CSCHOLAR Publishing INC

Volume 1 Number 3 2025

The Development of Humanities and Social Sciences

ISSN: 3067-7122

https://dhss.cscholar.com

The Development of Humanities and Social Sciences

ISSN: 3067-7122

Volume 1, Issue 3, 2025

Bimonthly (Issue No. 3)

Cover Design: ConnectSix Scholar Publishing INC

Publishing Unit: ConnectSix Scholar Publishing INC

Publisher's website: http://www.cscholar.com/

Publisher's address:

6547 N Academy Blvd #2265

Colorado Springs CO 80918

US

Website of the journal *The Development of Humanities and Social Sciences*:

https://dhss.cscholar.com/

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The Development of Humanities and Social Sciences, 2025, 1(3), 1-14
https://doi.org/10.71204/t7eftt51

A Study on Operating Capital Management Problems and Countermeasures of BYD Company Based on Channel Management

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Received: 29 June 2025/ Accepted: 20 August 2025/ Published online: 26 August 2025

Abstract

With the development of economy and the increasing awareness of environmental protection, new energy vehicles have entered the public's vision as an emerging industry. Good operation of working capital is conducive to the capital turnover of enterprises, saving the cost of capital and improving the solvency of enterprises. If enterprises do not pay attention to the management of working capital, it will impact the market position and competitiveness of enterprises. This paper takes BYD Company as the research object and uses a series of research methods. Based on the relevant theories and the working capital management theory from the perspective of channel, this paper analyzes the working capital status and asset structure of the company in the past three years, thereby leading to a new management model. Make the use and management of funds more clear in the production and marketing links. Through the calculation of working capital turnover cycle, the paper analyzes the working capital problems faced by enterprises in each channel, and puts forward corresponding management countermeasures.

Keywords: Capital Management; Channel Management; New Energy Automobile

1. Introduction

The Chinese economy continues to grow, and the market environment is constantly changing. The management of enterprise operating funds is increasingly attracting attention from the industry and academia. In the practical field, with the innovation of financial markets and the diversification of business models, the practice of working capital management is continuously exploring and developing. Many enterprises have begun to focus on optimizing their cash flow, using measures such as strengthening internal controls and improving the efficiency of fund utilization to achieve the optimal allocation of working capital. At the same time, with the rapid advancement of information technology, the means and methods of working capital management are constantly updated. The application of cutting-edge technologies such as supply chain finance and big data analysis has opened up new thinking paths and implementation strategies for enterprise working capital management.

Scholars have explored the theoretical framework, optimization measures, and core functions of working capital management from multiple perspectives, covering a wide range of key aspects such as performance evaluation systems, management model innovation, and financial risk prevention and control (Sun and Qi, 2021; Hu, 2023; Wang, 2024). Although scholars have made some progress in working capital management from the perspective of channel management, they still face many shortcomings. The traditional model focuses too much on a single financial indicator and ignores the correlation and overall nature between channels. In addition, factors such as incomplete information systems and unreasonable channel structures have constrained management efficiency. Therefore, it is urgent to conduct in-depth research to enrich the research results in this field.

As a leading enterprise in the new energy vehicle industry, BYD's working capital management is representative. BYD is at the forefront of new energy vehicle manufacturing in China, and its working capital management not only reflects the company's own operating conditions, but also provides reference for other companies in the same industry (Hong et al., 2018). This article selects BYD Company and conducts an in-depth analysis of the working capital management of new energy enterprises based on channel theory, identifying existing problems and deficiencies. Based on the analysis of the problem, propose targeted improvement suggestions.

The significance of this study lies in the in-depth analysis of BYD's problems and the proposal of improvement measures, which can not only provide guidance for BYD's fund management improvement, but also provide valuable reference for other new energy enterprises to optimize fund management. In addition, this also has important reference significance for the entire new energy industry, especially for new energy companies transformed from state-owned enterprises, in building enterprise fund management systems.

2. Analysis of the Current Situation of BYD's Operating Capital Management Based on Channel Theory

2.1. Analysis of Operating Capital Efficiency of Various Channels

As shown in table 1, after calculating the supply, production, and sales operation cycle, the turnover period based on channel operating funds is calculated. During the period of 2021-2023, the procurement turnover period showed an upward trend in 2022, followed by a downward trend in 2023. This change indicates that the improvement measures implemented by BYD Company for procurement channels are correct, which has enabled BYD Company to continuously improve the management efficiency of operating funds in this part. However, the production turnover period continued to decline during the period of 2021-2023, which means that BYD Company has a high efficiency in the utilization of funds in production and operation. The continuous decline in marketing turnover period from 2021 to 2023 indicates that BYD Company is making better use of funds in marketing channels; The turnover period of operating funds has been continuously decreasing from 2022 to 2023, indicating an improvement in the utilization of operating funds. The average operating capital cycle in the procurement channel is -69 days, and the average cycle time in the marketing channel is 134 days. BYD Company has a large amount of accounts payable in the procurement channel, so it can form strong bargaining power with buyers; On the other hand, BYD Company has a large amount of accounts receivable in its marketing channels, so the company should pay attention to the possibility of bad debts.

Table 1. BYD Company's channel based operating capital turnover period from 2021 to 2023

year	2021	2022	2023
Procurement turnover period	-58	-48	-101
Production turnover period	-52	-89	-139
Marketing turnover period	164	129	110
Business activity capital cycle	813	87	-68

2.2. Efficiency Analysis of Operating Funds in Procurement Channels

From Table 2, it can be seen that the procurement channel cycle fluctuates greatly over the past three years, rising from -58 days in 2021 to -48 days in 2022 and then decreasing to -101 days in 2023. This indicates that the company has a strong procurement process, strong

operational capabilities, and overall confidence in the procurement process.

Table 2. Detailed Statement of Operating Funds for Procurement Channels of BYD

year	2021	2022	2023
Raw material Inventory	43,354,782	79,107,199	87,676,748
Prepaid expenses	20,365,77	8,223,567	2,215,413
Accounts payable and bills	80,491,626	143,765,729	198,483,131
Procurement channel turnover period	-58	-48	-101

In the past three years, there has been a significant increase in accounts payable projects from 2022 to 2023, with a continuously rising proportion. However, a low proportion of monetary funds and a high proportion of accounts payable projects are not a good thing. If a company occupies them for a long time or suppliers urge payment, it can easily lead to short-term financial fractures and affect brand credit, resulting in increased financial risks.

In the past three years of the procurement channel operation cycle, it has been negative, indicating a significant reliance on supplier funds by the enterprise. This is manifested in the use of this capital flow to drive its own sustainable development, often leading to the expansion of production scale in the short term. However, from a strategic perspective, excessive reliance on financial support from suppliers may pose a potential threat to the stability of raw material supply, leading to the breakage of the company's financial chain, reducing the company's reputation value in the industry, and weakening cooperation with suppliers.

BYD should utilize its commercial credit in procurement channels and occupy funds from upstream suppliers to alleviate its financial pressure. However, this strategy needs to be used with caution to avoid excessive reliance on supplier funds, which could affect the cooperative relationship between both parties. BYD can ensure a healthy and stable cooperative relationship with suppliers through reasonable payment policies and credit management.

2.3 Analysis of Operational Capital Efficiency in Production Channels

As shown in Table 3, the production channel turnover periods of the company in 2021 and 2022 were -52 days and -89 days, respectively. The turnover period in 2023 was -139 days, indicating that the efficiency of operating capital management in the production process was high and the turnover speed of funds was fast during this period. From the

annual reports of the company in 2021-2023, it is shown that the awareness of external cooperation has been continuously enhanced. The company has successively reached strategic cooperation with the automotive parts technology company Faurecia Group, signed a joint venture agreement with Toyota, and signed a strategic alliance with Hino Auto Co., Ltd., continuously improving the internal quality of products and R&D capabilities to consolidate core technologies, gradually establishing the company's parts supply market, achieving the long-term development of the group, and reducing internal capital consumption.

Table 3. Detailed Statement of Production Channel Operating Funds of BY

year	2021	2022	2023
In product	14,360,249	26,812,272	30,236,001
Other receivables	1,410,751	1,910,009	2,757,912
Payroll payable	5,848,870	12,037,011	17,138,836
Other payables	41,348,102	122,123,841	164,972,849
Production channel turnover period	-52	-89	-139

The proportion of products in inventory has shown a downward trend in the past three years, at 23%, 16%, and 14% respectively. The increasing proportion of inventory year by year indicates the expansion of enterprise scale and the increase of production costs. Although the turnover speed of funds in the production process is fast, the proportion of products in the enterprise is relatively high, which invisibly increases the management expenses of products.

The main analysis of production channels is inventory management, to ensure that inventory production meets market demand rather than inventory backlog. Although the proportion of products in inventory has been continuously decreasing in the past three years, it is still at a high level, which increases the cost of inventory management.

BYD can improve the turnover efficiency of supply chain capital operations by continuously optimizing production processes and inventory control. Enterprises should strengthen monitoring of the production process to ensure smooth operation of production, while reducing inventory backlog to improve capital utilization efficiency.

2.4. Analysis of Operating Capital Efficiency in Marketing Channels

From Table 4, it can be seen that the turnover period of the enterprise has been

continuously decreasing from 164 days to 110 days from 2022 to 2023. The longer turnover period of the enterprise in the first two years may be due to the impact of Sino US trade on the external environment, resulting in a slow sales rate. Secondly, in 2023, the global economy was hit by the epidemic, causing the operation of the Chinese economy to first decline and then rise. The Chinese economy recovered strongly and became the only major economy in the world to achieve positive economic growth, gradually adapting to market changes. From the internal environment of the enterprise, the enterprise actively carried out strategic adjustments, technological innovation, and increased exports.

Table 4. BYD Company's Operating Funds for Marketing Channels

year	2021	2022	2023
Finished goods	17,786,026	31,793,681	38,712,460
Accounts receivable and bills	82,746,075	124,269,010	153,707,313
Advance from customers	1300	0	0
Taxes payable	1,779,018	4,326,394	7,852,324
Marketing channel turnover period	164	129	110

In the detailed list of operating channels, accounts receivable and bills account for the largest proportion, resulting in a long turnover period for marketing channels. Enterprises have expanded their sales through credit sales, and while seeing an increase in sales revenue, they should also pay attention to the risk of bad debts.

Enterprises sell products to customers and receive corresponding payment. The time lag in obtaining payment for goods is caused by the high proportion of accounts receivable, imperfect accounts receivable system, and insufficient capital turnover ability of the enterprise. Although the new energy vehicle industry has developed well in recent years, there is also a risk of a single sales channel.

BYD can strengthen communication and coordination with customers by establishing a rigorous accounts receivable management system to ensure timely collection of accounts receivable. With a credit evaluation system, BYD can assess customers' credit status and reduce the risk of bad debts. In addition, BYD can accelerate the turnover speed of accounts receivable and improve the efficiency of fund utilization.

2.5. Comparative Analysis of Working Capital Management with Target Enterprises

BYD and Great Wall Motors are both leading companies in the Chinese automotive industry, holding important positions in the fields of new energy vehicles and traditional fuel vehicles, respectively. BYD, as a representative of new energy vehicles, has shown outstanding performance in market expansion and technology research and development in recent years, while Great Wall Motors is known for its efficient management capabilities and stable profitability. By comparing the performance of two companies in working capital management, we can better understand their strengths and weaknesses in industry competition.

Table 5. Great Wall Motors Company's Channel Operating Capital Turnover

year	2021	2022	2023
Procurement turnover period	-127	-91	-79
Production turnover period	-16	-22	-18
Marketing turnover period	-0.7	4	2
Business activity turnover period	-143	-108	-94

Comparing Table 1 with Table 5, from 2021 to 2023, BYD's procurement turnover period increased in 2022 and significantly decreased in 2023, while Great Wall Motors continued to increase. BYD Company has made better improvements to its procurement channels than Great Wall Motors; The production turnover period of BYD has been continuously decreasing from 2021 to 2023, while Great Wall Motors has decreased from 2021 to 2022 and increased in 2023. BYD Company's utilization of production channel operating funds is better than Great Wall Motors' utilization of production channel operating funds; BYD's marketing turnover period continued to decline from 2021 to 2023, while Great Wall Motors saw an increase in 2021-2022 and a decrease in 2023. The turnover period of Great Wall Motors is much smaller than that of BYD. Great Wall Motors and BYD Company have relatively better utilization of marketing channel funds; The turnover period of operating funds for BYD continued to decline from 2021 to 2023, while Great Wall Motors continued to rise from 2021 to 2023. Although Great Wall Motors has continued to rise from 2021 to 2023, the data is smaller than BYD's. Great Wall Motors has better utilization of operating funds than BYD.

BYD and Great Wall Motors have their own strengths and weaknesses in operating capital management over the past three years. BYD has improved its capital utilization efficiency through vertical integration and supply chain optimization, but further improvements are still needed in accounts receivable and inventory management; Great Wall Motors needs to optimize the efficiency of fund utilization in its procurement and production processes, and strengthen cash flow management and capital structure optimization. Both companies need to continue to focus on optimizing channel management in order to improve overall capital utilization efficiency and competitiveness in their future development.

3. Problems and Causes of BYD's Operating Capital Management Based on Channel Theory

3.1. The Proportion of Payable Items is too High

According to BYD's 2021-2023 financial report disclosure information (see Table 2 for details), the company's supply chain financing scale has shown a significant growth trend. Its accounts payable and bill balance have increased year by year from 80491626 yuan in 2021 to 142765729 yuan in 2022, and reached 198483131 yuan in 2023, with a cumulative growth rate of over 146% over three years.

The new energy vehicle industry has high R&D investment and capital intensity, and BYD, as the industry leader, needs to continue investing to maintain its competitive advantage (Cai, 2022). This characteristic makes companies more inclined to meet their funding needs through short-term financing, such as accounts payable and short-term borrowings, rather than relying on long-term financing. In recent years, with the popularity of new energy vehicles, companies have increased their procurement of raw materials and components to cope with the rapid growth of the new energy vehicle market, resulting in an increase in accounts payable and notes payable.

3.2. When the Proportion of Products in Inventory is Relatively High

According to the financial data in Table 3, BYD Company's product to inventory ratio shows a decreasing trend from 23% to 14% from 2021 to 2023. However, in-depth analysis of absolute values reveals that the amount of this subject has significantly increased from 14.3602 million yuan in 2021 to 26.8123 million yuan in 2022. Although it has decreased to 20.236 million yuan in 2023, it still maintains a high level compared to the benchmark year. It should be noted that due to the continuous expansion of total inventory, although the proportion indicator has decreased, the actual capital occupation scale of product projects is still in the sensitive range of enterprise operation.

BYD is rapidly expanding in the new energy vehicle market, but its funding needs are increasing day by day. The excessive pursuit of scale expansion has led to the neglect of

quality control and financial management, resulting in gradually emerging financial pressures (Duan, 2024). The reduction of subsidies for new energy vehicles and fluctuations in market demand have also had an impact on BYD's funding chain. Although the company has reduced costs by optimizing supply chain management and improving production efficiency, changes in the market environment still have a negative impact on sales performance.

3.3. Accounts Receivable Account for a Relatively Large Proportion

According to the statistical data in Table 4, the accounts receivable scale of BYD Company's marketing channels has shown a significant growth trend in the past three years, reaching 82746075 yuan, 124269681 yuan, and 153707313 yuan respectively from 2021 to 2023. By calculation, it can be concluded that the average annual growth rate of this indicator exceeds 23%, accounting for a significant proportion of the overall revenue. Its continuous upward trend reflects the actual implementation effect of credit policies by enterprises in the process of market expansion.

The new energy vehicle and power battery business is a constantly developing field that requires continuous investment in research and development and capacity expansion, but capital expenditures are enormous (Feng, 2024). The fluctuation of operating cash flow in this industry poses greater challenges to accounts receivable management. In order to remain invincible in market competition, BYD has adopted a relatively relaxed sales credit policy, allowing customers with higher credit ratings to enjoy longer payment cycles. However, although this measure eased the financial pressure on customers, it also led to an increase in accounts receivable (Fan, 2024). Especially after 2020, the impact of the epidemic has led to a decrease in the repayment ability of some customers and an increase in the proportion of overdue accounts receivable. However, the company's failure to adjust its collection efforts and credit evaluation mechanism in a timely manner has led to certain risks.

4. Suggestions

4.1 Suggestions for Improving the Management of Operating Funds in Procurement

4.1.1. Optimize Supplier Management

BYD should establish detailed credit files when selecting suppliers, including key information such as the supplier's financial status, credit records, and delivery capabilities. This helps BYD better assess supplier risks and select reliable partners.

BYD should regularly evaluate suppliers' commercial credit, product quality, delivery time, and other aspects, and select high-quality suppliers based on the evaluation results. This helps BYD reduce procurement risks and ensure the stability and reliability of the supply chain.

BYD is committed to building a robust supply chain network, forming lasting partnerships with outstanding suppliers, effectively promoting the circulation and integration of internal and external information through an information sharing platform, improving procurement efficiency, and reducing costs. This cooperation model is not only beneficial for mutual benefit between both parties, but also drives the development of the entire industry chain. At the same time, establishing a stable cooperative relationship can not only ensure the quality of materials and delivery time, but also facilitate both parties to jointly explore innovative solutions and promote sustainable business development.

4.1.2. Strengthen Procurement Budget Management

To optimize its procurement strategy, BYD should establish a market research mechanism to collect detailed raw material price dynamics from various suppliers, thereby providing strong data support for decision-makers.

Based on in-depth analysis of market research, the procurement department needs to develop a practical and feasible procurement budget, and firmly implement it in practical operations to prevent financial overruns and resource depletion during the procurement process.

4.1.3. Optimize the Turnover of Operating Funds in Procurement Channels

BYD should try to minimize the occupation of funds from upstream suppliers, reduce financial pressure on suppliers by arranging procurement plans and payment times reasonably, and maintain good supplier relationships.

BYD can shorten the procurement cycle by restructuring and streamlining the procurement process, which can improve the efficiency of working capital utilization in procurement channels. In addition, integrating centralized procurement and bidding procurement strategies can also help reduce procurement costs and enhance the efficiency of fund utilization.

4.2. Suggestions for Improving Working Capital Management in Production

4.2.1. Optimize the Funding Structure

BYD should cleverly utilize short-term liabilities to meet the demand for current assets, while avoiding holding a large amount of current assets in pursuit of excessive liquidity. At the same time, current liabilities should not be used for long-term investments to ensure the stability of the funding structure. Only by flexibly utilizing various short-term liabilities can BYD better respond to the needs of capital turnover and corporate development, and maintain financial stability.

Establishing a strict credit approval system and a reasonable credit sales plan, selecting appropriate settlement methods based on customers' profitability, debt paying ability, and credit status, can effectively improve the speed of fund recovery and reduce bad debt risks.

By scientifically and reasonably managing credit sales business, the financial security of enterprises can be guaranteed and economic benefits can be improved. At the same time, regularly review the credit status of credit sales customers, adjust settlement methods in a timely manner, and ensure the long-term stable development of the enterprise. Establishing an effective credit sales management system is an indispensable and important link in the development process of enterprises.

4.2.2. Improve the Efficiency of Fund Utilization

By using advanced computer management systems to carry out centralized inventory management, this management method is scientific and efficient. Reserve quotas for various types of inventory such as raw materials and finished products are set, and information technology is used to reduce the occupation of inventory funds, thereby improving the speed of capital turnover. This approach can effectively manage enterprise inventory, optimize capital operations to the greatest extent possible, improve capital utilization efficiency, and provide strong support for the stable development of enterprises.

Comprehensive budget management is of great significance to enterprises. Fund budget management can accurately predict cash flow and fund demand, effectively control fund expenditure and utilization, and improve fund utilization efficiency. Only by strictly implementing fund budget management can enterprises avoid financial shortages and waste, ensure that funds are fully utilized and achieve maximum benefits. When carrying out comprehensive budget management, enterprises need to pay attention to the significance of fund budget management, do a good job in fund planning and forecasting, ensure that funds can be reasonably allocated and utilized, and achieve the optimal allocation of funds.

4.2.3. Balance Direct Sales and Distributor Channels

BYD should continue to optimize its channel structure and balance the relationship between direct sales and dealer channels. Direct sales channels have advantages in efficiency and market response speed, while dealer channels perform better in market coverage and after-sales service. Therefore, BYD needs to develop differentiated channel strategies based on different markets and consumer demands. By allocating resources reasonably and cultivating channel partnerships, we aim to enhance brand influence and market competitiveness. Only by maintaining balance, highlighting strengths and avoiding weaknesses, can we better meet consumer needs and achieve sustainable development. May BYD continue to strive for excellence and achieve greater success on its future development path.

Measures such as improving information transparency and establishing incentive mechanisms can reduce channel conflicts and enhance channel synergy. This provides strong support for BYD to integrate resources and enhance market competitiveness.

4.3. Suggestions for Improving Working Capital Management in Marketing

4.3.1. Optimize Channel Management and Improve the Efficiency of Fund Circulation

Establish a comprehensive credit file system and regularly evaluate the commercial reputation, product quality, and timely delivery of suppliers to maintain the stability of the supply chain.

By establishing long-term strategic partnerships with reputable suppliers, we can seek better procurement prices and payment terms, thereby reducing procurement costs and improving the efficiency of fund utilization.

4.3.2. Improve the Construction of Sales Network

BYD should continue to deepen its offline channels, optimize the layout of 4S stores and direct sales stores, especially by increasing the number of stores in first tier and new first tier cities to enhance brand influence and market share.

At the same time, we will strengthen the construction and operation of online channels, such as e-commerce platforms and social media, to provide consumers with convenient car purchasing and consulting services, and expand sales channels.

4.3.3. Optimize Sales Channels

Expand diversified sales channels, such as e-commerce platforms and second-hand car markets, to accelerate inventory turnover.

Establish close cooperative relationships with distributors, jointly carry out promotional activities, and increase inventory sales volume.

5. Conclusion

This article takes BYD Company in the new energy vehicle industry as an example and analyzes its working capital management in the past three years based on channel theory. It analyzes the turnover period of working capital in the three links of procurement, production, and marketing, identifies problems through analysis, and proposes suggestions. Therefore, we can draw the following conclusion: under the theory of channel management, analyzing the operational capital turnover efficiency of various channels, enterprises have strong procurement advantages and good profitability in the procurement channel. However, the problem of upstream capital occupation and delayed debt cannot be ignored. The continuous expansion of enterprise scale in production channels has led to the problem of inventory backlog and increased inventory management costs. Discovering an imperfect accounts receivable system in marketing channels can easily lead to bad debts for enterprises.

BYD must deeply understand the strategic significance of fund management and actively implement corresponding measures. In order to achieve steady improvement in its financial situation, it is necessary to take a series of strategic improvement measures in view of the problems exposed in BYD's operating fund management. The company can optimize its fund management effectiveness, ensure the effective utilization of funds and the stable development of the company. However, this article still has its shortcomings. Firstly, this article only analyzes BYD Company and does not represent that the new energy vehicle industry also has the same problems, nor does the proposed improvement suggestions apply to all companies in the new energy vehicle industry. Secondly, this article only analyzed the management of working capital and did not touch on other aspects.

Author Contributions:

Conceptualization, J.W.; methodology, Y.W.; software, Y.W.; validation, Y.W.; formal analysis, Y.W.; investigation, Y.W.; resources, Y.W.; data curation, Y.W.; writing—original draft preparation, Y.W.; writing—review and editing, J.W.; visualization, Y.W.; supervision, J.W.; project administration, J.W.; All authors have read and agreed to the published version of the manuscript.

Funding:

Not applicable.

Institutional Review Board Statement:

Not applicable.

Informed Consent Statement:

Not applicable.

Data Availability Statement:

Not applicable.

Conflict of Interest:

The authors declare no conflict of interest.

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The Development of Humanities and Social Sciences, 2025, 1(3), 15-29
https://doi.org/10.71204/0a06ct44

The Influence Mechanism of Personality Traits and Teacher Support on Vocal Performance of University Vocal Music Students

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Received: 10 June 2025/ Accepted: 23 August 2025/ Published online: 25 August 2025

Abstract

This study explores how student personality traits and teacher support influence vocal performance. Qualitative analysis reveals that teacher support significantly affects vocal performance differently depending on student personality traits. Findings indicate that personalized teacher support enhances vocal performance based on students' traits, offering practical guidance for improving vocal education practices. This study aims to uncover how student personality traits and teacher support impact vocal performance and provide insights for personalized vocal education. Qualitative methods were employed, including interviews and observations with students and teachers at a conservatory. Data analysis identifies how different types of teacher support affect students with varying personality traits. Teacher support significantly influences vocal performance, with different impacts based on personality traits. Extraverted students benefit from emotional support, while introverted students respond better to detailed guidance. Educators can enhance vocal performance by tailoring support strategies to individual personality traits. The findings also suggest developing personalized teacher training to improve support effectiveness. This study offers new insights into how personality traits and teacher support affect vocal performance, improving vocal education practices and contributing to educational policy development and innovation.

Keywords: Personality Traits; Teacher Support; Vocal Performance; Influence Mechanism; Qualitative Research

1. Introduction

In the field of vocal music education, teacher support and student personality traits are widely recognized as two critical factors shaping students' vocal performance. However, the interplay between these factors, as well as the mechanisms through which they jointly affect students' performance, has received relatively limited scholarly attention (Katz, 2020). Addressing this gap

is essential, as vocal music education requires not only the transfer of technical knowledge but also the cultivation of psychological resilience, motivation, and artistic expression. Personality traits play a fundamental role in students' musical learning and performance. Traits such as perseverance, extroversion, conscientiousness, and emotional stability influence not only the strategies students adopt in practice but also their overall persistence and performance outcomes (Zakaria et al., 2023). For instance, perseverance has been identified as a mediating factor that enhances learning effectiveness and improves vocal outcomes (Zhang, 2020). At the same time, teacher support—encompassing emotional, instructional, and evaluative dimensions—is indispensable in guiding students' technical skills, reducing music performance anxiety, and creating a safe environment that fosters self-efficacy and confidence (Nagórka & Tempczyk-Nagórka, 2024).

Recent research highlights that one-on-one tutorials and personalized teaching strategies play a particularly important role in vocal performance training. Teachers who integrate multiple forms of support can help students develop accurate self-perceptions and enhance their self-belief in their musical abilities. Such emotional and instructional interactions are crucial for motivating students, especially in managing the high levels of anxiety often associated with vocal performance (Kaleńska-Rodzaj, 2023). Moreover, integrating diverse musical experiences and creating supportive environments significantly enhance students' motivation and enthusiasm, underscoring the importance of teacher support in higher education contexts (Minors et al., 2024).

Beyond traditional teaching methods, innovation and reform in vocal pedagogy are also necessary to align instructional strategies with contemporary talent development needs. The incorporation of technology and creative teaching models has been shown to cultivate students' comprehensive musical ability and increase engagement with vocal training courses (Xi, 2024). Such practices emphasize that the effectiveness of vocal music education depends not only on technical expertise but also on the synergy between students' individual characteristics and the support structures provided by their teachers.

Despite these insights, several challenges remain. First, most existing studies explore the effects of teacher support or personality traits in isolation, with few systematically examining their interactive effects on vocal performance. Second, research in this area has relied heavily on quantitative approaches such as surveys and statistical modeling, which often overlook the deeper psychological and behavioral mechanisms that shape performance outcomes. Third, although teacher support has been shown to significantly influence student learning, insufficient attention has been given to differentiating the impact of emotional, academic, and evaluative support. Finally, current pedagogical strategies often fail to account for the diverse needs of students with different personality traits, resulting in a lack of personalized educational approaches (Zakaria et al., 2023; Minors et al., 2024).

