integration complexity, financial pressure, organizational resistance to change,

and talent shortages. **Table 2** summarizes these challenges, their impacts, and proposed countermeasures.

Table 2. Comparison of implementation challenges and countermeasures

Challenge category	Impact	Countermeasure
Technical integration	System compatibility issues, extended delivery timelines	Establish collaborative R&D platforms with universities and suppliers
Financial pressure	High equipment and R&D costs, cash flow strain	Phase investments and implement ROI evaluation mechanisms
Organizational resistance	High cross-department coordination costs and reluctance to adopt new models	Implement change management processes and strengthen internal training
Talent shortage	Insufficient core technical and project management staff	Combine university–enterprise collaborative training with selective outsourcing

To address these challenges, companies can mitigate technical integration risks by forming joint R&D partnerships and collaborating across the value chain; alleviate financial pressure through staged investments and rolling ROI evaluations; improve organizational acceptance of new strategies by creating dedicated change-management teams and conducting targeted training sessions; and rapidly fill key talent gaps via a hybrid approach that combines university collaboration, internal upskilling, and selective outsourcing. By deploying these countermeasures, industrial automation enterprises can steadily advance their growth strategies in automotive manufacturing and achieve the desired outcomes.

6. Conclusion

This paper proposes a growth strategy framework for industrial automation firms in automotive manufacturing, identifying four paths—market penetration, market development, product development, and diversification—and evaluating each by investment, technical fit, market risk, expected return, and organizational readiness. Small- to medium-sized enterprises should focus on market penetration and development by improving existing products and services, while firms with strong R&D can pursue product development and, eventually, diversification into "hardware + software + services." To address challenges like technical integration, financial constraints, organizational resistance, and talent shortages, companies should form joint R&D platforms, phase investments with ROI checks, strengthen change management and training, and close skill gaps via university partnerships and outsourcing. Continuous policy and market monitoring is essential to adapt offerings and achieve sustainable, agile growth.

Disclosure statement

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The Practice of Industry-Education Integration Under the "Government- Industry- University-Research" Model of University Industries

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Abstract: The "government-industry-university-research" model has significant practical significance in promoting the development of industries in colleges and universities and improving the quality of talent cultivation. This paper first provides a brief explanation of the concept and significance of the "government-industry-university-research" model, then conducts an in-depth analysis of the problems faced by the development of university industries, and finally proposes effective solutions to the problems faced by the development of university industries, hoping to provide some references and lessons for promoting the continuous development of university industries and the integration of industry and education.

Keywords: University industry; The "government-industry-university-research" model; Integration of industry and education

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1. Introduction

In the new era, as an important base for cultivating innovative talents in this country, the development of the university industry plays an important role in promoting the integration of industry and education, improving the quality of talent cultivation, and driving regional economic development, and has significant practical significance. The "government-industry-university-research" model is an innovative cooperation model that provides new ideas and directions for the development of university-industry through in-depth cooperation among universities, the government, industries, and research institutions [1]. The integration of industry and education is an important part of the "government-industry-university-research" model, which mainly refers to the close integration of industrial demands with education and teaching to enhance the effectiveness of course teaching, the quality of talent cultivation, and the core competitiveness of the university industry. However, there are many problems in the development of the university industry, such as small scale, incomplete relevant systems, and lagging

concepts, which seriously affect the healthy and sustainable development of the university industry. In the new era, the value of the "government-industry-university-research" model should be fully recognized and applied to the development of the university industry, thereby promoting the quality of talent, the level of science and technology, and the sustainable development of the university industry [2].

2. The connotation and significance of the "government- industry- university-research" model

2.1. Connotation

The "government-industry-university-research" model is an innovative cooperation model, mainly referring to the in-depth cooperation among regional governments, industries, schools, and research institutions, etc., to build a close cooperative relationship, achieve complementary advantages and resource sharing, and jointly promote the continuous development of talent quality, technological level, and university-industry, etc [3]. In this model, the regional government plays an important guiding, coordinating, and policy guaranteeing role, formulating relevant policies and systems to promote the in-depth cooperation of all parties, and coordinating and communicating with schools, industries, and research institutions. Industries also play an important role in providing accurate market demand and industrial platforms in a timely manner. In this model, the school provides strong human and research support for all parties, conducts technology research and development, and promotes the transformation of scientific and technological achievements. It provides a practical platform and technical support for research institutions. Compared with the traditional cooperation model, the "government-industry-university-research" model has distinct characteristics. It breaks through traditional limitations, breaks the situation of each acting independently, and forms a powerful synergy to jointly promote the healthy and sustainable development of the school's industry [4].

2.2. Significance

The application of the "government-industry-university-research" model in the university industry has significant practical significance. This article provides a brief analysis of the following aspects.

2.2.1. Promoting technological innovation

Under the "government-industry-university-research" model, in-depth cooperation among regional governments, industries, schools, and research institutions can be coordinated to achieve the optimal allocation of resources, providing strong support for promoting technological innovation [5]. At the same time, in-depth cooperation between universities and research institutions can promote the transformation of technological achievements, thereby continuously improving the technological level of enterprises and facilitating their smooth technological transformation. At the same time, the feedback and opinions from enterprises in the market also provide a clear and accurate direction for the development of scientific research, further accelerating the development of technological innovation.

2.2.2. Improve the quality of talent

The application of the "government-industry-university-research" model can also effectively improve the quality of talent cultivation. The integration of industry and education is an important part of the "government-industry-university-research" model. Under this model, schools engage in in-depth cooperation with industries to build

good cooperative relationships [6]. On this basis, both sides jointly carry out practical projects and require students to participate in the project practice. This will not only broaden students' horizons and enable them to understand the latest developments in the industry, but also effectively cultivate students' practical ability, innovation ability, and problem-solving ability, further improve the quality of talent cultivation, and provide strong talent support for promoting the development of the industry in colleges and universities.

2.2.3. Enhance the market competitiveness of the industry

Under the "government-industry-university-research" model, through in-depth cooperation among all parties, sufficient human resources, technological support, and policy guarantees can be provided for the development of universities' industries [7]. With the support of all parties, the technological level and management efficiency of the industry can be significantly improved, and policy guarantees can be provided for it, thereby effectively enhancing the market competitiveness of the industry, enabling it to seize the initiative in the increasingly fierce market competition and achieve sustainable development [8].

2.2.4. Serve the regional economy

Under the "government-industry-university-research" model, universities and industries can engage in in-depth cooperation with local enterprises to jointly promote regional industrial transformation and technological upgrading, thereby promoting the healthy development of the regional economy.

3. Challenges faced in the development of university industries in the past

In the past, there were many problems in the development of the university industry. This article will briefly elaborate on the following aspects.

3.1. Lagging ideas

In the past, some universities focused on and paid attention to the trends of industrial development, and devoted too much time and energy to industrial development, lacking a full understanding of its strategic significance. Some university administrators are lagging behind and lack market thinking. They still use administrative means in the process of developing the university industry, which seriously affects the healthy development of the university industry [9]. In addition, some university teachers' lack of interest in industrial practice and one-sided belief that teaching, research, and other work are their main duties will also cause some hindrance to the development of university industries.

3.2. The scale is small

As an important part of the university industry, university-run enterprises are generally small in scale and have certain deficiencies in terms of capital, talent, and market competitiveness. In terms of funds, compared with ordinary enterprises, township-run enterprises have limited financing channels and are difficult to obtain huge financial support, thus affecting the development of school-run enterprises. In terms of talent, due to the small scale and limited funds of school-run enterprises, they are unable to attract high-quality management and technical talents. In terms of market competition, university-run enterprises often lack strong market competitiveness and have a smaller market share.

3.3. Lack of accurate positioning

At present, some universities are blindly following the trend and actively developing the university industry without conducting an in-depth analysis of their own strengths and characteristics. Due to the lack of accurate positioning and the lack of in-depth research and practice, the phenomenon of industry homogenization is obvious [10]. At the same time, the university industry has not carried out in-depth cooperation with school education, research institutions, etc., resulting in the fact that the advantages of each party in talent cultivation, technological innovation, etc. have not been fully utilized, thus also hindering the development of the university industry.

3.4. Lack of market competitiveness

Weak innovation capacity is one of the main reasons for the lack of market competitiveness of school-run enterprises [11]. The management system of school-run enterprises is rather traditional, and the innovation mechanism is not perfect. At the same time, the lack of necessary economic investment in technological innovation has led to insufficient innovation capacity and difficulty in launching products with core competitiveness, thus putting them at a disadvantage in the market competition.

3.5. Lack of benefit-sharing and risk-sharing mechanisms

In the process of promoting the transformation of scientific and technological achievements, due to the lack of benefit-sharing and risk-sharing mechanisms, the enthusiasm of the government, research institutions, universities, and other parties to participate is not high. Universities and research institutions tend to focus more on professional title evaluation and publication of papers, and lack sufficient motivation for the transformation of scientific and technological achievements. At the same time, enterprises are reluctant to invest a large amount of resources in the process of participating in the transformation of scientific and technological achievements, considering market risks. In addition, there is a certain deficiency in the government's policy guarantee, and scientific and technological achievements cannot be smoothly transformed [12].

3.6. The relevant systems are not perfect

A sound system is an important prerequisite for the sustainable development of the university industry. However, the current system is not perfect, which poses certain obstacles to the development of the university industry. Take the property rights system as an example. There are certain problems with the ownership of school-run enterprises, which leads to an unscientific enterprise structure and low efficiency in management and decision-making.

4. Innovative strategies for university-industry development under the "government-industry-university-research" model

4.1. Innovate concepts and strengthen market awareness

In order to promote the healthy development of the university industry, it is necessary to reform ideas in a timely manner, strengthen market awareness, and innovative thinking. University administrators should conduct in-depth study and research on the laws of the market economy and incorporate the development of university industries into the improvement and development plans of universities. At the same time, efforts should be made to enhance publicity and promotion, and encourage teachers to carry out industrial practice, to effectively promote the transformation of scientific and technological achievements, continuously improve the technological level and core competitiveness of the university industry, and lay the foundation for the healthy development of the

university industry [13].

4.2. Integrate resources and optimize resource allocation

Under the "government-industry-university-research" model, the university industry should carry out in-depth cooperation with regional governments, universities, and research institutions, build stable cooperative relationships, integrate resources from all parties, thereby optimizing resource allocation and achieving resource sharing and complementary advantages. In response to the problem of insufficient financing, universities can introduce social capital to broaden financing channels for their industries.

At the same time, under the coordination of the government, they can also cooperate with financial institutions to secure more support from inclusive finance [14]. In response to the shortage of talent, the university industry can establish a sound talent introduction system to attract high-quality management and research talents to join, thereby enhancing its own management and innovation capabilities. For example, in 2018, the School Planning and Development Center of the Ministry of Education held a coordination meeting on the professional construction of the counterpart support campus at the main campus of China University of Petroleum (Beijing). The meeting conducted in-depth discussions on key issues such as integrating resources and optimizing resource allocation, and formed a new idea to solve the problem of talent shortage through talent training bases.

In addition, the university industry should conduct extensive and in-depth market research to understand market trends and actual demands, and use this as a reference to formulate effective marketing strategies and enhance brand awareness.

4.3. Make precise positioning and give full play to the advantages of universities

Colleges and universities should precisely define the direction of industrial development based on their own circumstances and characteristics. Closely integrate higher education and teaching with industrial development to create a new situation of mutual promotion and improvement in industry-education integration. In the case of science and engineering universities, they should actively develop industries such as new materials, automation, and intelligent manufacturing based on their own professional characteristics, and constantly adjust their development strategies according to the characteristics of the regional economy, so as to promote the sustainable development of industries in universities.

4.4. Strengthen innovation and enhance market competitiveness

Under the "government-industry-university-research" model, the university industry should engage in in-depth cooperation with regional governments, research institutions and universities, increase investment in the field of innovation, thereby promoting the transformation of scientific research achievements, enhancing its own productivity and market competitiveness, and laying the foundation for the sustainable development of the university industry [15]. To this end, first of all, investment in scientific research should be increased and continuously improve the technological level and innovation ability. Secondly, the innovation mechanism should be established and improved. With market demand as the guide, improve the innovation mechanism and promote the transformation of scientific research achievements. Finally, improve the management level. Actively introduce advanced management models and concepts both at home and abroad to improve the management level of school-run enterprises, thereby enhancing their own operational efficiency and market competitiveness.

4.5. Establish a benefit-sharing and risk-sharing mechanism to promote the transformation of scientific research achievements

In order to give full play to the role of the "government-industry-university-research" model, a mechanism of shared benefits and shared risks should also be established to facilitate the smooth transformation of scientific research achievements. First of all, the proportion of benefit distribution should be determined. In this regard, regional governments can introduce relevant regulations and policies to clarify the proportion of benefits for universities, research institutions, and industries in the process of transforming scientific research achievements, thereby deepening cooperation among all parties and fully mobilizing their enthusiasm.

Secondly, a risk compensation mechanism should be established. To promote deeper cooperation among all parties, the government should also establish a risk-sharing mechanism. A special risk compensation fund for the transformation of scientific and technological achievements could be established to provide certain compensation to enterprises, research institutions, etc. that take risks in the process of the transformation of scientific and technological achievements, to reduce the losses of all parties, promote in-depth cooperation among all parties and promote the transformation of scientific and technological achievements. For example, in 2024, Xi'an Jiaotong University signed a university-enterprise cooperation agreement with China XD Group Co., Ltd. to jointly establish the "XiDIAN - Jiaotong Joint Innovation Center" and accelerate scientific and technological innovation and the precise transformation of scientific and technological achievements through the establishment of a benefit-sharing and risk-sharing mechanism.

4.6. Improve the system and establish a sound guarantee system

First, the property rights system should be improved. Clarify the ownership of school-run enterprises, build a modern enterprise management system, improve the enterprise management structure, and continuously strengthen the construction of the board of directors and shareholders' meeting, so as to lay the foundation for improving the transparency and decision-making efficiency of enterprises. Secondly, the financial system of the enterprise should be improved. Financial management and supervision of school-run enterprises should be strengthened, and digital technology should be fully utilized to improve the efficiency of financial management. Finally, the personnel management system should be improved. Establish and improve the personnel management system based on the actual situation. The system of performance assessment and distribution according to work should be the main approach to fully motivate and motivate employees.

5. Conclusion

In conclusion, the application of the "government-industry-university-research" model in the development of the university industry has significant practical significance. However, there are still many problems in the development of university industries in the past. To address this, the healthy and sustainable development of the university industry should be promoted through innovative concepts, resource integration, and precise positioning, laying a solid foundation for improving the quality of talent cultivation, enhancing the market competitiveness of the university industry, and promoting regional economic development.

Disclosure statement

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Research on Layout Optimization of J Company's Grain and Oil Processing Workshop

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Abstract: Whether the workshop layout is reasonable has a significant impact on logistics efficiency, production costs, and production efficiency. This article takes the grain and oil processing workshop of Company J as the research object and conducts a field investigation of its grain and oil processing workshop using the SLP (System Layout Design) method. Based on the logistics volume of the production site and the correlation of each functional area, the correlation analysis is carried out from two aspects: logistics factors and non-logistics factors. The interrelationship diagram of the operation units in the workshop, the ranking of the comprehensive proximity of the operation units, and the location correlation diagram of the operation units were obtained, and the improvement plan was designed based on the principle of route optimization layout. Through the optimized design, transportation efficiency was enhanced, workshop area utilization was improved, production costs were reduced, and good social and economic benefits were created for the enterprise. It can also provide a reference for similar enterprises to carry out related work.

Keywords: SLP; Workshop layout; Facilities layout; Optimization

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1. Introduction

In today's rapidly developing world economy, manufacturing, as a pillar of the national economy, is the core driving force for the sustained growth of the national economy. In the increasingly fierce market competition, the enhancement of an enterprise's competitiveness not only depends on the strengthening of sales capabilities and the guarantee of product quality, but more crucially, on improving production efficiency and shortening the production and sales cycle of products [1, 2]. However, the on-site management practices of many manufacturing enterprises have exposed numerous problems, which have restricted their development potential. A typical phenomenon is that enterprises lack scientific facility layout planning in the initial construction stage and often rely on empiricism for equipment arrangement. With the continuous increase in order volume, this unscientific layout has directly led to a series of problems, such as chaotic material accumulation in the workshop, unnecessary repetition in the

production process, and mutual interference among people, machines, and materials. Eventually, it has caused a continuous decline in production efficiency and severely restricted the further development of the enterprise [3, 4].

In response to the above-mentioned predicament, the system layout design method offers a scientific solution. As a classic and important production facility planning method, the core of SLP lies in systematically analyzing the production process and logistics volume, constructing the interrelationship diagram among various operation units, and based on this, rationally arranging the operation unit areas within the workshop [5]. This method can effectively address the logistics congestion and efficiency bottlenecks caused by unreasonable layout, thereby ensuring the smooth progress of the production process and ultimately achieving the goal of optimizing the entire production system and enhancing the comprehensive competitiveness of the enterprise [6]. This paper uses the SLP method to analyze the layout of the grain and oil processing workshop of Company J, scientifically and reasonably arranges the workshop facilities, forms a reasonable logistics system, improves the efficiency of logistics operation, reduces the operating costs of the enterprise, achieves the optimization of the logistics efficiency and production costs of the production system, and thereby enhances the market competitiveness of the enterprise.

2. Layout of grain and oil processing workshops and production processes

J's grain and oil processing workshop is divided into multiple Spaces: preform injection molding workshop, cap injection molding workshop, pre-treatment room, pre-processing blending workshop, oil pressing workshop, filling workshop, water treatment area, dry package storage area, high-pressure air compressor room, reception room, transformer and distribution room, etc. J's grain and oil processing workshop is on the second floor and has one oil press production line, four filling and packaging lines, and three carton packaging lines. The raw materials enter the production workshop from the South, the produced products enter the filling line, the filling line is placed East-West, the preforms, caps and other packaging materials enter the filling and packaging line for sealing, then enter the carton packaging line for packing, the cartons are sealed, labeled and processed, and the finished products are conveyed into the temporary storage area on the first floor and then transported by forklifts to the workshop finished goods warehouse on the first floor. Outbound is completed on the right side of the first floor of the company according to the order. To describe the current layout of the workshop more clearly, the specific layout of the second floor is drawn as shown in **Figure 1**, and the correspondence between the numbers in the figure and the specific areas is shown in **Table 1**.

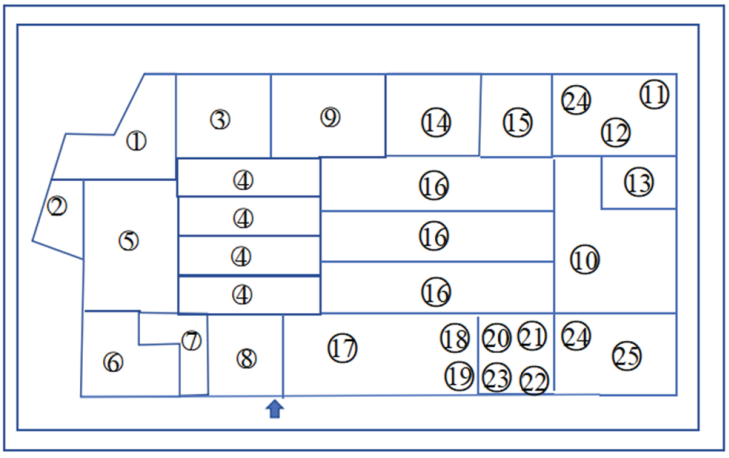

Figure 1. Original layout of the processing workshop

Table 1. Correspondence table of workshop area numbers

Numbers	Area division	Number	Area division
1	Transformer and distribution room	14	Carton label library
2	High-pressure air compressor room	15	Bottle cap warehouse
3	Preform injection molding workshop	16	Carton packaging line
4	Filling line	17	Water treatment area
5	Dry package storage area	18	Water treatment control room
6	Oil press line	19	Water treatment chemicals room
7	Preparation area before processing	20	Conference room
8	Pre-treatment room	21	Production office
9	Cap injection molding workshop	22	Reception room
10	Teleportation line	23	Fire Control Room
11	Driver's lounge	24	Toilet
12	Print room	25	Restaurant
13	Entry point		

3. Analysis of enterprise facility layout based on SLP

3.1. Logistics analysis

Based on the data of the logistics handling distance and material handling volume between each operation unit within the workshop, the logistics intensity between each operation unit pair was obtained by multiplying the logistics handling distance between each operation unit pair by the corresponding material handling volume. To more intuitively represent the logistics intensity between pairs of operation units within the workshop, A five-level classification system is introduced, using the letters A, E, I, O, and U to represent the five logistics intensity levels from high to low, respectively [7]. These grades are based on a careful assessment of the relative proportion of logistics intensity in total logistics routes and volumes.

Based on the resulting logistics intensity and logistics intensity grades, list the logistics intensity between pairs of operation units by numerical magnitude, and then classify the intensity grades according to intensity grade proportions. **Figure 2** shows a logistics interrelationship diagram for a more intuitive comparison of logistics intensities between different operation units.

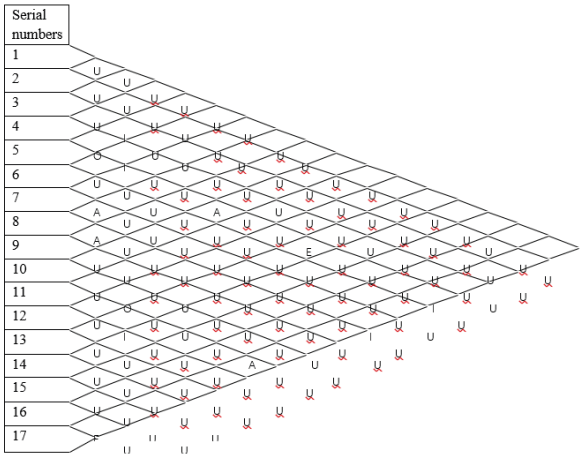

Figure 2. Diagram of logistics interrelationships

Observing the above figure, it can be seen that the pairs of operation units belonging to Grade A ultra-high logistics intensity are 9–15, 8–7, 4–9; There are 6–7, 14–15, 4–12 units that belong to the E category of extremely high logistics intensity. The other six pairs of operation units have a wide range or average level of logistics intensity, respectively, and there are also pairs of operation units with extremely low logistics intensity that can almost be ignored. These pairs of operation units have almost no direct logistics relationship, but each has its own role in the production process. Therefore, non-logistics relationship analysis is also required during layout optimization. To achieve the desired layout effect.

3.2. Analysis of interrelationships among job units

When determining the relationships among various work units, it is necessary to take into account both logistics and non-logistics relationships to form a comprehensive consideration system to obtain comprehensive relationships, and to achieve a reasonable layout based on these relationships [8]. The following will discuss how to accurately define relationships by setting weight ratios and quantifying calculations.

(1) Set the weight ratio

In the actual production process, the relative importance of non-logistics relations and logistics relations often varies depending on the specific demands and conditions of the workshop. In order to accurately reflect the different effects of these two relationships on workshop layout optimization, it is necessary to set appropriate weighting ratios to determine their importance. Generally speaking, the weighting ratio should be between 1:3 and 3:1. For processing workshops, where the logistics factor has a greater impact than the non-logistics factor, set the weighting value of the logistics and non-logistics interrelationship among each operation unit in the workshop to m:n=2:1 [9].

(2) Quantification calculation

Specifically, quantitative calculations use the following assignment criteria: A=4 (for very strong relationships), E=3 (for strong relationships), I=2 (for general relationships), O=1 (for weaker relationships), U=0 (for no direct relationship), X=-1 (for conflicting or negative relationships). Let the quantified value of the logistics relationship level for any two job units be M, the quantified value of the non-logistics relationship level be N, and the comprehensive relationship closeness value be Z; and the formula for calculating the comprehensive relationship closeness value Z is Z=m*M+n*N [10]. At the same time, the quantified value of the comprehensive interrelationship is calculated based on the division ratio of the comprehensive interrelationship grades among the operation units as shown in **Table 2**.