To address these gaps, this study investigates the interaction between personality traits and teacher support in shaping the vocal performance of university vocal music students. Specifically, it seeks to explore how distinct personality traits influence students' reception of teacher support, how different forms of support impact performance, and whether self-efficacy mediates these relationships. By integrating qualitative methods, the study aims to uncover the psychological and

behavioral processes underlying vocal performance and contribute to the design of more effective, individualized pedagogical strategies (Zhang, 2020; Xi, 2024).

In sum, this research provides new insights into the dynamic interplay between personality traits and teacher support in vocal music education. It highlights the importance of fostering effective teacher-student relationships, tailoring support to individual needs, and innovating teaching models to enhance both the technical and expressive dimensions of student performance. The findings are expected to offer practical guidance for educators in creating personalized and inclusive vocal training programs that align with the diverse learning needs of students in higher education (Nagórka & Tempczyk-Nagórka, 2024; Kaleńska-Rodzaj, 2023).

2. Literature Review

The influence of personality traits and teacher support on academic performance has been extensively studied across various educational domains, yet their combined impact on vocal performance in university vocal music students remains under explored (Nauzeer & Jaunky, 2021). Personality traits, as defined by the Big Five model, encompass dimensions such as openness, conscientiousness, extra version, agreeableness, and neuroticism, each contributing differently to learning outcomes and personal development (Hou, 2023). For instance, students high in conscientiousness are often more disciplined and goal-oriented, which can positively influence their practice habits and performance quality in vocal music (Lin et al., 2022).

Teacher support, encompassing emotional, academic, and evaluative dimensions, plays a crucial role in fostering a conducive learning environment (Bremmer & Nijs, 2020). Emotional support involves providing encouragement and empathy, academic support includes offering instructional guidance and resources (Tahirbegi, 2021), and evaluative support pertains to giving constructive feedback (Zhang, 2022).Research indicates that supportive teacher-student relationships enhance students' motivation, self-efficacy, and overall academic success. In the context of vocal music education, teacher support can significantly impact students' confidence, technical skills, and expressive abilities (Liu et al., 2021).

The influence mechanism of personality traits and teacher support on vocal performance of university vocal music students is a multifaceted area that involves various factors contributing to the development of students' vocal skills. Research in the field emphasizes the importance of personalized teaching methods and support systems tailored to individual students' needs (Zhu, 2024). Teachers play a crucial role in considering factors such as students' personal abilities, professional foundations, and available teaching resources to enhance students' vocal music performance (Xi, 2024).

Moreover, the cultivation of students' song-singing ability has become a focal point in vocal music teaching, promoting students' professional progress and comprehensive development (Chen, 2024). In addition to teacher support, students' personality traits and attitudes significantly impact their vocal learning skills. Studies have shown a positive correlation between students' learning attitudes and vocal learning skills, indicating that a positive attitude can enhance students' understanding of vocal music basics and improve their learning outcomes (Yang, 2024).

Furthermore, the application of positive psychology in vocal music classroom teaching has been highlighted as a beneficial approach. Correctly guiding students in the vocal learning process can greatly aid students in their vocal music learning journey (Zhang, 2020).

Innovative teaching methods, such as the integration of audio-visual multi-sensory teaching modes, have been shown to strengthen students' singing abilities and drive reform and innovation in the teaching profession (Zhang, 2023). Additionally, the use of information fusion technology has proven effective in improving the quality of vocal music teaching, leading to enhanced student performance (Chen, 2024). Furthermore, the application of big data technology in vocal music teaching has been recognized for its ability to reform educational methods, improve teaching efficiency, and elevate students' vocal music levels (Hu, 2024). Overall, the synthesis of these studies underscores the importance of personalized teaching approaches, teacher support, positive attitudes, innovative teaching methods, and the integration of technology in enhancing the vocal performance of university vocal music students. By considering these factors collectively, educators can create a conducive learning environment that nurtures students' vocal skills and fosters their overall development in the field of vocal music.

Teacher support can be categorized into emotional, academic, and evaluative forms. Emotional support involves the teacher’s encouragement and empathy, which are crucial in reducing performance anxiety and fostering a positive learning environment (Tahirbegi, 2021). Academic support includes the provision of instructional resources and guidance, which directly affect students' technical proficiency and confidence (Bremmer & Nijs, 2020). Evaluative support, through feedback and assessments, plays a critical role in helping students identify areas for improvement and refining their performance (Zhang, 2022). Research has consistently shown that each type of support interacts differently with students' personality traits, impacting their vocal performance.

3. Theories Underpinning the Study

This study on "The Influence Mechanism of Personality Traits and Teacher Support on Vocal Performance of University Vocal Music Students" is underpinned by two primary theoretical frameworks: Bandura's theory of personality traits and the theory of social support.

3.1. Bandura's Theory of Personality Traits

Albert Bandura's social cognitive theory emphasizes the role of observational learning, social experiences, and reciprocal determinism in the development of personality traits (Butković, 2024). Bandura posits that individuals are not merely products of their environments but actively shape their behaviors through cognitive processes (Yang, 2024). Key components of Bandura's theory relevant to this study include:

Reciprocal Determinism: This principle highlights the dynamic and reciprocal interaction between personal factors, behavior, and the environment. In the context of vocal performance, this means that a student's personality traits influence their vocal behaviors (Panda, 2023), which in turn are affected by their interactions with their environment, including their teachers and peers

(Desire et al., 2019). A crucial aspect of Bandura's theory, self-efficacy refers to an individual's belief in their capability to execute behaviors necessary to produce specific performance attainments (Zhang, 2022). Higher self-efficacy can enhance motivation and persistence, which are essential for vocal performance and practice (Heriani, 2024).

The theory of social support, which encompasses various forms of support including emotional, informational, and instrumental support, is critical in understanding the external factors that influence vocal performance. In an educational context, teacher support is a significant component of social support. Key aspects include:

(1) Emotional Support: This involves expressions of empathy, care, and encouragement from teachers. Emotional support can boost students' confidence and reduce performance anxiety, leading to better vocal performance (Zhang, 2023).

(2) Informational Support: Providing students with feedback, guidance, and information on vocal techniques and performance can help them improve their skills and knowledge. This type of support is essential for the technical and artistic development of vocal students.

(3) Instrumental Support: This includes tangible resources and assistance, such as providing practice materials, arranging performance opportunities, and offering logistical support. Instrumental support can help students focus on their practice and performance without being hindered by external challenges.

Combining Bandura's theory of personality traits with the theory of social support provides a comprehensive framework for exploring the mechanisms through which personality traits and teacher support influence the vocal performance of university vocal music students (Chudari et al., 2020). This integrated approach acknowledges the interplay between intrinsic personal factors and extrinsic social factors in shaping students' vocal achievements (Ngobeni, 2024). By examining these interactions, the study aims to uncover the complex processes that contribute to vocal performance in an educational setting (Zakaria et al., 2023).

Bandura's theory of personality traits theoretically supported by the Big Five personality traits theory, which encompasses openness, conscientiousness, extraversion, agreeableness, and neuroticism (Holman & Hughes, 2021). This theory posits that individuals exhibit varying degrees of these personality traits, which can influence their behaviors, responses to stimuli, and interactions with their environment. Specifically, conscientiousness has been linked to job characteristics and academic performance, highlighting its importance in predicting outcomes in various domains.

Furthermore, the study incorporates the Trait and Factor theory, which posits that an individual's personality can be explained by identifying a set of traits determined by psychological tests measuring aspects of personality (Ngobeni, 2024). This theory underscores the importance of considering personality traits in career counseling and decision-making processes to align individuals with suitable career paths based on their traits and preferences. In summary, the theoretical framework of the study integrates the Big Five personality traits theory, the Theory of Planned Behavior, the association between personality traits and learning strategies, and the

Trait and Factor theory to elucidate how personality traits and teacher support influence the vocal performance of university vocal music students (Sun, 2023).

3.2. The Cognitive Theory

Here is another theory, the cognitive theory. Cognitive theory is a broad framework focusing on mental processes and how individuals acquire, process, and use information. This theory asserts that thinking, perception, memory, and problem-solving are critical cognitive processes that influence how individuals learn and interact with the world (Çeliköz et al., 2019). One of the prominent cognitive theories is the information processing theory. This theory proposes that individuals process information in a step-by-step manner, akin to a computer's processing of data. It involves sensory input, attention, perception, memory, and retrieval processes, and it posits that these processes work together to influence learning and problem-solving. Another influential cognitive theory is the social cognitive theory, which focuses on how individuals learn and acquire knowledge through their social interactions and experiences (Özcan, 2023). This theory posits that individuals learn from observing and modeling the behavior of others, and that their beliefs, attitudes, and values are shaped by their social experiences. Finally, the cognitive load theory is another important cognitive theory that focuses on how the cognitive resources of individuals are used during learning and problem-solving. This theory posits that individuals have a limited amount of cognitive resources available, and that learning and problem-solving tasks that require significant cognitive resources can overload the system and lead to poor learning outcomes. The theory proposes strategies to manage cognitive load, such as breaking down complex tasks into smaller, more manageable components (Sui et al., 2020). Overall, the cognitive theory is a rich and complex framework that has important implications for understanding how individuals learn and process information. It provides valuable insights into the mental processes that underlie human behavior and cognition, and it has informed the development of many influential theories and approaches to education and learning (Turda, 2024).

4. Research methodology

This study employs a qualitative research design to explore the nuanced ways in which personality traits and teacher support influence vocal performance (Sari et al., 2021). Qualitative methods are particularly suited for this study as they allow for an in-depth exploration of participants' experiences, perceptions, and interactions within their educational environment (Radil et al., 2023).

The sample for this study consists of 20 university vocal music students, selected using purposive sampling based on their personality traits, specifically targeting students with high levels of extraversion and introversion. Interviews were conducted to assess how these traits influence their reception of teacher support and vocal performance. Data analysis followed a thematic approach, with responses categorized according to the types of teacher support (emotional, academic, evaluative) and the students' personality traits. Thematic coding was employed to identify common patterns and differences across the interviews.

4. Discussion

This section interprets and discusses the qualitative findings of the study "The Influence Mechanism of Personality Traits and Teacher Support on Vocal Performance of University Vocal Music Students." The discussion will focus on the main themes that emerged, exploring how personality traits and teacher support interact to influence students' vocal performance (Castillo-Allendes, 2024).

4.1. Personality Traits and Vocal Performance

The findings reveal that personality traits significantly shape the vocal performance of university vocal music students. Key traits identified include self-efficacy, resilience, and openness to experience (Zhang, 2022).

4.1.1. Self-Efficacy

Self-efficacy, or the belief in one's capabilities to achieve goals, emerged as a critical factor. Students with high self-efficacy displayed greater motivation, persistence, and confidence in their vocal practice and performance. This aligns with Bandura's self-efficacy theory, which suggests that individuals with higher self-efficacy are more likely to take on challenges and persist in the face of difficulties (Peng, 2023). High self-efficacy students were observed to set higher performance goals, engage in more effective practice routines, and recover more quickly from performance setbacks.

4.1.2. Resilience

Resilience, the ability to bounce back from setbacks, was another crucial trait. Resilient students were better at coping with criticism and failures, maintaining a positive outlook towards their vocal development. They tended to view setbacks as learning opportunities rather than failures, which is vital in the demanding field of vocal performance. This trait helps students to sustain their efforts and continue improving despite the inevitable challenges they face in their training (Castillo-Allendes, 2024).

4.1.3. Openness to Experience

Openness to experience, characterized by a willingness to explore new ideas and take creative risks, also played a significant role. Students high in this trait were more receptive to innovative vocal techniques and diverse musical genres. They showed a greater propensity for experimenting with their vocal abilities, which enhanced their overall artistic expression and versatility. This openness was crucial for artistic growth, allowing students to develop unique performance styles (Alzugaray et al., 2020).

4.2. Teacher Support and Vocal Performance

Teacher support was identified as a pivotal external factor influencing students' vocal performance. The support provided by teachers can be categorized into emotional, informational, and instrumental support (Tahirbegi, 2021).

4.2.1. Emotional Support

Emotional support, which includes empathy, encouragement, and positive reinforcement, was vital in boosting students' confidence and reducing performance anxiety. Students who felt emotionally supported by their teachers were more likely to take risks and push their boundaries in vocal performance. This support helped create a safe and nurturing environment, essential for fostering artistic growth and exploration (Zelenak, 2020).

4.2.2. Informational Support

Informational support, such as constructive feedback, technical guidance, and performance advice, directly impacted students' skill development and performance quality (Wang, 2022). Effective feedback helped students identify their strengths and areas for improvement, leading to more focused and effective practice sessions. Informational support also deepened students' understanding of vocal techniques and musical interpretation, essential for achieving high levels of performance (Bulut, 2021).

4.2.3. Instrumental Support

Instrumental support, including providing resources like practice materials, performance opportunities, and logistical assistance, facilitated students' practical needs (Cao, 2024). This type of support ensured that students had access to the necessary tools and platforms to hone their skills and showcase their talent. Instrumental support alleviated practical barriers to consistent practice and performance preparation, enabling students to focus more on their artistic development (Lewis & Hendricks, 2022).

4.3. Interaction Between Personality Traits and Teacher Support

The interaction between personality traits and teacher support was found to be a complex yet influential factor in vocal performance (Ritchie & Sharpe, 2021). The synergy between intrinsic traits and extrinsic support significantly enhanced students' performance outcomes.

4.3.1. Enhancing Self-Efficacy Through Support

Teacher support played a crucial role in enhancing students' self-efficacy. Positive reinforcement and constructive feedback from teachers bolstered students' belief in their abilities, motivating them to strive for higher levels of performance (Xi, 2024). This reciprocal relationship aligns with Bandura's concept of reciprocal determinism, where personal factors, behavior, and environmental influences interact dynamically (Khan, 2020).

4.3.2. Resilience and Adaptive Support

Students with high resilience benefited from adaptive support tailored to their individual needs (Jones, 2020). Teachers who recognized the unique challenges faced by each student and provided personalized support helped these students navigate difficulties more effectively. This personalized approach fostered a growth mindset, encouraging students to view challenges as opportunities for learning rather than insurmountable obstacles (Wong, 2020).

4.3.3. Openness to Experience and Creative Encouragement

Teachers who encouraged creativity and exploration helped students with high openness to experience to flourish (Khan, 2020). By fostering an environment that valued innovation and artistic expression, teachers enabled these students to experiment with new techniques and styles. This encouragement not only enhanced students' technical skills but also their artistic individuality and expression (Wang, 2024).

Student feedback revealed that extraverted students responded more positively to emotional support, citing feelings of increased motivation and reduced anxiety. In contrast, introverted students found academic and evaluative support more beneficial, with many highlighting the detailed feedback they received. Quantitative data, where available, indicated a noticeable improvement in performance for extraverted students who received higher emotional support, suggesting that personality traits play a significant role in the effectiveness of teacher support.

4.4. Implications for Practice

The findings have several practical implications for vocal music education:

(1) Holistic Support: Educators should provide a holistic support system that addresses emotional, informational, and instrumental needs (Cui, 2021). This approach ensures that students receive comprehensive support that fosters both technical and personal growth.

(2) Personalized Feedback: Tailoring feedback and support to individual students' personality traits and needs can significantly enhance their learning experience and performance outcomes. Recognizing and nurturing each student's unique strengths and addressing their specific challenges is key to effective teaching (Wang & Webb, 2023).

(3) Fostering Self-Efficacy: Teachers should focus on building students' self-efficacy through positive reinforcement, constructive feedback, and opportunities for success. A strong sense of self-efficacy empowers students to take on challenges and persist in their efforts (Cheng et al., 2022).

(4) Encouraging Resilience: Developing resilience should be an integral part of vocal training programs. Educators can help students build resilience by providing a supportive environment, encouraging a growth mindset, and offering strategies for coping with setbacks (Yue, 2023).

(5) Promoting Openness and Creativity: Encouraging students to explore and experiment with their vocal performance can lead to greater artistic development (Liu & Zhou, 2021). Teachers should create opportunities for creative expression and innovation within their curriculum.

4.5. Limitations and Future Research

While this study provides valuable insights, it has certain limitations that should be acknowledged. The qualitative nature of the study means that findings may not be generalizable to all vocal music students (Chen, 2023). Future research could employ a mixed-methods approach to validate these findings across a larger, more diverse sample. Additionally, longitudinal studies could provide deeper insights into how personality traits and teacher support interact over time to influence vocal performance (Lu, 2023).

In conclusion, this study highlights the intricate interplay between personality traits and teacher support in shaping the vocal performance of university vocal music students. By understanding these dynamics, educators can develop more effective teaching strategies that cater to the individual needs of their students, ultimately enhancing their vocal performance and overall educational experience (Hao et al., 2023).

Practical Implications for Personalized Pedagogy

Based on the interaction patterns, we propose a 2×3 support matrix

Extroverted students → Emotion-focused support (e.g., public praise, master-class exposure).

Introverted students → Academic-detail support (e.g., annotated scores, micro-targets).

High-neuroticism students → Evaluative support with sandwich feedback to buffer anxiety.

These strategies can be integrated into faculty-development workshops and syllabi redesign.

4. Conclusion & Proposed Framework

This study examined how specific personality traits and different dimensions of teacher support jointly shape students' vocal performance. Using qualitative methods, the findings revealed self-efficacy, resilience, and openness to experience as the most influential personality traits affecting students' learning strategies and artistic expression. Among these, self-efficacy proved to be a foundational factor: students with stronger beliefs in their own abilities demonstrated greater motivation, persistence, and confidence in practice and performance. Resilience further enabled students to overcome criticism and setbacks with a constructive mindset, sustaining long-term improvement in vocal training. Meanwhile, openness to experience encouraged exploration of diverse vocal styles and techniques, thereby enriching artistic growth and performance versatility.

The study also emphasized the crucial role of teacher support as an external driver of vocal achievement. Emotional support created a safe and trusting learning environment, reducing performance anxiety and encouraging expressive risk-taking. Informational support, such as targeted feedback and technical guidance, enhanced students' mastery of vocal techniques. Instrumental support, including provision of resources and performance opportunities, allowed students to fully participate in their training and showcase their abilities.

Importantly, the interaction between personality traits and teacher support was shown to be dynamic and reciprocal. Teacher support amplified the positive effects of traits such as self-efficacy and resilience, reinforcing students' confidence and motivation while simultaneously shaping their learning behaviors. This highlights the necessity of adopting tailored pedagogical strategies, in which teachers align support with students' individual personality characteristics.

In practice, this means that educators should design personalized teaching approaches. For instance, students with higher extroversion may benefit more from emotional encouragement, while introverted students may respond more positively to evaluative feedback and detailed academic guidance. Such differentiation not only enhances individual performance outcomes but

also fosters an inclusive, supportive learning environment that accommodates the diverse needs of vocal music students.

Overall, this study contributes to both theory and practice by demonstrating how the synergy between personality traits and teacher support drives vocal performance. Future vocal pedagogy can build on these insights to develop individualized teaching frameworks that maximize student potential, improve learning effectiveness, and promote sustainable artistic development.

Author Contributions:

Conceptualization, M.H and G.NA; methodology, M.H and G.NA; software, M.H and G.NA; validation, M.H and G.NA; formal analysis, M.H and G.NA; investigation, M.H and G.NA; resources, M.H and G.NA; data curation, M.H and G.NA; writing—original draft preparation, M.H and G.NA; writing—review and editing, M.H and G.NA; All authors have read and agreed to the published version of the manuscript.

Funding:

Not applicable.

Institutional Review Board Statement:

Not applicable.

Informed Consent Statement:

Not applicable.

Data Availability Statement:

Not applicable.

Conflict of Interest:

The authors declare no conflict of interest.

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The Development of Humanities and Social Sciences, 2025, 1(3), 30-47
https://doi.org/10.71204/5h17h214

Tripartite Game Analysis of Straw Burning Management Considering the Dispersed Locations of Farms

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Received: 18 August 2025/ Accepted: 4 September 2025/ Published online: 6 September 2025

Abstract

Against the backdrop of the dual carbon strategy and rural revitalization, straw burning poses environmental and carbon emission pressures, while high collection and transportation costs coupled with insufficient policy incentives hinder its effective recycling. By constructing a tripartite evolutionary game model involving farmers, straw collection/storage/utilization enterprises, and local governments—incorporating farmer dispersion factors—this study conducts sensitivity analyses on fixed costs, storage/transportation costs, penalty levels, purchase prices, and subsidy intensity. It evaluates the marginal effects of policy tools on straw recovery efficiency and system stability. Results indicate that both fixed costs and storage/transportation costs influence system evolution, though through distinct mechanisms. Moderate penalties, reasonable prices, and subsidies promote farmer-enterprise coordination, maximizing both straw resource utilization and environmental benefits. Farmer dispersion primarily affects convergence speed without altering the final equilibrium. Overall, the stable equilibrium of the straw collection and transportation system relies more on institutional design and market incentives than on objective spatial factors. Moderate penalties, prices, and subsidy policies can effectively promote tripartite coordination, achieving maximized straw resource utilization and environmental benefits. This provides a theoretical basis for optimizing rural straw management policies and offers guidance for achieving green transformation and sustainable agricultural development.

Keywords: Straw Recycling; Evolutionary Games; Accounting for Farmer Dispersion; Dual Carbon Goals; Rural Green Transition

1. Introduction

Driven by both the dual carbon strategy and rural revitalization, the resource utilization of agricultural waste has become a crucial component in advancing the green transformation of rural

areas. Among these, straw—a byproduct of agriculture with massive production and widespread distribution — represents both a potential renewable resource and an environmental burden constraining sustainable agricultural development . For a long time, some farmers have preferred to burn straw on-site due to the lack of efficient collection and storage channels and reasonable economic compensation. While this practice offers short-term convenience, it leads to air pollution, soil degradation, and increased carbon emissions (Liu and Ma, 2023). Taking the water source areas of the South-to-North Water Diversion Project as an example, the highly dispersed locations of farmers' residences and farmland significantly increase the costs of straw collection and transportation. Against this backdrop, the traditional "point-to-area" recycling model faces efficiency challenges. Balancing farmer income, corporate profitability, and government governance objectives has become an urgent practical challenge requiring resolution(Shi et al., 2018).

In recent years, academia and policy makers have conducted multidimensional explorations into the comprehensive utilization of crop residues. Some studies have focused on conversion technologies and energy utilization pathways for straw resources, emphasizing the potential of industrial chain extension and circular economy models in improving rural ecosystems. For instance, Chen (2022) proposed utilization methods including fertilization, fuel production, feed conversion, substrate preparation, and raw material processing; Kang Suoqian et al. (2019) analyzed straw recycling from a circular economy perspective, arguing that systematic recovery of rural straw could propel China's transition from linear resource utilization to circular cascading use ; Li and Song (2018) proposed diversified processing models including biological straw return to fields, straw papermaking, integrated "gas-heat-electricity-fertilizer" production, straw-based edible fungus humus preparation technology, and SRM. While these studies provide crucial theoretical and practical foundations for technological and industrial pathways, their limitations lie in predominantly focusing on process feasibility and industrial prospects, with insufficient consideration of multi-stakeholder behavioral interactions in straw governance.

To address the shortcomings of technology-oriented research, some scholars have turned to game theory and evolutionary game analysis frameworks to reveal how strategic interactions among farmers, enterprises, and governments shape straw management performance. For instance, He et al.(2023) used an evolutionary game model to demonstrate that a dual mechanism of subsidies and penalties can effectively curb farmers' burning tendencies, though its policy effectiveness is highly dependent on collection and storage costs and market price fluctuations. Bai (2024) further discovered that the dispersed locations of farmers significantly amplify cost pressures in the collection and storage process, making enterprises more likely to exit the straw market when lacking long-term policy incentives. These studies highlight the sensitivity of policy outcomes to game-theoretic dynamics, yet often simplify subject relationships into linear games, lacking systematic analysis of the interactions between policy instruments, market conditions, and geographical factors. Concurrently, policy implementation reveals coordination deficiencies: government regulations face fiscal constraints and enforcement delays, corporate collection models lack economies of scale, and individual farmer behaviors exhibit insufficient endogenous alignment with environmental objectives (Yang et al., 2024) .

Overall, while existing literature offers valuable analyses within policy and game-theoretic frameworks, it exhibits three shortcomings: First, research predominantly focuses on the behavioral decisions of individual actors or the evaluation of specific policy effects, lacking systematic modeling of the interactions among farmers, enterprises, and government. Second, existing game studies often assume homogeneity among farmers, failing to reveal how the dispersion of farmer locations affects straw collection costs, governance efficiency, and overall system stability. Third, most models remain theoretical, lacking empirical exploration through numerical simulations to test dynamic evolution and the marginal effects of policies.

To address these shortcomings, this study introduces innovations in three key areas: First, it constructs a tripartite evolutionary game model encompassing farmers, enterprises, and local governments, transcending previous bilateral or single-agent frameworks to comprehensively depict multi-agent interactions under diverse policy and market conditions. Second, it introduces the factor of farmer location dispersion into the straw management game analysis framework for the first time, revealing how this dispersion alters the game equilibrium by increasing collection costs, thereby affecting recycling efficiency and environmental benefits. Third, it employs numerical simulations to test the model's dynamic evolution, quantitatively evaluating the marginal effects of policy instruments — such as subsidies, penalties, and regulations — under different scenarios. This provides a more intuitive demonstration of the effectiveness boundaries and optimization pathways for policy tools. Compared to existing research, this study not only expands the theoretical application boundaries of game theory but also offers more operationally feasible analytical tools at the methodological level, providing more targeted and practical references for policy design.

2. Model Development

2.1. Scenario Description

This study focuses on the governance of straw burning within China's agricultural context, examining the interactive relationships among farmers, straw collection/storage/utilization enterprises, and local governments during the straw recovery process. The dispersed locations of farmers increase the difficulty and cost of straw collection. Enterprises' collection, storage, and utilization activities are influenced by market and policy environments. Meanwhile, governments regulate straw governance outcomes through regulatory and subsidy policies. The interplay of decisions among these three parties determines the efficiency of straw recovery and its environmental benefits. This study aims to reveal the dynamics of straw management within this tripartite interaction, providing insights for developing scientifically sound and effective policies. The strategic relationship among stakeholders is illustrated in Figure 1.

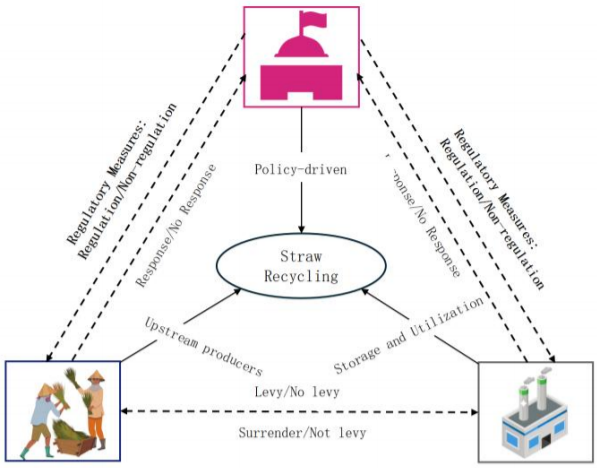

Figure 1. Game relations among stakeholders

2.2. Basic Assumptions

Assumption 1: Farmers' strategy choices are (sell, burn), where the probability of selling is $x \in [0,1]$. Thus, the probability of choosing to burn is $1-x$. The enterprise's strategy choices are (taxation, no taxation), with the probability of choosing taxation set as $y \in [0,1]$. The probability of choosing no taxation is $1-y$. The local government's strategy choices are (regulation, no regulation), with the probability of choosing regulation set as $z \in [0,1]$. The probability of choosing no regulation is $1-z$.