Table 2. Calculation table of comprehensive relationships among work units

Serial Numbers	Job unit pairs	Logistics relationship weighting: 2		Non-logistics relationship weighting: 1		Comprehensive relationship	
		Grade	Quantified values	Grade	Quantified values	Quantified value	Grade
1	1–2	U	0	I	2	2	O
2	1–13	U	0	X	-1	-1	X
3	1–17	U	0	X	-1	-1	X
4	2–13	U	0	X	-1	-1	X
5	2–17	U	0	X	-1	-1	X
6	3–4	U	0	O	1	1	O

Table 3 (Continued)

Serial Numbers	Job unit pairs	Logistics relationship weighting: 2		Non-logistics relationship weighting: 1		Comprehensive relationship	
		Grade	Quantified values	Grade	Quantified values	Quantified value	Grade
7	3–5	I	2	E	3	7	E
8	3–6	U	0	O	1	1	O
9	3–10	U	0	O	1	1	O
10	3–13	U	0	X	-1	-1	X
11	3–17	U	0	X	-1	-1	X
12	4–5	O	1	E	3	5	I
13	4–6	I	2	A	4	8	E
14	4–7	U	0	O	1	1	O
15	4–8	U	0	O	1	1	O
16	4–9	A	4	A	4	12	A
17	4–10	U	0	O	1	1	O
18	4–12	E	3	E	3	9	E
19	4–13	U	0	X	-1	-1	X
20	4–16	I	2	U	0	4	I
21	4–17	U	0	X	-1	-1	X
22	5–6	U	0	I	2	2	O
23	5–9	U	0	O	1	1	O
24	5–10	U	0	O	1	1	O
25	5–12	U	0	O	1	1	O
26	6–7	E	3	A	4	10	A
27	6–8	U	0	I	2	2	O
28	6–9	U	0	O	1	1	O
29	6–10	U	0	O	1	1	O
30	6–12	U	0	O	1	1	O
31	6–16	O	1	E	3	5	I
32	7–8	A	4	A	4	12	A
33	7–16	U	0	I	2	2	O
34	8–13	U	0	X	-1	-1	X
35	8–16	U	0	I	2	2	O
36	8–17	U	0	X	-1	-1	X
37	9–11	O	1	E	3	5	I
38	9–14	U	0	O	1	1	O
39	9–15	A	4	A	4	12	A
40	10–12	I	2	I	2	6	I

Table 3 (Continued)

Serial Numbers	Job unit pairs	Logistics relationship weighting: 2		Non-logistics relationship weighting: 1		Comprehensive relationship	
		Grade	Quantified values	Grade	Quantified values	Quantified value	Grade
41	10–13	U	0	X	-1	-1	X
42	10–17	U	0	X	-1	-1	X
43	11–14	U	0	O	1	1	O
44	13–14	U	0	I	2	2	O
45	14–15	E	3	E	3	9	E
46	16–17	U	0	X	-1	-1	X

3.3. A comprehensive classification based on closeness of relationship

As can be seen from **Table 2** above, the combined quantified values among the pairs of operation units range from -1 to 12, reflecting the combined closeness of different pairs of operation units in terms of logistics and non-logistics relations. By sorting the results of the comprehensive quantified values in the table from largest to smallest, the proportion of each quantified value range can be obtained, providing data support for the optimization of the workshop layout, and a more scientific and reasonable layout plan can be formulated based on the quantified analysis results. Compared with the data analysis in **Table 3**, the proportion of the comprehensive interrelationship grades occupied by the operation units conforms to the conventional proportion, so no further adjustment is needed.

Table 3. Classification of the degree of closeness of comprehensive interrelationships

Combined quantified values	Grade	Job unit pairs number	Proportion of job unit pairs
10–12	A	4	2.94%
7–9	E	4	2.94%
4–6	I	5	3.68%
1–2	O	20	14.71%
0	U	90	66.18%
-1	X	13	9.56%
Total	-	136	100.00%

4. SLP-based workshop layout optimization

4.1. Workshop layout optimization scheme design

After a detailed analysis of the interrelationships among the operation units, in order to more precisely guide the layout of the operation unit area and thereby determine the initial SLP optimization plan, the next step is to sort the operation units based on the comprehensive quantified values in **Table 3** mentioned earlier. This step is crucial for ensuring efficient collaboration among operation units, reducing logistics costs, and enhancing productivity, as shown in **Table 4**.

Table 4. Comprehensive proximity ranking table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1		1											-1				-1
2	1												-1				-1
3				1	3	1				1			-1				-1
4			1		2	3	1	1	4	1		3	-1			2	-1
5			3	2		1			1	1		1					
6			1	3	1		4	1	1	1		1				2	
7				1		4		4								1	
8				1		1	4						-1			4	-1
9				4	1	1					2			1	4		
10			1	1	1	1						2	-1				-1
11									2					1			
12				3	1	1				2							
13	-1	-1	-1	-1				-1		-1				1			
14									1		1		1		3		
15									4					3			
16				2		2	1	4									-1
17	-1	-1	-1	-1				-1		-1						-1	
The total	-1	-1	4	16	9	15	10	8	13	4	3	7	-5	6	7	8	-7
Sorting	14	15	12	1	5	2	4	6	3	11	13	9	16	10	8	7	17

Referring to the legend in **Table 5**, further transform **Table 3** into a visualized job unit position correlation diagram. The proximity between job unit pairs is represented as shown in **Table 6**, with different numbers and shapes of lines connecting each other. Job unit pairs with a comprehensive relationship level of grade A are represented by 4 lines, grade E by 3 lines, and so on. Draw the job unit position correlation diagram as shown in **Figure 3**. [11].

Table 5. Symbols for the nature of work of job units

Serial numbers	Name	Legend	Notes
1	Operations	○	A variety of machining processes in workshop production
2	Temporary storage	◇	Temporary inventory of semi-finished and finished products
3	Auxiliary	⊃	Assist the workshop to operate normally
4	Storage	▽	Regular inventory of production objects at the storage location

Table 6. Examples related to the location of work units

Quantitative value	Grade	Number of lines	The degree of closeness of the hierarchy
4	A	4 Straight lines	Absolutely necessary to get close
3	E	Three straight lines	Particularly important Approach
2	I	Two straight lines	Important
1	O	1 straight line	General
0	U	-	Not important
-1	X	1 curve	Don't want to get close

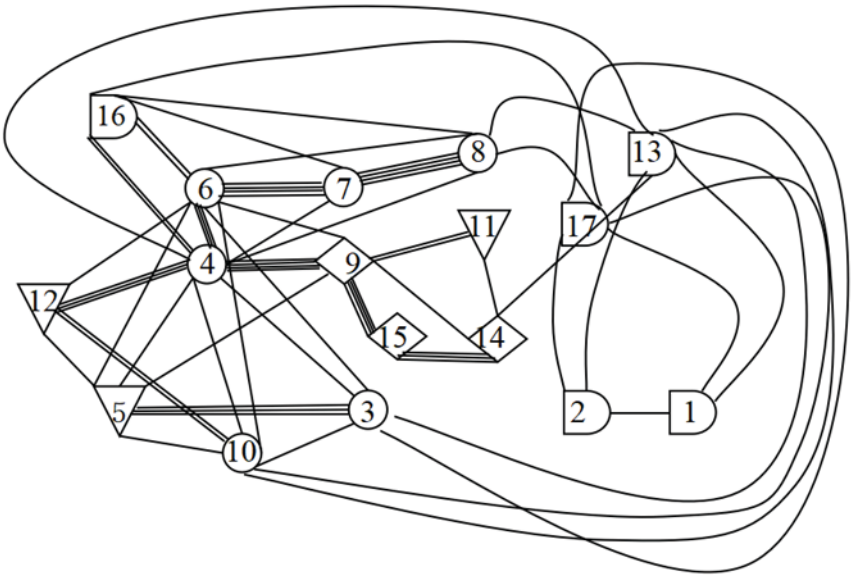

Figure 3. Job unit location-related map

Distribute the job units from center to edge according to their scores as shown in **Table 4**. The A-level job units with the highest scores and the strongest closeness will be placed in the center position, and since they are the closest to other units, only one distance unit interval is needed; Work units with slightly lower scores but still higher levels of closeness will be placed on the periphery of Class A units to ensure a certain degree of independence while maintaining close ties; U-level work units can be placed freely, as long as there is no obstruction; X-class job units should be placed as far apart as possible.

The proximity of each operation unit can be roughly understood from the above text. Then, in combination with the production situation of the workshop that has been statistically analyzed, make reasonable adjustments to each operation unit and draw the initial workshop layout optimization plan based on the SLP method according to a certain proportion, as shown in **Figure 4** below [12].

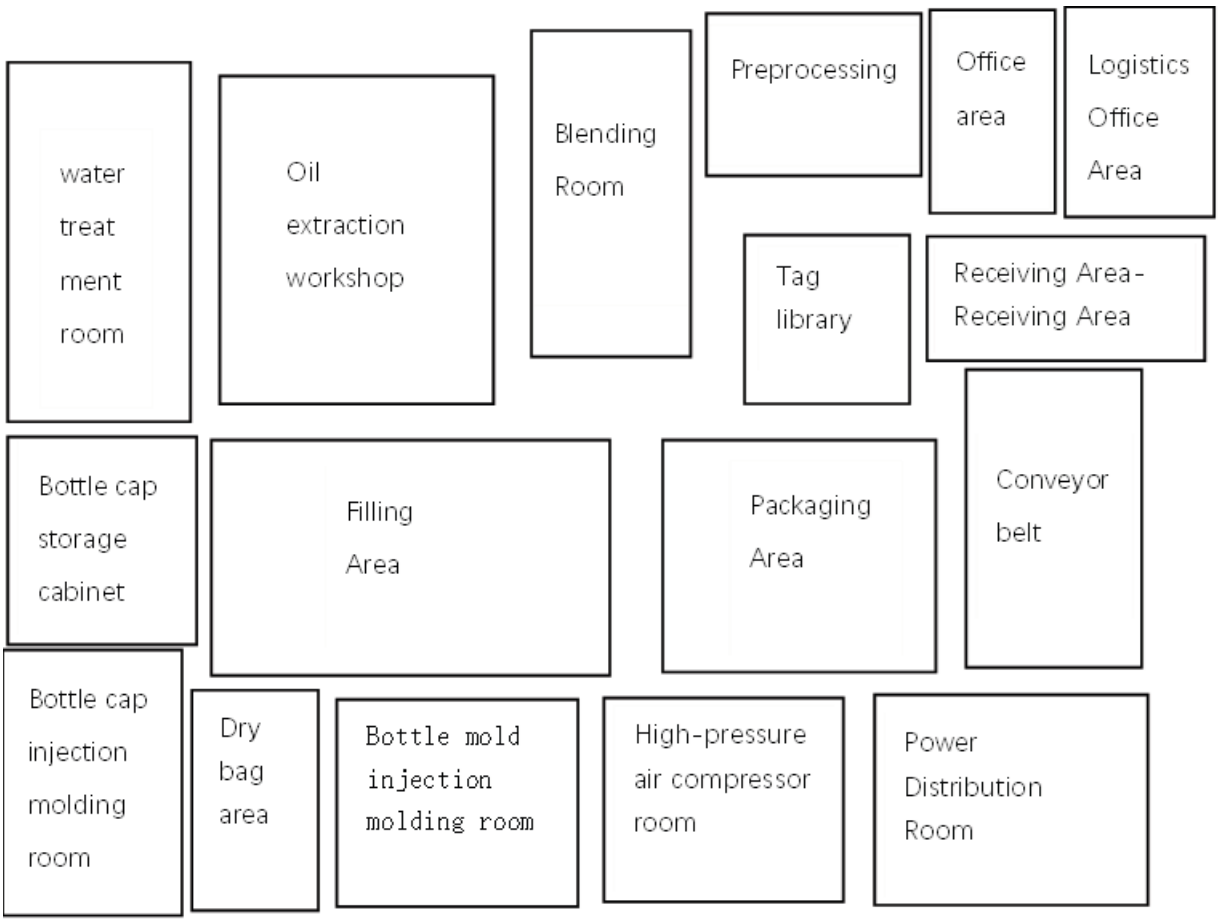

Figure 4. Initial optimized layout of the workshop

4.2. Scheme evaluation

In response to the problems with the existing layout mentioned earlier, an evaluation of the optimized plan is presented.

(1) The workshop layout is more in line with production requirements

The optimized plan takes into full account the continuity of the processing workshop workflow, the centralization of management and supervision, and the core principle of "people-oriented" in the application of the SLP method, comprehensively considering the working environment, health and safety of employees. While pursuing production efficiency and economic benefits, particular attention is paid to potential hazards such as noise, vibration and chemicals that may cause harm to employees' health. In the optimized layout, water treatment rooms that could be harmful to people are placed on the edge away from office workers and visitors who lack professional protection; At the same time, the new layout also places more dangerous distribution rooms at the edge, away from operation units such as dry packaging and filling areas where the situation could be exacerbated in the event of a fire or explosion.

(2) The distance for material handling is effectively shortened

In the original layout, there were overly long logistics routes such as from the cap warehouse to the filling room and from the oil press line to the water treatment room, which are also the key parts that need to be addressed in this optimization using the SLP method. Based on the straight-line distances between the

centers of each operation unit, the final optimized logistics handling distance of the workshop operation unit is 285, which is 23.18% lower than the original plan. It can be seen that the optimized plan is better than the original plan, indicating that there are significant problems with the original layout.

(3) The intensity of logistics was effectively reduced

Under the condition that the original volume of logistics remains unchanged, the logistics distance is shortened, and the logistics intensity is significantly improved. After optimizing the logistics process, the logistics intensity has been successfully reduced from 13,568 to 12,116. This significant change indicates that the optimized plan has achieved a marked improvement in logistics efficiency. Specifically, the logistics intensity was reduced by 1452, or 10.7%, which visually demonstrates the positive effect of the optimized plan in reducing logistics transportation costs and improving logistics operation efficiency.

(4) Easier to manage

Compared with the original layout, the optimized layout makes the work units with similar functions more concentrated and thus easier to manage. First, the centralized layout makes material management more efficient. In a relatively centrally managed warehouse, the storage, allocation, and search of materials can all be done in a relatively small area, which significantly reduces the time and cost of personnel movement and material handling. At the same time, centralized management also helps to reduce warehouse space and the need for special handling, further improving the efficiency of material management, allowing enterprises to better control and optimize inventory and reduce costs resulting from inventory loss and expiration. Secondly, the centralized layout also helps with personnel management. In workshops with the same functions, personnel are responsible for roughly the same content, and the relatively centralized layout can enhance communication among employees, command issuance by upper-level managers, and training effectiveness. Finally, the centralized layout also helps to enhance the safety of equipment. By strengthening security management of the same equipment, centralized layout can reduce the risk of theft, and also help to identify and address potential security hazards in a timely manner, facilitating regular management of equipment and subsequent equipment replacement.

5. Conclusion

This paper uses the SLP method to conduct a facility planning analysis of the J company workshop, divides the production units, and on the basis of analyzing the logistics and non-logistics relationships within the workshop, ultimately determines the comprehensive relationship levels of the operation intervals and proposes practical solutions. Through optimization, the logistics routes between processes avoided intersections, thereby significantly reducing the logistics intensity, minimizing material detours, lowering the labor intensity of workers, improving the working environment, and enhancing the utilization efficiency of the factory.

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Research on the Impact of the Digital Economy on the Innovation of Small and Medium-sized Enterprises

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Abstract: In the context of the digital economy, digital finance is becoming an important tool and service model to support the technological innovation of small and medium-sized enterprises. However, insufficient awareness among managers, an imperfect service system, limited supply capacity, and a weak risk prevention and control mechanism have restricted its support effect. To give better play to the role of digital finance, it is necessary to accelerate the construction of a service platform connecting digital finance and technological innovation, promote inclusive development, improve the service system, and strengthen risk supervision. By optimizing resource allocation, enhancing the accuracy and security of services, it can provide strong support for the technological innovation and digital transformation of small and medium-sized enterprises and promote the high-quality development of digital finance.

Keywords: Digital economy; Small and medium-sized enterprises; Technological innovation; Digital finance; Risk supervision

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1. Introduction

The digital economy, relying on cutting-edge technologies such as the Internet, cloud computing, big data, and artificial intelligence, has constructed a new economic form. According to The Research Report on the Development of China's Digital Economy (2024), as of 2023, the scale of China's digital economy reached 53.9 trillion yuan, accounting for 42.8% of GDP[1]. In this context, fintech and digital finance, as important components of the digital economy, are gradually becoming key financial tools for the technological innovation of small and medium-sized enterprises due to their high efficiency, convenience, and flexibility, providing strong support for their digital transformation and innovative development[2].

With the help of big data and artificial intelligence, digital finance has constructed accurate risk assessment models and intelligent service systems, providing customized financing solutions for small and medium-sized

enterprises, reducing innovation costs, optimizing processes, and improving efficiency. At the same time, it helps enterprises gain insights into industry trends and market changes, clarify innovation directions, and enhance their competitiveness [3]. However, technological innovation in small and medium-sized enterprises is usually accompanied by high investment, high risks, and long cycles, and the problems of difficult and expensive financing remain prominent. In response to this, digital finance provides a practical path to alleviate financing constraints and promote technological innovation through innovative financing models and technical means [4, 5].

2. Overview of the digital economy

2.1. Definition and characteristics of the digital economy

The digital economy is a new economic form that takes data as the core production factor, relies on modern information networks, and uses information and communication technology (ICT) to optimize resource allocation and improve economic efficiency. It covers all economic activities that directly or indirectly rely on data-driven resource allocation and productivity improvement. At the technical level, the digital economy includes cutting-edge technologies such as big data, cloud computing, the Internet of Things, blockchain, artificial intelligence, 5G communication, and edge computing. The in-depth integration of these technologies promotes industrial innovation and economic upgrading. At the application level, the digital economy is widely infiltrated into fields such as intelligent manufacturing, smart finance, digital trade, online education, and digital healthcare, greatly improving production and service efficiency [6].

As the main economic form following the agricultural and industrial economies, the digital economy has core characteristics such as data-driven, intelligent development, and full-factor digital transformation, profoundly affecting the production methods, lifestyles, and governance methods of society [7]. The development of the digital economy not only promotes the rise of emerging industries, such as the Internet platform economy and the artificial intelligence industry, but also reshapes the business models and value chain structures of traditional industries, accelerating the global resource restructuring, industrial upgrading, and economic structure optimization and adjustment.

2.2. Development status of China's digital economy

In recent years, the digital economy has become an important driving force for global economic growth. In particular, China has made remarkable progress in this field. According to the data in The Research Report on the Development of China's Digital Economy (2024), in 2023, the scale of China's digital economy exceeded 53.9 trillion yuan, accounting for 42.8% of GDP, becoming a key engine for promoting high-quality development. The government attaches great importance to the development of the digital economy and has issued policies such as The Digital Economy Development Plan (2021–2025) and The 14th Five-Year Plan for the Development of the Digital Economy, proposing to basically build a digital economy system by 2025 [8]. By accelerating the construction of new infrastructure, promoting industrial digital transformation, and improving the data factor market, China is creating an efficient, intelligent, and secure digital economy ecosystem.

In terms of infrastructure, China has made significant investments in fields such as 5G, cloud computing, big data centers, and artificial intelligence, building a globally leading digital infrastructure system. By the end of 2023, there were more than 3 million 5G base stations, achieving full coverage in major cities and some rural areas. Through the "Eastern Data and Western Computing" project, China optimizes the national data resource

allocation and computing power layout, helping the digital economy operate efficiently. At the same time, the wide application of gigabit optical networks and the Beidou Navigation System, as well as the rapid development of domestic chips and intelligent hardware, continue to enhance the independent and controllable capabilities of China's digital economy [9–11].

2.3. Industrial digital transformation and integrated application

The digital economy accelerates the transformation and upgrading of traditional industries, forming a two-wheel-driven model of digital industrialization and industrial digitalization. In the manufacturing industry, technologies such as industrial Internet, intelligent manufacturing, and digital twins have improved production efficiency and resource utilization rates, promoting the digital and intelligent development of manufacturing. In the financial field, technologies such as blockchain, artificial intelligence, and big-data risk control have promoted innovative services such as digital payment and intelligent investment advisory, enhancing the intelligence and inclusiveness of financial services [12]. In the agricultural field, technologies such as the Internet of Things and big-data analysis have helped the development of smart agriculture, improving the precision of agricultural production.

Digital trade and cross-border e-commerce are developing rapidly, reshaping the global trade pattern. In 2023, China's cross-border e-commerce import and export volume reached 2.3 trillion yuan, with a year-on-year growth of over 10%. Platforms such as Alibaba's AliExpress and ByteDance's TikTok Shop have expanded into international markets, enhancing the status of Chinese enterprises in global digital trade. At the same time, the pilot promotion of the digital yuan (e-CNY) helps the application of the yuan in cross-border payments, promotes the internationalization of the yuan, and provides an efficient and convenient payment solution.

2.4. Market-based allocation of data factors and digital security supervision

As a new type of production factor, the market-based allocation of data is crucial for the development of the digital economy. In 2023, China issued the "Reform Plan" for the Market-based Allocation of Data Factors, proposing to accelerate the promotion of data rights confirmation, circulation, trading, and value-added utilization to enhance the market value of data. Currently, cities such as Beijing, Shanghai, and Shenzhen have established data exchanges to promote the circulation and market-based pricing of data assets, improving the allocation efficiency of data resources [13]. The government is also accelerating the promotion of data security legislation to ensure the legality and compliance of data transactions and promote the healthy development of the data factor market.

With the rapid development of the digital economy, issues such as data security, network security, and personal information protection have become more prominent. To address network security threats, China has successively introduced laws and regulations such as the "Data Security Law" and the "Personal Information Protection Law", strengthened data security supervision, and established a network security review mechanism to ensure the safe and stable development of the digital economy. At the same time, the country actively promotes the research of technologies such as "trusted artificial intelligence" and "blockchain-based trusted authentication", aiming to build a safe and trustworthy digital economy environment [14].

2.5. The digital economy facilitates rural revitalization and sustainable development

The digital economy not only promotes urban industrial upgrading but also provides new impetus for rural revitalization. Models such as e-commerce, live-streaming e-commerce, and smart agriculture have entered rural areas, improving the circulation efficiency of agricultural products and farmers' incomes. Platforms such as Taobao

and Pinduoduo's "Rural Revitalization Plan" help local agricultural products sell online, enhancing the digital level of the rural economy. Technologies such as 5G and the Internet of Things have promoted the intelligentization of rural infrastructure and agricultural modernization.

The digital economy also promotes green and sustainable development. Intelligent manufacturing, the sharing economy, and low-carbon industries have improved resource utilization efficiency, reduced carbon emissions, and promoted green development. For example, cloud computing and artificial intelligence optimize energy scheduling and carbon emission monitoring, while the transparency of blockchain helps establish a green supply chain.

In general, the digital economy is reshaping the economic growth model. China has achieved remarkable achievements in digital infrastructure, industrial digitalization, digital trade, the data market, and digital security supervision, and has promoted rural revitalization and sustainable development. However, technological innovation, data security, and market supervision still face challenges. In the future, it is necessary to strengthen technological breakthroughs and data security governance to promote the high-quality development of the digital economy.

3. The impact of the digital economy on enterprise innovation

3.1. Solving funding constraints and expanding the sources of technological innovation funds for small and medium-sized enterprises

Under the traditional financial model, financial institutions such as banks have strict credit reviews for small and medium-sized enterprises, and the financing procedures are complex. This not only reduces the financing efficiency but also increases the cost of innovation and research, and development. Digital finance, through technologies such as big-data risk control and artificial-intelligence credit assessment, can more accurately identify and analyze the credit risks of enterprises, alleviate information asymmetry, optimize the allocation of financial resources, and promote the flow of funds to enterprises with innovation potential. For example, Tianjin Jincheng Bank launched the "Jincheng Loan". Enterprises can apply for credit online through WeChat official accounts or APPs, and the funds can be received in as fast as 1 minute, greatly improving the capital turnover efficiency and providing strong support for technological innovation [15].