Assumption 2: Farmers possess a certain quantity of disposable straw Q annually. Collection incurs a unit collection cost C_f, which increases due to the farmer's location dispersion factor θ. When farmers choose to burn straw, they receive a direct benefit R per unit of burned straw. However, if the government imposes regulatory measures, they face a penalty amount F. If farmers choose to sell straw to enterprises, they receive a unit purchase price P_u and government subsidy S_1, but must deduct collection costs and location dispersion costs. Thus, farmers' decision benefits primarily depend on balancing collection costs, burning benefits, selling prices, and government subsidies, while constrained by the intensity of government regulation.

Assumption 3: Enterprises' decisions on straw collection and storage are driven by the following dedicated parameters: unit purchase price paid to farmers P_u, transportation cost C_t, storage cost C_S, fixed investment cost C_n for participation, alternative business revenue L if not participating, long-term policy opportunity cost E lost by non-participation, and government subsidy per unit S_2. Considering the impact of supply dispersion: Transportation cost C_t increases monotonically with the farmer location dispersion factor θ. Furthermore, storage cost C_S also rises when purchase-sales scale or collection frequency decreases due to dispersion. To control these dispersion-related costs, enterprises may adopt strategies such as lowering purchase prices, raising acquisition thresholds, or reducing collection frequency. They tend to prioritize stable cooperation with village collectives or farmer organizations that exhibit "regional concentration and strong cooperative willingness" to minimize transportation costs.

During processing, enterprises convert raw straw into products at a conversion rate η and sell them at market price P_s.

Assumption 4: Local governments incur implementation costs C_g related to governance and oversight when enforcing regulations, while gaining reputational benefits M from regulatory actions. Under regulation, governments must provide subsidies S_1 and S_2 to farmers and enterprises respectively, while enhancing policy enforcement through penalties F for farmers engaging in burning. If the government refrains from regulation, it may incur environmental benefit losses K due to ineffective straw collection and storage, and face fiscal penalties N from higher-level governments. Thus, in choosing between regulation and non-regulation, local governments weigh regulatory costs and subsidy expenditures against reputational gains, environmental protection, and fiscal constraints.

Based on the assumptions outlined above, the payoff matrix for the three-party game can be derived as shown in Table 1.

Table 1. Payoff Matrix for the Three-Party Game

Strategy	Farmers	Enterprises	Local Governments
x, y, z	$P_u+S_1-C_f\theta$	$P_s\eta Q-P_uQ-C_t\theta-C_s-C_n+S_2$	$M-C_g-S_1-S_2$
$x, y, 1-z$	$P_u-C_f\theta$	$P_s\eta Q-P_uQ-C_t\theta-C_s-C_n$	$-K-N$
$x, 1-y, z$	$-C_f\theta$	$-E+L$	$M-C_g-S_1-S_2$
$x, 1-y, 1-z$	$-C_f\theta$	L	$-K-N$
$1-x, y, z$	$R-F$	$-C_n+S_2$	$M-C_g-S_1-S_2+F$
$1-x, y, 1-z$	R	$-C_n$	$-K-N$
$1-x, 1-y, z$	$R-F$	$-E+L$	$M-C_g-S_1-S_2+F$
$1-x, 1-y, 1-z$	R	L	$-K-N$

2.3. Model Solving and Analysis

2.3.1. Analysis of Farmers' Evolutionarily Stable Strategies

Expected payoff V_{11} for selling, expected payoff V_{12} for not selling, average expected payoff V_1, replicating dynamic equation F(x).

$$\begin{cases} V_{11} = y(C_f Q + P_u Q)(z-1) - yz(C_f Q - QS_1 + P_u Q) - z(QS_1 - C_f Q)(y-1) - C_f Q(y-1)(z-1) \\ V_{12} = yz(R-F) - Ry(z-1) + R(y-1)(z-1) - z(R-F)(y-1) \\ V_1 = \mathrm{x}V_{11} + (1-x)V_{12} \end{cases}$$

$$F(x) = -x(x-1)\left(-R - C_f Q + yP_u Q + zQS_1 + zF\right)$$
$$F'(x) = (2x-1)\left(R + C_f Q - P_u Q y - QS_1 z - Fz\right)$$

Proposition 1: There exists a threshold y* such that when y > y*, farmers' stable strategy is to sell straw; when y < y*, farmers' stable strategy is to burn straw; when y = y*, their stable strategy cannot be determined.

Proof: Let $G(x) = R + C_f Q - P_u Q y - QS_1 z - Fz$, $\partial G(x)/\partial y < 0$. Thus, G(x) is a decreasing function of y. When y > y*, G(x) < 0. Since F(x) | $_{x=1}$ = 0 and F' (x) | $_{x=1}$ < 0, x = 1 is stable. When y < y*, G(x) > 0, F(x)| $_{x=0}$=0, and F' (x) | $_{x=0}$ < 0, thus x = 0 is stable; when y = y*, F(x) = 0 and F' (x) = 0, making the stable strategy undeterminable. Q.E.D.

Proposition 1 indicates that in the three-party game involving farmers, enterprises, and the government, whether enterprises collect straw directly determines farmers' stable strategy. When enterprises prefer not to collect straw (y < y*), farmers find it difficult to gain benefits even if they choose to sell straw, while incurring transportation and opportunity costs. Thus, they are more inclined to choose straw burning as their stable strategy. Conversely, when enterprises prefer to collect straw (y>y*), farmers gain direct economic benefits from selling straw and may receive government subsidies or avoid environmental penalties. In this scenario, selling straw becomes the evolutionary stable strategy. When enterprises are at the critical point (y=y*), the stable strategy becomes uncertain, with outcomes heavily influenced by the strength of government intent z. If the government intensifies regulation against straw burning or increases subsidies for straw delivery, farmers are more likely to shift from burning to delivery. The phase diagram illustrating farmers' strategy choices is shown in Figure 2.

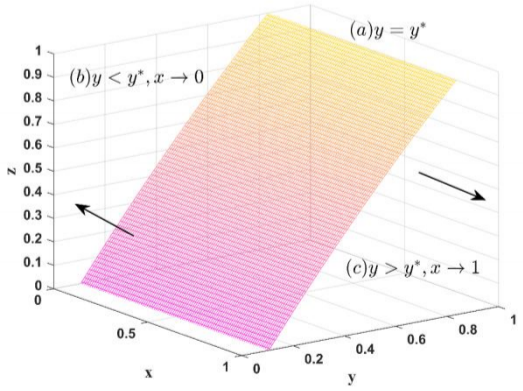

Figure 2. Dynamic Evolution Phase Diagram of Farmer Strategy Selection

2.3.2. Analysis of Evolutionary Stable Strategies for Enterprises

Expected payoff of choosing to pay taxes V_{21}, expected payoff of choosing not to pay taxes V_{22}, average expected payoff V_2, replicating dynamic equation F(y).

$$\begin{cases} V_{21} = (C_n + QS_2)(x-1)(z-1) - z(C_n + QS_2)(x-1) - \\ \quad x(z-1)(C_n - C_s - C_t\theta + P_sQ\eta + P_uQ) \\ \quad + xz(C_n - C_s + QS_2 - C_t\theta + P_sQ\eta + P_uQ), \\ V_{22} = x(E-L)(z-1) + z(E-L)(x-1) - (E-L)(x-1)(z-1) - xz(E-L), \\ V_2 = yV_{21} + (1-y)V_{22} \end{cases}$$

$$F(y) = -y(y-1)\left(C_n + E - L + QS_2 - C_s x - P_u Q x - QS_2 x - C_t \theta x + P_s Q \eta x + QS_2 xz\right)$$
$$F'(y) = -(2y-1)\left(C_n + E - L + QS_2 - C_s x - P_u Q x - QS_2 x - C_t \theta x + P_s Q \eta x + QS_2 xz\right)$$

Proposition 2: There exists a threshold z*. When z > z*, the stable strategy for firms is to collect straw; when z < z*, the stable strategy is to refrain from collecting straw; when z = z*, the stable strategy cannot be determined.

Proof: Let $G(y) = C_n + E - L + QS_2 - C_s x - P_u Q x - QS_2 x - C_t \theta x + P_s Q \eta x + QS_2 xz$, $\partial G(y)/\partial z > 0$.Thus, G(y) is an increasing function of z. When z > z*, G(y) > 0. Since $F(y)|_{y=1} = 0$ and $F'(y)|_{y=1} < 0$, y = 1 is stable. When z < z*, G(y) < 0, $F(y)|_{y=0} = 0$ and $F'(y)|_{y=0} < 0$, thus y = 0 is stable; when z = z*, F(y) = 0 and F′(y) = 0, making the stable strategy indeterminate. Q.E.D.

Proposition 2 indicates that the government's regulatory intensity decisively influences the decision-making of straw collection and storage enterprises. When the government adopts a lower regulatory intensity (z < z*), enterprises face difficulties in obtaining additional subsidies or advantages through government policies even if they engage in straw collection, while simultaneously bearing the operational costs of collection, transportation, and processing. Under such circumstances, enterprises are more inclined to refrain from collecting straw to avoid additional economic burdens. Conversely, when government regulation is stringent (z>z*), it signifies increased penalties for burning and proactive subsidy policies. Enterprises refusing to collect straw may face policy risks and social pressure, whereas collecting straw not only secures government subsidies but also fosters stable transactional relationships with farmers. Thus, straw collection becomes the enterprises' evolutionarily stable strategy. When government regulation is at the critical threshold (z=z*), the stable strategy becomes indeterminate, with outcomes influenced by external factors such as farmers' willingness to sell and market purchase prices. The phase diagram illustrating the firm's strategy selection is shown in Figure 3.

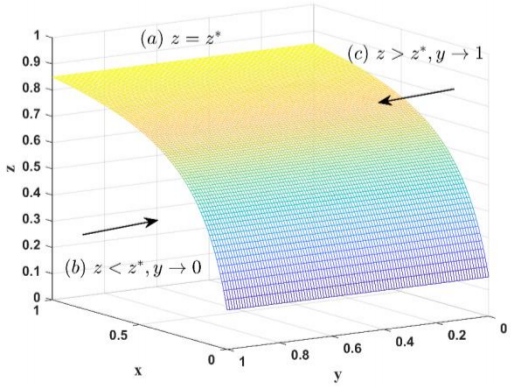

Figure 3: Dynamic Evolution Phase Diagram of Corporate Strategy Selection

2.3.3. Analysis of Evolutionary Stable Strategies for Local Governments

Expected payoff of choosing regulation V_{31}, expected payoff of choosing non-regulation V_{32}, average expected payoff V_3, replicating dynamic equation F(z).

$$\begin{cases} V_{31} = x(y-1)(C_g - M + QS_1) + y(x-1)(C_g - M + QS_2 - F\alpha) - xy(C_g - M + QS_1 + QS_2) \\ \qquad -(x-1)(y-1)(C_g + K - M - F\alpha) \\ V_{32} = Nx(y-1) - Nxy - (x-1)(y-1)(K+N) + Ny(x-1) \\ V_3 = zV_{31} + (1-z)V_{32} \end{cases}$$

$$F(z) = z(z-1)\left(C_g - M - N - F + QS_1 x + QS_2 y + Fx\right)$$

$$F'(z) = (2z-1)\left(C_g - M - N - F + QS_1 x + QS_2 y + Fx\right)$$

Proposition 3: There exists a threshold x* such that when x > x*, the government's stable strategy is to choose non-regulation; when x < x*, the government's stable strategy is to choose regulation; when x = x*, its stable strategy cannot be determined.

Proof: Let $G(z) = C_g - M - N - F + QS_1 x + QS_2 y + Fx$, $\partial G(z)/\partial x < 0$. Thus, G(z) is a decreasing function of x. When x > x*, G(z) < 0. Since $F(z)|_{z=0} = 0$ and $F'(z)|_{z=0} < 0$, z = 0 is stable. When x < x*, G(z) > 0, $F(z)|_{z=1} = 0$, and $F'(z)|_{z=1} < 0$, thus z = 1 is stable; When x = x*, F(z) = 0 and F′(z) = 0, making the stability strategy indeterminate. Q.E.D.

Proposition 3 indicates that farmers' behavioral preferences directly influence the government's regulatory choices. When farmers exhibit high motivation (x > x*), most farmers tend to sell straw, enabling straw resource utilization to be largely achieved through market mechanisms. Even without strict government regulation, satisfactory environmental governance outcomes can be maintained. In this scenario, to avoid additional regulatory costs and administrative resource consumption, the government is more inclined to choose non-regulation as a stable strategy. Conversely, when farmer willingness is low (x < x*), farmers are more likely to adopt straw burning strategies, causing environmental pollution and resource waste. Government inaction would not only degrade environmental quality but also risk triggering public pressure and governance accountability failures. Thus, regulation becomes the preferred evolutionary stable strategy. When farmer willingness is at the critical threshold (x=x*), the stable strategy becomes indeterminate. The final choice may be influenced by external factors such as corporate enthusiasm for straw collection and storage, policy implementation costs, and public concern for environmental protection. The phase diagram illustrating government strategy selection is shown in Figure 4.

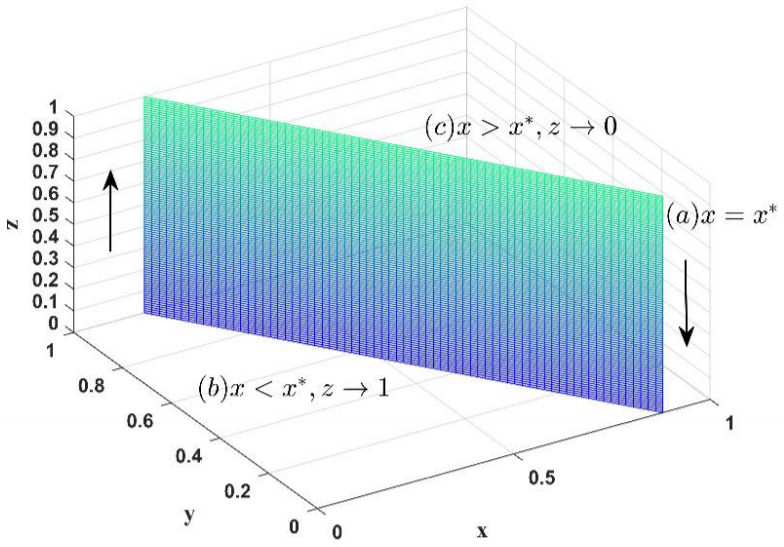

Figure 4. Dynamic Evolution Phase Diagram of Local Government Strategy Selection

2.3.4. Analysis of Evolutionary Stable Strategies in Three-Party Game Systems

The replicator equation describes the evolutionary dynamics of strategies within a population, and its single equilibrium solution does not necessarily correspond to the evolutionarily stable state of the entire system. According to (Friedman,1991) , the stability of equilibrium points in multi-party games must be assessed in conjunction with the overall system's dynamic characteristics. Therefore, in a three-party interaction scenario, constructing a joint replicator dynamics system and conducting local stability analysis of each equilibrium point via the Jacobian matrix is necessary for accurately analyzing the system's evolutionary trends. The Jacobian matrix for this system is as follows:

$$J_{(x,y,z)} = \begin{bmatrix} \frac{\partial F(x)}{\partial x} & \frac{\partial F(x)}{\partial y} & \frac{\partial F(x)}{\partial z} \\ \frac{\partial F(y)}{\partial x} & \frac{\partial F(y)}{\partial y} & \frac{\partial F(y)}{\partial z} \\ \frac{\partial F(z)}{\partial x} & \frac{\partial F(z)}{\partial y} & \frac{\partial F(z)}{\partial z} \end{bmatrix}$$

According to Lyapunov's First Law (Weinstein,1986), stable equilibria in multi-agent evolutionary games typically correspond to strict Nash equilibria, and strict Nash equilibria must be pure strategy solutions. In this system, calculations identified a total of 8 pure strategy equilibrium points, with their corresponding eigenvalues shown in Table 2. Only when the real parts of all eigenvalues at an equilibrium point are negative does that point possess local asymptotic stability, thereby qualifying as an evolutionary stable strategy (ESS) for the system.

Table 2. Evolutionary Game Equilibrium Points and Eigenvalues

Equilibrium Point	Eigenvalue 1	Eigenvalue 2	Eigenvalue 3
(0 , 0 , 0)	$R-C_fQ$	$C_n+E-L+QS_2$	$F-C_g+M+N$
(0 , 1 , 0)	P_uQ-R-C_fQ	$L-E-C_n-QS_2$	$F-C_g+M+N-QS_2$
(0 , 0 , 1)	$F-R+QS_1-C_fQ$	$C_n+E-L+QS_2$	$C_g-F-M-N$
(0 , 1 , 1)	$F-R+P_uQ+QS_1-C_fQ$	$L-E-C_n-QS_2$	$C_g-F-M-N+QS_2$
(1 , 0 , 0)	$R+C_fQ$	$C_n-C_s+E-L-P_uQ-C_t\theta+P_sQ\eta$	$M-C_g+N-QS_1$
(1 , 1 , 0)	$R-P_uQ+C_fQ$	$C_s-C_n-E+L+P_uQ+C_t\theta-P_sQ\eta$	$M-C_g+N-QS_1-QS_2$
(1 , 0 , 1)	$R-F-QS_1+C_fQ$	$C_n-C_s+E-L-P_uQ+QS_2-C_t\theta+P_sQ\eta$	$C_g-M-N+QS_1$
(1 , 1 , 1)	$R-F-P_uQ-QS_1+C_fQ$	$C_s-C_n-E+L+P_uQ-QS_2+C_t\theta-P_sQ\eta$	$C_g-M-N+QS_1+QS_2$

3. Numerical Simulation Analysis

Based on the practical significance of the cost-benefit trade-offs among farmers, enterprises, and local governments in their tripartite interactions, numerical simulations were conducted using MATLAB R2021a software. Under the assumption of stability, parameter values were assigned as shown in Table 3 below, incorporating practical considerations and relevant literature(Qin et al., 2023).

Table 3. Assignment of parameters

Para meter	Assign ment	Para meter	Assign ment	Para meter	Assign ment	Para meter	Assign ment	Para meter	Assign ment	Para meter	Assign ment
C_t	10	C_f	0.3	θ	0.5	R	1	P_u	0.15	K	6
C_S	8	η	0.5	P_s	6	C_n	6	L	4.5	E	4
S_1	0.2	S_2	0.8	F	0.8	M	5	N	6	C_g	0.5

3.1. Initial Path

To test the stability and effectiveness of the system evolution, the array from Table 3 was substituted into the model for simulation. Under the combination strategy of the initial intentions of the three entities, simulation results were obtained after 50 evolutionary iterations of the three

participating entities. The results are shown in Figure 5. As shown in the figure, at this point, the system exhibits only one evolutionarily stable equilibrium combination (sale, collection, regulation). The simulation results align with the conclusions drawn from the scenario analysis. This consistency demonstrates that the simulation findings and the stability analysis of the three-party evolutionary strategies share consistent conclusions and possess practical validity.

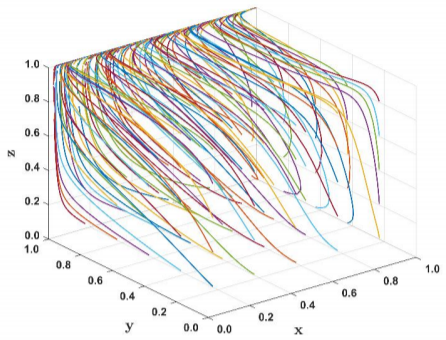

Figure 5. The influence of the initial intention of each subject on the evolution path

3.2. Sensitivity Analysis

3.2.1. Impact of Fixed Costs and Storage Costs on the Evolutionary Game System

Figure 6 illustrates the strategy evolution characteristics of the straw collection and transportation system under fixed input costs C_n and storage costs C_S. Results indicate that when fixed costs remain low, enterprises incur lower marginal collection costs. Collection firms can establish scaled "collection-transportation-storage-utilization" chains with minimal investment, leading the system to converge toward a stable equilibrium: farmers selling, enterprises collecting, and government regulating. As fixed costs rise to medium-high levels, convergence slows significantly but the system still achieves stability.

In contrast, storage cost C_S exhibits a distinct mechanism in shaping system evolution. Fixed cost C_n represents a non-recoverable, upfront entry cost borne by farmers during sales. Storage cost C_S, however, manifests as a variable cost continuously incurred by enterprises during collection and storage. When C_S is low, the tripartite game smoothly achieves a cooperative equilibrium, leading the system toward stability. However, once C_S exceeds a certain threshold, even if farmers retain their willingness to sell, enterprises gradually reduce their procurement scale due to sustained cost pressures. The system then undergoes a dynamic evolution from full coordination to partial coordination and eventually withdrawal.

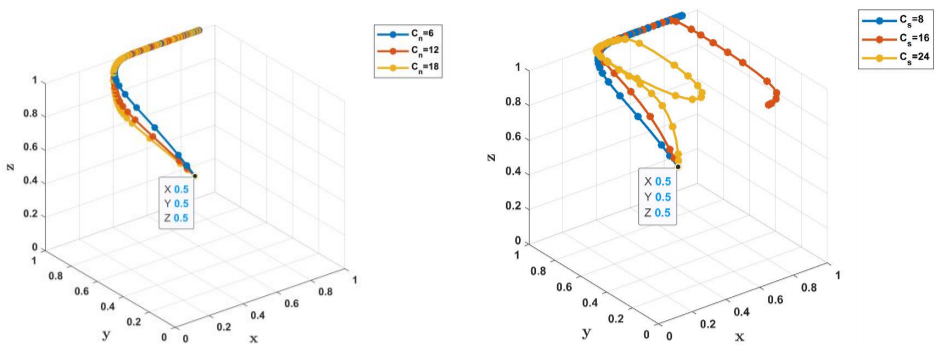

Figure 6. Impact of Different Costs on Evolutionary Game Systems

3.2.2. Impact of Penalty Levels on Evolutionary Game Systems

Figure 7 illustrates the strategic evolution outcomes of the straw collection and transportation system under varying penalty levels. When no penalties are imposed, the system ultimately stabilizes at $(0, 1, 1)$, where farmers refuse to sell straw and opt for burning instead. In this scenario, the absence of external constraints and punishment mechanisms diminishes farmers' willingness to sell. As penalty levels increase, the system's equilibrium gradually shifts toward the state $(1, 1, 1)$, indicating that moderate penalties significantly enhance farmers' motivation to sell. With strengthened farmer willingness, enterprises also become more inclined to participate in collection and storage under government regulatory pressure and cost constraints, achieving coordination. Further increases in penalty levels accelerate the evolutionary system's convergence toward a stable state.

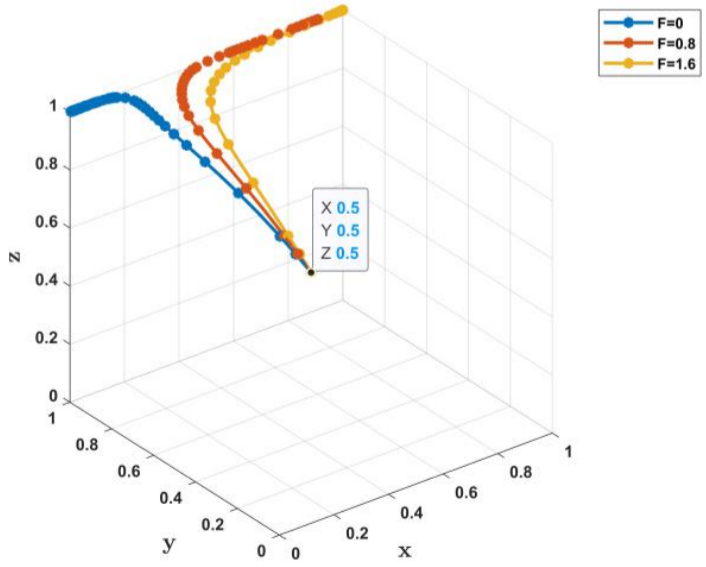

Figure 7. Impact of Different Penalty Levels on the Evolutionary Game System

3.2.3. The Impact of Unit Purchase Price on Evolutionary Game Systems

Figure 8 illustrates the strategic evolution outcomes of the straw collection and transportation system under varying unit purchase price levels. When the purchase price is low, the game system ultimately converges to a stable state $(1, 1, 1)$ where farmers are unwilling to sell and enterprises refrain from collecting — a non-cooperative equilibrium indicating that price signals fail to sufficiently incentivize collaboration between farmers and enterprises. As the purchase price rises to a moderate level, the system's equilibrium shifts to a state $(1, 0, 1)$ where farmers sell, government regulations are enforced, but enterprises remain cautiously engaged. At this point, due to relatively high collection and transportation costs, price incentives are still insufficient to fully drive enterprises to undertake large-scale collection. When purchase prices further rise to high levels, the system fails to converge to a stable equilibrium, manifesting as prolonged, fluctuating adjustments in the strategies of all actors. This outcome demonstrates that while excessively high prices boost farmers' willingness to sell, enterprises struggle to maintain stable profits due to prohibitively high acquisition costs, ultimately destabilizing the system.

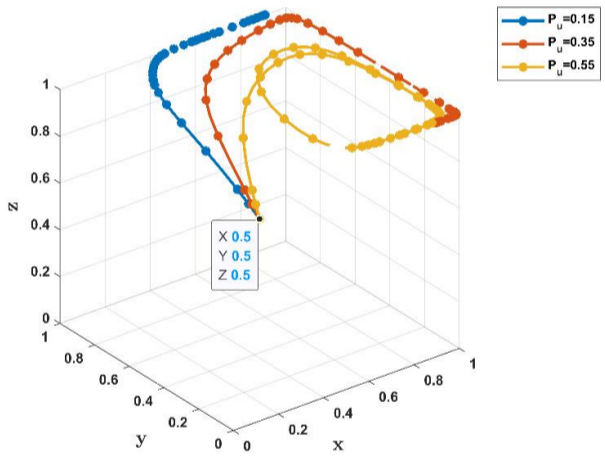

Figure 8. Impact of Different Unit Purchase Prices on the Evolutionary Game System

3.2.4. Impact of Subsidy Levels on Evolutionary Game Systems

Figure 9 illustrates the strategic evolution of the straw collection and transportation system under varying subsidy levels, where S_1 and S_2 represent subsidies provided by local governments to farmers and enterprises, respectively. For farmers, without subsidies, the lack of external incentives leads them to prefer burning, causing the system to ultimately evolve toward $(0, 1, 1)$. As subsidy levels gradually increase, farmers' willingness to sell straw grows, shifting the system's equilibrium toward $(1, 1, 1)$. However, when subsidies reach their maximum level, the system cannot stabilize because local governments cannot sustain such high payments.

For enterprises, without government subsidies, they cannot profit from straw collection and thus refrain from collection efforts. Farmers, lacking sales channels, also choose burning, preventing the system from stabilizing. As subsidies reached a moderate level, collection and transportation cost pressures eased, and the system began to stabilize at (1，1，1) . When subsidies to enterprises reached their maximum, farmers, guided by fairness theory, reduced their willingness to sell. Local governments, unable to sustain excessively large subsidies, began to opt for deregulation, shifting the system's equilibrium point to (0，1，0).