Relying on big-data analysis, machine learning, and other technologies, digital finance constructs accurate profiling models, deeply explores enterprise needs, and precisely matches financial products and services. The intelligent risk-control system can also provide customized financing solutions according to different stages of enterprises. This personalized service not only optimizes the financing environment but also provides a stable source of funds for technological innovation and business upgrading.

3.2. Increasing operating income and strengthening the internal driving force for technological innovation of small and medium-sized enterprises

With the popularization of digital payment tools such as Alipay and WeChat Pay, the market transaction efficiency has been significantly improved, the capital liquidity has been enhanced, and consumption has accelerated, promoting the increase of the operating income of small and medium-sized enterprises. The increased income not only improves the financial situation but also accumulates funds for technological innovation. For example, digital payments enable enterprises to achieve convenient capital transfer, enhancing their ability to invest in technological innovation.

Digital finance also optimizes the market matching degree of products and services through intelligent

marketing, user profiling, and other means, increasing market share. At the same time, it promotes the upgrading of the consumption structure and changes in demand, prompting enterprises to continuously carry out technological innovation and product research and development. The development of digital finance not only accelerates the process of enterprises optimizing their income structure but also becomes an important driving force for accelerating innovation.

3.3. Optimizing the innovation environment and strengthening the external pull for technological innovation of small and medium-sized enterprises

The rapid iteration and wide application of digital technologies provide a good external environment and technical support for enterprise innovation. In addition, digital finance, through technical means, alleviates information asymmetry in the financial market, promotes the rational allocation of resources, accelerates the process of market survival of the fittest, and enhances the competitive pressure and innovation motivation of enterprises. Facing fierce competition, small and medium-sized enterprises must enhance their competitiveness through technological innovation. At the same time, rich technical tools and innovation models further stimulate the innovation vitality of enterprises and promote the continuous development of technology.

3.4. Strengthening risk control and improving the security management mechanism for digital finance to serve small and medium-sized enterprises

With the rapid development of digital finance, information security and data risks have become more prominent. Small and medium-sized enterprises need to establish an information security management system, strengthen the protection of financial and core business data, and ensure the security of data during collection, transmission, and use. At the same time, they should develop emergency plans, monitoring systems, and conduct regular drills to improve their ability to respond to sudden risks.

The cognitive level of enterprise managers and employees affects their ability to use digital finance securely. Regular information and data security training should be carried out to enhance security awareness, master risk prevention knowledge, and improve the ability to prevent fraud, data leakage, and other issues. By constructing safe operation specifications and internal control mechanisms, human-induced security risks can be reduced, and the overall security management level can be improved.

The government and regulatory authorities should strengthen the supervision of digital finance, improve regulations, and establish a prudential supervision mechanism to ensure its standardized development. Regulatory agencies can use technical means such as big-data monitoring and artificial-intelligence risk control to accurately identify financial risks, ensuring that small and medium-sized enterprises can develop steadily while enjoying the digital dividend. In addition, the construction of an industry self-regulatory mechanism should be promoted, and enterprise compliance management should be strengthened to create a safe, efficient, and fair financial ecosystem, providing a stable and reliable support environment for the technological innovation of small and medium-sized enterprises.

4. Conclusion

The development of the digital economy provides comprehensive support for enterprise technological innovation. Especially through the innovative application of digital finance, it has successfully solved the funding constraints of small and medium-sized enterprises, broadened financing channels, increased operating income, optimized the

innovation environment, and strengthened the risk management capabilities of enterprises. In the future, the digital finance service system should be further improved, financial supervision strengthened, and the digital economy governance framework optimized to promote the technological innovation and digital transformation of small and medium-sized enterprises and provide a more solid support for high-quality economic development.

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Literature Review on the Investment Risks of Chinese Sporting Goods Manufacturing Enterprises under the "Belt and Road Initiative"

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Abstract: With the promotion of the "Belt and Road Initiative", Chinese sporting goods manufacturing enterprises are increasingly active in foreign investment in countries along the route, but due to regional differences, the investment risks they face are becoming increasingly complex. Based on CNKI and Web of Science databases, this paper systematically combines the theoretical framework and research progress of sporting goods manufacturing enterprises' outbound investment and its risk research, and focuses on analyzing the evolution, motivation, characteristics, and risk generation mechanism of enterprises' outbound investment mode. It further discusses the types and causes of investment risks, the evolution and application of risk assessment methods, and deeply analyzes the unique risk characteristics of sports manufacturing enterprises. On this basis, combined with the shortcomings of existing research, a future research direction is put forward, which provides a reference for follow-up theoretical research and practical operation.

Keywords: Sporting goods manufacturing enterprises; The Belt and Road Initiative; Outbound Investment; Risk Management; Systematic literature review

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1. Introduction

With the deepening of the Belt and Road Initiative (BRI), the globalization layout of China's sports industry has entered an accelerated period. As the core supporting sector of the sports industry, driven by policy dividend and market expansion, the focus of outbound investment has gradually shifted to BRI countries. The Outline of Building a Powerful Country in Sports of the State Council clearly puts forward "promoting sports industry to become a pillar industry of the national economy" and encourages sports enterprises to "going global" to participate in international competition [1]. Under the background of economic globalization, China's sporting goods manufacturing industry has achieved rapid growth in export trade by virtue of the advantages of the supply chain. From 2014 to 2019, the export volume of sporting goods increased by 3.31% annually, accounting for over

30% of the global market share [2].

However, the expansion of trade scale has not been transformed into the improvement of investment efficiency, and China's overseas sports investment presents the paradox of "scale surge but risk agglomeration". In the process of China's sports industry's outbound investment, it often faces conflicts from domestic and foreign policy environments and uncertainties brought by geopolitical sensitivity, which restrict the efficient flow and allocation of capital [3]. At the same time, the legal disputes caused by the acquisition, the legal regulations of the host country and the institutional obstacles brought by the changes of domestic policies may all amplify the legal risk [4]. Driven by the BRI, the investment of sporting goods manufacturing enterprises in BRI countries is facing complex and diversified systemic risks, which requires the theoretical circles to deeply deconstruct the logic of risk generation and the path of prevention and control.

To systematically analyze the investment characteristics and risks of Chinese sporting goods manufacturing enterprises in BRI countries, this paper conducts progressive analysis from three dimensions. First, combined with the background of industrial development, combining the evolution path, motivation logic, and basic characteristics of the outbound investment mode of sporting goods manufacturing enterprises, and then revealing the unique risk generation mechanism faced by them in the process of outward foreign investment. Secondly, from a theoretical perspective, this paper analyzes the types and causes of investment risks, summarizes the evolution trend and application characteristics of existing risk assessment methods, and evaluates their applicability and limitations in the field of sporting goods manufacturing. Finally, focusing on the practical challenges faced by the industry in the complex international environment, this paper tries to put forward a risk management framework that is more suitable for the actual needs of sports manufacturing enterprises.

Based on CNKI and Web of Science database, this paper adopts content analysis to review existing domestic and international research on the investment risks faced by Chinese sporting goods manufacturing enterprises in BRI countries. It summarizes the research characteristics and development trends, with the aim of providing systematic references for risk management in the context of outbound investment by Chinese sporting goods manufacturers.

2. Outbound investments of Chinese sporting goods manufacturing enterprises

With the acceleration of industrial globalization and digital transformation, the outbound investment in the field of sporting goods presents diversified characteristics. At present, the research mainly focuses on the change of investment mode, motivation analysis, and feature recognition, and reveals the evolution path and driving mechanism of investment activities in this field.

2.1. Evolution of outbound investment patterns

The outbound investment activities of sporting goods manufacturing enterprises have experienced a transformation from processing trade to overseas mergers and acquisitions and brand globalization, and gradually entered a new stage of integration of digitalization and sustainable development. In the leading stage of OEM and processing trade, enterprises rely on low-cost advantages to undertake international orders, investment is concentrated in production links, added value is low, and it is significantly affected by exchange rate and trade barriers [5]. In the period of large-scale expansion of sports enterprises, the leading enterprises have improved their competitiveness through overseas mergers and acquisitions and independent brand building, and their investment focus has shifted

to R&D and marketing [6]. In the era of the digital economy, the new changes brought by digital technology are affecting the sports industry and injecting new vitality into the development of the sports industry. The investment in the sports industry focuses on the integration of "sports-technology-industry" [7].

2.2. Motivations for outbound investment

The outbound investment of sporting goods manufacturing enterprises is driven by multiple factors. First, market-oriented factors promote enterprises to upgrade their product structure through investment, such as the rapid growth of the market scale of smart wearable devices and personalized customized products [8]. Secondly, technology-driven factors are empowering the transformation of the industry, as enterprises enhance production efficiency by investing in digital production lines and industrial internet platforms [9]. In addition, policy-driven factors are playing an increasingly significant role. Policy and strategic guidance, such as the "14th Five-Year Plan", the "Building China into a Sports Power" initiative, and the "Belt and Road Initiative" provide institutional support for industrial investment, encouraging enterprises to move up the global value chain [10].

2.3. Characteristics of outbound investment

The investment activities of sporting goods manufacturing enterprises show the following characteristics:

(1) Domestic investment

Domestic investment activities in the field of sporting goods manufacturing show obvious industrial agglomeration effect, but unbalanced regional development may lead to the "siphon effect", which further restricts the effective integration of the industrial chain. In this context, sporting goods manufacturing enterprises have higher requirements for the stability of the supply chain. The volatility of industrial access policies and the frequency of tax policy adjustment directly affect the capacity layout and cost structure of enterprises, while the stability of raw material supply and the volatility of labor costs constitute the core risk points [11]. The spatial distribution of financial resources also has a significant impact on the investment efficiency of the sports industry. The spatial spillover effects generated by financial agglomeration are particularly prominent in the eastern regions of China, where financial resources are more abundant [12]. At present, digitalization and innovation drive have become an important direction of industrial investment. Head enterprises such as Anta and Li Ning have continuously increased R&D investment and actively laid out new fields such as intelligent equipment and digital production, although there is still room for improvement in R&D investment intensity compared with international brands [13].

(2) International investment

From the perspective of outbound investment, leading international sporting goods manufacturing countries typically dominate the global value chain by controlling high-value-added segments such as research and development, branding, and marketing. In contrast, Chinese enterprises have long relied on low labor costs to embed themselves in mid- and low-end segments of production, with export activities primarily based on processing trade [2]. In the practice of overseas investment, localization of procurement and logistics efficiency are regarded as key influencing factors. In some BRI countries, the lack of supporting infrastructure makes it difficult for enterprises to achieve effective localized procurement, which significantly increases production and inventory costs [14]. The research on the export of cultural products also provides a useful reference for the sporting goods trade, indicating that enterprises should

pay attention to the changes in target market demand and optimize product structure to enhance the overall competitiveness [15]. In recent years, driven by the Belt and Road Initiative, China's sports industry has been gradually expanding its international development space by building regional value chains [16].

2.4. Risk generation mechanism of outbound investment

The risk generation mechanism of sports manufacturing enterprises' outbound investment has obvious industry characteristics. On the one hand, the position of sports enterprises in the global value chain is easily restricted, and there are many problems in their industrial chain, such as insufficient application of innovative technologies and blocked circulation of data elements, which lead to the suppression of "anti-climbing" in the competition with multinational companies and the risk of locking the low end of the global value chain [17]. On the other hand, digital transformation has also brought new challenges. Small and medium-sized enterprises are unable to bear digital investment due to limited funds and lack of talents, and may fall into a "transformation dilemma"; However, large enterprises need to face problems such as lagging return on R&D investment and data security [18]. In addition, uncertainty at the policy and trade levels is also an important source of risks. International trade frictions (such as tariff barriers) and domestic industrial policy adjustments (such as upgrading environmental protection standards) may have a significant impact on export-oriented enterprises [19]. In the dimension of culture and market, outbound investment often leads to management conflicts due to cultural differences, such as differences in operational concepts in the process of acquiring European football clubs, and misplacement of resource allocation caused by heterogeneity of domestic regional market demand, which are also risk types that sports enterprises need to focus on [20].

3. Theoretical framework and research methods of outbound investment risk

With the deepening of global economic integration and the advancement of the "Belt and Road Initiative", the scale of transnational investment has continued to expand. Meanwhile, the external environment faced by enterprises in overseas investment has become increasingly complex, making investment risk assessment a growing focus in academic research. A relatively systematic research framework for investment risk evaluation has been developed, encompassing key dimensions such as the construction of indicator systems, methodological approaches, identification of industry-specific characteristics, and dynamic optimization. This framework has been continuously enriched and expanded in both theoretical exploration and practical application.

3.1. Types and causes of investment risks

The types of investment risks are diversified due to the differences in investment fields and regional characteristics. Most of the existing studies are based on political and legal risks, economic and financial risks, cultural and managerial risks, market competition risks, and supply chain risk [21–25]. Political and legal risks are the basic risks of transnational investment, and their generation is closely related to the national governance system and policy stability [26]. Economic and financial risks originate from macroeconomic fluctuations and financial market instability, and have a significant direct impact on investment returns [27]. Cultural and managerial risks arise from cognitive differences in cross-cultural interaction, and their impacts are hidden and long-term [28]. Especially in overseas factories of sporting goods manufacturers, differences between labor management models and local cultural customs may lead to labor disputes and affect production continuity [29]. Market competition risk focuses on position game and market share competition in industrial value chain [30]. Supply chain risks are highlighted due

to insufficient industrial chain coordination and external shocks [31].

3.2. Evolution and application of investment risk assessment methods

At present, investment risk evaluation methods are gradually iterating from qualitative description to quantitative modeling, from static analysis to dynamic early warning, which enriches the technical path of risk identification and measurement. Different methods have their own advantages and complementarities in theoretical basis, application scenarios, and data dependence, which provide methodological support for diversified risk management. **Table 1** compares and analyzes the characteristics of common investment risk evaluation methods.

Table 1. Comparison of common investment risk evaluation methods

Method	Core features	Typical application scenarios	Advantage	Limitation	Representative literature
Fuzzy comprehensive evaluation model	Multi-factor fuzzy quantitative processing	Investment risk evaluation of BRI countries	Can deal with fuzziness and uncertainty	The index setting is subjective	Duan *et al.* (2018) [32]
Typical case analysis method	Qualitative induction of risk trigger points	Identification of Sudden Risks in Sporting Goods Trade	Easy to operate and have practical reference	The results are not universal	Ji *et al.* (2021) [33]
Fuzzy Analytic Hierarchy Process (FAHP)	Hierarchical modeling + fuzzy processing to improve the scientific nature of weight	Analysis on Investment Risk of Sporting Goods Market in Southeast Asia	Quantitative judgment, taking into account subjective and objective factors	Expert judgment is subjective	Chen *et al.* (2025) [34]
Entropy weight-TOPSIS model	Objective weighting + relative ranking analysis	Risk ranking and location selection of multinational sports trade	The calculation is simple and easy to explain	Neglect the correlation between indicators	Mou *et al.* (2025) [35]
Neural network algorithm	Nonlinear prediction ability based on data training	Dynamic early warning of risks in sports industry mergers and acquisitions	Accurate prediction and strong adaptability	Need a lot of training data, black box	Qin (2017) [36]
Big data-factor analysis method	Data-driven, hidden risk factors can be extracted	Macro + micro risk monitoring of countries along the route	Strong timeliness and deep structure can be excavated	Strong dependence on data quality	Wen *et al.* (2023) [37]

3.3. Investment risks of sports manufacturing enterprises

In the investment risk assessment of sports manufacturing enterprises, scholars put forward targeted risk response strategies from the perspectives of government, enterprise, and industry [38–40]. At the government level, the focus is on institutional guarantee and platform construction, such as guiding capital to invest in the international market by improving the legal system of investment funds, broadening the channels of social and overseas capital participation, implementing tax incentive policies, etc., and establishing an investment risk sharing database covering BRI countries to improve the efficiency of information acquisition and decision-making of enterprises [41]. In addition, strengthening the negotiation of bilateral investment agreements, clarifying the dispute settlement mechanism, and promoting policy stability and transparency will help reduce legal and institutional risks [42]. At the enterprise level, emphasis is placed on localization strategies and capability enhancement. First, improving internal risk investment mechanisms and strengthening operational incentives and constraints can enhance risk management capacity under complex environments [43]. Second, accelerating digital transformation—leveraging industrial

internet platforms to improve supply chain resilience and applying big data analytics to increase market sensitivity and emergency responsiveness—has become increasingly essential [44]. At the industry association level, attention is given to collaborative mechanisms and standard-setting. Promoting mutual recognition of industrial standards, reducing technical barriers, organizing joint overseas ventures, and sharing professional service resources are crucial for enhancing overall efficiency and global competitiveness [45]. Furthermore, the construction of cross-cultural communication platforms can facilitate coordination with host country governments and communities, reduce cultural conflicts and operational friction, and ultimately enhance the sustainability of enterprise operations [46].

4. Conclusion

In summary, regarding investment activities in the sporting goods sector, scholars have paid increasing attention to the diverse characteristics brought about by industrial globalization and digital transformation. From the perspective of investment model evolution, different stages have been identified; investment motivations include dimensions such as market demand, technological empowerment, and policy-driven strategies; investment characteristics are reflected in the domestic context as industrial clustering and regional imbalance, spatial spillover of financial resources, and digital innovation drivers, and in the foreign context as differences in value chain positions and regional expansion under the Belt and Road Initiative (BRI). In view of the investment risks of Chinese enterprises in BRI countries, the research covers political and legal, economic and financial, cultural and managerial, market competition, supply chain, and other risks, showing the complex risk map brought by the differences between countries along the route. In the research of investment risk evaluation, a variety of risk types are defined, and the evaluation methods are developed from qualitative to quantitative and intelligent. The coping strategies are put forward from the level of government, enterprises, and trade associations to provide support for investment decision-making.

However, several gaps remain in the current literature. First, research on the dynamic evolution of investment models in the sporting goods sector under the digital economy and comparative analysis with traditional models remains limited, and mechanisms for coping with emerging risks require further development. Second, in the context of BRI investments, insufficient attention has been paid to how small and medium-sized enterprises (SMEs) manage risks through digital transformation, to the risk characteristics of under-researched regions, such as the Middle East and Africa, and to the design of risk management tools tailored to the specificities of the sporting goods industry. Third, the dynamic mechanisms of investment risk assessment, data integration, and interdisciplinary collaboration remain underdeveloped; the closed-loop design linking assessment and response needs strengthening, and differences in investment strategies among firms of varying scales are often overlooked.

To address these gaps, future research could be deepened in the following areas to better respond to the investment risks faced by Chinese sporting goods manufacturing enterprises in BRI countries. First, it is essential to systematically construct an investment model evolution framework suited to the digital economy, and conduct in-depth comparative studies between traditional and emerging models in terms of risk exposure and return paths, with special attention to how digital platforms and intelligent manufacturing reshape the risk ecosystem. Second, research should focus on SMEs' investment practices along the BRI, exploring their risk identification and response mechanisms under digital transformation, filling empirical research gaps in regions such as the Middle East and Africa, and developing more targeted risk prevention tools based on the high sensitivity and mobility of the sporting goods industry. Third, risk assessment methods should shift from static evaluation to dynamic

early warning systems, leveraging big data and artificial intelligence to enhance model adaptability and real-time responsiveness, promoting interdisciplinary integration of data sources, analytical methods, and management strategies, and establishing a closed-loop system integrating evaluation, response, and optimization. Fourth, greater attention should be paid to differences in firm scale and resource endowments, with the aim of building a stratified and categorized risk assessment and response framework to enhance the success and sustainability of diverse actors in overseas investment.

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The Impact of Green Finance Development on Enterprises' Investment and Financing Strategies

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Abstract: With the global advancement of the concept of sustainable development and environmental protection work, especially under the systematic deployment of green development in the report of the 20th National Congress of the Communist Party of China, the development of green finance in China has an increasingly significant impact on enterprise operation and management. Against the backdrop of the continuous deepening of green finance, it has multi-dimensional and profound impacts on enterprises' investment and financing decisions, resource allocation, and development strategies. Based on this, this paper focuses on the level of enterprises' investment and financing strategies, deeply analyzes the specific impacts of green finance development on enterprises, analyzes them in combination with practical problems, and then proposes corresponding optimization countermeasures, aiming to provide theoretical support and practical references for enhancing the core competitiveness of enterprises in the context of green finance.

Keywords: Green finance; Enterprises; Investment and financing

Online publication: September 10, 2025

1. Introduction

Against the backdrop of increasingly prominent global climate change and ecological environment problems, green finance has become a key force in promoting green and low-carbon transformation and sustainable development. As one of the countries with the largest carbon emissions globally, China has attached great importance to the development of green finance in recent years. Especially after the proposal of the "Dual-carbon" goals, green finance has been given a strategic position. The government promotes the innovation of green financial products, standard construction, and environmental information disclosure through policy support, and improves the financial support mechanism.

The essence of green finance is to guide capital to low-carbon, environmentally friendly, and efficient clean industries, promoting a virtuous interaction between economic development and ecological protection. This provides enterprises with diversified financing tools (such as green bonds and green credit), improves the financing

structure and cost, and promotes green technology innovation and transformation. However, the green finance system is still in the stage of improvement, with problems such as insufficient information disclosure, inconsistent project standards, and the risk of greenwashing, bringing uncertainties and risks to enterprises. Small and medium-sized enterprises, in particular, face more challenges [1].

This paper will analyze the impact of green finance on enterprise strategies, explore the difficulties of small and medium-sized enterprises in green investment and financing, and put forward practical policy suggestions and strategic optimization plans to contribute to the high-quality development of the green economy.

2. The current situation of the impact of green finance development on enterprises' investment and financing strategies

2.1. Guiding enterprises to achieve green transformation and upgrading

Green finance is not only an innovation of financial products but also a mechanism for guiding enterprise transformation through the allocation of financial resources. With the improvement of the policy system, when formulating investment and financing strategies, enterprises no longer only focus on economic returns but also pay attention to green indicators such as environmental impact, carbon footprint control, and energy conservation and emission reduction. This change in concept has prompted enterprises to carry out green technology transformation, optimize the energy structure, and design low-carbon products, promoting the transformation of the production and operation system towards green, intelligent, and low-carbon directions.

Financial tools such as green credit and green bonds provide enterprises with financial support and cost advantages. For example, many commercial banks have launched a "green channel" approval mechanism, offering incentives such as preferential interest rates and simplified approvals for projects that meet environmental protection standards. In the capital market, enterprises that issue green bonds and conduct green asset securitization can obtain a higher market subscription rate and investor recognition, further enhancing their financing capabilities, market image, and brand value [2].

2.2. Reducing financing costs and optimizing resource allocation

The development of green finance has broadened enterprises' financing channels and reduced financing costs through differential financial policies. With the gradual refinement of green finance assessment standards and the maturity of the rating mechanism, financial institutions tend to allocate resources to environmental protection, energy-saving, and carbon-reducing enterprises [3]. Enterprises that meet the conditions of green projects can not only enjoy lower loan interest rates and longer loan terms but also receive government subsidies, tax incentives, and green guarantees.

2.3. Remodeling enterprises' investment and financing strategies and decision-making systems

Green finance has not only changed the financing tools and cost structure but also deeply influenced enterprises' investment and financing strategies and governance structures. Nowadays, when making major investment decisions, enterprises must incorporate environmental impact and carbon footprint accounting into feasibility studies and strategic assessments, strengthen green compliance reviews, and set green performance indicators. This has prompted enterprises to restructure their internal investment and financing processes, forming a dual-decision-making system with the core of "green benefits + financial returns".

To meet the requirements of green finance for information transparency, enterprises need to establish a systematic green investment and financing management system, including mechanisms such as green fund use planning, environmental impact target setting, project performance tracking, third-party certification, and compliance disclosure. This not only improves enterprises' environmental governance capabilities but also strengthens the trust foundation with financial institutions [4].