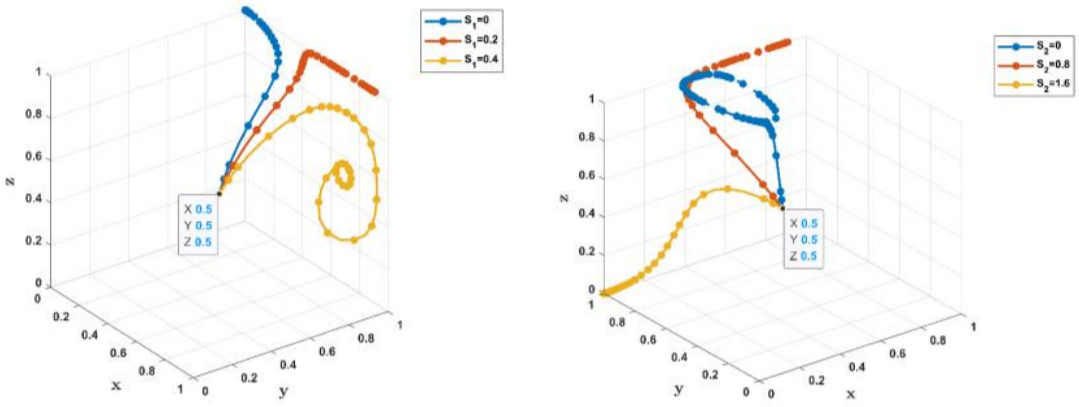

Figure 9. Impact of Different Subsidy Levels on the Evolutionary Game System

3.2.5. Impact of Farm Location Dispersion Factor on Evolutionary Game Systems

Figure 10 illustrates the strategic evolution of the straw collection and transportation system as a function of the dispersion factor of farm locations. When the dispersion factor is low — indicating concentrated farm locations — the three stakeholders can reach consensus relatively quickly, and the system rapidly converges to a stable state (1，1，1) . As the dispersion factor gradually increases — reflecting less concentrated or highly dispersed farmer locations — the system evolution time lengthens. However, it ultimately converges to the same stable state, with the equilibrium point remaining unchanged. This counterintuitive phenomenon can be explained through economic mechanisms. While dispersed farm locations increase transportation radii and collection costs, these additional expenses can often be partially internalized through government subsidies and policy regulations within the three-party game. This mitigates their impact on the system equilibrium. Consequently, the key to policy design lies in how to offset geographical disadvantages through subsidies, regulations, and price signals, enabling stable coordination across different regions under institutional arrangements.

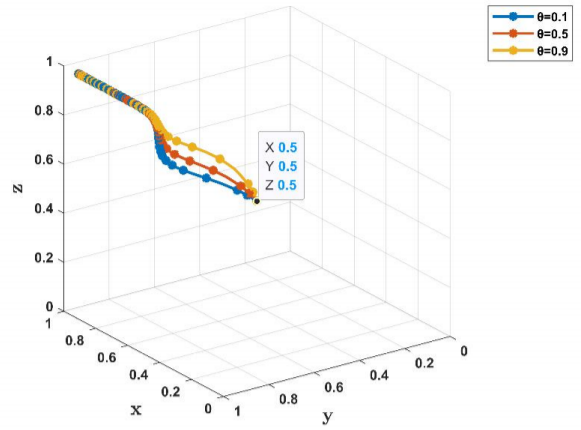

Figure 10. Impact of Different Farm Location Dispersion Factors on the Evolutionary Game System

4. Conclusions

4.1. Discussion

This study not only enriches the theoretical framework for game analysis in straw management but also provides more targeted evidence for policy formulation, emphasizing the pivotal role of policy instruments in achieving multi-stakeholder coordination and rural green transformation. Findings indicate that policy instruments such as subsidies, penalties, and regulations exhibit significantly differentiated marginal effects across different market and geographic contexts. This not only reveals the complexity of straw management but also offers insights for exploring more adaptive governance models.

From a broader sustainable development perspective, the study's findings align closely with the "dual carbon" strategy, green agricultural development, and circular economy initiatives. Straw management transcends mere agricultural waste disposal; it constitutes a systemic endeavor encompassing energy substitution, carbon reduction, and rural ecological revitalization. By unraveling the interactive mechanisms among farmers, enterprises, and governments, this research provides theoretical support for achieving policy-behavior synergy under conditions of local fiscal constraints, farmer dispersion, and market uncertainty. This perspective resonates with international academic discourse and policy practices. For instance, the European Union's Common Agricultural Policy (CAP) introduced "green direct payments" to incentivize eco-friendly farming practices and residue management. In India, Punjab and Haryana states enacted straw burning bans and subsidized harvesting equipment to curb straw burning, yet limited policy effectiveness persists due to absent long-term incentives. The United Nations Sustainable Development Goals (SDGs) explicitly address issues like "Responsible Consumption and Production" and "Climate Action," emphasizing the contribution of agricultural waste resource

utilization to global sustainable development. Thus, this research not only serves domestic policy needs but also offers insights for international sustainable development governance frameworks.

Future research may expand in the following directions:

First, introduce dynamic and phased policy tools to explore institutional adaptive adjustments across different time scales and their long-term impacts on system evolution. Dynamic policy design not only flexibly responds to market fluctuations and farmer behavior changes but also provides theoretical support for policy sustainability and resilience.

Second, calibrate and validate model parameters using regional empirical data to enhance the practical interpretability and operational applicability of research conclusions. This not only tests the model's extrapolation validity but also provides local governments with more targeted policy design references.

Third, incorporate external institutional factors such as emerging mechanisms like carbon trading, green finance, and rural energy substitution to examine their long-term incentive effects and cross-sectoral synergies in straw management. This expansion will facilitate examining straw management within the broader framework of green development and energy transition.

Fourth, conduct cross-regional comparative studies to reveal differentiated mechanisms of straw management across plains, hills, and mountainous areas. This addresses the "tailored to local conditions" requirement in sustainable development policies, providing theoretical and practical foundations for regionally differentiated policy design.

Overall, this study not only expands the application boundaries of game theory in agricultural environmental governance but also offers new perspectives for policy design within the context of sustainable development. By emphasizing the dynamic analysis of the interaction between farmer dispersion, cost constraints, and policy instruments, this research provides theoretical contributions and practical insights into achieving a balance among policy effectiveness, social equity, and ecological sustainability during the agricultural green transition.

4.2. Summary and Recommendations

To address the comprehensive utilization and management of agricultural straw collection and transportation in rural areas, this study constructs a tripartite evolutionary game model involving farmers, straw collection/storage/utilization enterprises, and local governments. For the first time, it incorporates the spatial dispersion of farmers into the analytical framework. Through numerical simulation, the model analyzes how policy instruments, market conditions, and spatial factors influence system evolution. The findings reveal:

First, while both fixed costs and storage/transportation costs increase system burdens, their mechanisms differ significantly. Fixed costs, acting as one-time entry barriers, primarily influence evolutionary speed, whereas storage/transportation costs, as ongoing burdens, may lead to gradual degradation of tripartite coordination. Second, penalty levels within an appropriate range effectively incentivize farmers to sell straw and encourage enterprises to participate in straw collection. However, penalties that are too low or too high may weaken the policy's binding effect. Third, purchase prices exhibit a pronounced threshold effect: low levels fail to generate incentives, moderate levels promote system coordination, while high levels destabilize the system due to cost-benefit imbalances. Fourth, subsidy policies provide positive incentives for both farmers and enterprises. However, excessive subsidies not only intensify fiscal pressures but may also trigger farmers' perceptions of unfairness, thereby disrupting system equilibrium. Finally, the dispersion factor of farmers' locations primarily affects the convergence speed of the system without altering the final equilibrium state. This indicates that while geographical distribution increases collection and transportation difficulties, it is not a decisive constraint under reasonable policy regulation. Overall, the equilibrium of the straw collection and transportation system relies more on policy tools and market conditions than on objective geographical factors, highlighting the critical role of institutional design in achieving green recycling and multi-party coordination.

Based on these findings, this study proposes the following policy recommendations: First, reduce fixed and storage/transportation costs through scaled operations and technological innovation to enhance system efficiency. Scaling and digital management minimize redundant transport and collection losses, alleviating cost pressures from farmer dispersion. Second, establish a reasonable penalty mechanism that curbs opportunistic behavior while avoiding counterproductive over-punishment, thereby ensuring active participation from both farmers and enterprises. Third, scientifically define the price range for straw acquisition to strike a balance between insufficient incentives at low levels and instability at high levels, ensuring price signals effectively guide market participants' behavior. Fourth, implement differentiated subsidy policies that balance the incentive effects for farmers and enterprises with fiscal sustainability, avoiding excessive benefits for either party that could raise fairness concerns. Fifth, optimize straw collection and transportation systems based on local conditions. In areas with dispersed farmer populations, mitigate geographical disadvantages through improved infrastructure, information management, and policy compensation to ensure the universality and fairness of institutional arrangements. Through these measures, synergistic optimization of straw recovery and utilization can be achieved while balancing environmental benefits, economic efficiency, and policy feasibility.

Author Contributions:

Conceptualization,M.C. and H.Z.; methodology, M.C. and H.Z.; software,H.Z.; validation, M. Z.; project administration,M.C.; funding acquisition, M.C. All authors have read and agreed to the published version of the manuscript. Please turn to the credit taxonomy for the term explanation. Authorship must be limited to those who have contributed substantially to the work reported.

Funding:

This research received no external funding.

Data Availability Statement:

No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflict of Interest:

The authors declare no conflict of interest.

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The Development of Humanities and Social Sciences, 2025, 1(3), 48-58
https://doi.org/10.71204/cs8f0w63

Research on the Path of Teaching Reform in Vocational Education Empowered by Internet of Things Technology in the Context of Digital Transformation

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Received: 27 July 2025/ Accepted: 6 September 2025/ Published online: 8 September 2025

Abstract

Under the influence of the ongoing round of scientific and technological revolution and industrial change, the in-depth integration of digital technology and vocational education system has become a key path to promote education transformation and upgrading.This paper takes the optimization and reconstruction of the talent cultivation system of higher vocational education as the core issue, systematically analyzes the real motivation and structural challenges of the teaching reform of higher vocational education empowered by digital technology, and further proposes the reform path mainly based on the "paradigm reconstruction and mechanism innovation".The study explores the practical reform strategy of "Introduction to Internet of Things Technology" from the aspects of teaching organization, construction of teaching material system, innovation of teaching mode and allocation of curriculum resources.Specific initiatives include: promoting the specialization of course content and synergistic teaching implementation by relying on a multi-principal collaborative teaching team; replacing the traditional teaching materials with a modular and task-oriented teaching materials system to enhance the dynamic adaptability of teaching resources; and promoting the blended teaching practice of online and offline integration by means of a smart teaching platform and information technology tools, so as to optimize the learning process and the experience of the learners.On this basis, a digitally empowered higher vocational education teaching path that adapts to future industrial needs and supports high-quality development is constructed.The study results can provide theoretical support and practical reference for higher vocational colleges and universities to realize the leap in talent cultivation quality.

Keywords: Higher Vocational Education; Digital Technology; Curriculum Reform; Blended Learning; Iot Technology Course

1. Introduction

At present, the next generation of digital technologies—represented by artificial intelligence, the Internet of Things, big data, and others—is evolving at an unprecedented speed and profoundly reshaping the global industrial structure and technological ecosystem (Rane, 2023). Under the background of this change, the vocational education system, as a key channel for technology diffusion and a key support platform for industrial upgrading, is undergoing deep-level systematic remodeling. On the one hand, the technology-driven society's demand for composite and innovative talents continues to rise, prompting the transformation of vocational education training mode from single-skill transmission to multi-dimensional competence construction paradigm (Shi & Yonezawa, 2023). On the other hand, this transformation requires more dynamic education content, more diversified teaching organization, and a more accurate and efficient teaching process (Rane, 2023). Facing the pressure of transformation and new development opportunities, higher vocational colleges and universities, as the core carriers of technical and skilled personnel training, should actively buttress the development trend of industrial intelligence and digitization, and build a connotative development path by focusing on the reconstruction of the curriculum system, the optimization of the teaching organization, the updating of teaching resources and the integration of intelligent tools and other key aspects. At the same time, the mechanism of teacher collaboration, school-enterprise linkage and interdisciplinary integration should be strengthened to provide a solid guarantee and sustained momentum for the construction of a high-quality vocational education system (Bing & Zhenzhen, 2025).

2. Literature Review and Problem Statement

With the deepening of China's strategic plan to comprehensively promote the high-quality development of education, the penetration of digital technology in the education system has continued to deepen, and its role in promoting the modernization of education and building the national core competitiveness system has become increasingly prominent (Shi & Yonezawa, 2023). Especially in the field of vocational education, the systematic introduction of digital infrastructure, informatization platforms and intelligent teaching tools is profoundly changing the logic of traditional teaching organization and talent cultivation paradigm. 2025, a number of competent national departments have jointly issued policy documents, clearly proposing to strengthen the construction of the digital base of education, and to promote the in-depth fusion of technological tools and educational activities, in order to accelerate the construction of new types of education ecosystems with technological competence at their core, and to support the structure of vocational education, education ecology, supporting the overall transformation and functional reorganization of the vocational education structure (Jing, 2024).

At the same time, the rapid evolution of key technologies represented by intelligent perception, data intelligence, edge computing and ubiquitous interconnection has pushed the socio-economic system to accelerate into the "human-machine collaboration - intelligent decision-making" oriented industry.shape. Driven by this trend, the demand of employers for composite and highly

adaptable talents is rising exponentially, which is no longer only concerned with the execution of job skills, but also emphasizes the comprehensive ability of practitioners in interdisciplinary thinking, data-driven application, system integration and innovation and collaboration. The vocational education system is facing a repositioning of the talent supply structure, and its internal logic needs to be shifted from "tool operation-oriented" to "technical understanding and scenario response" of the composite ability construction mode.

However, at present, most of the higher vocational colleges and universities are still lagging behind in the design of the curriculum system and the allocation of teaching resources, and the technical teaching content stays in the shallow stage such as software application, basic programming, and so on, and lacks the systematic guidance and scenario-based application training of the cutting-edge key technologies, and there is an obvious disconnect between the teaching process and the real industrial demand. This problem has seriously restricted the pace of professional education in line with the intelligent society. Therefore, accelerating the reconstruction of the curriculum system, innovating teaching methods, and iteratively updating teaching resources are urgent tasks. At the same time, constructing a vocational education pathway that adapts to the wave of digital technological change has become a pressing issue for higher vocational colleges and universities (Ridsdale, 2015).

2.1. Shift of Teaching Focus and Lagging Core Literacy

With the comprehensive promotion of the strategy of "deepening education digitization" at the national level, the institutionalized introduction of digital technology in vocational education has entered a stage of extensive development. In recent years, many higher vocational colleges and universities have formulated medium- and long-term technology development strategies to adapt to the future shape of education based on policy guidance, covering campus network infrastructure construction, intelligent teaching platform construction, and education informatization resource allocation and other dimensions.Under the joint promotion of institutional and financial support, all kinds of digital facilities and platform systems have achieved certain results in terms of technical architecture and functional integration. This presents a good situation for the construction of "an online campus"(Alier et al., 2012).

However, from a practical point of view, most institutions still have the tendency of "focusing on construction but not on education" and "concentrating on system but not on kernel" in the process of implementation, and the digital transformation work is mainly concentrated on the optimization and upgrading of the peripheral systems such as the automation of administrative affairs and the intelligent teaching environment, and fails to penetrate deeply into the course content and the content of the curriculum.Digital transformation mainly focuses on the optimization and upgrading of peripheral systems such as the automation of administrative affairs and the intelligence of the teaching environment. It fails to penetrate deeply into core aspects of teaching such as course content, teaching methods and the cultivation of students' core abilities.Especially in the complete cognitive path of "cutting-edge technology cognition - understanding - practical", institutions still lack systematic curriculum guidance, scenario-based teaching design and stage-by-stage competence evaluation mechanism, resulting in students' mastery of emerging technologies and the application of the ability to build an obvious gap.There

is an obvious gap, which affects the deep integration of digital technology and the growth process of talents(Opfer & Pedder,2011).

2.2. Outdated Teaching Content and Lack of Foresight

Most vocational institutions still prioritize basic digital skills courses, such as software applications, which fail to keep pace with the dynamic industrial demand. A national survey by the China Education Development Research Institute (2023) found that over 62% of institutions focus on basic computer operation, while only 15% have introduced advanced modules like cloud computing or data analysis. This mismatch reduces students' motivation and limits their ability to adapt to emerging industry contexts.

With the popularization of smart terminals and the diversification of information access paths, students' demand for technical learning has gradually shifted to comprehensive practice and the cultivation of application ability in complex situations.However, the traditional curriculum lacks adaptability in the form of teaching and content organization, which is difficult to stimulate students' cognitive interest and cannot effectively support them to build a digital mindset in line with the actual industry.Therefore, it is urgent for higher vocational education to reconfigure the existing curriculum system as a whole, integrate the core technology system of key areas such as cloud computing architecture, data governance concepts, perceptual network technology, intelligent algorithmic models and virtual simulation platforms into the teaching framework, and gradually build a curriculum content system oriented to the forefront of the industry and support for continuous updating, so as to push forward the synchronization between the teaching structure and the development of technology.

2.3. Lack of Effective Connection Between Technical Basic Courses and Professional Learning

Through the comparative analysis of the curriculum systems of many higher vocational colleges and universities, it is found that most of the current professional training programs have not yet realized the organic integration of digital technology content and professional core courses at the level of structural design.Although the basic information courses have been included in the teaching plan of most majors, and are usually set in the early stage of students' enrollment as a mandatory general education course, such courses are mostly based on the teaching of instrumental knowledge, and lack a systematic linkage mechanism with the content of professional learning.

In actual teaching, these courses show the characteristics of "module isolation", and lack of effective transition and integration design with the subsequent professional courses, which makes it difficult for students to understand the real value of related technologies in professional applications. In order to further verify this problem, this paper conducted a questionnaire survey on the third-year students (192 in total) of the mechatronics program of Hunan Bio-mechanical and Electrical Vocational and Technical College.The results show that the proportion of those who can understand the application value of technology in professional learning in a more in-depth way is only 6%, the proportion of those who have a basic understanding is 18%, the proportion of those who have superficial cognition reaches 41%, the proportion of those who

think that the technical content is not very relevant to their specialty is 33%, and the proportion of those who have no cognition at all is about 2%.

The results of this survey fully indicate that although digital skills courses have taken their place in the teaching system, there is still an obvious lack of cross-curricular integration and application deepening, which makes it difficult to effectively support the simultaneous enhancement of students' digital literacy and professional competence, and exposes the existence of a "disconnect between technology teaching and professional development" in the current teaching system. It also reveals that the current teaching system has the structural problem of "disconnection between technical teaching and professional development".

3. Methodology and Reform Strategies

Under the dual background of the continuous evolution of new-generation information technology and the deep reshaping of industrial structure, higher vocational education is faced with multiple challenges, such as lagging curriculum content, single teaching method and unbalanced teacher structure. In order to realize the transformation and upgrading of education and teaching mode, it is urgent to implement systematic reconstruction in multiple dimensions, such as teaching organization, resource development, teacher system and teaching evaluation, so as to promote the in-depth coupling of digital technology and the whole process of teaching. This paper takes the "Internet of Things Technology" course as an entry point to explore the path of change of the higher vocational education system in the context of technological empowerment, and puts forward four core implementation strategies in an attempt to build a reform program that meets the needs of future industries and is both innovative and operable.

3.1. Cross-border Collaborative Teaching Team

Reform requires collaborative teaching teams involving university professors, lecturers, and enterprise engineers. In the IoT course team, 45% are associate professors, 35% lecturers, and 20% enterprise experts, forming a dual-qualified structure that ensures 'two-way empowerment'. Figure 1 illustrates the team structure by professional title and industry participation.

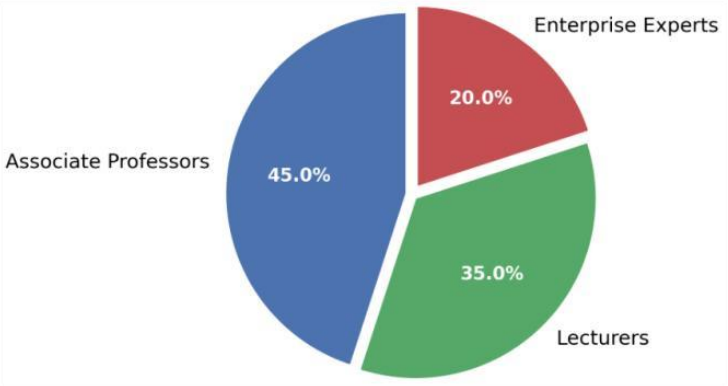

Figure 1. Composition of IoT course teaching team by professional title and enterprise participation

The first step to promote the reform of the professional curriculum system is to break through the traditional teaching mode of a single lecturer and build a composite teaching team

characterized by "cross-border collaboration".The team should be composed of university teachers, enterprise engineers and technicians and industry experts, through the division of labor and cooperation, the industrial line of practical experience and academic knowledge system effectively integrated to achieve "two-way entry, two-way empowerment" teaching and learning collaboration mechanism. In the construction of the "Internet of Things Technology" course, enterprise tutors can lead the project case analysis and practical training guidance, while school teachers are responsible for theoretical explanations and curriculum integration, to further enhance the industry suitability of the teaching content and the comprehensive effectiveness of the implementation of the curriculum.

3.2. Modular Teaching Resources

Restricted by the compilation cycle and publication mechanism of traditional teaching materials, there are problems such as fixed content and lagging update of teaching materials in the current higher vocational teaching, which is difficult to respond to the demand for dynamic adjustment of teaching content brought about by the rapid change of digital technology. To this end, we should promote the transformation of the teaching material system from closed to open, and encourage teachers to independently develop teaching resources with task-oriented and modularized structure according to the teaching objectives and industry needs.Each module can be developed around specific technical topics, examples include "IoT device integration and deployment," "data governance and cloud services," and "smart agriculture monitoring systems", to support the implementation of project-based teaching and personalized teaching design, thus enhancing the flexibility and effectiveness of teaching resources. It supports project-based teaching implementation and personalized teaching design, thus enhancing the flexibility and effectiveness of teaching resources.

3.3. Blended Teaching Mode

In the context of the rapid expansion of the digital learning environment, the teaching mode is no longer limited to the traditional offline classroom. It is urgent to build a blended teaching system that combines online and offline.Relying on the intelligent teaching platform, simulation experiment system, practical training data collection equipment and other technical tools, it can form a full-process teaching scenario covering "theoretical learning-skills training-task implementation".In the "Internet of Things Technology" course, the basic theoretical content can be transferred to the online module, through microclasses, visualization animation and other forms of self-study; while the project practice link is conducted offline, with the help of equipment construction and system debugging in the real environment, to strengthen the students' practical ability and technology transfer ability, and to build a "learning-practice-doing" teaching environment.The project practice session is completed offline with the help of equipment construction and system debugging in a real environment. This is done to strengthen students' practical operation ability and technology transfer ability, so as to build a complete closed loop of "learning-practice-doing".

3.4. Multi-dimensional Evaluation

In the competence-oriented talent cultivation mode, the traditional evaluation mechanism based on summative examination is difficult to fully reflect students' knowledge mastery and skill development.A diversified evaluation system based on formative evaluation and emphasizing both process and outcome should be constructed to strengthen the tracking and motivation of the whole process of students' learning behavior.Specifically, the quality of learning tasks, project implementation performance, teamwork ability, innovation and practice results can be incorporated into the evaluation index system, realizing the comprehensive evaluation of "quantitative + qualitative", "subjective + objective", and promoting the integrated operation of "teaching, learning, doing and evaluation", effectively enhancing students' learning initiative,Learning, doing, evaluation" integrated operation, effectively enhance students' learning initiative and comprehensive ability development level.

4. Case Study: IoT Technology Course Reform

Under the dual background of the accelerated evolution of the current new wave of digital technology and the deepening of the national agricultural modernization strategy, Internet of Things (IoT) technology, as the basic support platform for the construction of the intelligent agricultural system, has increasingly become an important module for the cultivation of technical and skilled personnel.Higher vocational education as a core type of education to support the transformation and upgrading of the national industry, the construction of its curriculum system urgently needs to closely follow the changes in the industrial structure and the forefront of technological development, to build the teaching content and teaching methods that are highly compatible with the emerging job competencies. This paper takes the "Internet of Things Technology" course of a higher vocational college as the research object, and systematically combs through the reform practices of the course in terms of reshaping the teaching concept, constructing the teaching path and optimizing the evaluation mechanism, aiming at providing a practical paradigm and theoretical support for the digital transformation of the relevant courses in the field of higher vocational education and the competence-oriented teaching mode (Yang et al.,2020).

4.1. Reconstruction of Teaching Objectives: From Knowledge Transmission to Competence Cultivation

In the traditional curriculum system, the design of "Internet of Things technology" courses generally focus on the linear transmission of basic knowledge, emphasizing the conceptual understanding and introduction of technical principles, but in the teaching practice, the precise docking with the actual needs of vocational positions is ignored, resulting in the lack of the ability to migrate students to the real work scenarios, even though they have mastered a certain amount of theoretical knowledge .As a result, although students master certain theoretical knowledge, they lack the ability to transfer it to real work scenarios .

This round of curriculum reform is based on the principle of "competence-oriented and task-driven", and the original teaching objectives have been systematically reconstructed, and the core

orientation of "staying close to industrial scenarios and strengthening the comprehensive ability" has been clearly put forward,highlighting technical practice" as the core orientation. In terms of specific goal setting, the course is no longer limited to enabling students to understand the components of the Internet of Things system and deployment process, but requires them to have the ability to independently complete the design, deployment and debugging of the greenhouse environment monitoring system in a real situation; at the same time, the course also focuses on students' comprehensive application ability training in the key links, such as data acquisition, remote control and visualization analysis, to promote the construction of a complete cognitive chain from "sensing - communication - analysis - management".At the same time, the course also focuses on students' comprehensive application ability training in data acquisition, remote control, visualization and analysis, and promotes the construction of a complete cognitive chain from "sensing-communication-analysis-management".Through the upgrading of the target level and the advancement of task scenarios, the course tries to realize the essential transformation from "knowledge inculcation" to "ability generation", which is truly in line with the talent cultivation logic of vocational education of "learning by doing, learning by doing".It truly fits the logic of vocational education, which is "learning by doing and learning by doing"(Tian,2025).

4.2. Optimization of Teaching Content: Constructing a Three-Tier Structure of "Basic-Application-Project"

In order to break the problems of fragmented knowledge and disjointed content, the course content is reconstructed according to "technical principles - core modules - typical tasks", and a three-tier knowledge structure system is constructed as shown in Table 1.

Table 1. Tertiary knowledge structure system table

Serial number	Structural system	content
1	Base layer	Includes sensor fundamentals, communication protocols, an introduction to embedded systems, etc.
2	Application layer (computing)	Covering agricultural information collection technology, wireless communication network construction, edge computing primer, etc.
3	Project level	Setting up typical tasks such as "intelligent irrigation system construction" and "agricultural data visualization platform development".

4.3. Innovative Teaching Modes: Exploring Diversified and Interactive Teaching Strategies

In terms of teaching organization, the curriculum reform actively introduces diversified teaching concepts and explores the teaching strategy of "task-oriented, project-driven and active participation" as the core.Through the integration of task-oriented teaching method, project-based learning path and flipped classroom mechanism, it realizes the teaching transformation from

"knowledge instilling" to "ability constructing".The overall structure of the course adopts the dual-track operation mode of "online theoretical module + offline practical module", which expands the teaching flexibility in time and space, and enhances the initiative and interactivity of students in different learning stages.For example, in the "wireless communication module configuration" teaching unit, students need to complete the theoretical learning and pre-testing tasks pushed by the online platform before the class; and then enter the offline phase, using real equipment to carry out the construction and debugging operation of LoRa or NB-IoT communication nodes .With the support of teachers' whole process guidance and on-site Q&A, students can realize the in-depth internalization of knowledge and scenario-based migration of skills, and promote the transformation of technical cognition into practical application ability(Miao et al.,2023).

4.4. Teaching Resource Construction: Developing Digital Resources and Simulation Platforms

In order to respond to the dual demand for diversity and real-time updating of resources in the digital teaching environment, the teaching team has developed and constructed a multi-form, scalable digital teaching resource system around the course content system.The resource types cover micro-course videos, knowledge mapping structure, interactive courseware and virtual simulation experiment platform, constituting a teaching resource matrix that supports multi-path learning.This resource system not only supports students' learning and task rehearsal in stages through modular structure. It also provides technical support for teachers to implement differentiated teaching and design personalized teaching scenarios.The virtual simulation system is based on the modeling of real engineering scenarios. This allows students to complete key process simulation and system debugging training in non-training environments, effectively breaking through the limitations of the traditional classroom in terms of space, time and resource allocation. At the same time, the platform also integrates process learning monitoring and data collection functions. This provides objective data support for teaching process management, learning behavior analysis and accurate evaluation, and enhances the effectiveness of closed-loop teaching(Wang & Li,2021).

4.5. Assessment of Teaching Effectiveness: Focusing on the Process of Data and Ability Performance

In the design of the course assessment system, the reform abandons the traditional mode of taking the summative examination as the only judgment standard, and builds a comprehensive evaluation system that integrates formative evaluation and multiple competency assessment.The system emphasizes the whole process of data-driven, and the evaluation dimensions cover the completion of learning tasks at different stages, the demonstration of project training results, online learning activity indicators, teamwork efficiency and innovative practice performance. By quantifying and systematically archiving students' performance in different learning stages, the system builds a closed loop of "evaluation-feedback-optimization", forming a mechanism for continuous improvement and positive incentives.The overall evaluation framework emphasizes "results and process, cognition and practice", strengthens students' adaptability and independent

problem solving ability in the real technology environment, and comprehensively improves their comprehensive literacy and professional competence (Darling-Hammond, 2010; Siemens, 2014).

5. Conclusion

This study demonstrates that IoT-empowered teaching reform in vocational education requires simultaneous improvement in teaching concepts, curriculum content, teaching methods, resource allocation, and evaluation mechanisms. The case study of the "IoT Technology" course shows that modular teaching resources, collaborative teaching teams, and blended teaching modes significantly enhance students' competence development. In future research, integrating advanced educational theories such as constructivism and connectivism can further strengthen the theoretical foundation of vocational education reform.

Author Contributions:

Yule Xia: conceptualization, writing—original draft, methodology; Rongyu He, Yanru Chen, Min Zhou, Hao Wu: supervision, review & editing, project administration.

Funding:

This work was supported by Faculty-level scientific research project of Hunan Biomechanical and Electrical Vocational and Technical College (Project No. 24YYB58). Scientific research planning project of Hunan Vocational and Adult Education Society (Project No. XH2024280); Project of Hunan Association of Educational Science Researchers (Project No. 501). Hunan Vocational Education and Adult Education Association 2024-2025 Research Planning Project (Project Approval Number: XH2024271); Hunan Vocational College Education and Teaching Reform Research Project 2024 (Project Number: ZJGB2024338); Hunan Education Science Researchers Association 2025 Project (Project Approval Number: XJKX25B439).

Data Availability Statement:

Not applicable.

Conflict of Interest:

The authors declare no conflict of interest.

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The Development of Humanities and Social Sciences, 2025, 1(3), 59-70
https://doi.org/10.71204/vkw73b72

Explaining High Output Efficiency in Strategic Emerging Industrial Spaces: A Spatial Economic Analysis of 78 Domestic and International Cases

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Received: 1 September 2025/ Accepted: 8 September 2025/ Published online: 10 September 2025

Abstract

At present, China attaches great importance to the development of new quality productive forces. As the spatial projection carriers of these forces, strategic emerging industrial spaces exhibit high-output efficiency that calls for theoretical explanation. Existing research has largely focused on the internal efficiency of industries, with insufficient attention paid to the mechanisms of spatial attributes ─ particularly the systematic analysis of spatial economic factors such as intensification, functional mixing, and location−bid rent relations. To address this gap, this study draws upon 78 samples of strategic emerging industrial spaces from China and abroad. By employing quantitative analyses of the density−scale relationship, calculating functional mixing through the information entropy model, and assessing spatial bid rent effects, the study uncovers the underlying causes of the high efficiency observed in new industrial spaces. The results demonstrate that high development intensity and high functional mixing are distinctive characteristics of strategic emerging industrial spaces. Their bid rent capacity in core urban areas exceeds traditional land rent gradients, presenting an empirical challenge to the Alonso model. This high-density, high-mixing spatial pattern fosters reverse industrial clustering in urban cores through mechanisms such as knowledge spillovers, industrial chain collaboration, and innovation network agglomeration, thereby reshaping the theoretical framework of spatial economics. The findings provide a partial explanation for the high-output performance of new industrial spaces and offer a theoretical foundation for optimizing industrial space policies and planning supply strategies.

Keywords: Industrial Space; Industrial City; Urban Spatial Performance; Urban Spatial Organization; Rent Gradient

1. Introduction

The state and relevant departments have attached great importance to the development of new industries, including advanced manufacturing and strategic emerging industries. At the same time, they have explicitly proposed improving the output efficiency of industrial land use (e.g., the policy orientation of "evaluating heroes by output per mu"), which has triggered a series of industrial spatial policy actions such as the redevelopment of inefficient industrial land and the promotion of "industries moving into multi-story buildings." In practice, however, there are significant differences in the output efficiency of industrial land across different cities, closely related to their industrial structures, technological levels, and spatial organization patterns. For instance, in 2022, Shenzhen's industrial added value per unit of industrial land reached approximately 51 billion RMB/km², far exceeding that of Shanghai (12.8 billion RMB/km²), Guangzhou (11.8 billion RMB/km²), Foshan (13 billion RMB/km²), Dongguan (14 billion RMB/km²), and Jiangmen (5.8 billion RMB/km²) during the same period. From an international perspective, some industrially advanced cities also demonstrate high output efficiency of industrial land, such as Tokyo (about 45 billion RMB/km²) and Singapore (about 48 billion RMB/km², converted to RMB).

Multiple factors influence the output efficiency of industrial land and industrial spaces. From the standpoint of classical spatial economic theory, Marshall proposed the theory of external economies to explain the effects of industrial agglomeration (Marshall, 2024). Porter further pointed out that industrial clusters are often accompanied by increased spatial density, which in turn generates scale effects, technological spillovers, and collaborative innovation effects (Porter, 1999). Weber's (1929) industrial location theory emphasized the impact of location factors on production costs and efficiency. Fujita et al. (2021) and Henderson (2024) argued that optimizing the spatial layout of industries can effectively enhance the efficiency and output performance of regional economic activities. Douglass (2000), based on studies of the Asia-Pacific region, highlighted that under globalization, the evolution of "mega-urban regions" reshapes urban economic networks, intertwining processes of industrial agglomeration and diffusion.

With respect to strategic emerging industries and advanced manufacturing, Kincaid et al. (2001), Hoover (1948), Richardson (1969), Greenhut (1956), and Smith (1981) proposed comprehensive analytical theories of industrial spatial layout, emphasizing the combined influence of natural resources, production costs, and market prices on industrial spatial agglomeration (Yue et al., 2022). Furthermore, new economic geography suggests that dominant industries often form regional industrial advantages driven by economies of scale and spillover effects. Domestic research also confirms the positive impact of industrial agglomeration on the output efficiency of industrial spaces (Chen, 2024). However, studies in spatial economics have not sufficiently addressed the role of spatial ontological factors—such as location, density, and spatial organization—on industrial spatial output. Whether spatial factors can explain differences in industrial space output efficiency will directly determine the effectiveness of industrial spatial policies and planning interventions. Therefore, it is necessary to summarize empirical evidence and establish the basic relationship between spatial ontological factors and industrial space output efficiency.

2. Research Methods

2.1. Selection of Typical Samples of Emerging Industrial Spaces

This study selected industrial space samples covering the major fields of advanced manufacturing and strategic emerging industries, including electronic information, integrated circuits, new energy, and biomedicine. The sample set includes Shenzhen, China ' s largest industrial city and the one with the highest output efficiency; other major industrial cities in China (e.g., Shanghai, Suzhou); as well as industrial parks from overseas countries and regions such as Japan, South Korea, Singapore, Germany, and Switzerland.

The selection followed the principles of representativeness, innovativeness, replicability, and industrial influence, ensuring that the research findings possess broad reference value and academic significance. For each industrial sector, the sample pool includes at least 1-2 typical cases from Shenzhen, 1-2 cases from other Chinese cities, and several overseas cases. In addition, key indicators such as regional characteristics, industrial types, functional layouts, innovation models, and development performance were comprehensively considered to construct a representative sample base.

In total, 78 industrial space samples were selected. Among them, 24 are from Shenzhen, such as the BYD Industrial Park in Pingshan and the Shenzhen Biopharmaceutical Innovation Industrial Park; 36 are from other Chinese cities, including the Tesla Shanghai Gigafactory and the Xiaomi Automobile Gigafactory in Beijing; and 18 are international cases, covering globally representative examples such as the Volkswagen Autostadt in Wolfsburg, Germany, and the Roche Industrial Park in Switzerland.

2.2. Sample Standardization and Selection of Spatial Economic Parameters

To facilitate data analysis and comparison, the selected samples in this study are organized into a unified database format, including the functional layout of the park, industrial types, land-use scale, development intensity, and the functional type of individual buildings. After classifying the functions of different components of industrial space, standardization is conducted based on 50 hectares as the standard unit. This process takes into account the internal functional topological relationships of the industrial space samples, resulting in a standardized industrial space sample database, which will be used for calculations such as spatial mixing degree.

Table 1. Overview of Indicators Included in Land-Use Scale, Development Intensity

Indicator Name	Unit	Data Type
Land Area	Hectares (ha)	Float
Floor Area	10,000 m² (w ㎡)	Float
Floor Area Ratio (FAR)	—	Float
Building Height	Meters (m)	Float
Story Height	Meters (m)	Float

Land Price / Rent	RMB / m² (yuan/㎡)	Int
Distance to City Center	Kilometers (km)	Int

2.3. Spatial Analysis Methods

After completing the baseline data collection and standardization of 78 industrial space samples, this study first groups and classifies the samples according to their geographical distribution (Shenzhen, other domestic cities, and overseas) and industrial attributes, so as to ensure that similar industrial characteristics and planning patterns are better reflected within the same group.

First, two key indicators—land area and floor area ratio (FAR)—are selected. A coordinate fitting approach is applied to conduct regression analyses on each group of samples, thereby deriving the functional relationship between scale expansion and development intensity across different regions or industrial types, which serves to characterize the level of spatial intensification.

Second, the regression parameters of each function—including slope, intercept, and potential inflection points—are estimated using the ordinary least squares (OLS) method. Extreme values are winsorized, and the model parameters are cross-validated through case interviews and literature checks to ensure robustness and explanatory power. These parameters are then compared against the on-site conditions of sample parks and reference data from the literature. Based on this, the information entropy model is employed to calculate the degree of functional mixing of industrial spaces.

Third, by analyzing the relationship between the distance of industrial spaces to city centers and their rental levels, this study evaluates the rent-bidding capacity of new industrial spaces and advanced manufacturing sectors, thereby examining the overall performance relationship of new industrial spaces in contemporary cities.

3. Spatial Economic Analysis of Sample Spaces

3.1. Spatial Intensification Level of New Industrial Spaces

The relationship between land area and development intensity directly reflects the level of intensification in industrial spaces. The smaller the land area and the higher the development intensity, the greater the level of intensification. Whether higher levels of intensification lead to higher output performance constitutes the first sub-question explored in this study.

For all overseas industrial samples, except for a few specialized or highly advanced industrial types (such as semiconductors and integrated circuits, safety and environmental protection, and precision instruments and equipment), most industrial spaces exhibit a relatively convergent trend in their demand for land area and FAR. In contrast, industrial spaces in Chinese cities other than Shenzhen generally show lower FARs and larger land areas. This phenomenon may be associated with relatively abundant land resources, historical path dependence in urban planning and

industrial layout, and insufficient anticipation of space demand for industrial development. Model analyses conducted using the same approach indicate that new industrial spaces and advanced manufacturing sectors in Chinese cities (excluding Shenzhen) also demonstrate a certain gradient relationship between land use and development intensity. However, their level of intensification is still lower than that of the overseas samples.

Overall, it is evident that the spatial intensification level of Shenzhen’s industrial spaces is higher than that of other domestic cities, and even exceeds that of overseas countries and regions. Specifically, when the land area is less than 80 hectares, the floor area ratio (FAR) of Shenzhen’s industrial spaces is approximately 1.5 times that of the international samples and 1.2 times that of other domestic cities. When the land area exceeds 80 hectares, its FAR even reaches twice that of other domestic cities. Considering that Shenzhen’s industrial output per unit of land is comparable to that of developed countries and regions overseas, yet several times higher than that of other domestic cities, the degree of spatial intensification can partly explain the differences in industrial space performance between Shenzhen and other Chinese industrial cities. However, it does not fully account for the phenomenon of Shenzhen achieving output performance levels similar to those of overseas countries and regions. In addition, among the overseas samples, the data points reflecting the relationship between land area and FAR tend to converge, indicating that the morphological patterns of advanced industrial spaces overseas are becoming more uniform. Medium-intensity industrial spaces built on relatively small plots have become the mainstream overseas, whereas in China, the morphological differences in new industrial and advanced manufacturing spaces remain relatively significant.

3.2. Functional Organization of New Industrial Spaces

The functional organization of new industrial spaces plays a crucial role in determining their overall effectiveness (Zhu, 2023). A layout characterized by high spatial mixing within industrial parks enhances spatial vitality and functional synergies (Wang & Meng, 2020). Such a configuration tightly integrates functions of R&D, production, and living services within the park, not only increasing its attractiveness to high-end talent and investment but also providing strong support for strengthening upstream–downstream collaboration in industrial chains and enhancing innovation capacity. Given the increasingly critical role of functions beyond production and manufacturing—such as R&D, innovation, and social interaction—this study’s second sub-question examines the functional organization and performance of industrial spaces from the perspective of functional mixing. Spatial mixing degree is a quantitative indicator used to measure the diversity and balance of functional zoning within a given area. Its core idea is to evaluate the relative proportions and distribution characteristics of different functional types, thereby reflecting the coordination and integration of spatial layouts. A higher level of spatial mixing indicates that functional zones are more diverse and balanced, potentially generating stronger synergies between functions. The development of new quality productive forces imposes higher requirements on the spatial organization of cities, with key features such as knowledge spillover effects, industrial chain collaboration, and the spatial agglomeration of innovation networks, driving industrial spaces toward higher density and higher degrees of mixing (Yang,

2020). At present, the calculation of spatial mixing degree typically relies on information entropy or related indices, which provide an intuitive means of quantifying the diversity and balance of functional distributions (Zagorskas, 2016). The calculation formula is as follows:

$$H = -\Sigma_{i=1}^{n} P_i \cdot \ln(P_i)$$

Where: H denotes the spatial mixing degree, with a value range of [0, 1];

P_i represents the proportion of the i-th functional zone;

n is the total number of functional zones.

A value closer to 1 indicates a more diverse and balanced functional distribution.

To further investigate the differences in spatial organization patterns among Shenzhen, other domestic industrial cities, and overseas countries and regions, this study selected six representative types of industrial parks — intelligent connected vehicles, intelligent robotics, biomedicine, synthetic biology, marine industry, and semiconductor integrated circuits — and calculated and compared their spatial mixing degrees of functional zoning. The analysis results show that industrial park samples in Shenzhen generally exhibit higher spatial mixing degrees than those in comparable domestic and overseas parks. Shenzhen's parks tend to integrate more diverse functional zones — such as R&D, production, office, commercial, and residential facilities — within limited spaces, thereby achieving tightly nested and synergistically coexisting multifunctional layouts. Such high-mixing spatial configurations not only improve land-use efficiency but also enhance the coupling between industrial activities and the effects of innovation linkages.

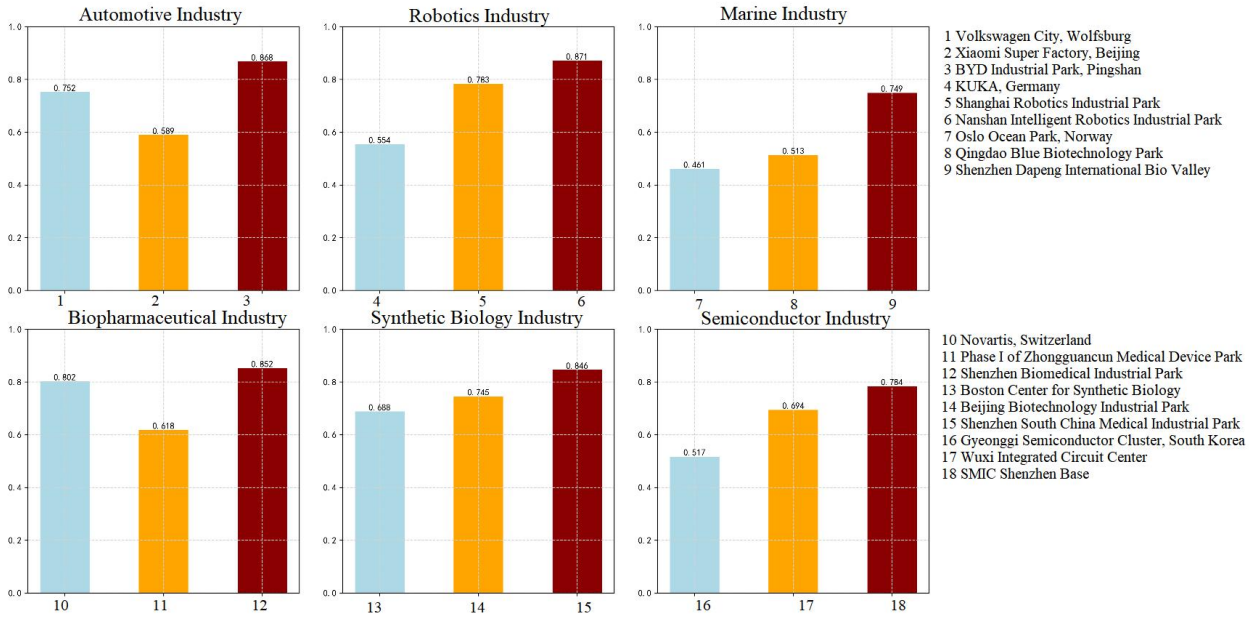

Figure 1. Comparison of spatial mixing degree indices across different types of industrial parks

For example, in the intelligent robotics sector, the entropy index of Shenzhen Nanshan Intelligent Robotics Industrial Park is 0.871, significantly higher than that of Germany’s KUKA Industrial Park (0.554) and the Shanghai Intelligent Robotics Industrial Park (0.783). In the marine industry, the entropy index of Shenzhen Dapeng International Bio Valley is 0.749, which is significantly higher than that of the Oslo Marine Park in Norway (0.461) and the Qingdao Blue Bio-Industrial Park (0.513). Overall, Shenzhen’s industrial parks consistently demonstrate higher spatial mixing degrees compared with similar parks in other domestic regions and overseas (Figure 1). This can partly explain why the output performance of Shenzhen’s industrial parks surpasses that of other Chinese industrial cities, but it does not fully account for the phenomenon of Shenzhen achieving performance levels comparable to those of overseas countries and regions.

3.3. Location–Bid Rent Relationship of New Industrial Spaces

Rent levels constitute an important indicator reflecting the output performance of space. In traditional urban spatial models, rent levels are highly correlated with urban location. Thus, the location–bid rent relationship of industrial spaces represents a key parameter for characterizing spatial performance. Spatially, projects in strategic emerging industries with stronger unit-area output capacity tend to locate closer to city centers and adopt high-density development models (Wei, 2024). This not only enables the effective utilization of limited land resources in central areas but also promotes industrial agglomeration and collaborative development. Moreover, due to their locational advantages, such projects are more competitive in attracting investment and high-level talent.

Taking Shenzhen as an example, a comparison across different land-use types within the same location shows that some plots designated for emerging industries in core areas have already achieved higher unit output efficiency than commercial and office land in the same area. Conversely, when comparing the same land-use type across different locations, some non-core new industrial land parcels demonstrate unit revenue levels that surpass those of similar plots located in the core area. Under high-density development conditions (FAR $\geqslant$ 3.0) with relatively small land areas, the spatial boundaries between industrial and commercial functions tend to blur, and the two become highly coupled within the same spatial domain. While such highly mixed spatial forms improve land-use efficiency to a certain extent, they also pose challenges for planning and management—particularly in contexts where multiple stakeholders are involved and land-use rights are highly fragmented. Balancing spatial rationality with distributive equity of returns thus becomes a pressing issue to be addressed in policy design.

Analyzing the functional characteristics of strategic emerging industries and their fit with spatial carriers helps to develop a more systematic understanding of the locational logic underlying advanced manufacturing and related industries in central urban districts or core areas. According to the traditional urban spatial structure theory established on the Alonso bid rent model, manufacturing has typically been considered more suitable for peripheral urban locations in order to minimize costs and achieve functional separation (Figure 2 and Figure 3). However, strategic emerging industries exhibit attributes distinct from traditional manufacturing in terms of industrial structure, technological trajectory, and spatial requirements, thereby challenging the

explanatory power of such theoretical assumptions. Their greater reliance on knowledge spillovers, R&D collaboration, and innovation ecosystems drives them to cluster in dense, high value-added central urban areas, reconstructing the organizational logic of industrial space. As a result, the spatial distribution logics built upon traditional location theories and bid rent models are increasingly inadequate for fully capturing the contemporary development patterns of new industrial spaces.

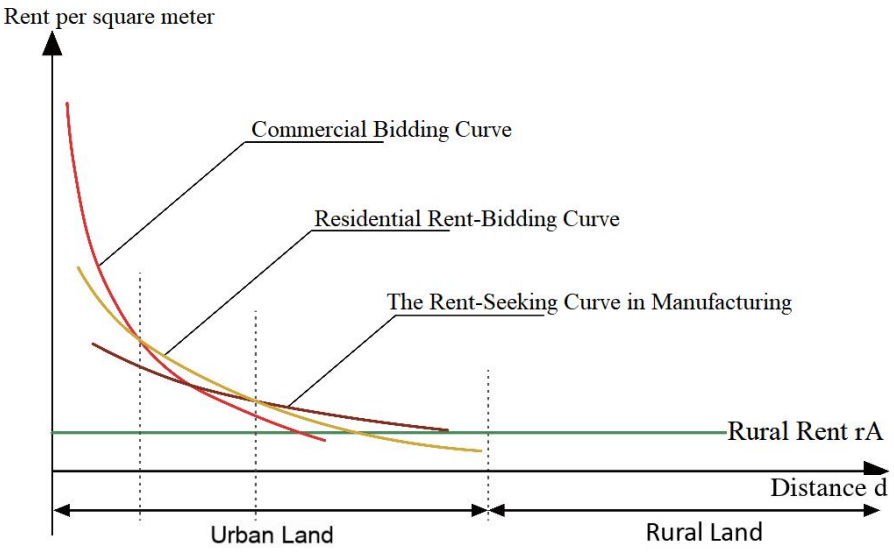

Figure 2. Manufacturing located in the third concentric zone in Alonso's "location–bid rent" model

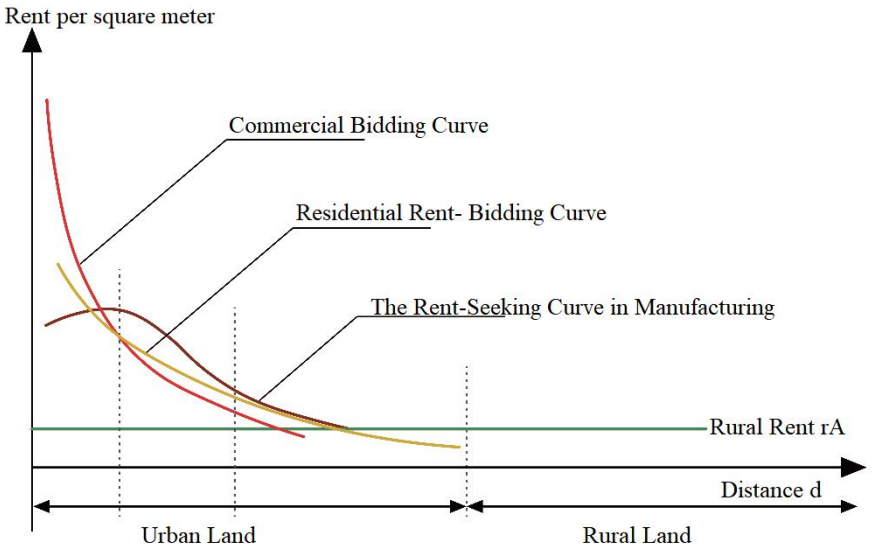

Figure 3. Certain new industries and advanced manufacturing sectors enter the core zone, challenging the traditional Alonso model

4. Discussion

Based on the above analysis of all samples in terms of industrial space intensification and functional mixing, the following conclusions can be drawn:

(1) For Shenzhen and other domestic industrial cities, higher levels of industrial space intensification and functional mixing can partly explain the differences in output efficiency between the two. However, since the differences in intensification and functional mixing are smaller than the actual differences in per-unit output, this suggests that production factors such as talent and technology, together with spatial ontological elements, jointly influence the output efficiency of industrial spaces.

(2) For Shenzhen and overseas countries/regions, the two exhibit similar levels of spatial output efficiency, but significant differences in spatial intensification and diverse patterns in functional mixing. This indicates that production factors such as talent and technology in developed countries and regions provide stronger support for the output efficiency of industrial spaces.

(3) This study also observes that the bid rent capacity of some strategic emerging industries has significantly surpassed that of commercial and service land in the same locations, demonstrating strong payment capacity and high-output characteristics in core urban areas. This phenomenon breaks through the constraint of the Alonso curve on the spatial zoning of industrial land. Representative industries such as electronic information, integrated circuits, the digital economy, and new energy rely heavily on the agglomeration effects of knowledge-intensive factors, reinforcing their spatial tendency to cluster around R&D hubs and high-end service clusters (Huang, 2023). This indicates that high value-added industries not only differ from traditional industrial models in their technological pathways but also exhibit stronger centrality preferences in spatial organization, a conclusion that has been supported by other studies (Xu, 2021).

These findings suggest that under the drive of new quality productive forces, the organizational paradigm of industrial space is undergoing profound restructuring. Its spatial logic is no longer solely constrained by land rent costs but is increasingly driven by a combination of factors such as knowledge flows, technological innovation, and capital concentration. This paradigm shift has transformed urban core areas from traditionally defined “high-rent, non-industrial zones” into the preferred carriers of new productive forces, characterized by higher levels of intensification and functional mixing consistent with the features of central urban spaces. This implies that industrial space supply policies targeting new quality productive forces should emphasize the cultivation and regulation of spatial intensification and functional mixing. At the same time, such policies should avoid one-sided reliance on “high-intensity” development or “office-building-oriented” models. A healthy process of industrial cultivation must also fully respond to the developmental needs of talent, enterprises, and technology.

5. Conclusion

This study systematically reviews and empirically analyzes the spatial characteristics of strategic emerging industries and advanced manufacturing in Shenzhen and other representative domestic and international cities, from multiple dimensions including spatial density, functional

mixing, and locational distribution. The results show that Shenzhen significantly outperforms in terms of both spatial intensification and functional integration of strategic emerging industries. Its high-density and highly mixed land-use patterns not only meet the pressing demands of limited urban land resources and industrial upgrading but also provide a solid spatial foundation for inter-firm collaborative innovation and resource sharing.