3. Problems in the impact of green finance development on enterprises' investment and financing strategies

3.1. Imperfect market system and lack of unified green finance standards

Although China's green finance has achieved phased results, it is still in the initial stage of exploration overall. The market system construction is imperfect, and the institutional system is not yet systematic. On the one hand, the categories of green financial products are relatively single [5]. The product structure is mainly composed of green credit and green bonds. Emerging tools such as green funds, green insurance, and carbon financial derivatives have developed slowly, and a diversified and full-cycle-covering financial product system has not yet been formed, making it difficult to meet the financing needs of different types of enterprises.

On the other hand, the definitions, identifications, and evaluation standards of green projects have not been unified. Although there are policy documents such as the "Green Bond-Supported Project Catalogue (2021 Edition)" for reference, there are still significant differences among different financial institutions in the definition of green assets, review dimensions, and identification processes. There is a lack of a unified green rating and certification system. In addition, the carbon financial market has not been fully established. The national carbon market is still in the pilot stage of quota trading. The pricing mechanism, trading rules of carbon assets, and their effective connection with enterprise financing mechanisms are still immature, restricting the guiding role of green finance in resource allocation [6].

3.2. Imperfect information disclosure mechanism and lagging regulatory system

The core of green finance is "transparency" and "sustainability". However, in current practice, the imperfect green information disclosure system remains a key issue restricting the high-quality development of green finance [7]. Some enterprises do not disclose information on the environmental performance of green projects and carbon emission reduction in a timely and standardized manner, and there are even cases of exaggerated publicity or false statements. This not only hinders financial institutions from accurately assessing project risks and sustainability but also damages the rights and interests of investors and the market trust foundation.

At the same time, China's green finance regulatory system is relatively lagging, and a systematic regulatory framework and strong law-enforcement mechanism have not yet been formed. There are overlapping responsibilities and regulatory blind spots, especially in aspects such as green project review, post-event supervision of green bonds, and third-party verification [8–10]. Although the "Measures for the Legal Disclosure of Enterprise Environmental Information" was issued in 2022, its implementation intensity and coverage are still limited, and there is a lack of a coordination mechanism with financial supervision, making it difficult to effectively curb "greenwashing" behaviors and affecting the resource-guiding efficiency and credibility of green finance.

3.3. Unstable capital source structure and limited financing channels

Stable and diversified financing sources are the basis for enterprises to achieve green transformation. However, currently, China's green finance still highly depends on policy-based funds and government-guided funds, and the supply of market-based green financial resources is insufficient. On the one hand, local fiscal funds and special green subsidies dominate. Once the policy direction is adjusted or the finance is tightened, it is easy to cause the financing chain of enterprise green projects to break, restricting the stability of their medium-and long-term development plans.

On the other hand, diversified green financing tools such as green bonds, carbon finance, and green asset securitization are still in their infancy. The market depth is insufficient, and the motivation for financial innovation is not strong, resulting in a single financing method for enterprises and limited risk-resistance capabilities. Especially for small and medium-sized enterprises, due to a lack of collateral, weak information disclosure capabilities, and small-scale green projects, they generally face the dual dilemma of "difficult and expensive financing" and find it difficult to fully enjoy the policy dividends of green finance.

In addition, there is no linkage mechanism between the carbon market and green credit. Enterprises find it difficult to obtain liquidity support through the realization of carbon assets, which is also not conducive to the formation of an effective assessment, trading, and financing loop for green assets.

3.4. Insufficient enterprise green awareness and high-risk barriers to green investment

The sustainable operation of green finance requires the active strategic participation of enterprises and the internalization of the green concept. However, currently, there is still a significant lack of enterprises' awareness of green development. Some enterprises regard green transformation as an "external pressure" rather than an "internal driving force", respond passively to green finance policies, and are not enthusiastic about developing green projects. Especially in small and medium-sized enterprises and traditional manufacturing industries, the green strategy has not been embedded in the long-term plans of enterprises, resulting in a lack of a synergistic effect between green finance and enterprise strategies [11].

In addition, most green investments are concentrated in high-tech fields such as new energy, new materials, and energy conservation and emission reduction. These projects have long cycles, high technical thresholds, and large capital requirements, with high uncertainty and failure risks.

4. Countermeasures for enterprises' investment and financing strategies under the influence of the green finance market

4.1. Promoting the construction of the green finance market system and unifying financial standards and certification mechanisms

The orderly development of the green finance market requires the coordinated participation of multiple stakeholders and institutional construction. Currently, the development of green finance in China is still in a stage with inconsistent standards and incomplete norms. It is necessary to accelerate the construction of the standard system and market mechanism.

On the one hand, the government should increase support for small and medium-sized enterprises and promote the transformation of green finance from "dominated by large enterprises" to "inclusive and shared". By setting up green special subsidies, implementing tax exemptions and reductions, providing financing guarantees and interest-subsidized loans, etc., the participation threshold for small and medium-sized enterprises can be

reduced, and their motivation for green transformation can be enhanced [12].

On the other hand, financial institutions should be encouraged to strengthen product innovation, expand new-type financial tools such as green insurance, green leasing, and carbon asset securitization, and improve the coverage and service flexibility of green finance [13].

In addition, a unified and authoritative green standard system should be constructed, clarifying the identification standards, evaluation methods, and certification processes of green projects. International experience, such as the EU Taxonomy, can be drawn on to promote the integration of China's green standards with global standards and improve the transparency and international compatibility of green financial products.

4.2. Improving the information disclosure mechanism and the green regulatory system

A sound information disclosure system and a standardized regulatory mechanism are important guarantees for the effective operation of green finance. Enterprises should establish a perfect information disclosure mechanism and take the initiative to disclose key indicators such as the use of funds for green projects, environmental benefits, and carbon emission reductions to meet the supervision needs of financial institutions and the public.

Regulatory agencies should establish a whole-process supervision system covering pre-event, in-event, and post-event, especially strengthening the authenticity review and performance evaluation of products such as green bonds and loans. Severe punishment should be imposed on "greenwashing" behaviors to increase the cost of violations and build a long-term governance mechanism for green finance.

At the same time, the construction of a unified information disclosure platform should be promoted, and a national-level green finance information sharing system should be established to improve data transparency and achieve information connectivity and risk co-governance among regulatory departments, financial institutions, and enterprises [14].

4.3. Broadening diverse green financing channels and stimulating enterprises' financing vitality

Constructing diverse and stable financing channels is the key for enterprises to optimize their investment and financing structures and achieve green transformation. Enterprises should reasonably select green financing tools according to their development stages and project characteristics. For example, mature enterprises can use stable tools such as green bonds and credit, while growing enterprises can introduce green equity financing and venture capital.

The government and regulatory departments should encourage the establishment of green industry development funds, green technology funds, etc., to guide the wide participation of social capital; accelerate the construction of a green finance comprehensive service platform, promote the development of green industrial chain finance, and improve the efficiency and coverage of capital flow.

In addition, financial institutions such as banks, securities companies, and insurance companies should be promoted to establish green service franchise mechanisms, set up green rating systems and risk tolerance mechanisms, and customize financing plans for enterprises, especially to improve the financing availability and capabilities of small, medium, and micro-enterprises.

4.4. Strengthening enterprises' green awareness and capacity building, and consolidating the foundation for strategic implementation

Enterprises are important actors in the green finance system, and their green awareness and capabilities are the core guarantees for investment and financing transformation. Enterprises should integrate the green concept into

strategic formulation and daily operations and build a management system with the core of Environment, Social, and Governance (ESG).

The green awareness of management and employees should be enhanced through environmental protection regulations training, carbon management construction, and green performance evaluation. At the same time, since green projects mostly involve fields such as new energy and energy-saving and environmental protection, enterprises should strengthen their technology research and development and innovation capabilities to enhance the controllability and implementation rate of projects.

To alleviate the shortage of talents in the field of green finance, enterprises should also accelerate the cultivation of cross-disciplinary and composite talents in green finance, environmental science, and technical economics, build a professional talent echelon, and improve the comprehensive capabilities of project evaluation, implementation, and management [15].

5. Conclusion

As an important financial means to achieve the "Dual-carbon" goals and promote the construction of ecological civilization, green finance is profoundly reshaping the investment and financing strategic logic and resource allocation methods of enterprises. Starting from the impact of green finance on enterprises, this paper systematically sorts out its positive effects in promoting green transformation, optimizing the financing structure, and remodeling the decision-making system. At the same time, it also analyzes the practical problems currently faced in the development of green finance, such as inconsistent market standards, insufficient information disclosure, limited financing channels, and insufficient enterprise capabilities.

To address the above challenges, this paper proposes countermeasures, including promoting the unification of green finance standards, improving the information disclosure mechanism, expanding financing paths, and enhancing enterprises' green governance capabilities, aiming to provide a reference for enterprises to build a sustainable investment and financing system that adapts to the green finance environment.

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Research on the Design of Ideological and Political Objective Matrix for Accounting English Course Based on OBE –– with Reference to the Competency Framework of Certified Public Accountants

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Abstract: In recent years, the field of higher education in China has put forward clear requirements for the construction of ideological and political education in courses. Accounting English, as an important course for cultivating international accounting talents, urgently needs to integrate professional ethics and national consciousness into professional teaching [1]. In response to the lack of a professional reference system for ideological and political education in accounting English courses, this paper, guided by the OBE educational concept, constructs a three-dimensional objective matrix model based on the international Certified Public Accountant (CPA) competency framework. By deconstructing the IFAC professional competence standards, a mapping mechanism of "professional competence-language carrier-ideological and political content" is proposed.

Keywords: OBE education; Accounting English; Course-based ideological and political education; Certified public accountant; Competency matrix

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1. Introduction

With the advancement of the "Belt and Road Initiative", the proportion of international business in China's certified public accountants industry has gradually increased, but the lack of professional ethics exposed in cross-border financial fraud cases urgently needs to be addressed [2]. At present, there are two major predicaments in traditional accounting English teaching: one is the separation of professional and ideological and political education: language courses focus on the translation of terms and ignore the ethical requirements in CPA professional standards; The evaluation criteria are ambiguous: the effectiveness of ideological and political

education lacks measurable indicators such as "sufficiency of audit evidence" [3]. This paper aims to construct a matrix of ideological and political goals in accounting English based on the CPA competence framework. To achieve two major goals: visualization (such as refining "integrity education" into measurable outcomes like "accurately translating the IAS 24 related party disclosure clause and explaining its anti-corruption connotation") and dynamic adaptability (matrix parameters can be updated in line with the revision of the Code of Ethics for Certified Public Accountants of China).

2. Construction of the theoretical framework

2.1. Core Concept coupling

2.1.1. Localization adaptation of the OBE concept

The OBE (Outcome-based Education) educational concept was systematically proposed by Spady in 1994, and its core is "organizing the teaching process with the ability Outcome that students ultimately obtain as the orientation [4]. Introducing the OBE concept into the ideological and political construction of accounting English courses requires a "triple localization adaptation" from theory to practice:

The first adaptation is the reconstruction of theoretical logic: traditional accounting English courses mostly adopt the linear teaching model of "textbook chapters → language knowledge points → exercise training", while the "Backward Design" based on OBE follows the reverse path of "practice requirements → ability indicators → course objectives → teaching content". The second adaptation is to align with professional standards: China's Certified Public Accountant Competency Guidelines (2022) explicitly require "adherence to professional ethics in a bilingual environment", and how to quantitatively assess compliance with professional ethics is intrinsically consistent with the "measurable outcomes" emphasized by OBE [5, 6]. The third localization strategy is teaching implementation innovation: building a dynamic adjustment mechanism based on the OBE's "continuous improvement" principle, for example, starting from enterprise research (discovering new fraud methods), to updating the competency matrix (such as adding "ESG report verification "requirements), and then to adjusting teaching cases (supplementing English disclosures related to the dual carbon goals). For example, after the typical case "Luckin Coffee Financial fraud", SEC penalty document analysis can be promptly incorporated into the teaching content to cultivate students' awareness of "honest practice" and language proficiency of "international regulatory rules".

2.1.2. Deconstruction of the CPA competence framework

The Competency Framework for Professional Accountants, released by the International Federation of Accountants (IFAC) in 2021, provides a systematic standard for the competency development of certified public accountants worldwide [7]. In light of the characteristics of the accounting English curriculum, this study extracted three core competencies (technical competence, professional ethics, and international vision) as professional benchmarks for the construction of the target matrix.

First of all, technical competence is the foundation of a certified public accountant's practice. In the accounting English course, it is mainly manifested as an accurate understanding of International Financial Reporting Standards (IFRS) and the ability to apply English. For example, students need to master the English expressions of professional terms such as "fair value measurement" and be able to interpret the disclosure requirements of IAS 36 asset impairment standard. This ability corresponds directly to the professional dimension of the course, requiring students not only to understand accounting principles but also to be able to

conduct technical discussions in English, such as analyzing impairment of goodwill in cross-border mergers and acquisitions.

Professional ethics are presenting new complexities in the context of globalization. IFAC emphasizes that certified public accountants must adhere to professional ethics in a multicultural environment. Accounting English courses should focus on core issues such as conflict of interest and confidentiality, and develop students' ability to conduct ethical analysis in English through real cases, such as the incident of Ernst & Young auditors leaking client information. An international perspective is a new requirement for CPAs due to the surge in cross-border business.

The course should cover practical content, such as the collaborative framework of International Auditing Standards (ISA) and the writing of anti-money laundering (AML) reports in English [4]. These three capabilities form the "iron triangle" of ideological and political education in accounting English courses: technical competence provides the professional foundation, professional ethics establishes the value bottom line, and international vision expands the development pattern. By deconstructing the IFAC standards, the original macroscopic ability requirements are transformed into specific language tasks that can be taught and evaluated, achieving a precise transformation from professional standards to curriculum objectives.

2.2. Mapping model of ideological and political elements

This study established a three-order correspondence of "ability-language-ideological and political", as shown in **Table 1**.

Table 1. Mapping of certified public accountant competency to ideological and political elements

CPA competence items	Language expression	Ideological and political mapping points
Financial analysis skills	Notes to financial statements	Digital economy responsibility
Audit independence	Writing of audit engagement letters	Awareness of integrity and self-discipline

3. Goal matrix design

3.1. Matrix construction methods

The core innovation of this study lies in the construction of the target matrix using the dual-axis positioning method of "Bloom's taxonomy × CPA capability dimension" (**Figure 2**). This methodological design takes into full account the particularity of accounting English courses, organically combining the cultivation of professional abilities in the cognitive domain with the shaping of ideological and political literacy in the emotional domain to form a multi-dimensional and stereoscopic teaching objective system [8].

Figure 2. Bloom's taxonomy × CPA competency dimension

Cognitive dimension (Memory/comprehension/application)	→	Professional competence axis
Emotional dimensions (acceptance/response/evaluation)	→	Ideological and political literacy axis

For the horizontal axis design, this study sets up a professional competence development path from shallow to deep based on the cognitive dimension of Bloom's classification of educational goals. On the vertical axis, this study innovatively employed the emotional dimension of Bloom's taxonomy to construct a ladder for cultivating

ideological and political literacy [9].

3.2. Weight distribution scheme

Determine the three-dimensional weights by Delphi method:

Points score = 0.4 x (professional) + 0.3 x points (language) + 0.3 x (education) score score = 0.4 * (score) + 0.3 * (language score) + 0.3 x points (education)

4. Teaching implementation path

4.1. Curriculum content reconstruction

4.1.1. Textbook development principles

In the construction of ideological and political education in accounting English courses, textbooks, as the main carrier of knowledge transmission, need to follow the core principle of "the unity of professionalism and ideology" in their development [10]. This study proposes the "explicit annotation" development strategy, which can achieve the organic integration of professional knowledge and value guidance by adding the "Ideological and Political Focus" sidebar in international authoritative textbooks such as the ACCA Audit Textbook. This innovative approach to textbook development has three notable features: First, the content of the annotations adheres to the development concept of "originating from the profession and exceeding the profession". Secondly, the annotation form is structured with three elements: "professional links", "case extensions", and "value guidance" [11, 12]. Third, the annotation standards establish a strict review mechanism.

4.1.2. Construction of the teaching case library

Based on the OBE educational philosophy and the requirements of ideological and political education in the curriculum, this study can design a "trinity" template for accounting English teaching cases, organically integrating professional knowledge points, language ability training, and ideological and political elements into a unified teaching context.

4.2. Innovation in teaching methods

4.2.1. Scenario simulation teaching method

This study innovatively designed a role-playing scenario simulation teaching program for "International Accounting Dispute Mediation" to achieve the three-dimensional goals of professional knowledge imparting, language ability cultivation, and ideological and political value guidance through immersive teaching experience. In terms of professional competence development, the scenario simulation focuses on training students' ability to use IFRS and GAAP differential analysis to solve practical problems. This process not only strengthens students' mastery of the technical details of international accounting standards but also cultivates their professional judgment ability in the international business environment, directly corresponding to the "application of International Accounting Standards" ability requirement in the Certified Public Accountant examination syllabus. At the level of ideological and political value guidance, scenario simulation can particularly emphasize the construction of China's accounting discourse power. By presupposing the active position of Chinese enterprises in international accounting disputes, guide students to think about how to reflect Chinese characteristics in the coordination of international accounting standards, how to express China's accounting position in international language, etc.

4.2.2. Empowering with digital tools

A bilingual mini-program called "CPA Ethical Decision Tree "can be developed to transform ethical dilemmas in the practice of certified public accountants into an interactive learning experience. In terms of scenario construction, the mini-program can adopt a progressive complexity design. Primary scenarios focus on a single ethical issue (such as whether to accept suspicious credentials provided by the client), intermediate scenarios involve multiple considerations (such as facing audit fee pressure and time limit requirements simultaneously), and advanced scenarios simulate cultural conflicts in cross-border audits (such as regulatory differences in revenue recognition in different countries). In terms of the decision-making feedback mechanism, the tool can be designed with a three-dimensional scoring system: the professional dimension assesses whether the options comply with the auditing standards (such as whether necessary alternative procedures have been executed); The language dimension examines the accuracy of relevant professional expressions (such as whether terms like "material misstatement" can be used correctly); The ideological and political dimension measures the value orientation of professional judgment (such as whether it reflects the principle of public interest first).

5. Quality assurance system

5.1. Design of evaluation mechanism

This study is based on a three-dimensional evaluation system of Portfolio Assessment, which systematically collects evidence of students' growth in three dimensions: professional competence, language proficiency, and ideological and political literacy, to achieve a comprehensive and process-oriented evaluation of students' learning outcomes [13].

In the dimension of professional competence assessment, the portfolio mainly collected three types of evidence materials: ACCA sample question answering records (demonstrating the degree of understanding of international accounting standards), simulated audit working papers (reflecting practical operation ability), CPA exam real question analysis reports (reflecting knowledge transfer ability). The language competence assessment dimension emphasizes language output in real contexts. Core evidence includes: translation of key paragraphs of annual reports of listed companies (Chinese-English translation), draft and revision process of audit opinions, video of simulated speeches at international accounting conferences, etc [14]. The ideological and political literacy assessment is the innovation focus of the system, mainly based on the following evidence for comprehensive evaluation: business ethics case analysis report (with references to Chinese and foreign professional ethics standards), accounting professional ethics skit performance video, reflection logs from participating in industry integrity building activities, etc. The evaluation adopts a "dual coding" strategy: it assesses both formal elements (such as the logical rigor of the analysis report) and substantive content (such as the independence of value judgments).

5.2. Continuous improvement mechanism

To ensure the timeliness and scientific nature of the ideological and political objective matrix of the accounting English curriculum, this study may establish a systematic annual review system for matrix parameters to form a closed-loop improvement mechanism of "monitoring-evaluation-feedback-optimization" [15]. The mechanism is based on the International Standards for the Education of Professional Accountants issued by the International Federation of Accountants (IFAC), and the dynamic adjustment of the course objectives is achieved through annual review.

6. Conclusion

This study innovatively achieved the organic integration of the international Certified Public Accountant competency standards and the construction of ideological and political education in the accounting English curriculum by constructing an ideological and political education objective matrix based on the OBE concept. The main contributions of the study are as follows: First, a three-dimensional mapping model of "professional competence - language carrier - ideological and political content" was established, transforming abstract ideological and political requirements into observable and evaluable concrete learning outcomes; Second, a series of teaching tools, including the scenario simulation teaching method and the "trinity" case library, were developed, providing replicable implementation paths for ideological and political education in finance and economics courses; Third, a dynamic and updated quality assurance mechanism has been established to ensure that the course content is in line with industry development. These innovations not only address the lack of a professional reference system for ideological and political education in accounting English courses, but also explore an effective way to localize international professional standards.

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Research on Optimizing the Index System of Value Assessment of Transportation Infrastructure Assets

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Abstract: This paper focuses on the optimization of the evaluation index system for the value of transportation infrastructure assets. It analyzes the shortcomings of the current system and explores the directions for optimizing the index system from the perspectives of functionality, economy, social impact, environmental impact, and sustainability. The paper also discusses the application of the optimized index system in practical evaluation and the measures to ensure its effectiveness. The research aims to enhance the evaluation mechanism for the value of transportation infrastructure assets, providing a more scientific basis for decision-making, addressing challenges in asset management, improving the level of asset management in transportation infrastructure, and meeting the demands of high-quality development in the transportation sector in the new era.

Keywords: Transportation infrastructure; Asset value evaluation; Index system; Optimization research

Online publication: September 10, 2025

1. Introduction

In recent years, the development of transportation infrastructure in our country has seen remarkable achievements, with the transportation infrastructure network gradually improving and the transportation sector entering a new era of high-quality development. However, the increasing pressure on facility management and maintenance, along with extensive operational management, has accelerated the depreciation and loss of transportation assets. Transportation infrastructure is a crucial foundation for social and economic development, and its asset valuation is vital for resource allocation, investment decisions, and asset management. While the current evaluation index system is effective, it fails to fully reflect the true value of assets, with issues such as one-sided indicator selection and unreasonable weight settings. Optimizing the existing system can enhance the accuracy of evaluations, providing valuable references for the planning, construction, operation, and maintenance of transportation facilities, thereby promoting the continuous and healthy development of the transportation sector.

2. Problems existing in the index system of value assessment of transportation infrastructure assets

2.1. The selection of indicators is not comprehensive

The current indicator systems primarily focus on the economic and physical attributes of transportation infrastructure, often overlooking its social, environmental, and sustainable development values. In the evaluation process, the emphasis is typically placed on economic indicators such as construction costs and operational revenues, while neglecting the social benefits of transportation infrastructure, such as boosting regional economic growth and enhancing travel convenience for residents, as well as its impact on the ecological environment and long-term sustainability. For instance, some evaluation systems fail to consider the social welfare benefits of transportation facilities, such as improving access to educational resources and medical services along the route, and their potential value in addressing climate change and reducing ecological damage [1]. This one-sided selection of indicators results in evaluation outcomes that do not fully reflect the comprehensive value of assets, making it difficult to meet diverse evaluation needs.

2.2. The weight of indicators is not set reasonably

The setting of indicator weights is a critical factor affecting the accuracy of evaluation results. In the current indicator system, some weights lack scientific basis and are often based on subjective assumptions. Some evaluation systems overemphasize economic indicators while underestimating social and environmental factors, leading to an assessment that leans heavily towards economic value and fails to objectively reflect the actual impact of various factors on asset value. Moreover, different types of transportation infrastructure have distinct characteristics, but the existing indicator system does not adequately consider these differences and adopts a uniform weight setting model. For example, when evaluating urban rail transit versus rural roads, the weight ratios are not adjusted according to the former's social service attributes and the latter's agricultural support functions, which affects the relevance and rationality of the assessment.

3. The optimization direction of the asset value evaluation index system of transportation infrastructure

3.1. Expand the coverage of indicators

Based on the existing economic and physical attributes, incorporate social value, environmental value, and sustainability indicators to establish a comprehensive evaluation system. Social value indicators can include promoting regional employment, optimizing industrial layout, and improving residents' quality of life. Environmental value indicators should cover the protection of the ecological environment, reducing energy consumption, and decreasing pollutant emissions. Sustainability indicators should address the durability, maintainability, and adaptability to technological updates of assets. Specifically, social value indicators can be further refined to assess the enhancement of community cohesion and the promotion of equal public services. Environmental value indicators can extend to the consideration of biodiversity conservation and the maintenance of ecosystem integrity. Sustainability indicators can be expanded to predict the compatibility with future functional upgrades [2]. By broadening the scope of these indicators, we can more comprehensively reflect the overall value of transportation infrastructure assets, making the evaluation results more meaningful.