At the same time, some new industrial land parcels in Shenzhen ' s core areas already demonstrate a bid rent capacity surpassing that of traditional commercial and office land, reflecting the strong adaptability and spatial restructuring capacity of emerging industries in high-value locations. The findings suggest that, in addition to production factors such as talent and technology, spatial ontological elements can also partly explain the high output efficiency of new industrial spaces.

By extension, current industrial space policies should establish more adaptive linkages between the development of new quality productive forces and the supply and distribution of industrial spaces. On the one hand, policy guidance should be strengthened to promote the agglomerated development of innovative enterprises in strategic emerging industries, optimize spatial resource allocation, and enhance overall industrial efficiency. On the other hand, the traditional planning logic of industrial land use should be transcended to build a more integrated, high-efficiency, and adaptive system of industrial spaces.

As new quality productive forces continue to evolve, the organizational logic of industrial spaces will also keep iterating. Therefore, it is essential to conduct in-depth research on the interactive mechanisms among industry, space, and policy, so as to provide a systematic cognitive framework for the evolution of industrial spaces and deliver scientific support for the cultivation and accommodation of future industries.

Author Contributions:

Yiyao Yang, Qi Wang, and Leixian Guo contributed to the conceptualization, methodology, and data analysis of the study. Qijun Li provided guidance on theoretical framing and critical revisions of the manuscript. Leixian Guo supervised the overall project and coordinated the research process. All authors have read and agreed to the published version of the manuscript.

Informed Consent Statement:

Not applicable.

Data Availability Statement:

Not applicable.

Conflict of Interest:

The authors declare no conflict of interest.

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The Development of Humanities and Social Sciences, 2025, 1(3), 71-80
https://doi.org/10.71204/rdgxkd34

Big Data Technology in Corporate Financial Analysis: A Systematic Literature Review

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Received: 19 August 2025/ Accepted: 20 September 2025/ Published online: 22 September 2025

Abstract

In the digital era, the rapid advancement of information technology and the deepening of corporate digital transformation have made big data technology an indispensable tool for supporting financial analysis. This paper presents a comprehensive review of the application of big data technology in corporate financial analysis, systematically synthesizing relevant studies from both domestic and international literature. First, it outlines the fundamental concepts of big data technology and corporate financial analysis, followed by a critical examination of existing research from three perspectives: technology types, application domains, and research methodologies. Building on this analysis, the paper proposes a "technology – data – decision" mechanism of action and elaborates on specific application scenarios within corporate financial analysis, including refined cost management, decision-support analytics, risk management and early warning, as well as customer value and profitability assessment. Subsequently, it synthesizes the limitations of current research and highlights promising avenues for future inquiry. The findings of this review offer valuable insights for enterprises seeking to achieve a deeper integration of financial analysis and big data technologies in the information age.

Keywords: Big Data Technology; Financial Analysis; Data Integration; Decision Support

1. Introduction

With the rapid development and in-depth application of big data intelligent technology (Li, 2020), the application of big data technology has become a non-trivial and valuable research topic in the field of corporate financial analysis. As a key link in the enterprise operations, financial analysis, with its accuracy and guidance, directly affects an enterprise's strategic decisions and crucial development plans. Amid the wave of digital transformation, traditional financial analysis, which involves massive data calculations and cumbersome steps, is facing numerous challenges

and threats. Therefore, the development and application of big data technology provide new methods and ideas to solve this problem (Abawajy et al., 2018).

This paper focuses on expounding the application of big data technology in enterprise financial analysis through the "technology-data-decision" mechanism of action. Its primary purpose is to systematically sort out the current research status of the application of big data technology in corporate financial analysis, provides an in-depth discussion of existing research results, mainstream application scenarios, and key technical paths in this field. On this basis, the paper will comprehensively analyze the significant advantages brought by big data technology to enterprise financial analysis, such as improving the accuracy of financial forecasting, enhancing the efficiency of risk identification, and optimizing the rationality of resource allocation. At the same time, it will also explore the limitations that cannot be ignored, including problems related to data quality, technical bottlenecks in data processing, and challenges in talent team building. Furthermore, the paper will look forward to the future development trends of this field from a forward-looking perspective.Through such a comprehensive research framework, this paper strives to provide valuable reference for deepening theoretical research in the academic community and guiding specific practices of enterprises in financial management.

2. Basic Overview of Big Data Technology and Corporate Financial Analysis

In the tide of the information age, big data technology has increasingly become a hot topic of concern for enterprises. Nowadays, big data technology has developed relatively maturely, with richer databases and more advanced technical operations. Technologies such as data mining (Werner et al., 2021), data warehouses, cloud computing, and machine learning are continuously developing (Wang, 2019) and have been widely applied in enterprises gradually, with the integration of financial intelligence and management accounting functions (Zhang et al., 2019). On this basis, integrating big data technology with corporate financial analysis business can process massive corporate financial data at a high speed (Bach and Mirjana, 2019) and present real and scientific analysis results to enterprise decision-makers in various visualized forms, injecting new vitality into enterprise development decisions and management. Zhu (2024) proposed that big data based on financial analysis has the following characteristics: massive data, multi-type data, data mining, data insight, and the characteristic of "social transformation".

Financial analysis is an important and non-trivial step in enterprise operations. It is a process of systematically analyzing and evaluating an enterprise's financial status, operating results, and cash flows based on the enterprise's financial statements and other relevant materials, using a series of specialized analysis methods and techniques. China's financial analysis has gone through four stages: financial statement analysis,capital market financial analysis,business-finance comprehensive analysis, and big data financial analysis (Jin et al., 2023). Traditional financial analysis simply relies on sample data, with large data volume, cumbersome and complex processing steps, and low efficiency. With the in-depth development and application of computer technology and big data technology, traditional financial analysis has been gradually impacted to a certain extent, have been challenged (Zhang et al., 2022), and the external market environment

of enterprises has also undergone profound and ineluctable changes. More and more enterprises have gradually begun to continuously integrate big data technology with financial analysis, breaking through the limitations of traditional financial analysis. They can conduct real-time analysis of enterprise financial data, comprehensively and scientifically process a large amount of financial data (Chen et al.,2014), significantly accelerate the speed of data acquisition, and significantly improve the efficiency of data processing, in order to create greater and vital value for enterprises. Jin et al. (2023) pointed out that, for example, ChatGPT can generate visual charts, demonstration documents, etc., according to user natural language instructions, which to a certain extent improves the intelligence and automation of financial analysis, and promotes the evolution of financial analysis towards the trends of multi-dimensional data sources, improved visualization, and enhanced automation and intelligence.

Based on a comprehensive review of existing domestic and foreign research, the following analyses are presented:

At the technical type level, most literatures only focus on the application of big data analytical technologies such as data mining and machine learning in enterprise financial analysis, while research on technical aspects like data governance technology and real-time data processing technology is relatively insufficient. This emphasis leads to an incomplete depiction of the full application chain of big data technology in enterprise financial analysis, neglects the overall perspective, and results in weak persuasiveness of conclusions.

At the application field level, most literatures take industry-leading enterprises such as financial institutions and large Internet companies as research objects, with insufficient research covering traditional manufacturing industries as well as small, medium, and micro enterprises. They fail to fully consider the characteristics of different industries, making it impossible to effectively promote single-case findings to the entire industry.

At the research method level, some literatures use small samples or static data for analysis, or their samples are mostly from large enterprises and public data, with insufficient coverage of small and medium-sized enterprises and private data. This makes it difficult to reflect the dynamic impact of the "real-time, massive, and multi-dimensional" characteristics of big data technology on enterprise financial analysis. In addition, most theoretical research in the literatures only stays at the simple superposition of principles, leading to over-generalized conclusions with insufficient differentiation and lack of in-depth integration with actual enterprise application scenarios. Some assumptions of research models are disconnected from the actual financial scenarios of enterprises, failing to provide accurate action guidelines for different enterprises.

3. Mechanism of Big Data Technology in Financial Analysis: Technology-Data-Decision

In response to the above research, this paper proposes a "technology-data-decision" mechanism of action. That is, through the application of big data technology, massive enterprise financial data is analyzed to generate new and instructive actionable insights , which assist enterprise managers in making scientifically sound and effectively supported decisions.

The main contents of big data financial analysis include: first, accounting statement analysis, analyzing balance sheets, profit statements, cash flow statements, and identification of financial statement window-dressing; second, financial analysis capabilities, including solvency analysis, operating capacity analysis, profitability analysis, development capacity analysis, and comprehensive financial performance analysis (Jin et al., 2023). In today's digital era, with the continuous development of big data technology, the innovative application scenarios of big data technology in corporate financial analysis are constantly expanding, such as refined cost analysis, decision support analysis, risk management and early warning (Hu and Tsai, 2024), customer value and profitability analysis, etc. The logical mechanism of "technology-data-decision" plays a role in all of them, continuously injecting new creative vitality into enterprise decision-making.

3.1. Refined Cost Analysis

Cost control is a key factor in enterprise operations, and low cost helps enterprises gain a competitive advantage. Big data technology can help enterprises trace the cost of each step of enterprise expenditure's data. All links of enterprise operations, from raw material procurement, production and processing to product sales, logistics and transportation, are closely connected with big data technology (Li, 2020). Financial personnel systematically analyze various implicit indicators of enterprise operations by using big data technology, and conduct a vertical comparison between the enterprise's historical data and the current operating financial data, thereby identifying potential areas for cost optimization , thereby adjusting procurement strategies, reducing production costs, optimizing cost structures, and enhancing the market competitiveness of enterprises (Zhang, 2022),providing support for enterprise decision-making and realizing the "technology-data-decision" mechanism of action.

3.2. Decision Support Analysis

The ultimate goal of big data financial analysis is to provide useful and valuable financial analysis information to the management teams of enterprises. In accordance with the "technology-data-decision" mechanism of action, big data models are capable of conducting in-depth analysis and making predictions about the future development orientations of the enterprise as well as the shifting market trends based on historical financial data of the business, evolving trends in the market, and data concerning consumer demands, thereby supplying decision-makers within the company with scientific and reliable financial information (Kumar et al., 2025). By means of such comprehensive and detailed information, the management of the enterprise can acquire a profound and thorough understanding of the company's current status and operational conditions, and further formulate scientific and rational strategic decisions that are conducive to the long-term strategic development of the enterprise.

3.3. Risk Management and Early Warning

Financial risk management runs through the entire process of enterprise operations. By leveraging big data technology, enterprises can conduct real-time monitoring of their financial status, achieve financial sharing, pay close attention to technical risks within the enterprise, and avoid excessive reliance on data (Ding and Cui, 2017).It enables in-depth analysis of diverse financial indicators of enterprises, such as asset-liability ratio, current ratio, and accounts

receivable turnover rate (Jin et al., 2023). Once these indicators deviate from the normal range, big data technology can promptly issue alerts, allowing enterprises to make scientific decisions and to take timely remedial measures. This not only helps reduce bad debt losses but also effectively prevents and resolves potential risks, thereby maintaining the stable operation of the enterprise (Lin, 2022).

3.4. Customer Value and Profitability Analysis

The value interaction between customers and enterprises stands as the core goal of business operations. By leveraging big data technologies, enterprises are able to integrate diverse types of consumer data, including the volume of consumers, their geographical distribution, varying preferences, and credit-related information. Through analyzing the profit contribution degrees of different consumer groups, these enterprises can facilitate the implementation of differential pricing strategies, better promote diversified marketing approaches, create value while delivering it effectively, and constantly enhance the precision of corporate customer management as well as the overall profitability of the business.

The process of big data analysis and mining can be divided into data acquisition, data preprocessing, analysis and mining (Firmansyah & Harsanto, 2023), and data visualization (Qiao et al., 2021). Relying on the advantages of big data technology in deep data value mining and large-scale data processing (Zhang,2021), big data financial analysis can efficiently process financial data, make financial data clear and systematic, thereby effectively integrating data, analyzing enterprise operating performance, accurately refining the enterprise's market positioning, and promoting enterprises' strategic transformation and upgrading in the digital era.

In accordance with the "technology-data" mechanism of action, big data financial analysis can efficiently process financial data, making it clear and systematic. This enables effective data integration, analysis of enterprise operating performance, implementation of scientific decision-making, precise refinement of enterprise market positioning, and promotion of enterprises' strategic transformation and upgrading in the digital era. Ant Group is a good example here. Its micro-lending business (Huabei, Jiebei) relies on big data technology to analyze multi-dimensional data such as consumers' spending habits and credit records, build an accurate credit evaluation model for corporate decision-making, realize automated lending, effectively identify credit risks in financial analysis, and optimize capital allocation.

These application scenarios of big data technology in financial analysis, by virtue of the massive data processing capability and in-depth research and analysis capacity of big data technology, enable enterprises' financial analysis to be more forward-looking, accurate, scientific and guiding. Specifically, the powerful data processing functions of big data allow enterprises to efficiently integrate and process huge volumes of structured and unstructured financial data, while its advanced analytical models can dig out hidden patterns and potential trends behind the data. This not only makes financial analysis break through the limitations of traditional methods relying on fragmented data and experience judgment, but also promotes it to move steadily towards the direction of intellectualization,where it keeps pace with cutting-edge technological developments, thus providing more solid decision-making support for enterprise development.

4. Existing Problems and Challenges of Big Data Technology in Corporate Financial Analysis

Opportunities and challenges coexist. While big data financial analysis has demonstrated remarkable advantages, it is also confronted with a variety of risks and challenges, and encounters multiple practical bottlenecks in the process of practical implementation.

Some research points out that enterprise financial transformation is a systematic project. At present, China's accounting informatization still remains in the stage of data storage and integration, and there is still a huge gap between current practices and the requirements of the financial shared service model. Specifically, the existing informatization construction is mostly limited to the simple accumulation and basic integration of financial data, lacking in-depth mining and efficient utilization of data value, which makes it difficult to meet the high standards of financial shared services for data timeliness, accuracy and collaborative application, thus restricting the further advancement of big data financial analysis in practice.

Challenges such as information security issues, lack of professional talents, and gaps in data security-related laws have set certain obstacles for enterprises to fully realize big data financial transformation. Firstly, in the era of big data, information security issues have received more and more attention. The protection of enterprise information and data has become a key link in enterprise development in the big data era. Enterprise financial data may involve commercial secrets of enterprises. In the application process of big data technology, deviations will inevitably occur in the collection, processing, and dissemination of financial data. Once financial data is leaked or maliciously stolen by competitor enterprises, it will cause immeasurable losses to enterprises. Therefore, how to protect enterprise data security in the data era has become an issue that enterprises must pay attention to currently (Zhang and Wang, 2016). Secondly, the gap in professional talents also affects the modernization process of enterprise financial analysis. Traditional financial personnel have low data literacy, and there is a lack of compound talents with both financial analysis and big data technology. Financial personnel have incomplete professional skills and do not have relevant theoretical knowledge of big data financial analysis, so they cannot truly implement the application of big data technology in the field of financial analysis. Finally, Qi and Deng (2019) proposed that the inverted U-shaped relationship between enterprise R&D investment and financial performance will be adjusted by environmental regulations. The country has relatively blank legislation in the field of big data and financial analysis, and there are few laws and regulations to protect the security of enterprise legal financial data, making most enterprises lack effective means to safeguard their legitimate rights and interests and enterprise data security cannot be strongly guaranteed.

5. Future Research Directions

Research on the integration of financial analysis and big data is relatively scattered, lacking a systematic theoretical system, and the theoretical framework has not yet been fully constructed. To promote the in-depth application of big data technology and corporate financial analysis, we should focus on the above problems and challenges to think about countermeasures, and actively

explore and innovate paths suitable for the technological progress of enterprise financial analysis. Future research directions should focus on the following aspects:

To promote the digital transformation of financial analysis and develop financial intelligence, enterprises should strengthen the protection of financial data security. With the rapid development of big data intelligent technology and the in-depth integration of key technologies such as data mining, machine learning, and deep learning in the field of financial analysis, enterprises should accelerate the formulation of protection rules for core data. Build big data models, clarify the channels and usage standards for financial data collection, storage, and transmission, improve operational capabilities and information construction, continuously improve the risk early warning system, and protect data security in an all-round way.

Cultivate a team of big data financial talents, optimize and upgrade enterprise big data technology tools, improve the technological level of enterprises, train employees' professional skills, and train high-quality financial talents (Li et al., 2018). Highlight the innovative content of financial analysis in strategic decision-making functions, cash flow support functions, capital securities market functions, and material and intellectual integration efficiency, and increase the depth of integration between enterprise financial analysis and big data technology (Zhou and Yang, 2023). Financial personnel themselves should have a strategic overall view beyond financial thinking. Enterprises should be brave in innovation, build an intelligent talent team, cultivate intelligent financial talents (Li et al., 2018; Zhang et al., 2022), cultivate compound talents with both financial analysis and big data technology, and actively learn the scientific theoretical system of financial analysis and big data technology and apply it to enterprise production practice.

The government should adopt an overall and balanced approach, accelerate legislative protection for big data financial analysis, and strengthen policy guidance in this field. It needs to establish data security management systems, continuously fill gaps in relevant legal aspects, and improve the legal framework governing big data technology and financial analysis.These efforts aim to provide legal safeguards for enterprises developing big data financial analysis, encourage them to pursue an innovative path in this area, and enhance their core competitiveness in the digital era. Such measures will create a standardized and secure environment, enabling businesses to fully leverage big data in financial analysis while ensuring compliance and sustainable development.

In addition, to vigorously promote the in-depth,all-round and far-reaching application of big data technology in corporate financial analysis, it is not only absolutely necessary for all parties mentioned above to make arduous and continuous efforts, but also highly imperative for society to further significantly enhance the overall data literacy of the entire populace to a much higher level. It is of essential importance to strengthen professional and precise technical guidance for small and medium-sized enterprises,which are the backbone of the economic entity. Actively promote the open, transparent and orderly opening of public data to enterprises and the public, ensuring that the data is not only accessible but also of high quality and reliability. Integrate diverse, scattered and heterogeneous data across various departments, breaking down data silos and promoting seamless data flow. Urge enterprises to strictly ensure the absolute fairness,

complete transparency and unshakable authenticity of their own financial data, leaving no room for doubt or ambiguity. We should accelerate the process of comprehensively reshaping the value chain of corporate financial analysis through advanced big data technology, continuously strengthen technical integration at a deeper level and carry out innovative algorithm innovation, break down the long-standing business barriers between financial and big data systems with determination, promoting smooth integration. Moreover, have regulatory authorities intensify strict, impartial and uncompromising supervision, using sophisticated monitoring means to prevent any form of data fraud. In this way, we can gradually form a strong, widespread and lasting social consensus of "technology for good", where technology serves the public interest and promotes the healthy development of the economy and society.

6. Conclusion

With its profound and all-encompassing impact, big data technology is profoundly and thoroughly reshaping the complex and evolving landscape of enterprise financial analysis. In the era dominated by big data, it plays an absolutely pivotal and irreplaceable role in smoothly promoting the profound and comprehensive modernization transformation of enterprise financial analysis. This review clearly shows that enterprises have achieved truly remarkable results in applying big data technology to various financial analysis scenarios in accordance with the "technology-data-decision" mechanism, including refined cost analysis, decision support analysis, risk management and early warning mechanisms, as well as customer value evaluation and profit analysis. However, they still face challenges in several aspects: prominent information security vulnerabilities, an obvious shortage of highly specialized talents proficient in both big data and finance, and huge gaps in the legal framework related to data security, all of which hinder the further development of big data-driven financial analysis.

Future research ought to conduct in-depth exploration into the systematic theoretical analysis concerning the fusion of big data technology and financial analysis. It should attach great importance to accurately grasping the orientation of enterprises' economic transformation. As big data technology advances with each passing day at a rapid pace, the financial transformation of China's enterprises is expected to progress steadily toward digitalization and intelligent transformation. digitalization and cutting-edge development.

Author Contributions:

Conceptualization, Sihan Zhang; writing-original draft preparation, Sihan Zhang; writing-review and editing, Sihan Zhang. All authors have read and agreed to the published version of the manuscript.

Funding:

This research received no external funding.

Institutional Review Board Statement:

Not applicable.

Informed Consent Statement:

Not applicable.

Data Availability Statement:

Not applicable.

Acknowledgments:

I am full of sincere gratitude to my teacher, Yicong Zhang, for providing the platform. Throughout the process of writing this literature review, her meticulous guidance, insightful suggestions, and unwavering support have been invaluable. Thanks to the editorial department, it is a great honor for us to publish our literature review in this journal.

Conflict of Interest:

The author declares no conflict of interest.

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The Development of Humanities and Social Sciences, 2025, 1(3), 81-99
https://doi.org/10.71204/1p7n5w97

A Literature Review on the Role of Artificial Intelligence in Marketing

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Received: 25 August 2025/ Accepted: 20 September 2025/ Published online: 22 September 2025

Abstract

With the rapid advancement of artificial intelligence (AI) technologies, their application in marketing has become increasingly widespread. This paper reviews and synthesizes existing literature to examine the multifaceted impacts of AI on marketing practices. The findings indicate that AI offers significant advantages, including enhanced marketing efficiency, cost reduction, and the facilitation of personalized recommendations. These capabilities contribute to improved consumer experience and engagement, thereby fostering stronger brand loyalty and promoting brand image development. Nevertheless, the review also highlights inherent limitations of AI, particularly in emotional expression and authenticity perception, which may undermine consumer trust.

Keywords: Artificial Intelligence; Marketing; Consumer Behavior

1. Introduction

In the digital era, marketing continuously seeks innovation and breakthroughs to adapt to evolving consumer behaviors and media environments. As an emerging force, AI is reshaping traditional marketing with unique advantages: 24/7 operation, precise data analysis, personalized recommendations, and real-time interaction. It shows great potential in improving efficiency, diversifying methods, and enhancing consumer experience. Many companies have introduced AI in hopes of gaining a competitive edge in the competitive market (Haleem et al., 2022). However, despite the increasingly widespread application of AI, systematic research on its impact on the education sector remains relatively scarce. This review aims to synthesize relevant literature and deeply explore the current application status, advantages, challenges, and future research directions of AI in marketing, provide theoretical guidance and practical references for marketers, and assist enterprises in better utilizing AI to enhance marketing effectiveness and consumer experience.

While this review focuses primarily on marketing, insights from AI's application in education provide a valuable comparative perspective, helping to further illustrate the universality of AI's core capabilities and enrich the analysis of its role in marketing.

2. The Impact of AI on Brand Image

Among the diverse impacts of AI on marketing, brand image stands as a foundational pillar, shaping consumers' long-term perceptions and directly influencing their loyalty to the brand. As the bedrock of brand-consumer relationships, it merits priority analysis to understand how AI's technical capabilities translate into sustained market influence (Petrescu and Krishen, 2023).

The impact of AI on brand image is a long-term process. Brand image is a collection of consumers' inherent perceptions of a brand and the differentiated information conveyed by the brand, which can be achieved through strategies such as strategic positioning, visual design, user experience, and emotional value, in order to enhance user loyalty and market competitiveness (Ostberg and Hartmann, 2025).

The appearance design, language style, and interactive capabilities of AI play a significant role in conveying brand personality and values. An AI image that is both approachable and professional can not only significantly enhance the brand's appeal and credibility but also establish a positive brand image in the minds of consumers. The application of hybrid intelligence further enhances this process by combining human creativity with AI's computational power, enabling brands to shape their image more accurately and attract consumers (Petrescu and Krishen, 2023). For instance, Xinhua News Agency's 'Xin Xiao hao' and CCTV's 'Xiao sha', AI systems modeled after real individuals, excel in news reporting with high accuracy and stability (Wang, 2023). These systems improve news efficiency and deepen consumers' emotional bonds with the brand through continuous interaction and efficient service, which is crucial for fostering brand loyalty and enabling brands to gain a competitive edge in the market.

While AI enhances brand image through personalized interactions, its inability to exhibit genuine emotional depth stems from fundamental technical constraints. Current AI systems rely on pattern recognition of surface-level cues (e.g., facial expressions, lexical sentiment) rather than authentic emotional experience. Unlike humans, who interpret emotions through contextual, cultural, and experiential lenses, AI processes emotions as data points and thus reduces complex affective states to algorithmic outputs (Davenport et al., 2019). This limitation risks fostering "emotional fatigue" among consumers: over time, preset "warm" language or simulated empathy in AI interactions may be perceived as inauthentic, eroding trust in brands that over-rely on such tools (Niu, 2024). Socially, this could normalize superficial emotional exchanges, weakening consumers' capacity for deep interpersonal engagement, a shift with implications for long-term brand-consumer relationships.

AI can analyze customer data, preferences, and behaviors to provide valuable insights, while human judgment can be utilized to create relevant and engaging content, offers, and interactions. This combination makes marketing strategies more personalized and precise (Petrescu and Krishen, 2023). The "task automation" capability of AI technology enables AI to efficiently

process vast amounts of data, thereby delivering brand messages with greater precision. For instance, AI can dynamically adjust its language and interaction style in real time to better meet consumer needs (Davenport et al., 2019).

AI's strengths in personalized recommendations and precision marketing enhance brand satisfaction and loyalty (Gao et al., 2023). Its 24/7 live streaming attracts consumers by analyzing behavior data to deliver personalized recommendations (Zhu et al., 2025). This precise interaction meets individual needs and strengthens the consumer-brand emotional bond. Based on real-time data analysis, AI can instantly adjust the recommended content during live streaming, ensuring that every viewer receives information that matches their interests and needs. This personalized experience makes consumers feel the brand's attention and understanding, thereby enhancing their trust and reliance on the brand (Huang and Rust, 2020).

Consumers' acceptance of AI often hinges on their trust in artificial intelligence technology. Studies indicate that if AI frequently encounters technical issues during live broadcasts, such as incoherent speech, uncoordinated movements, or delayed information updates, these issues may significantly undermine consumers' trust in the brand and even trigger dissatisfaction and resistance. Therefore, ensuring the technical stability and information accuracy of AI is crucial for maintaining the brand image (Huang and Rust, 2020).

3. The Effect of AI on Consumer Engagement

A positive brand image, while crucial, cannot endure without active consumer engagement. AI’s role in shaping brand perception is intrinsically linked to its capacity to drive consumer participation, whether through real-time interactions or personalized experiences (Zhu et al., 2025). This chapter examines how AI promotes such engagement, a critical bridge between brand image and consumer loyalty.

Consumer engagement refers to the extent to which consumers actively participate in interactions during marketing activities. With the rapid development of artificial intelligence technology, the application of AI in live streaming sales has significantly enhanced consumer engagement. Studies have found that AI effectively captures consumers' attention and strengthens their sense of participation through real-time interaction, personalized recommendations, and entertaining elements (Zhang et al., 2024; Zhu et al., 2025).

In terms of real-time interaction, AI can quickly respond to audience questions, demonstrate product features, and continuously attract consumers' attention through interactive games and other methods (Zhang et al., 2024). For example, AI can capture audience questions in real time and quickly generate accurate responses using natural language processing technology. This efficient interaction method significantly increases consumers' willingness to participate. Experimental data shows that compared to traditional anchors, the time to solve problems when consumers interact with AI is reduced by 32%, and the interaction frequency is increased by 41% (Zhang et al., 2024).

AI also enhances engagement via personalized content recommendations based on consumer interests (Zhu et al., 2025). By analyzing historical behavior, it offers customized product suggestions, improving satisfaction and loyalty. Studies show such recommendations increase purchase conversion rates by 27% and repurchase by 19% (Zhu et al., 2025). When consumers view personalized products recommended by AI during live streams, their average dwell time is extended by 58 seconds compared to non-personalized recommendation scenarios, and the number of interactive comments is increased by 3.2-fold (Zhu et al., 2025). These significant improvements in engagement indicate that AI's personalized recommendation strategy has remarkable effects in practical applications.

A sense of humor and a relaxed interactive style also play a significant role in AI's interaction with consumers. Research indicates that humor can significantly enhance consumers' perceived entertainment, thereby increasing their engagement (Zhang et al., 2021). With the application of artificial empathy technology, emotional resonance and support can significantly enhance consumers' sense of engagement and willingness to interact (Liu-Thompkins et al., 2022).

When AI employs humorous expressions during live streaming, consumers are more likely to perceive the interaction as fun and warm (Zhang et al., 2021). Experimental data reveals that when AI uses humorous expressions, consumer engagement is 43% higher than when formal language is used, specifically manifested in a 2.3-fold increase in likes and a 1.8-fold increase in comments (Zhang et al., 2021). Further experiments indicate that a sense of humor can also effectively reduce consumers' defensive mentality, making them more receptive to product information. In an experiment targeting cosmetics live streaming, the use of a humorous AI style increased consumers' purchase intention by 34% (Zhang et al., 2021). This suggests that humor can not only effectively attract consumers' attention but also subtly influence their purchasing decisions, generating significant and long-lasting effects on brand marketing activities.

AI enhances consumer engagement through real-time interaction, personalized recommendations, and humorous elements (Zhang et al., 2024; Zhu et al., 2025). Despite its efficiency in resolving issues quickly and increasing interaction frequency (Zhang et al., 2024), AI's impact on *engagement quality* (not just quantity) remains debated. While it boosts participation metrics, its scripted, pattern-based emotional responses (Davenport et al., 2019; Niu, 2024) can trigger the "emotional fatigue" detailed in Chapter 2. Here, fatigue does not just erode brand trust (as in Chapter 2) but also weakens engagement depth: even with frequent interactions, the lack of genuine emotional resonance prevents meaningful connections that sustain long-term participation. In contrast, human communicators flexibly adjust tone and empathy to build authentic bonds, meaning AI excels in quantitative engagement but lags in qualitative emotional bonding—a trade-off requiring future research on balancing efficiency and human-like emotional intelligence.

Beyond AI's inherent capabilities like real-time interaction and humor, the way AI collaborates with humans also plays a key role in shaping consumer engagement, as different collaboration modes can amplify or weaken the effectiveness of AI's engagement strategies.

According to the use and gratification theory, AI-human collaboration can be divided into two modes: "assistive" and "supervised" (Zhang et al., 2024). Assistive AI is driven by humans in real-time through motion capture devices and language, featuring high flexibility and interactivity; whereas supervised AI automatically generates live broadcast content, with humans only responsible for supervision. Due to its flexibility and real-time response capability, consumer engagement in assistive AI is 67% higher than that in supervised AI. Consumers interact an average of 4.2 times more in assistive AI live broadcasts, and their dwell time is extended by 2.1 minutes. This indicates that assistive AI can significantly enhance consumers' perceived entertainment, thereby increasing engagement (Zhang et al., 2024).

The application of artificial empathy technology has also opened up new possibilities for AI's emotional expression. Through emotion recognition and expression, AI can better understand consumers' emotional states and enhance their engagement through emotional resonance (Liu-Thompkins et al., 2022). For instance, AI can identify consumers' negative emotions through sentiment analysis technology and provide emotional support through empathetic care, thereby alleviating consumers' negative emotions and enhancing their willingness to participate. This emotional interaction not only enhances consumers' engagement but also bridges the emotional gap between AI and human interaction, making AI more human-like in the eyes of consumers (Liu-Thompkins et al., 2022).

4. The Influence of AI on Purchase Intention

Increased consumer engagement, fostered by AI’s interactive strategies, often serves as a precursor to purchasing decisions. When consumers actively participate in marketing interactions, their interest in products deepens, creating a natural pathway to conversion (Wu et al., 2024). This chapter explores how AI converts engagement into concrete purchase intention.

AI can effectively drive consumers' purchase intention by providing detailed product information, answering consumer questions, and showcasing product advantages (Gao et al., 2023). For instance, Taobao's virtual anchors assist consumers with quickly locating products that meet their needs through real-time interaction and personalized recommendations, thereby significantly improving purchase efficiency (Wang et al., 2023). Furthermore, AI's personalized recommendations and precise marketing strategies further elevate consumers' interest and demand for products, ultimately promoting purchasing behavior (Zhang et al., 2024).

While AI-driven personalized recommendations and efficient interactions significantly boost consumers' purchase intention (Zhu et al., 2025; Wang et al., 2023), their effectiveness directly hinges on consumers' perceptions of the AI system's credibility and human-likeness. Studies show that when AI is excessively anthropomorphic yet lacks genuine emotion, it tends to trigger consumer unease and resistance (Wu et al., 2024). Moreover, if recommendations are seen as prioritizing conversion efficiency over genuine needs, their utilitarianism or even manipulativeness can inhibit purchase intent. In contrast, human recommenders, drawing on experience, intuition, and empathy, provide more persuasive and warm guidance. Thus, AI's role in driving purchase intention depends not only on technology but also on its close ties to

consumers' psychological identification, the system's transparency, and emotional acceptance. This debate reveals that AI marketing is not merely a technical race but a contest over trust and human-centered design.

From the perspective of perceived value theory, the "perceived usefulness" and "perceived pleasure" of AI are key factors influencing consumers' purchase intention. Perceived usefulness refers to consumers' belief that AI can enhance their purchasing efficiency and decision-making quality, while perceived pleasure is related to the emotional satisfaction and entertainment experience consumers gain from interacting with AI (Zhu et al., 2025). When consumers perceive the usefulness and pleasure of AI, their purchase intention will be significantly enhanced (Zhu et al., 2025). The capabilities of AI technology in task automation and context awareness enable AI to better understand consumers' specific needs and provide highly personalized recommendations (Davenport et al., 2019). For instance, when Lancôme used AI in its live broadcast, it successfully established consumers' trust in AI through transparent data usage policies and authentic emotional expressions, thereby significantly enhancing purchase intention (Zhu et al., 2025).

However, consumers' trust in AI and their acceptance of AI-recommended content also exert a significant influence on their purchase intention. If consumers perceive AI recommendations as unreliable or lacking in humanity, their purchase intention may be diminished (Zhu et al., 2025). Studies have revealed that AI systems with a designed sweet smile and natural simulated movements are more readily accepted by consumers, thereby enhancing their purchase intention (Wu et al., 2024). Furthermore, the "uncanny valley effect" of AI may pose a dual barrier affecting consumers' purchase intention and societal trust (Wu et al., 2024). On an individual level, when AI’s appearance or behavior closely resembles humans but lacks genuine emotions, consumers feel uneasy, which diminishes their interest in the product and weakens purchase intent. On a broader societal level, this dissonance triggers inherent distrust: authenticity is crucial in persuasive marketing interactions, and AI’s imitated emotion (rather than genuine affect) erodes the credibility of its recommendations, even amid advanced personalization capabilities. This effect complements algorithmic biases, for instance those that prioritize conversion over fairness (Li, 2024), as key obstacles to AI-driven purchase conversion. This distrust is further intensified by opaque decision-making processes, known as 'black-box algorithms,' which make consumers wary of hidden manipulation and reduce their willingness to purchase, despite the AI's advanced capabilities.

5. The impact of AI on brand loyalty

While AI effectively enhances immediate purchase intent, its strategic value extends far beyond one-time transactions. True brand success hinges on fostering long-term loyalty, and through sustained engagement and personalized care, AI plays a pivotal role in transforming occasional buyers into loyal advocates (Gao et al., 2023). This chapter explores this enduring impact.

AI positively impacts brand loyalty in multiple ways, especially in the realm of emotional connections and interactions. Studies show AI simulates human emotions to form deep connections with consumers, enhancing their identification with the brand. In live streams, its

warm tone and positive engagement convey brand values, making consumers feel cared for (Gao et al., 2023).

AI enhances the emotional connection between consumers and brands through human-machine interaction and automated analysis (Kaplan et al., 2021). By emulating emotions, AI strengthens this bond, leading to better brand identification, higher satisfaction, long-term loyalty, and increased repeat purchases (Zhu et al., 2025; Liu et al., 2025). Through positive interaction modes, AI can effectively convey the brand's values, making consumers feel cared for and close to the brand.

AI is capable of generating highly personalized product recommendations and shopping guidance based on consumers' purchase history, browsing behavior, and preference data (Gao et al., 2023). It can also dynamically adjust live-stream scripts according to user preferences, showcase related products, and offer exclusive promotions. This real-time adaptive interactive experience not only meets consumers' immediate needs but also deepens brand memory through contextual marketing (Wang et al., 2024; Cheng et al., 2023), which underscores the value of real-time interaction: during live streams, AI can respond to viewers' comments and questions in seconds, creating a seamless communication mechanism that breaks the one-way nature of traditional marketing. As consumers receive immediate feedback, they essentially transition from product users to brand advocates. This sense of being valued in the consumption experience becomes a key touchpoint for sustaining long-term loyalty.

The development of brand loyalty is a long-term and complex process, demanding continuous efforts from AI across multiple fronts. AI must continuously enhance its technical performance to ensure smooth and stable live-streaming (Zhang et al., 2024). By advancing speech recognition and natural language processing technologies, AI can more accurately grasp consumers' intentions and deliver more precise services. Additionally, optimizing interactive content is crucial for boosting brand loyalty. AI needs to continuously adjust and refine live-stream content based on consumer feedback to maintain its appeal and relevance. By offering high-quality audio-visual effects and a seamless shopping experience, AI can further elevate consumer satisfaction and loyalty. For instance, AI can leverage virtual reality (VR) and augmented reality (AR) technologies to create immersive shopping experiences, thereby enhancing brand attractiveness.

6.The Impact of AI on Dissemination Models

As an innovative application form, AI is gradually changing traditional communication modes. From news broadcasting to live streaming e-commerce, from brand promotion to educational entertainment, AI's use cases are becoming increasingly diverse, demonstrating immense potential and value.

The primary applications of AI in the field of news broadcasting include the automated generation and broadcasting of news content. Through text-to-speech technology, AI can quickly and accurately convert news articles into voice broadcasts, greatly enhancing the efficiency of news production. For instance, Indonesia's TV One television station introduced AI for news broadcasting in 2023, becoming the first television station in the country to adopt AI technology

for this purpose (Fitria, 2024). China's Xinhua News Agency also launched the world's first AI news anchor as early as 2018, marking the entry of news communication into the era of intelligence (Fitria, 2024). AI can support news broadcasting in multiple languages, providing a powerful tool for international communication. Its speech synthesis technology can achieve seamless switching between different languages, meeting the needs of global audiences. This multilingual capability not only enhances the coverage of news but also improves the timeliness and accuracy of international communication.

In the field of live-streaming e-commerce, AI enhances consumers' shopping experience by analyzing user data and providing personalized product recommendations and shopping suggestions. E-commerce platforms such as Taobao have introduced AI virtual anchors for live-streaming sales promotion and product marketing (Shi, 2024). AI plays a significant role in brand promotion. Brands such as Shiseido and L'Oréal have applied AI to brand promotion, successfully capturing a significant degree of consumers' attention and enhancing brand influence through the image and interaction of virtual anchors (Zhu et al., 2025). AI collects and analyzes real-time user data to provide precise insights, helping brands optimize strategies and improve conversion rates and consumer satisfaction. Advances in generative AI technology enable brands to generate high-quality visual content at lower costs and higher efficiency. For instance, visual content generated by the Realistic Vision model is perceived by consumers as more realistic than real images, and this phenomenon of "AI hyperrealism" provides new possibilities for brand promotion (Hartmann et al., 2025).

AI has demonstrated strong technical advantages in the field of language expression. The digital virtual anchor 'Aquamarine' launched by Shandong Radio and Television Station has performed exceptionally well in news broadcasting, especially in handling pauses and stress (Niu, 2024). Despite AI's excellent performance in technical processing, it still has limitations in emotional resonance and personalized expression. Real anchors have more advantages in emotional expression and interactivity, and can better establish emotional connections with viewers. Therefore, the complementary cooperation between AI and real anchors has become the key to future development. In live e-commerce, AI can be responsible for generating and displaying high-quality visual content in real time, while real anchors can enhance consumers' willingness to purchase through emotional expression and interactive strategies. The advantages of generative AI in visual content generation can compensate for its shortcomings in emotional expression. By combining the advantages of both, more effective marketing outcomes can be achieved (Hartmann et al., 2025).

The application of AI in the field of education includes virtual classroom hosting and course content generation. AI can achieve efficient teaching content generation through speech synthesis technology in the field of education, while supporting multilingual teaching (Wang, 2023). AI enables real-time interaction, providing students with learning support and feedback. Its efficient content generation capability and interactivity make the educational process more flexible and personalized, thereby improving learning outcomes.

The application of AI in the entertainment field includes the creation of virtual idols and the development of interactive entertainment content. The virtual idol "Hatsune Miku" is a classic

case of AI application in the entertainment field, and it achieves interaction with the audience through speech synthesis technology (Shi, 2024). Through simulated emotional expression and creative content generation, AI systems can attract the audience's attention and enhance the attractiveness and influence of entertainment content.

The impact of AI on dissemination models, marked by personalized delivery, real-time interaction, and data-driven optimization, has revolutionized marketing and media. These same capabilities extend seamlessly to education, where parallel demands for efficient knowledge dissemination, adaptive learning support, and engaging interaction mirror AI's transformative role in reshaping how information spreads. Next, we explore how these proven AI strengths are reshaping educational practices.

7. The Application of AI in Education

The application of AI in marketing has highlighted its strengths in personalized recommendation, real-time interaction, and data-driven optimization, capabilities that are equally impactful in education. Just as marketing relies on AI to match consumer needs with content, education depends on tailored knowledge delivery and adaptive learning support. This chapter explores how AI, building on the same technical foundations as its marketing applications, is transforming educational management, teaching practices, and learning outcomes.

7.1. The Role of AI in Education

AI in educational management automates administrative tasks and optimizes resource allocation, enabling institutions to manage homework, grading, and feedback more efficiently (Chen et al., 2020). For instance, Intelligent Tutoring Systems (ITS) can automatically grade and provide feedback, reducing the burden on teachers and allowing them to devote more time to teaching and guiding students (Zhang and Aslan, 2021). Furthermore, AI can predict learning outcomes by analyzing student data, aiding educational institutions in better planning and allocating resources (Zhang and Aslan, 2021).

The application of AI in teaching primarily focuses on personalized learning and the development of intelligent teaching tools. AI technologies such as intelligent tutoring systems and chatbots can provide customized content and feedback based on students' learning styles and abilities (Harry, 2023). AI-driven personalized learning systems can significantly enhance students' academic performance and learning motivation (Harry, 2023). Meanwhile, the integration of technologies like virtual reality (VR) and augmented reality (AR) with AI offers students an immersive learning experience, further enhancing learning outcomes (Zhang and Aslan, 2021). Student-AI Collaboration (SAC) is an important direction for future education. Through interdisciplinary teaching, real-world problem-solving, and creative tasks, students can learn and grow together with AI tools (Kim et al., 2022). Students can also utilize AI tools for data analysis, model building, and creative expression, thereby enhancing their problem-solving and innovation abilities (Kim et al., 2022).

AI has also demonstrated immense potential in enhancing learning outcomes. By analyzing students' learning behaviors and data, it can provide real-time feedback and personalized learning paths, effectively improving learning efficiency and effectiveness (Chen et al., 2020). AI can accurately identify students' learning difficulties and provide targeted tutoring and resources to help students overcome learning obstacles (Harry, 2023). Additionally, AI, when combined with simulated and gamified learning environments, can effectively stimulate students' interest and engagement, thereby enhancing learning outcomes (Zhang and Aslan, 2021).

7.2. Challenges Faced by AI in the Field of Education

7.2.1. Technical Challenge

The reliability and stability of AI systems are crucial issues. Many AI systems exhibit limited intelligent computing capabilities in practical applications, making it difficult to meet the complex demands in educational scenarios (Selwyn, 2022). In intelligent tutoring systems, AI needs to accurately understand students' learning status and provide personalized feedback, but current technological advancements may not consistently achieve this goal.

7.2.2. Privacy and Security Challenges

Data privacy and security issues are also significant challenges faced by AI in education. Educational institutions need to ensure the protection of student data and prevent data leakage and abuse (Chen et al., 2020). Algorithmic bias in AI systems may lead to unfair treatment of certain student groups, which is a problem that cannot be ignored in a diverse educational environment (Harry, 2023). The bias and unfairness of AI systems may have adverse effects on certain student groups;thus, ensuring fairness and transparency in the design and implementation of AI systems is necessary (Harry, 2023).

7.2.3. Educational Practice Challenges

The introduction of AI technology has the potential to transform traditional teaching methods and learning environments, enabling personalized learning through precision education (Wang, 2023). This transformation necessitates that teachers acquire new skills and knowledge to effectively utilize AI tools. However, many teachers may currently lack the necessary training and support, making it challenging for them to adapt to effective human-AI interaction.

The application of AI in education also faces challenges related to uneven resource allocation. Educators in schools and regions with abundant resources are more likely to access and use advanced AI technology, while those in regions with scarce resources may find it difficult to keep pace with this trend (Selwyn, 2022). This inequality could lead to further differentiation in education quality, further marginalizing students from disadvantaged groups.

7.2.4. Emotional Social Challenges

AI technology is not a neutral tool, but rather deeply embedded in social values and ideologies (Selwyn, 2022). The risk of 'dehumanization' in AI-driven education arises not from the technology itself, but from its misalignment with human developmental needs. Education is inherently a social process that depends on spontaneous emotional cues, such as a teacher's

empathy when a student is frustrated or peers' laughter during collaborative learning. These aspects are beyond AI's capabilities. AI's emotional responses, based on preset algorithms, lack the unpredictability and authenticity of human interaction, potentially hindering students' ability to interpret complex social signals (Selwyn, 2022). On a societal level, this could widen the gap in emotional abilities, with students in AI-intensive classrooms possibly lagging in empathy compared to those in more humanities-oriented environments.

Furthermore, AI exacerbates educational inequity through resource stratification. Wealthier institutions can afford advanced AI tools, such as adaptive learning systems with diverse and unbiased datasets, while underfunded schools rely on limited, outdated systems—often trained on homogeneous data that fail to address the needs of marginalized students (Harry, 2023). This creates a 'digital caste system,' where AI amplifies existing disparities rather than democratizing education. The root cause lies in profit-driven AI development: companies prioritize scalable, high-revenue solutions over inclusive design, perpetuating systemic inequities.

In addition, the transformation of the roles of teachers and students poses a significant ethical challenge. With the application of AI in education, the role of teachers may shift from knowledge transmitters to learning facilitators, while students may transition from passive recipients to active explorers (Zhai et al., 2021). This role transformation necessitates profound changes in the education system and may also elicit resistance from both teachers and students.

8. Comparative Analysis Between AI and Humans

Whether in marketing or education, the effectiveness of AI hinges on an understanding of its strengths relative to human capabilities. While AI excels in efficiency and data processing, humans retain unique advantages in emotional intelligence and creativity, and this balance is critical to maximizing its value. This chapter compares AI and humans across key dimensions to clarify their complementary roles.

8.1. Advantages of AI Compared to Humans

8.1.1. Efficiency and Stability

AI possesses the ability to work around the clock, unrestricted by time and space, and adept at handling breaking news in real-time, thereby significantly enhancing the efficiency of news dissemination. For instance, when a non-anthropomorphic female AI virtual anchor delivers news broadcasts using an anthropomorphic voice, viewers perceive the highest level of attraction. Moreover, AI's ability to work continuously reduces the time cost of news broadcasting significantly (Xue et al., 2022). Through automated analysis and human-computer interaction, AI technology can notably boost content production efficiency (Kaplan et al., 2021). The world's first AI synthetic news anchor, jointly launched by Xinhua News Agency and Sogou at the World Internet Conference in 2018, is capable of delivering news in real-time, significantly enhancing the efficiency and timeliness of news dissemination. Furthermore, Japan's virtual streamer Hatsune Miku has also demonstrated the all-weather application capability of AI technology in

the entertainment sector, garnering a substantial audience through virtual concerts and real-time interactions.

AI can also automate repetitive tasks, ensuring efficient execution of marketing activities in areas such as payment processing, logistics tracking, and customer service (Huang and Rust, 2020). However, human broadcasters, due to physiological limitations, require rest and preparation time, making it difficult for them to compete with AI in terms of working hours and efficiency in handling repetitive tasks.

8.1.2. Data Processing Capabilities and Personalized Services

AI, through deep learning and natural language processing technology, can analyze user behavior data in real time, providing personalized recommendations and shopping guidance (Shi, 2024). It can analyze users' purchase history and browsing behavior to recommend products that best meet their needs, thereby improving user conversion rates and satisfaction (Shi, 2024). In Taobao Live, AI analyzes users' browsing history and purchase records to recommend products that may interest them, enhancing their shopping experience and willingness to purchase; short video platforms such as Tiktok also utilize AI for personalized content recommendations, pushing videos that best match users' interests based on their viewing history and interactive behavior, thereby increasing user stickiness and platform activity.

In live-streaming e-commerce, AI can adjust content and interaction methods in real-time based on different users' interests and needs. In an auxiliary human-machine collaboration mode, it can quickly respond to user demands, enhancing users' engagement and willingness to purchase (Zhang et al., 2023). During the "618" shopping festival, JD's AI significantly improved the purchase conversion rate of users by analyzing users' questions and feedback in real-time and adjusting the display order of recommended products. Human hosts often fall short of AI in terms of efficiency and accuracy when dealing with large amounts of user data and providing personalized services.

8.1.3. Cross-Cultural Adaptability

AI can adjust its designed image, designed language, and content strategies according to different cultural backgrounds, thereby attracting audiences from diverse cultural backgrounds. It can enhance the audience's sense of identification and participation by incorporating local cultural elements (such as clothing and language style) (Li, 2024). The South Korean virtual anchor "Rozy" successfully entered the Chinese market by adjusting its designed image and language style, demonstrating AI's adaptability in different cultural contexts. Humans, limited by their own cultural backgrounds and language habits, require longer periods of adaptation and learning in cross-cultural communication, making it difficult for them to adjust quickly to different cultural environments like AI can.

8.1.4. Cost-effectiveness

In terms of operating costs, adopting AI eliminates the need to pay salaries, benefits, and other personnel-related expenses, significantly reducing operating costs. Its use can greatly reduce labor costs while improving the efficiency and quality of content production (Shi, 2024). Xinhua News

Agency's AI news anchors not only reduce labor costs but also enhance the efficiency and quality of news reporting through 24-hour uninterrupted work; e-commerce platforms such as Taobao and JD.com significantly reduce labor costs and improve sales efficiency and user satisfaction by using AI for live-streaming sales promotion. However, employing humans requires paying higher salaries, benefits, and other expenses, resulting in higher labor costs in the long run.

However, despite these clear advantages, AI also has distinct disadvantages compared to humans: it is particularly lacking in areas that rely on emotional connection, creativity, and trust, which remain human strengths.

8.2. The Disadvantages of AI Compared to Humans

8.2.1. Lack of Emotional Resonance

AI exhibits notable deficiencies in emotional expression and empathy. Despite significant advancements in task automation, AI technology still faces challenges in "contextual awareness" and conveying simulated genuine emotions (Davenport et al., 2019). This limitation may lead to reduced consumer trust in AI, especially in scenarios requiring high emotional interaction. AI lacks genuine emotions and personalized expression, and is unable to establish deep connections with viewers through emotional empathy like human anchors. When dealing with complex emotions and unexpected situations, it often appears mechanized and indifferent (Niu, 2024). Shandong TV's AI virtual anchor "Hailan" appears mechanized in emotional expression during news broadcasts, despite proper technical processing, and fails to establish deep emotional connections with viewers.

In contrast, humans are able to establish deep connections with viewers through emotional expression and interactive strategies. For example, Dong Qing from CCTV is able to forge a profound emotional bond with viewers through her delicate emotional expression and interactions, thereby enhancing viewers' willingness to watch and loyalty. By perceiving the on-site environment and audience feedback, humans can adjust their expression in real time, making the content more infectious and attractive (Niu, 2024).

8.2.2. Trust Issues

The audience has a low level of trust in AI. The inherent impression of traditional news anchors negatively moderates the influence that AI's appeal exerts on their willingness to watch. Even if AI possesses high perceived appeal, the audience may still reduce their willingness to watch due to insufficient trust (Xue et al., 2022).

The low trust in AI among audiences can be attributed to epistemological differences. Humans tend to trust information sources they perceive as accountable. However, AI systems, which operate through opaque algorithms, lack clear accountability. When an AI news anchor disseminates misinformation, responsibility is diffused among developers, companies, and users (Xue et al., 2022). In contrast, human broadcasters build trust through long-term reputational stakes, such as career consequences for inaccuracies. This disparity erodes trust in institutional information systems, as audiences' distrust in AI-delivered news or educational content weakens the systems designed to inform and educate.

Humans, through long-term professional experience and genuine interaction, can earn the trust and recognition of their audience. Their adaptability in complex situations and proficiency in deep language expression make them more trusted among viewers (Xiao and Duan, 2024).

8.2.3. Technical Dependency

AI relies heavily on technical support and a stable network environment. Technical failures or network delays can directly affect AI's performance, thereby reducing user experience (Shi, 2024). However, humans can continue to complete tasks through their adaptability and creativity in the event of technical failures or unexpected situations. When facing breaking news or technical issues, human anchors can flexibly adjust content and expression methods to ensure the smooth progress of the program (Xiao and Duan, 2024).

8.2.4. Lack of Creativity

AI has limitations in the production of creative content. It primarily relies on preset models and algorithms, lacking the flexibility and creativity of human anchors. When dealing with breaking news or complex situations, AI often fails to engage in deep thinking and respond flexibly, as human anchors do (Xiao and Duan, 2024).

The creative limitations of AI stem from its dependence on statistical pattern-matching rather than original thought. Generative AI tools, such as content creators, recombine existing data but cannot conceptualize novel ideas beyond their training datasets (Hartmann et al., 2025). For instance, an AI generating lesson plans will not "invent" new pedagogical approaches—only refine existing ones. This hinders innovation in education and marketing, where breakthroughs often arise from challenging established norms. Socially, over-reliance on AI creativity could homogenize cultural production, diminishing diversity in thought and expression.

Human streamers are able to provide more attractive and impactful content through deep thinking and creative expression. Through emotional expression and cultural accumulation, they are better able to meet the emotional needs and aesthetic expectations of their audiences (Niu, 2024).