3.2. Scientifically determine the weight of indicators

Considering the type, function, and regional characteristics of transportation infrastructure, a scientific method should be used to determine the weight of each indicator. Techniques such as the Analytic Hierarchy Process (AHP) and the Delphi method can be employed, combining quantitative and qualitative approaches to integrate expert opinions with actual conditions, thereby reasonably assessing the importance of each indicator. For different types of transportation infrastructure, such as highways, railways, and ports, the weight of indicators should be adjusted based on their specific characteristics to highlight their core value elements. For instance, in port assessments, the weight of logistics efficiency indicators should be increased, while in assessments of highways near scenic areas, the emphasis on ecological protection indicators should be heightened. Additionally, the process of determining weights should involve multiple stakeholders to ensure that the weight settings reflect the needs of all parties. A scientifically determined weight setting can enhance the objectivity and accuracy of the assessment results, making the evaluation system more targeted and practical.

3.3. Improve the index quantification method

To address new social, environmental, and sustainability indicators, a scientific quantification method should be established. By constructing a reasonable quantification model, indicators that are difficult to quantify directly can be transformed into measurable values. For social value indicators, the impact of transportation infrastructure on regional economic growth and travel time savings can be indirectly assessed through analysis. Environmental value indicators can be quantified based on the impact on ecosystems and resource conservation. Sustainability indicators can be measured by considering the asset's lifespan and trends in maintenance costs. During the quantification process, it is essential to clearly define the calculation dimensions and conversion coefficients for each indicator. For example, subjective indicators such as resident satisfaction can be converted into numerical scores through standardized questionnaires, and the degree of ecological impact can be calculated based on the loss of ecosystem service value [3]. A well-developed quantification method ensures the practicality of the evaluation process and enhances the reliability of the results.

4. Application of the optimized asset value evaluation index system for transportation infrastructure

4.1. Improve the scientific nature of investment decisions

The optimized indicator system comprehensively reflects the overall value of transportation infrastructure assets, providing a more reliable basis for investment decisions. In the early stages of project investment, this system can evaluate different investment options, allowing for a comparison of their comprehensive benefits in economic, social, environmental, and sustainability aspects, thus selecting the optimal investment plan. This approach helps avoid investment decision-making errors caused by a sole focus on economic gains, ensuring that investments align with the overall social interests and long-term development needs, thereby enhancing the rationality and effectiveness of transportation infrastructure investments. In specific decision-making processes, projects can be prioritized based on their comprehensive value scores, giving priority to those that, although offering average short-term economic returns, significantly improve regional livelihoods, protect the ecological environment, and have strong long-term sustainability, ensuring that investment directions are closely aligned with national development strategies and regional actual needs.

4.2. Strengthen the efficiency of asset management

By leveraging an optimized indicator system, we can more accurately assess the value of transportation infrastructure assets, thereby providing robust support for asset management. During the operation of these assets, regular evaluations allow us to promptly monitor changes in asset value, identify issues in their use and maintenance, and develop targeted management strategies. This approach helps allocate maintenance funds effectively, enhancing the efficiency and longevity of assets while reducing operational costs. Additionally, it provides a scientific basis for the renewal, renovation, and disposal of assets, ensuring efficient management and value preservation [4]. For instance, when formulating asset maintenance plans, we can allocate resources based on the assessed value decay rates and maintenance urgency of different sections and facilities, prioritizing timely maintenance for assets that are crucial to the overall traffic network and have significant social value.

4.3. Promote rational transportation planning

The optimized indicator system takes into account the multifaceted value of transportation infrastructure, providing a more comprehensive reference for traffic planning. When formulating traffic plans, the evaluation results can guide the rational layout of transportation infrastructure and coordinate the development of different types of transportation facilities across various regions. The impact of transportation infrastructure on society and the environment is fully considered, ensuring that the planning scheme meets economic development needs while also aligning with ecological protection and sustainable development goals. This enhances the foresight and scientific nature of traffic planning, promoting the improvement of the transportation network and the overall efficiency of the transportation system. In practical planning, the road network density and route directions can be optimized based on the traffic demand and capacity of different regions as reflected by the evaluations, avoiding excessive construction that could damage ecologically sensitive areas. At the same time, it ensures accessibility in remote areas, achieving balanced allocation and sustainable use of transportation resources.

5. Measures to ensure the effective implementation of the optimized index system

5.1. Establish and improve relevant system norms

Develop evaluation standards and operational guidelines for the optimized indicator system, clearly defining the evaluation process, methods for calculating indicators, and requirements for applying the results. Detailed operational guidelines should be provided for each step, including specifying the sources of data collection, the steps and formulas for quantifying indicators, and the format for compiling evaluation reports. Through institutional development, ensure that the evaluation work is conducted according to established procedures, enhancing the standardization and consistency of the evaluation. Additionally, establish a review and supervision mechanism for evaluation results, forming a professional review team to rigorously verify the authenticity of data and the applicability of methods during the evaluation process. Cross-verify the evaluation results to prevent human interference, ensuring the objectivity and fairness of the evaluation results, thus laying a solid institutional foundation for the promotion and application of the indicator system.

5.2. Strengthen the training of professional evaluation talents

The valuation of transportation infrastructure assets involves knowledge from multiple fields and requires a high level of professional competence from evaluators. To enhance the development of professional talent, it is essential to establish a multi-level training system that offers tailored courses for different levels of evaluators.

For entry-level personnel, the focus should be on foundational theories and operational skills, while advanced personnel should concentrate on evaluation strategies and innovative methods in complex scenarios. The training content should closely align with the practical needs of the optimized indicator system and include in-depth analysis of typical evaluation cases. Regular training sessions, interdisciplinary academic exchanges, and practical case studies can help evaluators better understand and apply the optimized indicator system, equipping them with multidisciplinary knowledge and advanced evaluation techniques. The goal is to cultivate a group of versatile evaluators who are proficient in both transportation engineering technology and have a solid understanding of economic, environmental, and social issues, thus ensuring the effective implementation of the indicator system.

5.3. Promoting the integration of evaluation technology and information technology

Using information technology, develop evaluation software and an information management platform tailored for the optimized indicator system. The platform should feature real-time data updates, multi-dimensional analysis, and visual presentations, supporting dynamic tracking of the evaluation process and intuitive results [5]. Through information tools, achieve efficient collection, processing, and analysis of evaluation data, thereby enhancing the efficiency and accuracy of the evaluation process. Establish a database of traffic infrastructure asset information, integrating various data such as design parameters, construction history, operational data, and maintenance records, to provide comprehensive data support for evaluations. Promote the integration of evaluation technology with big data, artificial intelligence, and other new technologies, using algorithm models to automatically identify key factors and potential correlations in evaluations, thereby enhancing the intelligence level of evaluations and improving the practicality and operability of the indicator system.

6. Conclusion

Optimizing the evaluation index system for traffic infrastructure assets is a crucial step to meet the demands of social development. It significantly enhances the scientific nature of evaluation results and promotes the scientific management of traffic infrastructure. By broadening the scope of indicators, scientifically setting weights, and refining quantification methods, a more comprehensive and reasonable evaluation system can be established. This system, when applied to investment decisions, asset management, and traffic planning, can promote the healthy development of the transportation sector and lay a solid foundation for the efficient allocation and sustainable use of resources in the transportation field. With institutional support, talent development, and technological integration, the optimized index system can be effectively implemented, providing robust support for the evaluation of traffic infrastructure assets, and helping the industry achieve higher-level development in the new era.

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Research on the Optimization of the Marketing Strategy for the Danxia Mountain Scenic Spot in Guangdong Province

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Abstract: Danxia Mountain scenic area is a famous world natural heritage site and national 5A tourist attraction in China. It is renowned for its unique Danxia landform and rich biodiversity, and it has high ecological, scientific research, and tourism value. In recent years, the upgrading of consumption, the promotion of personalized and in-depth tourism, and the wide application of digital technology in culture and tourism have presented many challenges to the current marketing strategy of scenic spots. Based on the 7P marketing mix theory, this paper systematically analyzes the marketing strategy of the Danxia Mountain scenic area in seven dimensions: product, price, channel, promotion, personnel, tangible display, and service process. The analysis reveals several issues, including a limited product selection and a significant tendency toward homogenization. There is insufficient diversity in online and offline marketing channels, a lack of emotional resonance and international vision in promotional content, an imperfect professional talent echelon, traditional and interactive tangible displays, and an unbalanced service process system. These issues make it difficult to fully meet the needs of different customer groups. Based on this analysis, and considering the characteristics of the scenic spot's resources and the tourism market's trends, the paper offers targeted optimization suggestions. These include innovating experience projects, expanding marketing channels, strengthening talent cultivation, enriching tangible displays, and improving the service system. The aim is to enhance the market competitiveness and tourist satisfaction of scenic spots, promote the integration of culture and tourism while protecting natural heritage, and provide a reference for optimizing the marketing strategies of similar natural heritage sites.

Keywords: Danxia mountain scenic spot; Marketing strategy; Tourist experience; Landscape resources

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1. Introduction

In recent years, as consumption has upgraded, tourists' demands have diversified [1]. The new format of cultural tourism has accelerated the transformation to high-quality development, meeting the market's personalized, in-depth consumption demands [2]. In 2024, China's tourism industry's local market grew strongly, and globalization

accelerated. Simultaneously, policies such as the "Domestic Tourism Promotion Plan (2023–2025)" promoted the high-quality development of the tourism industry [3]. According to the data, the number of counties with national A-level tourist attractions increased from 73% in 2012 to 93% in 2023, strongly supporting the local economy. In the first quarter of 2024, domestic tourist spending reached 1.52 trillion yuan, a 17% year-on-year increase, significantly affecting consumption. The number of people entering and exiting the country exceeded 141 million, a 117.8% year-on-year increase. Currently, sustainable tourism and digital transformation are the new directions in tourism development. AR/VR, big data, and artificial intelligence bring new opportunities for marketing scenic spots [4]. This paper focuses on the current situation and trends in the marketing strategy of the Danxia Mountain scenic area. It analyzes the root causes of the problem from multiple dimensions, explores breakthrough paths, and proposes feasible optimization countermeasures.

2. Introduction to the Danxia mountain scenic area

Located in Shaoguan City in Guangdong Province, Danxia Mountain is an area with a high concentration of Danxia landforms [5]. It is known as "China's Red Stone Park" because it has the most typical development, the most complete types, and the most abundant shapes of Danxia landforms in the world [6]. As a World Natural Heritage Site and a World Geopark, the area's core feature is its red sandstone conglomerate landforms, which are "as beautiful as Wudan and as bright as Mingxia." The geological relics span hundreds of millions of years and fully document the formation and evolution of the Danxia landform, making them highly valuable for scientific research [7, 8]. The area is rich in biological diversity and is home to many rare animals and plants. It is an important base for ecological protection and scientific research. Danxia Mountain also has a rich cultural and historical heritage [9]. It contains relics of the ancient Yue ancestors, ancient Shanzhai sites, and cliff stone carvings by literati from past dynasties. The natural and cultural landscapes complement each other. Shaoguan Danxia Mountain Tourism Investment and Management Co., Ltd. (a state-owned enterprise established in 2004 under the direct management of the Shaoguan Municipal People's Government) is now in charge of operations and management. The company's business scope covers natural landscapes, geological relics, humanities, history, and other resources. The company focuses on tourism, leisure, and science and technology education, and is committed to providing tourists with a high-quality experience. Currently, it has been awarded national 5A tourist attraction status and national ecotourism demonstration area status.

3. Marketing strategy status of the Danxia mountain scenic spot

3.1. Product and price strategy

The core products of the Danxia Mountain Scenic Spot are designed to meet diverse visiting needs, encompassing essential access and transportation services as well as characteristic experience items. These include entrance tickets, which serve as the primary access pass; the Jinjiang Gallery cruise and Xianglong Lake ferry, offering unique water-based perspectives to appreciate the landscape; interval transportation facilitating convenient movement between scenic areas; the Danxia cruise highlighting the mountain-water integration scenery; and the cableway project enabling effortless access to overlook panoramic views. The entrance ticket is priced at 100 yuan, with a 48-hour validity period that allows visitors to explore the scenic spot in depth without rush. To enhance accessibility and inclusivity, the scenic spot implements a tiered discount policy: full-time undergraduate students and younger individuals enjoy half-price tickets; families of active servicemen are eligible for preferential rates;

and the elderly aged 70 and above, active servicemen, ex-servicemen, journalists, and people with disabilities are entitled to free admission, reflecting both social care and efforts to expand its visitor base.

3.2. Channel and promotion strategy

Online channels release information through official websites, advertise on tourism platforms and social media, and cooperate with tourism bloggers and photographers for promotion. Offline, cooperation with tourism service providers, local farmers, and handicraft merchants will enrich the shopping experience for tourists. The full-price ticket will be reduced by 20% (80 yuan per person) during major holidays, such as May Day, National Day, and Spring Festival. During National Day, visitors can enter the park for free by wearing Hanfu (excluding additional items). Special groups, such as children under 6 and the elderly over 65, can receive free or discounted tickets. Dongguan citizens can receive free admission with valid identification and enjoy a 20% discount on business projects within the park. Additionally, photography contests, carnivals, and tours with thousands of cars and people are held irregularly.

3.3. Service and management strategy

The scenic spot has established a "Civil Air Defense + Technical Defense" supervision system and set up a comprehensive law enforcement brigade. This brigade conducts real-time inspections through the monitoring system. The scenic spot also guides indigenous people to participate in planning and construction, provides employment and training opportunities, and drives the development of surrounding homestay and farmhouse entertainment. The scenic spot cooperates with universities and scientific research institutions to carry out geological and biodiversity research. This forms an integrated model of production, study, and research, making it a model for the sustainable development of a world natural heritage site. Regarding smart tourism, big data scheduling, electronic access control, license plate recognition, and UAV patrol systems are used to optimize management. The construction of 46 kilometers of Yuedan Highway and seven comprehensive service centers promotes the integration of "mountain into city, mountain city."

4. Problems with the Danxia mountain scenic spot's marketing strategy

4.1. Product homogeneity and insufficient experiences

Danxia Mountain scenic area is a famous world natural heritage site and national 5A tourist attraction in China. It is renowned for its unique Danxia landform and rich biodiversity, and it has high ecological, scientific research, and tourism value. In recent years, the upgrading of consumption, the promotion of personalized and in-depth tourism, and the wide application of digital technology in culture and tourism have presented many challenges to the current marketing strategy of scenic spots. Based on the 7P marketing mix theory, this paper systematically analyzes the marketing strategy of the Danxia Mountain scenic area in seven dimensions: product, price, channel, promotion, personnel, tangible display, and service process. The analysis reveals several issues, including a limited product selection and a significant tendency toward homogenization. There is insufficient diversity in online and offline marketing channels, a lack of emotional resonance and international vision in promotional content, an imperfect professional talent echelon, traditional and interactive tangible displays, and an unbalanced service process system. These issues make it difficult to fully meet the needs of different customer groups. Based on this analysis, and considering the characteristics of the scenic spot's resources and the tourism market's trends, the paper offers targeted optimization suggestions. These include innovating experience projects, expanding marketing

channels, strengthening talent cultivation, enriching tangible displays, and improving the service system. The aim is to enhance the market competitiveness and tourist satisfaction of scenic spots, promote the integration of culture and tourism while protecting natural heritage, and provide a reference for optimizing the marketing strategies of similar natural heritage sites.

4.2. Low marketing channel and promotion efficiency

First, there are shortcomings in online channels. The official website's functions are basic, and updates are delayed. The WeChat official account's content lacks interest, and Dithering and Xiaohongshu mainly feature scenic materials. User-generated content is insufficient and lacks "memorable moments," and coverage is limited. Second, there is excessive reliance on traditional offline travel agencies, and the customer coverage of free and medium-to-high-end customized tours is insufficient. There are no electronic navigation or online queuing functions in the scenic area. Congestion frequently occurs in peak seasons, such as at Jiujiu TIANTI Zhandao, which negatively impacts the experience. Third, the promotional positioning is vague and does not convey emotional value. The slogan, "Color is like Wudan, can be like Mingxia," only describes the landscape. It does not highlight the international image of "World Natural Heritage," and few foreign tourists visit. New media promotion mainly uses static content with weak interactivity. There is insufficient excavation of local stories, and the publicity lacks highlights.

4.3. Lack of talent and service system

First, most of the staff are local residents who lack professional quality and systematic training. They have problems such as a cold service attitude, low ticket-selling efficiency, and perfunctory explanations by the guides. The management team lacks professionals and relies on traditional experience. They have an insufficient grasp of tourism trends and weak adaptability. Second, there are limitations in tangible displays. The infrastructure is aging; some footpaths are damaged, and guardrails are loose. The number of rest areas and toilets is insufficient, and the sanitary conditions are poor. The exhibition hall mainly consists of static pictures and texts and lacks interactive devices. Third, the service process is not evenly covered. The tourist route is unreasonable. There is no shuttle bus from the gate to the ticket check-in gate, which is about two kilometers away. This is inconvenient for tourists who don't drive. The single entrance design leads to long wait times during peak season. Inconsistent management standards and incomplete information release affect the tourist experience.

5. Suggestions for optimizing the marketing strategy of the Danxia mountain scenic spot

5.1. Innovative products and experience projects

First, introduce the "low altitude + tourism" model. Cooperate with UAV enterprises to provide photography services and develop hot air balloon and helicopter tours to enhance the experience. Design cultural and creative plush toys based on the scenic spot's characteristics to meet consumers' aesthetic and social needs. Second, build campsites to extend tourists' stay time (in line with the 48-hour ticket validity), drive consumption of surrounding catering and accommodation services, and enrich the product system.

5.2. Expanding channels and upgrading promotion

First, optimize the functions of the online platform. Upgrade the official website and WeChat public account.

Add interactive content on Douyin and Xiaohongshu. Guide users to generate content. Create an IP matrix. Sell tickets and cultural and creative works simultaneously through live broadcast promotional activities. Second, expand offline cooperation. Reduce dependence on traditional travel agencies, and strengthen cooperation with medium- and high-end, customized travel agencies. Add electronic navigation and online queuing systems to ease congestion during peak seasons. Third, implement precise positioning and promotion. Highlight the international image of "World Natural Heritage" to attract overseas tourists. Excavate local stories to strengthen emotional resonance. Carry out themed activities in combination with the seasons, such as flower viewing in the spring, boating in the summer, climbing in the fall, and tea making in the winter, to increase appeal.

5.3. Improve talent and service quality

First, establish a regular training mechanism to improve employees' business ability and adaptability. Simultaneously, train community residents to strengthen their service awareness. Attract professional, multifaceted talent, and optimize the management team structure. Second, enhance the tangible display. Create an exclusive cartoon image of the scenic spot with an animation team or collaborate with "Shiji Niangniang" to strengthen brand awareness. Add interactive facilities, such as ceramic art and bamboo weaving. Introduce AR technology to bring cultural relics to life. Establish a Danxia opera troupe to tell Danxia stories through ethnic minority cultural creations and create a distinctive cultural identity. Third, improve the service system. Clarify job responsibilities to reduce overlap or gaps. Establish an emergency response process and an employee incentive mechanism. Collect tourist feedback through questionnaires and social platforms. Make regular adjustments to standardize the catering and shopping environment and improve the overall experience.

6. Conclusion

Based on the 7P marketing mix theory, this paper systematically analyzes the current marketing strategy of the Danxia Mountain scenic spot and finds shortcomings in product structure, channel expansion, promotional transformation, talent development, physical display, and service processes. These shortcomings make it difficult for the scenic spot to adapt to the current tourism market's diverse needs and digital trends. To address these issues, the paper proposes several optimization strategies, including innovative experience projects, expanding marketing channels, strengthening talent cultivation, enhancing tangible displays, and improving the service system. These strategies aim to help the scenic spot overcome the challenges of homogenization and enhance its market competitiveness. As a World Natural Heritage Site and a National 5A Scenic Spot, optimizing Danxia Mountain's marketing strategy is important not only for its own sustainable development but also for the cultural and tourism integration and high-quality development of similar natural heritage sites. Through the implementation of these suggestions, Danxia Mountain is expected to balance resource protection and tourism development, meet tourists' needs, build a unique brand advantage in the cultural and tourism market, and improve ecological and economic value.

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Challenges and Optimization Pathways of Moutai's Digital Supply Chain Finance Model

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Abstract: In the era of the digital economy, traditional supply chain finance models face challenges such as information fragmentation, inefficient processes, and insufficient credit transmission, necessitating digital transformation. This study focuses on Kweichow Moutai Group, systematically analyzing its innovative practices in supply chain finance and examining the mechanisms through which digital technologies enhance core enterprise credit empowerment, improve supply chain collaboration efficiency, and optimize risk management. The research reveals that Moutai Group has transformed supply chain finance from unilateral credit granting to ecosystem-based credit sharing by establishing an IoT-enabled asset verification platform, developing smart contract-driven bill financing systems, and building a blockchain-based multi-party credit alliance. This model significantly lowers financing barriers for small and medium-sized suppliers while creating new value chain growth points through data assetization strategies. Finally, the study proposes further improvements from the perspectives of technical standardization and adaptive regulatory frameworks.

Keywords: Digital technology integration; Liquor industry chain; Credit penetration; Intelligent risk control; Ecosystem-based financing

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1. Introduction

In the rapidly evolving digital economy, traditional supply chain finance (SCF) models face significant challenges, including information asymmetry, inefficient credit transmission, and high risk management costs, necessitating a digital transformation to enhance financial efficiency across industrial chains. As a leading enterprise in China's liquor industry, Kweichow Moutai Group operates a complex supply chain spanning raw material cultivation, brewing, warehousing, logistics, and distributor networks, characterized by substantial capital requirements and long cycles [1]. Conventional credit models struggle to meet the financing needs of small and medium-sized enterprises (SMEs) in its upstream and downstream ecosystem.

In recent years, Moutai Group has leveraged digital technologies—such as the Internet of Things (IoT),

blockchain, and big data—to construct a novel SCF ecosystem anchored in core enterprise credit and supported by data assetization [2]. This innovation has transformed the traditional unilateral credit model into a multi-party credit-sharing paradigm. The new approach not only significantly reduces financing costs for SMEs but also uncovers new value chain growth points through data monetization strategies, offering a pioneering case for digital financial innovation in asset-heavy industries.

2. The drivers behind Moutai's digital transformation of supply chain finance

The digital transformation of Moutai Group's supply chain finance (SCF) stems primarily from the inherent limitations of traditional financial models in addressing the complexities of its extensive industrial chain. As a leading player in China's liquor industry, Moutai's supply chain encompasses long-cycle processes ranging from sorghum cultivation and base liquor production to warehousing, logistics, and distributor networks [3]. Small and medium-sized enterprises (SMEs) operating upstream and downstream frequently struggle with financing accessibility and affordability. Traditional bank credit models, which rely heavily on collateral and financial statements, fail to transmit the core enterprise's creditworthiness effectively to peripheral suppliers. Consequently, businesses at the supply chain's tail end—lacking qualifying collateral—often face liquidity crunches [4]. Compounding this issue is the prevalence of data silos, where fragmented information across different stages prevents financial institutions from verifying trade authenticity in real time, exacerbating adverse selection and moral hazard risks. Since 2018, intensifying industry competition and rising ESG demands have pressured Moutai to adopt digital solutions that enhance capital allocation efficiency across its supply chain, thereby stabilizing and future-proofing its ecosystem.

A more profound catalyst lies in the transformative potential of digital technologies in industrial finance. Moutai's supply chain presents numerous asset scenarios ripe for digitization: soil moisture data from sorghum farms, IoT-monitored fermentation pits, blockchain-based liquor traceability, and more [5]. These real-time datasets offer dynamic risk-assessment dimensions beyond traditional credit metrics. By converting physical assets into verifiable digital assets, Moutai replaces "collateral-based credit" with "data-driven credit," enabling previously intangible factors—such as the value of brewing techniques or inventory liquidity—to serve as financing foundations. Furthermore, Guizhou Province's "Big Data Strategy" and Moutai's own "Smart Moutai" initiative synergistically promote the market-oriented deployment of data. For instance, the 2021 launch of the "SCF Cloud Platform" (a collaboration with Industrial Bank) integrated order, logistics, and capital flow data to automate accounts receivable verification and enable credit splitting, boosting credit transmission efficiency by over 40%.

External shifts further accelerated this transformation. The COVID-19 pandemic exposed the fragility of offline financial services amid supply chain disruptions, while Moutai's digital platform ensured financing continuity via remote asset validation and smart contract settlements [6]. Concurrently, regulatory support—exemplified by the China Banking and Insurance Regulatory Commission's (CBIRC) 2022 Guidelines on Promoting SCF to Serve the Real Economy—legitimized innovations like blockchain-based bill discounting and digital warehouse receipt pledging. Crucially, digitization transcends risk mitigation to unlock new value streams. By analyzing distributor sales histories and consumer behavior, Moutai dynamically adjusts prepayment financing limits and designs tailored financial products for premium clients, transitioning from "financing services" to "data-driven value-added services." These practices underscore that Moutai's SCF digital evolution is fundamentally propelled by a triad of forces: technological advancement, industrial pain points, and policy tailwinds.

3. The architecture of Moutai's digital supply chain finance model

Moutai's digital supply chain finance (DSCF) model is built upon its closed-loop, full-industry-chain ecosystem, reconstructing the traditional financial value chain through three core principles: data transparency, credit sharing, and intelligent collaboration. At the foundational technological level, Moutai has established a hybrid infrastructure combining blockchain and IoT. Blockchain nodes connect core enterprises, tier-one suppliers, financial institutions, and regulators to ensure the immutability of trade authenticity, while IoT devices are embedded in critical stages such as raw material cultivation, base liquor production, and logistics, collecting real-time data on temperature, humidity, and transport routes to create a digital twin of the physical supply chain. This "on-chain/off-chain" dual verification mechanism effectively mitigates traditional SCF pain points like invoice fraud and duplicate financing [7]. For example, in Moutai's 2022 "digital warehouse receipt pledge" collaboration with ICBC, IoT sensors dynamically monitored stored liquor conditions while hashed data was recorded on-chain, granting movable asset financing a risk-control credibility comparable to real estate collateral.

At the business middle layer, Moutai developed an intelligent analytics platform integrating "four flows" (order, logistics, capital, and invoice), powered by AI-driven dynamic credit assessment models. Unlike traditional financing, which relies on static financial statements, this platform evaluates suppliers based on behavioral data and distributor performance metrics to generate customized credit scores [8]. For upstream sorghum farmers, the platform incorporates satellite weather and soil moisture data, automatically adjusting prepayment financing limits when droughts threaten yields. For downstream distributors, point-of-sale (POS) system integration enables automated sales-revenue deductions and profit releases, optimizing cash flow. This data-centric approach reduced non-performing loans by 63% and cut approval times from 7 days to 2 hours.

The application ecosystem layer features a modular network connecting financial institutions and third-party service providers via open APIs. Moutai digitizes its core enterprise credit into transferable electronic claims, enabling multi-tier supplier receivable financing. It also embeds scenario-specific financial products, such as the "Fermentation Capacity Loan" (co-launched with CCB), which uses real-time base-liquor production data as collateral, aligning financing with actual output. Notably, the architecture incorporates a regulatory sandbox, sharing anonymized data with tax and customs authorities to verify trade authenticity while ensuring data sovereignty. This balances compliance with innovation, such as leveraging export declarations to enhance cross-border trade financing. By 2023, this open yet secure model reduced supply chain financing costs by 35% and improved turnover efficiency by 28%, demonstrating how Moutai's DSCF merges ecosystem inclusivity with regulatory robustness.

4. Implementation results and case studies of Moutai's digital supply chain finance model

Moutai's digital supply chain finance (DSCF) model has achieved remarkable success, significantly optimizing financial resource allocation across the entire industrial chain while enhancing ecosystem-wide collaboration efficiency. In terms of economic benefits, the model has cumulatively provided over ¥120 billion in financing support to upstream and downstream enterprises, with 68% allocated to SMEs, reducing overall financing costs by 4–6 percentage points compared to traditional models [9]. For instance, in 2023, Moutai's core suppliers saw their average payment terms shortened from 90 days to 45 days, while distributor inventory turnover rates improved by 40%, and overall capital utilization efficiency increased by approximately 30%. Crucially, by leveraging blockchain-verified trade data and smart contract automation, financial institutions reduced due diligence costs by 57%, maintaining a non-performing loan rate below 0.8%—far lower than the industry average of 2.5%. This dual

advantage of cost reduction and efficiency gains propelled the market penetration rate of Moutai's SCF products from 22% to 76% within three years, cementing its role as a bidirectional value hub between industrial and financial stakeholders.

A standout case is the "Red Tassel Sorghum Order Loan", a collaboration between Moutai and Agricultural Bank of China. By integrating IoT-based crop monitoring with blockchain order traceability, the project brought 26,000 local sorghum farmers in Guizhou into a digital credit system. Using satellite remote sensing to track crop growth and smart contracts to secure purchase orders, farmers gained access to unsecured prepayments—up to 60% of expected output value—based solely on digital orders. During the 2022 drought, the system automatically triggered risk alerts via soil moisture data, unlocking ¥30 million in emergency credit for affected farmers to ensure zero disruption in raw material supply. Recognized as a "FinTech-enabled Rural Revitalization Demonstration Project" by the People's Bank of China, the initiative boosted farmers' average annual income by ¥12,000 while guaranteeing full traceability of Moutai's ingredient quality. Another breakthrough innovation is the "Digital Baijiu Warehouse Receipt Pledge", which transformed Moutai's base liquor inventory into standardized digital assets [10]. Equipped with smart warehouse systems to monitor ceramic jar storage conditions in real time and linked to the Shanghai Commercial Paper Exchange for electronic warehouse receipt circulation, a mid-sized distributor secured ¥80 million in pledged financing with fund disbursement slashed from 15 working days to 72 hours, at an interest rate 1.8 percentage points lower than comparable products.

The model's extensibility shines in cross-border trade scenarios. The 2023 "Export Data Chain Finance" initiative for Southeast Asian markets enabled "customs declaration triggers financing" by cross-verifying AEO-certified customs data with blockchain export documents. A Singaporean importer obtained offshore credit from Bank of China using blockchain bills of lading, cutting the trade cycle from order to delivery by 60% and saving approximately $30,000 per transaction in letter of credit costs. Such cases validate the model's adaptability to complex trade environments—McKinsey estimates that applying Moutai's approach to the FMCG sector could unlock a ¥200 billion SCF market potential. With Moutai now piloting DPU (Data Payment Unit)-based cross-border settlements in partnership with SWIFT, its financial infrastructure is reshaping global liquor trade, signalling China's DSCF models' readiness for international adoption.

5. Challenges and optimization pathways of Moutai's digital supply chain finance model

While Moutai's digital supply chain finance (DCF) model has achieved notable success, it also faces multifaceted challenges. On the technological front, deep integration of blockchain, IoT, and AI continues to encounter data silos, with 20%–30% of supply chain data failing to synchronize in real-time due to inconsistent ERP interface standards among suppliers.

Market adoption issues persist as well. A cognitive gap exists among traditional distributors toward digital financial tools—only 23% of liquor dealers aged 45+ can independently operate digital warehouse receipt pledge systems, and in 2023, 17% of Guizhou's approved supply chain financing quotas went unused due to operational errors. More critically, the weak digital infrastructure of SMEs hampers progress: about 60% of packaging suppliers still rely on manual bookkeeping, rendering their operational data unfit for institutional due diligence, thereby diluting the model's financial inclusivity. Deeper ecosystem conflicts arise from partners perceiving data sharing as a competitive risk. One ceramic bottle supplier, for example, lost out on a 1.2-percentage-point green finance

interest subsidy by withholding production energy data, highlighting unresolved benefit-distribution mechanisms.

To tackle these challenges, Moutai is rolling out a series of multilayered optimizations. On the technological front, its 2024 "Starlink Initiative" aims to integrate industrial IoT platforms using edge computing nodes. This will enable millisecond-level interactions between field sensors, fermentation pit monitors, and blockchain systems, with the goal of reducing data discrepancies to below 5%. Legally, the "Cross-Border Digital Asset Rights Sandbox," developed with China University of Political Science and Law, is testing smart contracts that auto-adapt collateral clauses across jurisdictions, targeting judicial reciprocity for blockchain receipts in RCEP nations first. For market education, the innovative "Digital Navigator" program trains 500 hybrid experts in both liquor trade and fintech to provide on-ground assistance, projected to boost traditional dealers' operational proficiency by 50%. To bridge SME digital divides, a "lightweight SaaS toolkit" bundles inventory management and tax reporting with automated data-cleansing interfaces that generate bank-compliant reports—a "low-threshold digitization" solution already helping 83 packaging factories in Zunyi secure inaugural credit loans.

More transformative is the ecosystem governance overhaul. The pilot "Data Contribution Credit System" quantifies partners' data-sharing into tradable digital equities, redeemable for loan-rate discounts or premium product distribution rights—a "data asset securitization" approach that raised core suppliers' data completeness from 72% to 94% in 2023 trials. Concurrently, the "Supply Chain Finance Maturity Index," co-developed with Central University of Finance and Economics, integrates ESG metrics into supplier ratings, granting sustainability-driven firms 20% higher credit lines. These systematic refinements not only tackle immediate pain points but also forge a new paradigm for supply chain finance in the era of global digital trade.

6. Conclusion

Through a systematic examination of Moutai Group's digital SCF model, this study demonstrates how digital technologies reshape traditional credit value chains. Key findings reveal that Moutai's integration of IoT-enabled asset verification, blockchain-driven smart contract settlements, and big data risk control models has shifted the paradigm from "exclusive core enterprise credit" to "ecosystem-wide credit sharing," effectively addressing SME financing challenges. The success of this model highlights that digital transformation not only enhances SCF operational efficiency but also generates new business value through data assetization. However, challenges remain in standardizing technologies, defining data sovereignty, and establishing cross-institutional regulatory frameworks. Future advancements in 5G, AI, and digital currency applications promise to further propel SCF toward greater intelligence and ecosystem integration.

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Analysis on the Cultivation of Digital and Intelligent Professionals in University Economics

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Abstract: With the rapid development of the digital economy, technologies such as big data, blockchain, and artificial intelligence are reshaping the economic development model, and data has become a means of production for economic and social development. The application of digital and intelligent technologies in the field of economics can efficiently process complex statistical data and bring profound changes. At this stage, digitalization and intelligence have also become the core force driving changes in various fields, directly affecting the higher education system. The wave of digitalization and intelligence brings not only technological innovation but also changes in thinking patterns and industrial structures. Therefore, colleges and universities should thoroughly explore the teaching model of economics majors to cultivate talents that meet the needs of the industry and further promote economic development. Based on this, this paper analyzes and studies the cultivation of digital and intelligent professionals in economics in colleges and universities for reference.

Keywords: Colleges and universities; Economics; Digitalization and intelligence; Talent cultivation

Online publication: September 10, 2025

1. Introduction

The rapid development of the digital economy directly affects the overall operation of the economy and puts forward higher requirements for the cultivation of economics professionals. However, at this stage, there are still problems, such as the disconnection between theory and practice in the cultivation of economics talents in colleges and universities, making it difficult to meet the needs of industries for talent cultivation. Therefore, it is necessary to strengthen the reform of digital and intelligent talent cultivation in college economics. This is not only the requirement for higher education to adapt to economic and social development, but also an important channel to promote the development of the economics discipline.

2. Overview of digital intelligence

Digital intelligence, as a development model integrating digitalization and intellectualization, represents an

advanced state of information technology. Digitalization makes full use of computer technology to convert various types of information into digital form, enabling the collection, storage, transmission, and processing of data. In the economic field, enterprises generate a large amount of data information during their operations, including consumers' behavioral information and market dynamic data. All these data can be recorded, thereby forming an integrated data resource. Such data not only covers traditional economic statistical indicators but also includes unstructured data, which provides more diversified materials for economic analysis. Intellectualization, on the other hand, emerges based on the data accumulated through digitalization. It effectively utilizes technologies such as artificial intelligence and machine learning to achieve self-learning, analysis, and judgment. In economic research, machine learning algorithms can conduct in-depth analysis of massive data resources and automatically identify the relational structures within the data. Deep learning models can be used to effectively predict macroeconomic development patterns, thereby providing assistance for the formulation of economic policies. In the financial sector, intelligent systems can analyze market data and investors' personalized characteristics to provide them with precise investment advice, which helps improve work efficiency [1].

3. Significance of cultivating digital and intelligent professionals in university economics programs

3.1. Meeting the talent development needs of the new era

The "Recommendations of the Central Committee of the Communist Party of China on Formulating the 14th Five-Year Plan for National Economic and Social Development and the Long-Range Goals for 2035" proposes the optimization and upgrading of the economic system and the acceleration of digital construction. Currently, the development of the digital economy is entering an era driven by data. In the context of the new era, talents with only traditional professional knowledge systems can no longer meet the requirements of the industry. At this stage, economics professionals need not only basic knowledge in the field of economics but also basic digital and intelligent operation skills. For example, economics professionals need to build a systematic knowledge system integrating "economics + digital intelligence", master basic theories such as microeconomics and macroeconomics, and also grasp programming languages like Python and R for data processing and modeling, as well as skillfully use big data analysis platforms such as Hadoop and Spark for data mining. Only by mastering this series of digital and intelligent operational skills can they ensure their application in work and provide assistance and support for future employment [2].

3.2. Responding to complex economic phenomena of the era

Economics professionals should not only possess basic knowledge and skills but also develop good thinking qualities to address key issues. Firstly, developing data thinking. Students need to extract key information from massive amounts of data, interpret it, and analyze problems based on such information. When participating in market research activities, students can abandon traditional sampling survey methods and instead use big data technology to obtain more accurate and comprehensive market information, conduct in-depth analysis of consumers' behavioral data, and fully understand the current changes in market demand. Secondly, developing algorithmic thinking. This involves using algorithms to solve more complex economic problems and understanding the role of algorithms in resource allocation and price formation. In addition, interdisciplinary integration thinking is particularly important. Economics should integrate with computer science, mathematics, and other disciplines, which requires students to develop interdisciplinary knowledge and abilities to address economic issues arising in

the digital and intelligent era [3].

3.3. Adapting to changes in the job market

On one hand, traditional economics-related positions are increasingly demanding digital and intelligent skills from practitioners. Analysts in the financial industry can no longer rely solely on basic financial analysis; they must also make full use of data analysis tools for calculations and quantify specific risk indicators. On the other hand, digitalization and intelligence have spawned many emerging professions, including digital strategy analysts. These new professions provide more employment opportunities for economics students, but they also intensify employment competition [4].

4. Specific manifestations of higher education promoting digital and intelligent development

4.1. Strengthening knowledge innovation, research, and development work

Colleges and universities possess relatively complete academic resources. Many educators are also top-notch scientific research talents, and their research and technical facilities are relatively sophisticated. Therefore, colleges and universities are also important positions for knowledge innovation and technological development. Research teams in colleges and universities conduct in-depth research in the field of digitalization and intelligence, committed to optimizing artificial intelligence algorithms, ensuring the protection of big data, and solving some technically difficult problems. For example, in economic research, new economic research models are explored by integrating digital technologies with economic theories. Studies are conducted on how to utilize the decentralized characteristics of blockchain and apply artificial intelligence technologies to optimize relevant economic policies, thereby providing assistance and support for economic development [5].

4.2. Realizing industrial upgrading and transformation

Colleges and universities establish cooperative relationships with enterprises and effectively utilize the collaborative development model of industry, education, research, and application. Through industry-university-research cooperation projects, they transform digital research achievements into practical productivity, thereby facilitating the digital and intelligent upgrading of traditional industries. For instance, colleges and universities cooperate with manufacturing enterprises, using big data analysis technology to optimize production plans, further improving product quality, and ensuring the reduction of production costs [6]. Colleges and universities also need to strengthen cooperation with service-oriented enterprises, develop intelligent service platforms, thereby ensuring service quality and delivering an excellent customer experience. Moreover, colleges and universities should provide digital training and consulting services for industries to help enterprise employees improve their own literacy, develop key digital and intelligent skills, and better adapt to industrial changes.

5. Strategies for cultivating digital and intelligent professionals in economics in colleges and universities

5.1. Strengthening the construction of curriculum system to ensure the cutting-edge nature of knowledge

Colleges and universities should attach importance to the macro construction of curriculum system, introduce

digital-related courses such as Big Data Economics and Data Science and Technology. These courses can teach students the basic principles of the application of intelligent technologies in the field of economics. In addition, interdisciplinary educational resources should be introduced to further break the limitations of disciplinary teaching, so that students can broaden their knowledge horizons in practical learning and learn to use knowledge from multiple disciplines to solve practical problems. At the same time, curriculum teaching should conform to the requirements of the times, continuously update and improve educational content, and introduce cutting-edge achievements and cases, so that students can truly contact real cases for learning and thinking, and improve their professional quality and ability [7–9]. For example, in Econometrics, some core courses on basic economic metrics should be integrated into the knowledge framework system of digital economy applications.

Colleges and universities in different regions should adapt to the development trend of the economy and society, constantly optimize and update courses, and build characteristic curricula to meet the development needs of the industry.

5.2. Innovating course teaching methods to enhance students' motivation

Against the backdrop of the digital and intelligent era, teachers should focus on innovating course teaching approaches and adopt diverse methods for teaching.

First, teachers can design project-based teaching activities, enabling students to truly learn to actively apply knowledge in the process of completing projects and develop good practical exploration abilities. For example, teachers can set up enterprise projects, allowing students to apply relevant knowledge in project practice, thereby enhancing their practical capabilities. In this process, students can utilize knowledge in the fields of economics, statistics, and computer science to properly process and organize market data [10]. Second, teachers can create an online-offline hybrid teaching model. By leveraging the advantages of online teaching platforms, they can provide rich educational resources to promote students' learning and development. Then, teachers can conduct in-class discussions, practical operations, and guidance offline, which is also conducive to cooperative learning between students and teachers.

Virtual simulation teaching can make full use of virtual reality technology and augmented reality technology to create a more realistic learning environment for students, enabling them to complete practices in the corresponding environment and improve their problem-solving abilities. For instance, in market research projects, students use web crawler technology to collect market data, employ Python for data cleaning and analysis, and utilize Tableau for visual display, ultimately forming a market analysis report, which helps cultivate students' practical abilities and team spirit.

5.3. Strengthen practical teaching links and enhance the importance attached to education

For students majoring in economics, they need to have not only solid theoretical knowledge but also strong practical application abilities. To this end, colleges and universities should pay attention to early investment, build a digital and intelligent practical teaching platform, introduce advanced educational resources and equipment, and provide students with a good platform for practical learning. This includes big data laboratories, fintech laboratories, etc., with the introduction of cutting-edge equipment resources to create a favorable practical environment. For example, colleges and universities cooperate with financial institutions to organize financial data analysis projects, where students participate in projects such as stock market trend prediction. They also carry out cooperation with internet enterprises to conduct in-depth mining of market data information and analyze user

behavior data, thereby providing support for the development of enterprises [11–13].

5.4. Focus on the construction of teaching staff and enhance teaching innovation capability

Colleges and universities should adopt various methods to improve teachers' teaching ability, enhance their digital and intelligent literacy, and boost teaching innovation capability. They can organize teachers to participate in digital and intelligent technology training courses, seminars, and other activities, so that teachers can fully understand the current development of digitalization and intellectualization, as well as its application status in the economic field, and then integrate practical experience into teaching work. Moreover, schools need to strengthen the training of interdisciplinary talents, recruit professionals in the fields of computer science, mathematics, and statistics, constantly enrich the professional teaching staff, and provide new method guidance for teaching work. In addition, schools need to establish and improve the incentive system for teachers, optimize the professional title evaluation and performance assessment, and incorporate teachers' digital and intelligent literacy and digital and intelligent achievements into the assessment and evaluation, which will also help promote teachers to actively engage in the research of digitalization and intellectualization. Schools should also recruit senior professors from relevant fields outside the school and digital technical personnel with rich practical experience as part-time teachers, so as to strengthen academic exchanges and guidance, improve the quality of education as much as possible, and achieve good teaching benefits [14].

5.5. Develop curriculum textbooks and lesson plans to enhance learning autonomy

In the context of the digital era, colleges and universities should strengthen cooperation with economic industries, build digital economy platforms, and actively collect data and information from students' feedback, so that enterprises, schools, and scientific research institutions can participate in the construction of the digital economy discipline system. The core courses of the major should be carried out in accordance with the logic of big data + intelligence + economy, and ensure the effective integration of soft courses and hard courses. Relevant technologies in the field of big data analysis can be integrated into lesson plans to ensure the cutting-edge nature of theories. Furthermore, teachers should develop virtual teaching courseware, build online quality courses, and upload these resources to the learning platform, so that students can participate in independent learning and practice activities and solve problems encountered in the learning process [15].

6. Conclusion

To sum up, against the backdrop of the digital and intelligent era, the cultivation of economic professionals in colleges and universities is facing unprecedented opportunities and challenges. It is a systematic and dynamic project. This requires educators to conduct in-depth analysis and research on the in-depth connotations of digitalization and intelligentization, grasp the current situation of talent cultivation, and thus carry out the cultivation of digital and intelligent talents. With the curriculum system as the core of education, teaching methods as the engine of innovation, practice as the way to improve capabilities, and the teaching staff as the guarantee of quality, a more complete educational mechanism can be built. In future research, colleges and universities should continue to pay attention to the development of digital technologies, so as to continuously reform the current talent cultivation mechanism and better adapt to the development characteristics of the times.

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Research on the Development Path and Policies of the Digital Economy in Agriculture

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Abstract: Against the backdrop of digital transformation, the agricultural digital economy is showing promising development trends, yet it also faces numerous challenges that hinder its high-quality growth. To align with the requirements of agricultural digital transformation in the new era, it is necessary to accelerate the construction of digital infrastructure, create a favorable industrial environment, enhance the overall quality of the workforce, and implement a comprehensive approach to elevate the development level of the agricultural digital economy, thereby driving the high-quality development of modern agriculture. This article focuses on the development of the agricultural digital economy, summarizes relevant policies and practical pathways, and aims to provide references for related theories and practices.

Keywords: Development path; Agriculture; Digital economy; Policy

Online publication: September 10, 2025

1. Introduction

According to the requirements of the national 14th Five-Year Plan, digital agriculture has become an inevitable path for the modernization and transformation of agriculture. By introducing digital economy concepts into the agricultural sector and deeply integrating digital technologies with the agricultural industry, it is possible to comprehensively reconstruct agricultural production and management processes, thereby promoting green and sustainable agricultural development. Unlike traditional agricultural economies, the agricultural digital economy covers the entire agricultural production process, relying on technologies such as artificial intelligence, the Internet of Things, and big data to assist farmers in real-time, efficient data acquisition, providing data support for making optimal decisions. However, despite the promising prospects for the development of the agricultural digital economy, numerous challenges remain that require further refinement and improvement.

2. Challenges faced by the agricultural digital economy

2.1. Incomplete digital infrastructure

In some remote mountainous areas and rural regions with relatively low overall economic levels, broadband network infrastructure is inadequate, and new communication technologies such as 5G and high-speed fiber optics have not yet been fully deployed or popularized. Many farm fields still face issues with insufficient signal coverage. In core production areas such as livestock farms and large-scale planting bases, the density of IoT device deployment is relatively low, and data collection on agricultural production environments—including weather conditions, soil moisture levels, and crop growth—is incomplete, making real-time transmission and sharing of such data difficult. Smart sensing devices suitable for complex field environments are scarce due to high costs, making large-scale adoption challenging. Agricultural producers often opt for low-cost digital tools, such as portable data collection terminals and lightweight farm management apps, resulting in agricultural production data that cannot be standardized or structured for collection and integration [1].

2.2. Low technical literacy among farmers

Farmers are a crucial force in the development of the agricultural digital economy, and enhancing their technical literacy is of utmost importance. However, the current rural labor force is predominantly composed of middle-aged and elderly individuals who are unfamiliar with operating computers and smartphones and cannot collect and process agricultural technology knowledge and market data. Commonly used agricultural apps and online payment tools are difficult to operate, making it challenging for farmers to participate in online sales on a large scale. Additionally, most farmers have low acceptance of new technologies and a superficial understanding of how to apply cutting-edge technologies, leading to negative emotions such as resistance and reluctance.

2.3. Incomplete policy and institutional framework

Although the state has implemented digital rural policies from a macro perspective, there is a lack of detailed planning for the agricultural digital economy sector. There is no systematic, forward-looking national strategic plan, and development goals and implementation pathways remain unclear. Interdepartmental collaboration is low, with significant departmental barriers, resulting in limited synergies between policy formulation and implementation. This prevents the formation of a policy synergy, hindering the implementation of policies [2]. Significant differences exist in the agricultural foundations and characteristics of different regions, yet policy considerations for regional differences are insufficient, and regional policy coordination and collaboration are inadequate, hindering the high-quality development of the agricultural digital economy.

3. Development pathways for the agricultural digital economy

3.1. Continuously deepening the construction of information infrastructure

The development of the agricultural digital economy relies on a robust information infrastructure. Through forward-looking and systematic planning, a secure, intelligent, and efficient digital foundation should be established to drive the digital transformation and upgrading of the agricultural supply chain. According to the Ministry of Agriculture and Rural Affairs' "2023 National Digital Agriculture Development Report" and the Ministry of Industry and Information Technology's Communications Industry Statistical Bulletin, the current status and development goals of China's agricultural digital infrastructure are outlined in **Table 1**.

Table 1. Current status and development goals of agricultural digital infrastructure (2023–2027)

Indicators	Current status in 2023	Target for 2025	Target for 2027	Pathway
5G network coverage in administrative villages	62%	85%	100%	Increase the special fund for telecommunications services in administrative villages
IoT device coverage rate	18%	40%	65%	Promote low-cost sensors
Proportion of smart agricultural machinery	12%	25%	40%	Purchase subsidies + equipment sharing model
Cold chain digital monitoring rate	35%	60%	85%	Establish a regional logistics platform

Vigorously implement the rural broadband network upgrade project, accelerate the rollout of high-speed fiber-optic networks to villages and households, and achieve full coverage of 5G networks. Promote the application of advanced information technologies such as low-frequency 5G and satellite internet, and explore cost-effective network coverage solutions. In agricultural core production areas such as livestock farms and large-scale planting zones, accelerate the deployment of 5G private networks to meet the demand for low-latency, high-concurrency data transmission; vigorously promote the construction of IoT coverage in farmland, and in fields such as soil moisture monitoring or weather monitoring, promote the construction of LPWAN low-power wide-area networks to expand the coverage of communication networks [3].

Establish an intelligent IoT sensing system to efficiently collect and process agricultural production data. Under the leadership of relevant departments, increase funding for research and development and popularize agricultural smart sensors, such as lightweight crop phenotyping collection devices and soil parameter sensors. Focus on developing multifunctional integrated smart terminals that combine image recognition, environmental monitoring, and other functions to reduce the difficulty and cost of deploying agricultural smart terminals. Promote the application of satellite remote sensing and drone remote sensing equipment to establish an integrated data collection system; accelerate the popularization and application of intelligent agricultural machinery operation monitoring terminals to monitor data such as fertilizer application rates, seed sowing rates, and fuel consumption in real-time, supporting the digital processing of the entire agricultural production process [4].

Establish a regional digital platform to facilitate collaboration among departments such as meteorology, land resources, markets, and water conservancy, achieving comprehensive collection of agricultural production data and agricultural-related data across the entire supply chain, and establishing an interconnected regional agricultural resource database; design standardized API interfaces, strengthen application development across different scenarios, and enhance data filtering, cleaning, and analysis capabilities. In areas such as processing plants and farms, deploy edge computing gateways on a large scale to process local data in real-time, providing precise data support for equipment fault diagnosis, pest and disease early warning, and soil moisture analysis, and effectively improving the system's data response speed.

Accelerate the digitalization of cold chain logistics, upgrade and renovate existing cold chain infrastructure at production sites, and focus on building cold storage facilities and pre-cooling facilities, providing environmental temperature and humidity control equipment for agricultural operators; Promote the implementation of RFID tagging systems to achieve seamless tracking and recording of agricultural product information throughout the supply chain; establish county-level smart cold chain logistics warehousing and distribution centers, implement a shared delivery model, and achieve comprehensive monitoring and control of the logistics delivery process.

Based on collected data, dynamically optimize logistics routes to provide a robust infrastructure foundation for the sustained and stable growth of the agricultural digital economy [5].

3.2. Deepen digital talent cultivation

In the context of agricultural digital economic development, continuously deepening digital talent cultivation is of critical importance. Encourage higher education institutions to establish majors in agricultural big data, agricultural IoT, etc., to promote the deep integration of agricultural knowledge and digital technology, and focus on cultivating composite talents with a solid foundation and strong practical abilities. Appropriately increase project practice, internships, and training in course design to support students' participation in agricultural production on the front lines, and focus on enhancing students' problem-solving abilities and digital literacy [6].

Deepen school-enterprise cooperation, invite experts and scholars to guide course development, and cultivate composite talents that fully meet market development needs. Organize agricultural practitioners to actively participate in digital training. For farmers with lower educational levels and older age groups, adopt methods such as on-site demonstrations and short video tutorials to focus on improving farmers' digital technology application literacy. For new professional farmers with a certain foundation in agricultural knowledge, organize advanced training activities centered on topics such as intelligent agricultural system management and big data analysis. Develop online learning platforms and combine online and offline training models to overcome spatial and temporal constraints, enabling farmers to learn agricultural knowledge and skills anytime and anywhere. Farmers are encouraged to obtain agricultural digital skills certificates, with those who pass the assessment receiving special subsidies. The improvement of farmers' digital skills is also incorporated into the criteria for recognizing new professional farmers. A Pioneer Award is established to recognize and reward farmers who excel in agricultural digital production and management, creating county-level digital benchmarks [7].

3.3. Strengthening market regulation and control

Understanding the characteristics of the agricultural digital economy, a modern regulatory system is established to balance risk prevention and innovation incentives. Establish an agricultural SaaS platform, formulate differentiated access lists, and improve the quality and security of regulatory data; promulgate and implement the "Agricultural Data Transaction Management Measures," which define data property rights and revenue distribution mechanisms, to support agricultural data collection and processing. Establish a sandbox regulatory mechanism, set up regulatory pilot zones in smart farm scenarios, encourage agricultural production and operation enterprises to adopt new business models, and dynamically adjust and improve regulatory details. Establish a comprehensive traceability system, introduce blockchain technology to collect data on agricultural production records, logistics temperature control, and product quality inspection, store it on the blockchain to prevent data tampering and theft; implement AI video inspection + blockchain evidence storage for green products and regional specialty products to ensure product patent security and prohibit counterfeit and substandard products in the market.

4. Policy research on agricultural digital economy development

4.1. Existing policies

Under the backdrop of agricultural digital economy development, the state has issued the "Digital Rural Development Action Plan (2022–2025)" to accelerate the construction of 5G communication network infrastructure support; the "Guidelines for Agricultural Machinery Purchase Subsidies (2023 Revision)" to

include autonomous driving terminals in the scope of agricultural machinery purchase subsidies, with the highest subsidy reaching 30%; The Implementation Plan for the Farmer Digital Literacy Enhancement Project focuses on organizing new professional farmers to participate in specialized training, with a target of training 5 million people over three years. Despite the issuance of a series of policy frameworks by the state, issues have emerged, including a focus on hardware over maintenance, insufficient coverage of small-scale farmers, inadequate coverage of data services and software systems, and homogenization of training content. In terms of policy implementation, at the county level, there is a fragmented and uncoordinated execution status, failing to leverage interdepartmental collaboration; incentive subsidies are limited to hardware procurement, with insufficient funding support for subsequent software services, leading to a large number of idle devices.

4.2. Policy improvements

While existing agricultural digital economy policies have achieved some results, there is still significant room for improvement. Current policies focus primarily on short-term projects and lack long-term strategic planning. It is necessary to develop a medium- to long-term plan for the agricultural digital economy based on actual conditions, establish goals, tasks, and safeguards for each phase, and establish a coordinated, coherent, and comprehensive policy framework. The agricultural digital economy involves multiple departments. To address issues such as policy overlap and unclear responsibilities, a cross-departmental policy coordination mechanism should be established to facilitate information transmission and sharing, thereby enhancing the effectiveness of policy implementation. Additionally, efforts should be intensified to develop core technologies for the agricultural digital economy. For agricultural digital economy projects, funding should be prioritized to guide social capital investment, and differentiated support policies should be formulated to promote balanced and high-quality development of the agricultural digital economy.

5. Conclusion

In summary, under the backdrop of the development of the agricultural digital economy, relevant departments should increase efforts in information infrastructure construction, enhance funding to improve the facility system, strengthen digital talent cultivation and market regulation, and promote interdepartmental collaboration to optimize and improve supporting policies. This will enhance the vitality of the agricultural digital economy and drive the modernization and transformation of agriculture.

Disclosure statement

The author declares no conflict of interest.

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Strategic Development Analysis of MINISO Based on the Business Model Canvas

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Abstract: As a representative enterprise in the retail industry, MINISO takes cost leadership and product differentiation as its core strategy to compete actively in the global market. However, multi-brand retailers continue to appear in the domestic market and the existing "dollar stores" in the foreign market already have a certain number of loyal customers. Therefore, MINISO needs to understand its principles for creating, delivering, and capturing value. By strengthening its own competitive advantages, it could achieve differentiation when confronting challenges in both domestic and international markets. Based on the analysis of MINISO's business model canvas, this paper puts forward corresponding strategic development suggestions.

Keywords: Business model; Development strategy; Retail industry

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1. Introduction

MINISO is a global retail company with IP creative design as its core feature, and is committed to providing consumers with a diversified range of fashionable home and lifestyle products. Since opening its first physical store in mainland China in 2013, the enterprise has successfully established two proprietary brands: "MINISO" and "TOP TOY". Through its global strategic expansion, MINISO has built an extensive retail network worldwide and grown into a globally recognized consumer brand. Based on its continuous innovation-driven product strategy, MINISO has developed a comprehensive matrix of quality products catering to diverse lifestyle scenarios. The enterprise maintains product vitality through a high-frequency new product launch mechanism, adheres to an integrated business philosophy of fashion design and utilitarianism, and meets consumers' diverse needs for a better life by implementing strict quality control and a consumer-friendly pricing system [1].

2. The business model of MINISO

The business model is a core framework for creating, delivering, and capturing value [2].

2.1. Target customer segment

Target customer segment serves as the strategic foundation in the business model canvas. Precisely identifying customer needs and pain points, it enables enterprises to build a sustainable path for value creation. Operating within the daily consumer goods sector, MINISO primarily targets a mass customer segment, fulfilling the similar needs of its target customers through a diverse range of household products. Beyond the mass customer segment, MINISO also strategically caters to the price-sensitive younger customer segment [3]. Young consumers tend to respond more quickly to market shifts and price fluctuations, and their needs are likely to exhibit dynamic changes, including both functional and emotional consumption dimensions. They are not only concerned with basic living needs, such as personal care products and daily textiles, but also show interest in products that cater to their interests or emotions, like blind box collectibles and IP-themed display bags. Such dynamic demand changes enable MINISO to strategically diversify its product matrix, and then realize the effective development of the market, so as to attract a broader customer segment.

2.2. Value proposition

The value proposition is the value that a company provides to its customers through its products and services, and it is the reason why the target customer segment chooses the company [4]. The fast-paced lifestyle is one of the main characteristics of contemporary society. It is reflected not only in the workplace's emphasis on efficiency but also in the fragmented communication in social life and the short-form and instant nature of leisure and entertainment. Therefore, the consumption habits of customer segments tend more towards immediate fulfillment. However, the retail industry faces a highly competitive market environment and an omni-channel purchasing path that integrates online and offline channels. Therefore, against the background of accelerated decision-making patterns, customers need to identify companies that could meet their needs in terms of high quality, variety, and affordability among numerous enterprises. MINISO's value proposition is also reflected in this, by "returning to the essence of products," it ensures both the artistic quality and cost-effectiveness [5]. MINISO integrates its diverse product matrix, competitive pricing mechanism, and brand image of a better lifestyle. Through its key product categories, it helps customers enjoy a simple yet high-quality life and build a unique lifestyle.

2.3. Distribution channels

Distribution channels describe the ways in which a company interacts with and communicates with its customer segments. MINISO's distribution channels are primarily divided into online and offline channels. For the retail industry, offline channels enable consumers to observe the physical details, experience the quality, and test the usability of products. The offline channels help consumers quickly determine whether the products meet their expectations. In 2024, the number of MINISO's offline stores increased from 6,413 to 7,504, with the number of stores in overseas markets growing by approximately 25.37%. The majority of these overseas stores are concentrated in the Asia-Pacific region, where the company is consolidating its relatively mature market presence. The significant increase in the number of stores in North America demonstrates that MINISO's globalization strategy has effectively enhanced its market share overseas. For instance, by integrating with local culture to convey the concept of "Chinese MINISO, Happy World" and choosing prosperous areas to enhance its brand image [6]. The number of MINISO stores in mainland China has remained relatively stable, with a growth rate of about 11.72%. MINISO not only operates in first-tier and second-tier cities but also in third-tier and lower-tier cities, maintaining stability while expanding. MINISO's offline channels include not only its own stores, but

also franchisees and agents, and the multi-channel distribution layout helps the enterprise to accelerate its market penetration. MINISO could create limited edition self-operated stores with personalized or characteristic themes, such as MINISO LAND, which becomes a popular tourist attraction. At the same time, the franchise or agency system could break through the regional barriers, quickly enter the sinking market with the help of the unified decoration style, becoming a leisure and consumption space for people in the shopping malls [7]. MINISO's online channels are present on mainstream e-commerce platforms and food delivery platforms, including its official mini-program and stores on Rednote. With the popularity of short videos and live-streaming channels, MINISO's online channels are no longer limited to simply displaying product links, they also include time-limited flash sales and group buying discounts. Therefore, MINISO should continue to improve the online customer flow conversion rate to drive online customers to offline stores.

2.4. Customer relationship

Customer relationships describe the nature of the relationships an enterprise establishes with specific customer segments. MINISO maintains customer relationships through its official accounts on social media platforms, such as WeChat official accounts, social messages, posts on Rednote, and short videos to update ongoing events. Beyond marketing through official accounts, MINISO also organizes offline promotions, such as the advertisement in Hangzhou CBD on World Smile Day in combination with the current AI trend. To improve its service mechanism, MINISO has established feedback channels across all distribution channels. It categorizes common issues to quickly identify solutions and provides customer service representatives to address personalized needs. By creating targeted and customized customer connections, MINISO enhances customer loyalty and increases repurchase rates.

2.5. Revenue streams

Revenue streams describe the income that an enterprise generates from its customer segments. According to the 2024 Annual Report, MINISO's main revenue streams are the sales of household products and toys of TOP TOY. Among these, sales to franchisees dominate account for 51.32% of product revenue, retail sales from self-operated stores represent 20.46%, sales to offline agents contribute 21.82%, and online channels comprise 6.09%. In addition to product sales, MINISO's revenue sources also include licensing fees, royalties, and consulting service fees, which are relatively small compared with product sales. From a geographical perspective, MINISO's primary revenue originates from the Chinese mainland (60.68%), followed by other Asian regions (14.96%), North America (11.68%), with Latin America and Europe collectively representing less than 10%. This indicates that MINISO 's localization strategy has been effective, and it can make use of the regional commonality to adjust the adaptation in Asia, but the regional market is more concentrated, and the European and American markets need to be explored, so the globalization strategy should be further deployed.

2.6. Key resources

Key resources describe the essential resources required to make the business model operate. From the distribution channels, it can be seen that MINISO's rapid expansion in both domestic and international markets has some correlation with its franchisees and agents. In the domestic market, MINISO mainly operates through a partnership franchise model, charging a certain amount of licensed trademark royalties, goods deposit and decoration prepayment, which authorizes them to sell MINISO products [8]. Partners are responsible for expenses such as

rent, labor costs, and utilities. However, the goods deposit system reduces the inventory pressure on partners and helps them reduce certain market risks. MINISO would unify the decoration of the store, including basic decoration, display cabinets, equipment, and accessories, and will also provide professional training for employees to maintain a consistent brand image [9]. Moreover, 38% of the daily turnover (33% for food items) is transferred to the partner's account on the following day as income, and ensures that partners have a stable source of cash flow, achieving a win-win situation for both parties [10]. In foreign markets, due to local market characteristics, legal regulations, and other factors, MINISO mainly operates through agents with rich local resources to expand the market in a more localized way. Therefore, the agent model involves buying out and distributing products to help MINISO mitigate certain operational risks.

2.7. Key activities

Key activities are the essential activities required to make the business model work. In 2024, the MINISO brand offered over 12,600 product combinations, creating diverse consumption scenarios. These offerings comprehensively cover lifestyle home goods, digital accessories, beauty and personal care products, among other categories, precisely catering to different consumers' quality lifestyle needs. The TOP TOY brand focuses on new-generation cultural consumption and offers around 11,000 product combinations, creating a diverse, trendy-toy ecosystem centered on blind boxes, with creative brick toys, collectible model kits, and other offerings. This serves the interest-driven consumption of the younger customer segment, such as the anime merchandise market. Compared with other established companies, MINISO's self-branded products maintain relatively low pricing. The company attracts customers with high-demand daily necessities, driving entry-level consumption. By leveraging the relevance within its product matrix, MINISO deepens its value proposition. For example, it has built a "disposable product demand chain" around travel scenarios, transforming single-product consumption into scenario-based consumption. TOP TOY builds a youth engagement hub through trendy toy products, collaborating with diverse IPs to attract young customer segments. This advances MINISO's expansion into evolving consumption characteristics and preferences [11].

2.8. Key partnership

The partnership defines the network of partners that enable the business model to function effectively. MINISO adheres to the cost leadership strategy and product differentiation strategy. While maintaining price advantages, it emphasizes distinctive designs to consistently deliver high-quality products to the market. Therefore, suppliers and IP collaborators become indispensable partners. MINISO's suppliers are mainly located in mainland China, with the majority concentrated in the Pearl River Delta region. Through its "volume-based pricing + buyout customization + no delayed payment " model, MINISO collaborates with high-performing suppliers across various fields. This approach ensures rapid supplier responsiveness while maintaining controlled product quality and cost [12]. In IP collaborations, MINISO partners with numerous well-known IPs to develop products suitable for various scenarios. For example, it has created plush toys and bag accessories with CHiiKAWA, charms and stationery with PIXAR, and scented candles with Harry Potter. A single IP element can permeate multiple product categories, attracting fan groups while creating competitive differentiation from industry peers. MINISO also creates immersive offline experiential spaces like pop-up stores featuring limited-time access. This approach enhances the marketing buzz while driving profit growth, further promoting interest-driven consumption.

2.9. Cost structure

Cost structure defines the costs incurred by operating the business model [13]. Driven by its diversified development strategy and product artistry focus, IP licensing fees constitute a significant component of MINISO's cost structure. Unlike POP MART however, MINISO does not emphasize creating its own IP culture, instead prioritizing collaborations with established IPs. While IP collaborations generate price premiums for the company, partnerships with established IP holders may create negotiating disadvantages during royalty discussions. The high cost of licensing fees may affect the company's profit margin. With the implementation of its globalization strategy, the expansion of directly-operated overseas stores has driven up operating expenses. Prime commercial locations command premium rents, while distinctive interior designs require substantial investment. At the same time, in order to enhance its brand image, the company's marketing and promotion costs are also on the rise. For example, the planning and scene construction of pop-up stores with multiple IP themes, as well as cooperation with social media influencers, are all continuous investments made by the company in market promotion.

3. Strategic development recommendations for MINISO

3.1. Attract the customer segment of family units

Individual consumers currently constitute MINISO's primary customer base. However, the needs of customer groups based on family units have not yet been fully addressed by MINISO. MINISO can conduct market research through corporate WeChat communities and other methods to understand the demand for family-oriented products. By creating a family product matrix and shaping family product scenarios, MINISO can reduce household purchasing costs with cost-effective products and create a consumption environment suitable for family units. MINISO could leverage community engagement initiatives to host family-inclusive activities, providing interactive leisure spaces for family-based customer segment. This approach offers emotional value while reinforcing brand identity, ultimately embedding the brand into daily life experiences. This family-based customer segment also includes pet families. The new generation of customers heals themselves through companionship with their pets, gaining stable emotional support and value resonance in complex interpersonal relationships or fast-paced social environment. Pets are inevitably important family members, so the pet economy has significant potential. MINISO could collaborate with IPs to launch pet-friendly products, and demonstrate its care and affection for the pet domain by organizing public welfare activities and taking concrete actions to fulfill social responsibilities, thereby increasing consumer identification.

3.2. Strengthen the strategic position of TOP TOY

IP collaborations hold significant importance in MINISO's development strategy, but without exclusive licensing, the market will be flooded with homogeneous products that consumers will compare [14]. This may even dilute the high-premium effect that IPs originally command. MINISO can compensate for this shortfall by strengthening the strategic position of TOP TOY. As a trendy toy brand, TOP TOY is committed to creating in-depth communication experiences and consumption scenarios with young people. Although TOP TOY currently has an insufficient number of original IPs, it is incubating its own IPs through stable collaborations with artists [15]. The domestic cultural and creative market currently has significant potential for development. TOP TOY could engage in in-depth collaborations with cultural institutions across the country to develop products with unique cultural characteristics. TOP TOY has a more diverse range of trendy toy products compared to MINISO, such as acrylic stands and badges. TOP TOY could gain deeper insights into the market demands of the new generation, and

enhance its strategy for interest-driven consumption. TOP TOY is also committed to developing Chinese building blocks, including display blocks, scene blocks, and mechanical blocks. TOP TOY can create building blocks themed domestic culture and integrate technologies such as AR, to help MINISO expand its product categories and ultimately broaden its consumer market.

4. Conclusion

The retail industry is characterized by intense competition and dynamic changes in consumer demand. MINISO, with its core strategies of cost leadership and product differentiation, targets young consumer segment and conveys the concept of "high-quality yet affordable products". By integrating online and offline channels, MINISO has pursued a global expansion while assembling a diversified product portfolio. To consolidate existing strengths and develop new growth curves, MINISO could explore new scenarios of family consumption, deepening customer value of family units. Additionally, MINISO could strengthen the strategic position of its trendy toy brand through the incubation of original IP, and the integration of local cultural elements would allow MINISO to better engage the interest-driven consumption market. Ultimately, these would enable MINISO to evolve from a retailer into a lifestyle advocate.

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The Impact of the Internationalization of ESG Standards on the Trade Competitiveness of Multinational Enterprises: A Difference-in-Differences Test Based on Global Manufacturing Listed Companies

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***A*bstract:** This paper takes global manufacturing listed companies from 2010 to 2022 as samples and uses the difference-in-differences (DID) method to empirically examine the impact of the internationalization of ESG standards on the trade competitiveness of multinational enterprises and their mechanisms. The research finds that the internationalization of ESG standards significantly enhances the trade competitiveness of multinational manufacturing enterprises, and this effect is dynamic and sustainable. The mechanism analysis indicates that the internationalization of ESG standards exerts its influence through three pathways: reducing enterprise financing costs, promoting technological innovation, and enhancing brand reputation. The heterogeneity analysis shows that this effect is more significant in enterprises from developed countries, high-pollution industries, and larger enterprises. This paper provides micro-level evidence for understanding the economic consequences of the internationalization of ESG standards and offers policy implications for multinational enterprises to cope with the global ESG rule changes and enhance their trade competitiveness.

Keywords: Internationalization of ESG standards; Trade competitiveness; Multinational enterprises; Difference-in-differences method; Manufacturing industry

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1. Introduction

1.1. Research background

With the increasingly prominent issues such as global climate change and the wealth gap, the concepts of environment (Environment), society (Social), and governance (Governance, abbreviated as ESG) have gradually become an international consensus. The international trend of ESG standards has significantly strengthened.

International institutions such as the United Nations Principles for Responsible Investment (PRI) and the Global Reporting Initiative (GRI) have promoted the convergence of ESG disclosure and evaluation standards. Regional regulations such as the EU's Sustainable Finance Disclosure Regulation (SFDR) and the US' Climate-related Financial Disclosures Rule (CFDR) have further strengthened ESG compliance requirements. According to data from the Global Sustainable Investment Alliance (GSIA), the global ESG investment scale exceeded 40 trillion US dollars in 2022, increasing nearly fivefold compared to 2010. ESG standards have become a key institutional factor influencing the cross-border operations of enterprises [1, 2].

Manufacturing, as the core area of global trade, faces particularly prominent ESG compliance pressure for multinational enterprises. On one hand, developed countries link ESG standards with trade rules through policies such as the "Carbon Border Adjustment Mechanism" (CBAM), forming a new type of "green trade barrier"; on the other hand, the attention of consumers and investors to the ESG performance of enterprises has increased, forcing enterprises to improve their ESG practices. In this context, whether and how ESG standard internationalization affects the trade competitiveness of multinational manufacturing enterprises has become a question that academic and practical circles urgently need to answer.

1.2. Research significance

1.2.1. Theoretical significance

Existing research mostly focuses on the impact of ESG on enterprise financial performance, while paying less attention to its correlation with trade competitiveness, and lacks analysis of the institutional change of ESG standard "internationalization" [3, 4]. This paper, based on institutional economics and signal transmission theory, constructs an analytical framework for the impact of ESG standard internationalization on trade competitiveness, enriching the relevant theoretical system.

1.2.2. Practical significance

It provides references for multinational manufacturing enterprises to cope with ESG standard differences and formulate internationalization strategies; it provides policy basis for governments of various countries to coordinate ESG standards and balance trade liberalization and sustainable development goals.

1.2.3. Research approach and structure

This paper first reviews the literature and proposes research hypotheses; then, it selects global manufacturing listed companies from 2010 to 2022 as samples, uses the difference-in-differences method to test the impact of ESG standard internationalization on trade competitiveness; then, it deepens the research conclusion through mechanism analysis and heterogeneity test; finally, it summarizes the research findings and proposes suggestions.

2. Research hypotheses

The internationalization of ESG standards affects the trade competitiveness of multinational enterprises through the following paths:

(1) Compliance cost effect: In the short term, enterprises need to invest resources to meet international ESG standards, which may increase costs and reduce trade competitiveness (H1a: Short-term negative impact).

(2) Signal transmission effect: In the long term, meeting ESG standards conveys the quality signal of the enterprise to the international market, enhancing the trust of consumers and partners, and expanding

market share (H1b: Long-term positive impact).

(3) Innovation-driven effect: To meet the high standards, enterprises may promote green technological innovation, increasing product value-added and international competitiveness (H1c: Positive impact through technological innovation).

(4) Risk mitigation effect: The internationalization of ESG standards reduces the risks of cross-border operations for enterprises caused by environmental or social issues (such as trade sanctions, lawsuits), stabilizing trade activities (H1d: Positive impact through risk reduction).

Overall, the long-term positive effect may dominate; thus, the main hypothesis is proposed: H1: The internationalization of ESG standards generally enhances the trade competitiveness of multinational manufacturing enterprises.

3. Research design

3.1 Sample selection and data sources

The sample consists of global manufacturing companies from 2010 to 2022. The data are sourced from Wind, Bloomberg, and Thomson Reuters databases. The selection criteria are as follows: (1) Exclude ST and *ST companies; (2) Exclude samples with missing key data; (3) Exclude companies from countries that did not participate in major ESG international initiatives (such as PRI, GRI). The final result includes 12,834 companies and 98,652 annual observations.

3.2. Variable definitions

(1) Dependent variable: Trade Competitiveness (TC). Measured by "export intensity", which is the proportion of export revenue to total revenue of the company

(2) Core explanatory variables: Difference-in-Differences(DID).

(a) Treatment group: Companies in the country or the main market that adopted international ESG high standards(such as EU SFDR) during the sample period.

(b) Control group: Companies not subject to international ESG high standards constraints [5].

(c) Policy time (Post): Set as Post =1, when the policy shock occurs(GRI standard 5.0 was released and ESG internationalization accelerated), otherwise Post = 0; DID=Treatment Group dummy variable(Treat) × Post.

3.3. Model specification

Employ a two-way fixed effects double difference-in-differences model:

$$TC_{it} = a_0 + a_1 DID_{it} + \sum a_k \, Controls_{kit} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

i: enterprise; t: year; μ_i: Firm fixed effects; λ_t: year fixed effects; ε_{it}: random disturbance term; a_1: The net effect of the internationalization of ESG standards on trade competitiveness.

4. Empirical results and analysis

4.1. Descriptive statistics

Table 1 presents the descriptive statistics of the main variables. The mean value of trade competitiveness (TC) is

0.32, indicating that the average export volume of the sample enterprises accounts for 32% of their total revenue. The standard deviation is 0.21, showing significant differences in the degree of export dependence among the enterprises. The mean value of the DID variable is 0.45, suggesting that approximately 45% of the sample enterprises are directly affected by the internationalization of ESG standards. The distribution of the control variables is within a reasonable range, and no extreme values were found to interfere [6].

Table 1. Descriptive statistics of key variables

Variable	Mean value	Standard deviation	Least value	Maximum
TC	0.32	0.21	0.00	0.98
DID	0.45	0.50	0.00	1.00
Size	23.15	2.18	18.32	29.67
Lev	0.52	0.19	0.08	0.94
ROA	0.08	0.06	-0.23	0.31
R&D	0.05	0.04	0.00	0.22
Age	21.36	12.54	3.00	112.00
Top10	0.54	0.18	0.15	0.92
GDPg	2.31	2.15	-8.20	14.50
Open	0.85	0.42	0.21	3.12

4.2. Heterogeneity analysis

Table 2 shows that the effects of the internationalization of ESG standards exhibit significant heterogeneity:

(1) Country type: The DID coefficient of enterprises in developed countries (0.068) is significantly higher than that of developing countries (0.032), as the ESG foundation of enterprises in developed countries is more complete and the compliance cost is lower.

(2) Pollution level of industries: The DID coefficient of high-pollution industries (such as chemicals and steel) (0.071) is higher than that of low-pollution industries (0.043), as ESG standards impose stronger constraints on high-pollution industries and there is greater room for improvement.

(3) Enterprise size: Large enterprises (with total assets higher than the median of the sample) have a DID coefficient (0.065) higher than small enterprises (0.039), as large enterprises have more resources and are better able to adapt to international standards.

Table 2. Results of heterogeneity analysis

Grouping criteria	Subsample	DID coefficient	Standard error	*t* value	Observation value
National type	Developed countries	0.068***	0.015	4.53	56,218
	Developing countries	0.032**	0.016	2.00	42,434
Degree of industrial pollution	High-pollution industries	0.071***	0.017	4.18	41,257
	Low-pollution industries	0.043***	0.013	3.31	57,395
Enterprise size	Large enterprises	0.065***	0.014	4.64	49,326
	Small enterprises	0.039**	0.016	2.44	49,326

5. Research findings and policy recommendations

5.1. Research findings

The internationalization of ESG standards significantly enhances the trade competitiveness of multinational manufacturing enterprises, with long-term effects being stronger than short-term ones. Mechanically, it achieves this through reducing financing costs, promoting technological innovation, and enhancing brand reputation. The effects are more pronounced in enterprises in developed countries, in high-pollution industries, and in large enterprises.

5.2. Policy recommendations

At the enterprise level: Multinational manufacturing enterprises should actively align with international ESG standards, integrating ESG into their strategic planning; increase green technology research and development to offset compliance costs through innovation; utilize ESG certifications to convey quality signals and expand international markets. At the government level: Developing countries should accelerate the alignment of ESG standards with international standards, while providing policy support (such as subsidies, training) to help enterprises reduce compliance costs; promote the establishment of regional ESG coordination mechanisms to avoid fragmentation of standards. At the international organization level: Promote the inclusive development of ESG standards, considering the adaptability of enterprises in developing countries, and formulate phased implementation rules.

6. Conclusion

The core research findings indicate that the internationalization of ESG standards can significantly enhance the trade competitiveness of multinational manufacturing enterprises, and this enhancement effect is dynamic and sustainable. The internationalization of ESG standards operates through three pathways: reducing enterprise financing costs, promoting technological innovation, and enhancing brand reputation. These effects vary, and in multinational manufacturing enterprises from developed countries, belonging to high-pollution industries, and those with larger scales, the enhancement effect of ESG standards on trade competitiveness is more significant. On the one hand, this provides empirical evidence at the micro level for understanding the economic consequences of ESG standard internationalization; on the other hand, it offers policy references and insights for multinational enterprises to respond to global ESG rule changes and enhance their own trade competitiveness.

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Analysis of Influencing Factors of Platform Economy on the Allocation Efficiency of Labor Resources

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Abstract: Against the backdrop of the rapid development of digitalization today, the platform economy, as an emerging economic form, is profoundly changing the operation mode and resource allocation methods of the labor market. The efficiency of labor resource allocation is an important indicator to measure the vitality and potential of economic development in a country or region. It is not only related to the welfare level of workers but also directly affects the productivity level and development quality of the entire society. With the help of modern information technology means such as Internet technology, big data algorithms, and mobile communication devices, the platform economy closely connects originally scattered individual workers with employers, building a large and complex networked trading platform. Based on this, this paper focuses on the impact and role of the platform economy on the efficiency of labor resource allocation, aiming to stabilize the efficient operation of the labor market.

Keywords: Platform economy; Labor resources; Allocation efficiency; Influencing factors

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1. Introduction

1.1. Definition of platform economy

Platform economy relies on internet technology to build a bilateral or multilateral market system, with participants including service providers, consumers, producers, and other relevant parties [1]. The core of this economic form lies in establishing an open network platform that effectively integrates scattered information, resources, and services to achieve precise connection and efficient matching between supply and demand sides. In this process, the platform not only acts as a transaction medium but also serves as a resource integrator and distributor, promoting the optimal allocation of various resources and improving the operational efficiency of the entire market. Moreover, platform economy emphasizes resource integration rather than simple transaction matching. It uses internet technology to connect numerous participants, forming a large and complex ecosystem. Within this system, various resources can be recombined and optimally allocated [2]. In this way, it not only meets enterprises'

demand for specific types of talents but also helps workers find more suitable job positions, maximizing the degree of job-person fit.

1.2. Characteristics of platform economy

1.2.1. Flexibility

Platform economy has broken the time and space constraints of traditional working modes. With the help of internet platforms, workers are no longer restricted by fixed workplaces and can seek job opportunities worldwide. For example, a freelance designer can provide services to enterprises in different countries without worrying about obstacles caused by geographical locations. This possibility of remote work has greatly enhanced the flexibility of the labor market, allowing individuals to choose the most suitable working environment and schedule according to their own situations. Meanwhile, platform economy also enables workers to participate in work either part-time or full-time, meeting the needs of different groups of people for work intensity and rhythm [3]. Some people may prefer short-term projects or scattered tasks, while others hope to maintain a stable career development path, and platform economy can provide corresponding solutions.

1.2.2. Diversity

With the development of digital technology, emerging industries such as shared mobility, online education, and self-media creation are constantly emerging, providing job seekers with more abundant choices. These new types of occupations not only broaden employment channels but also promote changes in society's demand for skills, stimulating workers' motivation for self-improvement [4]. For instance, online education platforms have enabled many people with professional knowledge to find new development directions. They can share their experience through methods such as recording courses and live teaching, attracting a large number of students eager to learn new skills. In addition, platform economy has promoted the integration and development of cross-industry fields, making originally distinct professional areas begin to infiltrate each other. For example, traditional media practitioners can transform into content creators with the help of short-video platforms. Such cross-boundary cooperation not only increases the number of employment positions but also promotes the exchange and innovation of knowledge and technology.

2. Factors affecting the low efficiency of current labor resource allocation

2.1. Unreasonable structure of the labor market

From the perspective of industrial distribution, traditional manufacturing industries absorb a large number of laborers. However, with technological progress and industrial upgrading, some positions in these industries are gradually replaced by automated equipment, putting laborers originally engaged in such work at risk of unemployment and forcing them to seek employment opportunities in other industries [5]. Nevertheless, although emerging industries are developing rapidly, the talents they need must possess high professional knowledge and skill levels. For laborers transferring from traditional industries, there are insurmountable knowledge and technical barriers. The mismatch between supply and demand hinders the flow of labor between different industries and exacerbates the structural contradictions in the labor market.

From a geographical perspective, the eastern coastal areas attract talents from all over the country due to factors such as a high level of economic development and a sound industrial system, forming a situation of highly dense labor [6]. Correspondingly, although the central and western regions also have a certain number of labor

resources, due to the relatively backward local economic development, insufficient job opportunities, and poor working environment, they cannot effectively retain local labor, resulting in a brain drain.

In terms of enterprise scale, large enterprises can provide more favorable salary packages and broad career development space by virtue of their own strength, thus being more favored by job seekers. In contrast, although small and medium-sized enterprises (SMEs) are numerous and occupy an important position in the national economy, they have limited funds and weak anti-risk capabilities, putting them at a disadvantage in attracting and retaining outstanding talents. This leads to the excessive concentration of labor in a few large enterprises, while many SMEs face difficulties in recruiting workers, disrupting the ecological balance of the labor market, and restricting the effective utilization of labor resources in the entire society [7].

2.2. Information asymmetry in the labor market

In the traditional labor market, there exists a significant information gap between employers and job seekers, making it difficult for both parties to achieve effective matching. For job seekers, they usually cannot fully and accurately understand key information such as the internal working environment of the enterprise, career development prospects, and specific salary packages. This makes it hard for job seekers to make optimal career choices, leading to misjudgments of their own career development directions and thus affecting their personal career planning. Secondly, the channels for releasing recruitment information are scattered and lack unified standards. Different enterprises post recruitment information on different platforms, with vastly different information formats and description methods. To obtain complete information, job seekers have to spend a lot of time and energy browsing multiple websites or applications, which increases the cost of job hunting. Due to the lack of effective supervision, some enterprises may exaggerate the advantages of positions or conceal work risks, further exacerbating information asymmetry [8].

For employers, information asymmetry also brings many challenges. On the one hand, enterprises find it difficult to judge whether the actual ability of job seekers meets the job requirements during the resume screening stage. Many job seekers beautify their resumes to enhance their competitiveness, and it is hard for enterprises to accurately evaluate their real level based solely on resume content. On the other hand, the information that enterprises can obtain during the interview process is also limited [9]. Although they can gain an in-depth understanding of candidates through the interview link, it is still difficult to fully grasp the true situation of their work attitude, teamwork ability, and adaptability.

2.3. Low match between labor skills and market needs

On one hand, there is a significant discrepancy in skill structure between talents cultivated by the traditional education system and the demands of modern enterprises. The update speed of universities' major settings and curriculum content fails to keep up with the rapidly changing trends in technological development, leaving graduates' knowledge and skills unable to meet practical work requirements. For example, the information technology industry has developed rapidly in recent years, with new technologies emerging constantly in fields such as artificial intelligence and big data. However, the teaching of related majors in some universities remains at the level of basic theories, lacking in-depth explanations of cutting-edge technologies. As a result, computer science graduates often need to spend a lot of time on secondary training after entering the workplace to adapt to job demands [10].

On the other hand, some workers have limited professional skills and face narrow channels for improvement.

Older workers or those engaged in traditional industries, who have long been engaged in repetitive labor, possess relatively single skills. When their industries are impacted by emerging industries, it is difficult for these workers to quickly transition to other positions or new fields. Meanwhile, the distribution of vocational skills training resources for in-service personnel in society is uneven. High-quality training programs are mostly concentrated in developed regions and large enterprises, leaving employees of small and medium-sized enterprises and workers in remote areas with few opportunities to access high-quality training. This further exacerbates the disconnection between labor skills and market demands.

Furthermore, there is a phenomenon in the recruitment process of enterprises where academic qualifications are valued over skills. Excessive attention is paid to the educational background of job seekers while their practical operational abilities are ignored, resulting in the overlooking of talents who truly possess the skills required for the positions. [11]. In addition, with the acceleration of globalization, multinational corporations frequently adjust their layouts in the domestic market, creating a large number of new job positions. However, domestic laborers have insufficient ability to learn and absorb foreign advanced technologies and management concepts, making it difficult for them to keep up with the pace of the international market. This low degree of matching not only reduces the effective utilization rate of human resources but may also hinder the healthy development of the local economy.

3. Factors influencing the efficiency of labor resource allocation in platform economy

3.1. Information sharing and optimized matching

Within the framework of platform economy, the matching process between workers and employers has undergone fundamental changes. With the strong support of internet technology, both parties can achieve efficient information exchange on specific platforms, facilitating in-depth two-way communication regarding job seekers' skill demonstrations, work experience sharing, and career expectations [12]. For instance, many online recruitment platforms allow job seekers to upload detailed resumes, portfolios, and even video introductions, enabling employers to gain a more intuitive understanding of candidates' comprehensive qualities. Employers can also promptly update key information such as job requirements and corporate culture, ensuring that job seekers obtain the most accurate overview of the enterprise.

On the other hand, the real-time circulation of information has broken down many barriers in the traditional labor market. Geography is no longer a limiting factor for the mobility of outstanding talents, as job seekers can easily access work opportunities worldwide through the internet. Meanwhile, flexibility in terms of time has also significantly improved. Previously constrained by fixed work schedules, job seekers can now browse recruitment information and respond quickly at any time. Enterprises, too, no longer have to wait for specific recruitment cycles; they can initiate the interview process immediately once suitable candidates appear.

Furthermore, the platform economy has enhanced the transparency of the labor market. All participants can easily obtain real feedback on salary levels, welfare benefits, and industry development prospects. This highly transparent environment encourages enterprises to pay more attention to their own image building and strive to provide more attractive working conditions, thereby further stimulating the vitality of the entire market. Workers can also make rational decisions based on sufficient information, avoiding misjudgments or losses caused by information asymmetry, and effectively promoting the continuous improvement of resource allocation efficiency [13].

3.2. Enriching job positions and enabling flexible employment

The traditional employment model is mainly based on full-time and fixed positions. However, in the context of the platform economy, forms such as part-time work, freelance work, remote work, and short-term contracts have gradually become the norm. The new employment methods have broken the constraints of time and space, providing workers with more diversified choices.

Firstly, part-time work allows workers to participate in multiple projects simultaneously and accumulate experience in different fields. For example, a designer can provide services to multiple clients in their spare time, which not only increases their sources of income but also broadens their professional horizons. For enterprises, it enables more flexible allocation of human resources, reduces labor costs, and improves operational efficiency. Secondly, freelancers have achieved true independent entrepreneurship with the help of the platform economy. They directly connect with clients through various online platforms, reducing intermediate links and improving transaction transparency [14]. Take programming as an example; developers can freely choose projects they are interested in to participate in, without being restricted by region or company size. Thirdly, the remote work model has changed the traditional office model. With the help of Internet technology and collaborative tools, employees can work anytime and anywhere. For some knowledge workers, remote work not only improves work efficiency but also enhances the quality of life. For instance, tasks such as copywriting and data analysis can be completed online, saving commuting time and reducing the negative impacts caused by problems like traffic congestion.

Fourthly, short-term contracts provide enterprises with greater flexibility in employment. In the face of fluctuations in market demand, enterprises can quickly adjust their personnel structure according to actual business needs. For example, during the peak season of e-commerce promotions, logistics companies can sign short-term contracts to quickly expand their delivery teams; during the off-season, they can timely reduce labor costs. For job seekers, short-term contracts offer more opportunities to try new fields, helping them accumulate experience in different industries and enhance their comprehensive competitiveness.

3.3. Adjusting salaries to activate the market

In the traditional employment model, significant wage gaps between regions and industries have led to idle or mismatched labor resources in some areas. However, under the platform economy model, the salary structure has become more transparent and dynamic. Enterprises can quickly adjust salary standards according to market demand to ensure they attract suitable talents. For example, although jobs like food delivery riders and online ride-hailing drivers involve high work intensity, their relatively high piece-rate wages have attracted a large number of job seekers, especially young people who are eager to earn high returns through short-term intensive work.

The platform economy also grants workers greater autonomy, allowing them to choose career paths that best suit their development based on personal preferences. Some emerging professions, such as live streamers and self-media creators, have attracted many job seekers with their flexible working hours and considerable incomes [15]. These professions are not restricted by fixed workplaces, enabling workers to carry out their jobs anytime and anywhere. As a result, even in remote areas, people can enjoy salary packages similar to or even higher than those in big cities, breaking down geographical barriers and promoting talent mobility across the country.

The salary growth driven by the platform economy is not an disorderly expansion but a reasonable distribution guided by market demand. On one hand, it encourages workers to continuously improve their skills to adapt to market changes; on the other hand, it prompts enterprises to optimize internal management processes and enhance production efficiency and service quality. Over time, this will form a positive cycle: outstanding talents

gather due to high salaries, enterprises become more competitive with high-quality employees, and this in turn drives the entire industry and even the national economy to move toward a higher level.

4. Conclusion

To sum up, the platform economy has played an irreplaceable role in improving the efficiency of labor resource allocation. By breaking down geographical barriers, the platform economy connects employers and job seekers nationwide and even globally, providing a broader range of employment options for various types of talents, and enhancing both the success rate of job hunting and the accuracy of talent matching.

Through optimizing information-sharing mechanisms, expanding the variety of job positions, and adjusting salary and welfare systems, we can not only address the existing major issues but also prepare for potential new challenges in the future. This will inject new vitality into the sustained and healthy development of China's economy and society.

Disclosure statement

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Exploring Strategic Collaboration Between Traditional Automakers and New Energy Vehicle Manufacturers Under the "Dual Credit" Policy

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Abstract: Under the impetus of the "Dual Credit" policy, traditional fuel vehicle manufacturers are confronted with significant pressure to meet new energy vehicle credit requirements. To address this challenge, these manufacturers are increasingly adopting the Original Design Manufacturer (ODM) strategy to collaborate with new energy vehicle enterprises, thereby acquiring credits and expanding their market presence. However, this strategic approach not only intensifies competition between new energy and traditional fuel vehicle markets but also reshapes the profit distribution between the two types of firms. Drawing upon the framework of the Dual Credit policy, this study establishes a Cournot game model to examine the strategic interactions between traditional fuel vehicle manufacturers and new energy vehicle producers. It further investigates the optimal production decisions under the ODM strategy and evaluates their implications for market dynamics and corporate profitability. The findings reveal that, although the ODM strategy heightens market competition, it leads to substantial profit improvements for both types of manufacturers compared to the alternative of directly purchasing credits, while also fostering the growth of the new energy vehicle sector. Moreover, the Case study demonstrates micro-level impact of the dual credit policy on enterprises' response strategies, offering valuable insights for policymakers and industry decision-makers.

Keywords: Credit compensation mechanism; Market competition dynamics; Profit optimization; Cournot game model; Industry synergy

Online publication: September 10, 2025

1. Introduction

Against the backdrop of the global push for sustainable transportation, the automotive industry is undergoing a significant transformation toward new energy vehicles. Governments worldwide have introduced policy measures to expedite this transition, with China's "Dual Credit" policy emerging as a pivotal regulatory framework. This policy, implemented by the Chinese government, serves as a comprehensive regulatory mechanism designed