8.2.5. Summary

AI and humans exhibit significant differences in multiple key areas, primarily in terms of work capability, emotional interaction, content creation, cultural adaptation, cost-effectiveness, and dependence on technology. By comparing these areas, one can clearly see the respective strengths and limitations of both. The specific comparisons are as follows:

Table 1. Comparison of Advantages and Disadvantages Between AI and Humans

Comparison dimension	AI advantages	AI disadvantages	Human advantages	Human disadvantages
Emotion and interaction	No emotional fluctuations, stable output of standardized content	Emotional expression is mechanical, lacking empathy and deep	Senses audience emotions, conveys genuine feelings via tone and body	Mood can be influenced by personal state, leading to fluctuations that may

	(Davenport et al., 2019; Niu, 2024)	audience connection (Niu, 2024)	language, and enhances resonance (Niu, 2024)	affect output stability (Niu, 2024)
Work efficiency and duration	Works 24 hours non-stop, operates without time or space restrictions, and is suitable for high-frequency, repetitive tasks (Xue et al., 2022; Kaplan et al., 2021)	Lacks the ability to autonomously adjust rest periods, relies on technical maintenance, work is directly interrupted when there is a malfunction (Shi, 2024)	Can flexibly respond to unexpected tasks and adjust the pace according to the on-site situation (Xiao and Duan, 2024)	Due to physical and time constraints, it is impossible to work around the clock, and efficiency in handling repetitive tasks is low (Huang and Rust, 2020)
Personalized service	Leveraging data analysis, accurately push content/products that meet user needs, and adjust strategies in real-time (Shi, 2024)	Relies on preset algorithms, weak response capability for non-standardized demands (Davenport et al., 2019)	Personalized interactions can be provided with more warmth through human observation and experience (Niu, 2024)	Struggling to handle large-scale user data, the precision of personalized recommendations is lower than that of AI (Shi, 2024)
Creativity and adaptability	Can quickly generate standardized content, reducing repetitive creation costs (Hartmann et al., 2025)	Lacks independent thinking and poor adaptability when facing unexpected situations such as live stream failures or unexpected questions (Xiao and Duan, 2024)	Possesses independent thinking ability, can creatively design content, and flexibly handle unexpected crises (Niu, 2024)	Creativity is limited by personal experience and state of mind, which may lead to restricted ideas (Xiao and Duan, 2024)
Cross-cultural adaptation	Can quickly adjust language, image, content strategies, and integrate local cultural elements (Li, 2024)	Limited understanding of the deep cultural connotations such as customs and metaphors, leading to 'cultural misalignment' (Li, 2024)	Through long-term learning, one can understand cultural nuances and convey a more authentic sense of cultural identity (Li, 2024)	Cross-cultural adaptation requires long-term accumulation, slow adjustment speed, and high costs (Li, 2024)
Costs and operations	No salaries, benefits, or other human resource costs; cost-	Early-stage technology development and	No need for high technical investment, suitable	High labor costs such as salaries, training, and management create

	effective for long-term use (Shi, 2024)	equipment maintenance costs are high, relying on professional team support (Shi, 2024)	for small-scale, personalized scenarios (Shi, 2024)	significant cost pressure when applied on a large scale (Shi, 2024)
Trustworthiness and authority	Suitable for transmitting standardized, data-type content, with strong consistency in output (Xue et al., 2022)	Audience trust levels are relatively low, especially for major events and emotional content, where recognition of authority is weak (Xue et al., 2022)	Long-term professional accumulation forms a professional image, resulting in high trustworthiness in interpreting complex content and reporting major events (Xiao and Duan, 2024)	Personal reputation may affect audience trust in content (Xiao and Duan, 2024)
Dependence on technology	Technological iteration can quickly enhance capabilities (Shi, 2024)	Highly dependent on the network, hardware, and algorithms, failures directly affect work, leading to a decline in user experience (Shi, 2024)	Low dependence on technology, equipment failures can be remedied manually (Xiao and Duan, 2024)	The ability to use technical tools is limited by personal skills, which may affect efficiency (Selwyn, 2022)

9. Prospects for Future AI Research

Based on the quantitative and qualitative analysis results of AI in marketing literature, this article proposes the technological development and research prospects of AI in the education industry.

Firstly, technical optimization and intelligent enhancement are crucial for the application of AI in the field of education. How can we enhance the reliability and stability of AI in understanding students' learning progress and providing personalized feedback? Can we improve natural language processing and sentiment analysis technology to enable AI to more accurately capture students' learning needs? Currently, AI still has limitations in these areas. Through technological advancements, AI can more precisely understand students' learning status and provide more targeted guidance (Selwyn, 2022).

Secondly, educational equity and resource allocation are issues that cannot be ignored in AI applications. Will the introduction of AI exacerbate the inequality in educational resource allocation, leading to further marginalization of students from disadvantaged groups? Schools and regions with abundant resources are more likely to access advanced AI technology, while regions with scarce resources may struggle to keep up with this trend. Can policy support and technology

sharing be utilized to enable regions with scarce resources to equally access AI? How can low-cost and easy-to-operate AI solutions be designed to accommodate the educational needs of different regions? These issues require in-depth research to ensure that the popularization of AI does not further marginalize students from disadvantaged groups (Selwyn, 2022).

Furthermore, the transformation of teacher and student roles poses new challenges brought about by AI applications. Will AI completely replace human teachers, or will it need to form a complementary relationship with them? Will the shift of teachers from knowledge imparters to learning guides lead to profound changes in the education system? Will the transformation of students from passive recipients to active explorers have a positive impact on educational outcomes? Future research can explore the impact of this role shift on the education system and how to help teachers and students adapt to this change. Will the overuse of AI weaken humanistic values in education, making the educational process more mechanized? How can we balance technology and humanistic care in the application of AI to avoid "dehumanization" in the educational process? Will AI ignore students' emotional and social needs, thereby affecting the overall quality of education? Future research can explore how to retain humanistic care in education in the application of AI. In the future, AI can collaborate with human teachers, with AI responsible for knowledge impartation and data processing tasks, while human teachers focus on emotional support and social interaction, thus achieving a balance in education (Zhai et al., 2021).

The synergy between human teachers and AI is pivotal to the future development of education. The introduction of AI does not signify the replacement of human teachers, but rather provides a new tool for education. Can the synergy between human teachers and AI maximize educational outcomes? Can AI handle repetitive, data-driven tasks, while human teachers focus on solving complex problems and providing emotional support? How can a blended teaching model be designed to enable both AI and human teachers to jointly enhance the quality of education? This collaborative model may become the mainstream trend in future education (Zhai et al., 2021).

Lastly, the innovation and transformation of educational models present new opportunities brought about by AI applications. Can AI drive the innovation of educational models, such as achieving precision education and personalized learning? Can AI support diverse learning methods, such as flipped classrooms and project-based learning? Will the application of AI fundamentally change traditional teaching methods and learning environments? In the future, we can explore how to utilize AI to achieve these innovations, thereby enhancing learning efficiency and educational quality.

In summary, the application of AI in the field of education holds significant potential while confronting challenges. Future research needs to delve into areas such as technology optimization, educational equity, emotional socialization, and synergistic collaboration between human teachers and AI. By balancing technology and humanistic care, equity and efficiency, AI is expected to become an important driving force for educational transformation, providing students with a more personalized, inclusive, and efficient educational experience. Ultimately, the ideal direction for the joint development of AI and education is the synergy, rather than opposition, between human teachers and AI.

Author Contributions:

Zirui Wang: Conceptualization, writing-original draft preparation, writing-review and editing; All authors have read and agreed to the published version of the manuscript.

Funding:

This research received no external funding.

Institutional Review Board Statement:

Not applicable.

Data Availability Statement:

Not applicable.

Conflict of Interest:

The author declares no conflict of interest.

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The Development of Humanities and Social Sciences, 2025, 1(3), 100-111
https://doi.org/10.71204/tdhndr96

The Logical Reconstruction and Path Exploration of the Vitality of Ideological and Political Theory Courses in the Era of Artificial Intelligence

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Received: 14 September 2025/ Accepted: 27 October 2025/ Published online: 3 November 2025

Abstract

Artificial intelligence (AI), exemplified by large-scale models, is reshaping the educational landscape and accelerating the transition from digitalization to intelligent transformation. Ideological and Political (IP) courses face both new opportunities and emerging risks. Anchored in value orientation and educational principles, this paper traces the historical logic of change and identifies key structural challenges: attention dispersion, algorithmic enclosure, and capacity mismatch. We propose a three-dimensional framework of influence. First, a cognitive shift from indoctrination and rote memorization to problem-driven, evidence-based, and reflective learning. Second, a discursive shift from one-way transmission to multi-source co-construction with explicit value interpretation. Third, a relational shift from knowledge mediation to value leadership, instructional design, and data stewardship. Building on this framework, we outline practical pathways for intelligent content iteration, immersive experiences combined with rational debriefing, personalized support grounded in integrity safeguards, and renewed teacher professionalism for human–machine collaboration. Finally, we propose an institutional architecture emphasizing value guidance, collaborative mechanisms, shared resource ecosystems, digital–ethical literacy for teachers, and proportionate data governance. We argue that only through coupling value rationality with technical rationality, under transparent and auditable safeguards, can IP courses enhance their ideological depth, emotional resonance, and practical effectiveness.

Keywords: Artificial Intelligence; Ideological and Political Theory Course; Educational Digitalization; Human–Machine Collaboration; Algorithmic Enclosure

1. Introduction

Artificial intelligence (AI) technologies, represented by large-scale models, are being integrated across the entire educational chain, transforming knowledge production, learning organization, classroom interaction, and governance. This transformation goes beyond a mere media upgrade; it reconstructs the fundamental logic and value order of education (Selwyn, 2019; Holmes et al., 2019).

As a core course for fostering virtue and cultivating talent, the Ideological and Political (IP) course must, while upholding Marxist positions and core socialist values, actively respond to changes in students' cognitive habits, attention structures, and media environments. In practice, AI is reshaping classrooms—from one-way instruction to problem-driven, evidence-based inquiry; discourse is expanding from singular authority to plural collaboration; and teacher–student relations are evolving toward value co-creation (Luckin et al., 2016; U.S. Department of Education, 2023).

The vitality of IP courses therefore rests on coupling value rationality with technical rationality. Value orientation determines the direction, human–machine collaboration defines the path, and institutional safeguards ensure continuity. Only when conceptual renewal, pathway innovation, and institutional optimization interact can IP courses enhance their ideological depth, theoretical rigor, and emotional resonance in the AI era (Holmes, Bialik & Fadel, 2019; UNESCO, 2023; OECD, 2021).

2. The Historical Logic of Ideological and Political Education in the Era of Artificial Intelligence

Education is undergoing a transition from digitalization to intelligentization, marked by structural shifts in pedagogy, learning models, and governance. The Ideological and Political (IP) course is necessarily embedded within this system-wide transformation. The central reform challenge lies in integrating the advantages of artificial intelligence (AI) without compromising the course's value orientation. From a macro perspective, this transformation reveals how intelligentization reshapes educational content, interpersonal relationships, and value formation (OECD, 2021).

2.1. The Paradigm Shift Toward Intelligentization in the Educational Ecosystem

As a general-purpose technology driving the advent of the "intelligent+" era, AI is catalyzing a comprehensive transformation in higher education—advancing from digitalization to networking, and ultimately to intelligentization. Its influence extends far beyond tool substitution; it is fostering a holistic reconstruction of knowledge production, learning modes, pedagogical relationships, and governance structures. From intelligent learning platforms and virtual simulation laboratories to large educational models and adaptive recommendation systems, AI technologies are redefining the architecture of contemporary education.

Learning paradigms are shifting from linear instruction to data-driven, inquiry-based, project-oriented, and immersive learning. The teacher–student relationship is evolving from one-way

knowledge transmission to human–machine collaboration and community-based knowledge co-creation. Simultaneously, teaching evaluation and educational governance are becoming increasingly refined, process-oriented, and traceable through real-time data and learning analytics.

Within this evolving context, Ideological and Political (IP) education—as a cornerstone course dedicated to moral cultivation—must not only preserve its value orientation and theoretical integrity but also respond proactively to the profound changes in students' cognitive patterns and media ecology. Under the guiding principle of value rationality, it is crucial to align technical rationality with educational objectives, thereby constructing a new human–machine co-education paradigm.

The essential reform question, therefore, is how to translate the perceptive, interactive, and computational strengths of AI into enhanced value guidance and educational effectiveness for IP courses—while ensuring that such applications remain interpretable, controllable, and accountable. This forms the core theoretical and practical proposition of ideological and political education in the age of artificial intelligence.

2.2. Structural Risks and Governance Challenges in the Intelligent Era

First, the reconfiguration of the attention economy and classroom order. Algorithm-driven, short-form, and fragmented information flows have reshaped students' media consumption habits. Sustained attention and deep reading are increasingly displaced by instant feedback and sensory stimulation. In this context, rational discussion and systematic reasoning within classrooms are weakened by the hyper-informational structure of modern learning environments. The resulting "attention deficit" not only limits teachers' ability to organize discourse and guide thematic progression but also undermines the depth of theoretical internalization and the stability of value identification among students. Consequently, Ideological and Political (IP) courses face a persistent imbalance between the density of knowledge and the rhythm of its expression.

Second, the proliferation of algorithmic "filter bubbles" and the rising complexity of value guidance. Platform algorithms amplify users' existing preferences through personalized recommendation systems, enclosing students within "echo chambers" that reinforce prior beliefs and weaken reflective reasoning. This narrows the discursive space for public deliberation. For IP education, such an information ecology creates a dual challenge: clarifying both factual judgments and value judgments. Teachers must counteract partial or biased cognition produced by data-driven mechanisms while reconstructing a shared framework of values within pluralistic narratives. As a result, the standards of evidence, reasoning pathways, and evaluative systems in teaching have become increasingly complex and demanding.

Third, the weakening of the teacher's role and the mismatch in competency structures. As AI delivers on-demand solutions for information retrieval, knowledge generation, and task completion, the teacher's traditional role as a knowledge mediator is gradually eroded. Classroom authority is shifting from knowledge scarcity to meaning construction. When teachers lack sufficient digital literacy and fail to evolve from "lecturers" into value-oriented mentors, a "second digital divide" emerges—one where technological resources are abundant but professional competence and ethical oversight remain insufficient. This imbalance fosters the

instrumentalization of teaching processes and the dominance of quantitative evaluation, thereby eroding the fundamental mission of IP education: to cultivate virtue and shape values.

3. The Mechanisms of Artificial Intelligence's Influence on Ideological and Political Education

The integration of artificial intelligence (AI) into education represents more than a technological upgrade. It constitutes a multidimensional transformation—driven by data mining, algorithmic recommendation, and scenario generation—that reshapes knowledge provision, learning models, and teacher–student relationships. Together, these shifts redefine the operational logic of ideological and political (IP) courses. At the cognitive level, learning analytics and adaptive technologies have revolutionized students' approaches to knowledge construction. Classrooms are evolving from one-way indoctrination and rote memorization to learning cycles centered on problem exploration, evidence-based reasoning, and reflective revision. At the discursive level, generative algorithms and recommendation mechanisms have restructured classroom discourse—from unilateral teacher exposition to multi-source co-construction among teachers, students, and intelligent systems. This interactive structure enhances students' sense of agency, participation, and epistemic engagement. At the relational level, the diffusion of intelligent tools and reorganization of teaching processes have weakened the teacher's traditional role as a sole knowledge intermediary, encouraging a transformation toward value guidance, instructional design, and data stewardship.

3.1. Transformation of the Cognitive Paradigm

The introduction of AI is dismantling the traditional cognition model centered on teacher lecturing and student memorization. Historically, classrooms depended on one-way instruction and passive reception, limiting students' ability to form coherent reasoning chains. Under AI's influence, classroom logic is shifting toward a cyclical learning process driven by problem-solving, empirical reasoning, and reflective refinement.

First, learning analytics and adaptive recommendation systems capture students' learning trajectories and cognitive challenges in real time, dynamically adjusting content according to conceptual complexity. This diagnostic–feedback–practice mechanism reduces redundancy and extraneous cognitive load, allowing more time for deep thinking and logical analysis.

Second, intelligent question–answer systems, knowledge graphs, and scenario generation tools contextualize abstract theories within authentic tasks and real-world issues. These systems guide students to engage in evidence-based reasoning and value-oriented judgment during problem-solving.

Third, AI can translate learning behaviors, discussion processes, and revisions into interpretable data chains, helping students develop metacognitive awareness as they formulate questions, collect data, construct explanations, and refine reflections. Through these mechanisms, students evolve from passive recipients to active explorers and meaning constructors. This

transformation deepens the cognitive rigor and logical coherence of IP courses, while fostering the joint cultivation of rational argumentation and conscious value awareness.

3.2. Reshaping of the Teaching Relationship

Artificial intelligence is pushing classrooms toward platformization, algorithmization, and generativity, transforming knowledge delivery from singular authority to diversified collaboration. With intelligent tools, students can independently pose questions, gather information, and generate preliminary answers, while teachers assume the roles of knowledge integrators and value calibrators. Consequently, classroom discourse shifts from one-way transmission to multi-source dialogue, jointly shaped by teachers, students, and intelligent systems. In this process, the teacher's role becomes even more critical. On one hand, teachers must apply academic judgment to correct algorithmic biases and filter informational noise, ensuring the accuracy of knowledge and the rigor of reasoning. On the other hand, they must exercise value leadership—elevating empirical narratives into theoretical insights and aligning technology-mediated discourse with Marxist positions and core socialist values. Thus, AI does not diminish the teacher's authority; rather, it reinforces the teacher's central role as a value interpreter and meaning constructor. This transformation propels IP education from unilateral indoctrination toward multi-source co-creation, cultivating an interactive, reflective, and value-oriented communicative environment..

3.3. Reshaping Pedagogical Relationships

As AI increasingly undertakes information retrieval, assessment, and routine learning tasks, the traditional authority of teachers—once grounded in knowledge scarcity—is eroding. Classroom authority has shifted from information provision to meaning production, prompting a fundamental redefinition of the teacher's role.

First, teachers must become value leaders. Through agenda-setting and evaluative criteria, they offer students clear and stable value orientations amid pluralistic narratives, ensuring that IP courses remain anchored in the cultivation of core socialist values.

Second, teachers must serve as instructional designers. Beyond content delivery, they should leverage data insights from AI to design learning tasks, organize peer evaluations, and plan cross-contextual knowledge transfer. By integrating online and offline, synchronous and asynchronous, and human–machine collaborative modalities, teachers can achieve holistic process optimization.

Third, teachers must act as data stewards. They should delineate data collection boundaries, establish ethical protocols, and uphold governance principles of interpretability, traceability, and accountability. These measures prevent the alienation of technology into tool worship or evaluative fetishism, preserving the humanistic integrity of education.

Only through this triadic transformation—encompassing value leadership, instructional design, and data governance—can teachers sustain their professionalism and irreplaceability in an AI-driven educational environment. Ultimately, the rise of artificial intelligence does not diminish the teacher's significance; rather, it elevates the threshold of competence, urging teachers to evolve from transmitters of knowledge into genuine constructors of value and meaning.

4. Practical Pathways for Empowering Ideological and Political Education through Artificial Intelligence

The value of artificial intelligence (AI) in education lies not merely in tool substitution but in its ability to employ data, algorithms, and contextual generation as key drivers for the systemic reconstruction of curriculum content, learning experiences, individualized support, and teacher competencies. For ideological and political (IP) education, its vitality depends on transforming technological potential into sustained gains in value guidance and competency development. This transformation requires a closed-loop mechanism linking content delivery with learning processes, individual support with faculty development, and ensuring that all innovations operate under institutionalized systems of quality assurance and ethical governance. Only through such an integrated and regulated framework can AI genuinely empower IP education to achieve both pedagogical effectiveness and value-oriented transformation.

4.1. Intelligent Updating and Dynamic Iteration of Classroom Content

Artificial intelligence offers IP courses end-to-end enhancement in topic selection, content organization, and knowledge expression. By applying learning analytics and public opinion data, teachers can precisely identify differences in students' value orientations, interests, and cognitive baselines—shifting lesson preparation from generalized forecasting to evidence-based alignment. Through knowledge graphs and text generation tools, the core concepts, fundamental principles, and contemporary practices of Xi Jinping Thought on Socialism with Chinese Characteristics for a New Era can be systematically integrated and presented within a unified logical framework, bridging theory and practice while reinforcing argumentative coherence and the timeliness of examples.

Building on this foundation, dynamic micro-adjustments to content depth and narrative complexity can be made using classroom interaction data and formative assessments, achieving continuous renewal and adaptive iteration—creating "teaching that evolves with context." Simultaneously, adherence to authoritative sources and standardized citation norms enables a dual mechanism of factual verification and value calibration, ensuring political reliability, theoretical rigor, and evidential verifiability within a coherent knowledge structure. Through these mechanisms, IP courses can achieve genuine resonance with contemporary social issues and alignment with students' developmental needs, thus realizing both theoretical vitality and pedagogical relevance.

4.2. Constructing Immersive Learning Experiences and Their Rational Transformation

Effective IP education requires that students generate meaning within perceptible contexts and consolidate consensus through reflective structures. The integration of AI with virtual and augmented reality technologies brings historical and contemporary issues into classrooms in experiential and scenario-based ways. Students may, for example, enter virtual reconstructions of wartime base areas during the Anti-Japanese War to engage in mission-based explorations, or participate in policy simulations and public deliberations on current governance challenges through role-playing and position statements. In such quasi-real environments, learners

experience value conflicts, evidence-based reasoning, and ethical decision-making, linking cognitive understanding with affective and moral engagement.

However, immersion is not the endpoint of instruction. Through teacher-guided debriefing and structured questioning, emotional resonance must be transformed into conceptual clarification and theoretical comprehension, forming a pedagogical chain that progresses "from narrative, to experience, to theory." Complementary multi-evidence assessments—including process-based assignments, peer evaluations, and oral defenses—make learning outcomes observable, interpretable, and traceable. This approach safeguards against technological spectacle and sensory overload, ensuring pedagogical integrity and promoting the rational internalization of values through reflective cognition rather than emotional stimulation alone.

4.3. Personalized Learning Support and Differentiated Guidance Mechanisms

The core value of AI lies in its capacity to facilitate data-driven individualized enhancement. By continuously analyzing students' learning trajectories, performance, and interaction behaviors, AI can generate tiered learning paths and task modules adapted to differences in prior knowledge and interest. This ensures both equitable attainment of learning standards and appropriately differentiated levels of challenge. Real-time questioning and automated feedback lower the threshold for help-seeking, while analytic learning reports identify shared difficulties and individual bottlenecks, providing teachers with a data-informed basis for targeted intervention.

At the level of value guidance, data-informed learner profiling helps reveal conceptual misconceptions and weaknesses in reasoning. Teachers can then organize focused discussions and supplement instruction with relevant cases, avoiding uniform and unreflective ideological transmission. Simultaneously, a robust system of academic integrity safeguards—including originality statements, citation norms, and plagiarism detection—serves as a baseline constraint. These measures, combined with open-book and evidence-based assessments, encourage the legitimate use of intelligent tools while preventing learning substitution and overreliance. In this way, the cultivation of competencies and the internalization of values advance in parallel, ensuring that technological empowerment reinforces rather than undermines the formative mission of IP education.

4.4. Transformation of Teachers' Professional Roles and Restructuring of Competency Frameworks

With the deep integration of AI in education, teachers' professionalism is no longer defined by information scarcity but by their capacity for meaning production and value interpretation. For IP education, teachers must complete a substantive transformation—from knowledge transmitters to value leaders, instructional designers, and data stewards.

At the value level, teachers should take responsibility for agenda-setting and evaluative thresholds, constructing analytical frameworks centered on public issues and guiding students to form stable yet open value orientations within pluralistic contexts.

At the instructional level, teachers should use data insights to design decomposable learning tasks, organize peer evaluations, and facilitate cross-contextual knowledge transfer. By coordinating online and offline, synchronous and asynchronous, and human–machine collaborative modes, teachers can achieve systemic optimization of instructional design.

At the governance level, teachers must define clear boundaries for data collection, specify legitimate uses, and uphold ethical red lines to ensure compliance with the principles of interpretability, traceability, and accountability. These measures prevent the over-quantification and instrumentalization of education, preserving its humanistic essence.

Accordingly, digital and ethical literacy has become a decisive factor in sustaining the vitality of IP education. The extent to which these competencies are cultivated determines whether AI can be transformed into a lasting source of ideological guidance and intellectual empowerment, ensuring that technological progress remains anchored in the moral mission of education.

5. Institutional Guarantees for Enhancing the Vitality of Ideological and Political Education in the Era of Artificial Intelligence

The deep integration of artificial intelligence (AI) into the educational system has ushered ideological and political (IP) courses into a stage of comprehensive restructuring—encompassing content delivery, pedagogical processes, evaluation mechanisms, and ethical governance. To transform technological potential into sustainable educational efficacy, institutional design must serve as the foundational driver. This involves building an interlocking policy and operational framework that reinforces key dimensions such as value orientation, collaborative mechanisms, resource ecosystems, teacher competency development, and regulatory compliance. Only through stable and systematic institutional support can IP education achieve sustainable development and enduring vitality, ensuring that technological innovation remains aligned with the moral and educational mission of cultivating virtue and shaping minds.

5.1. Principle Construction of Value Orientation

In a context where technical rationality coexists with value rationality, the foremost task of institutional design in IP education is to establish a normative order in which “values take precedence, and technology serves as an instrument.” The moral mission of education must be translated into binding requirements across curricular objectives, instructional implementation, and quality evaluation. Whether applied in algorithmic recommendation, scenario generation, or learning analytics, all technological uses must ultimately serve the interpretation of Marxist positions, viewpoints, and methodologies, and the cultivation of core socialist values—preventing formal innovation from displacing intellectual deepening. To achieve this, curriculum standards, teaching guidelines, and assessment criteria should explicitly define hierarchical indicators and evidentiary forms for value-oriented goals, ensuring that technological applications remain interpretable, auditable, and accountable. Such a system safeguards against the deviation of “technological prosperity and ideological hollowing,” preserving the essential purpose of IP education—to integrate technological progress with the enduring mission of moral and ideological formation.

5.2. Human–Machine Collaborative Education Mechanisms

At the institutional level, AI should function as an amplifier of teachers' professionalism rather than a substitute for it. The design of collaborative processes and role allocations must revolve around the interactive chain linking teachers, students, and intelligent systems. Supported by university-based "AI + Ideological and Political Education" experimental platforms, a closed-loop mechanism can be established covering lesson preparation, classroom teaching, assessment, and feedback. Within this structure, teachers lead topic selection and value interpretation; intelligent systems manage data processing, resource integration, and personalized recommendations; and students achieve active growth through task-based learning and peer evaluation. By clearly defining procedural standards and quality thresholds, such a mechanism both harnesses the efficiency dividends of technology and reinforces the teacher's irreplaceable role in meaning production and value leadership. Ultimately, it aligns efficiency enhancement with the moral mission of education, enabling human–machine synergy to advance both pedagogical innovation and ideological integrity.

5.3. Co-construction and Sharing of Digital Resource Repositories

The high-quality delivery of IP education depends on the creation of an authoritative, systematic, and dynamically updatable resource ecosystem. A three-tier "Digital Ideological and Political Education" repository—at the national, provincial, and inter-university levels—should be developed through graded co-construction and cross-domain sharing to prevent redundant development and resource fragmentation. Resource inclusion must follow the principles of political reliability, theoretical rigor, and data verifiability, supported by standardized metadata annotation, version control, and periodic review mechanisms. These measures ensure that textual, data-based, and multimodal materials maintain consistency in ideological orientation, academic integrity, and normative compliance. Through open licensing and usage evaluation, high-quality cases and practice-based materials can circulate precisely across different courses and teaching units, supporting continuous iteration under the pedagogical model of "shared content, differentiated design." This framework promotes the ongoing renewal of course content while ensuring that all resources collectively reinforce the intellectual depth, practical relevance, and ideological coherence of IP education.

5.4. Systematic Enhancement of Teachers' Digital Literacy

Teachers remain the decisive factor in determining whether AI can be effectively integrated into IP education. Capacity building should be implemented through regular training programs, interdisciplinary learning communities, and context-based workshops, forming a progressive development pathway comprising three stages: tool proficiency, collaborative innovation, and curriculum reconstruction. Digital literacy, ethical awareness, and data governance competence should be incorporated as core indicators in faculty recruitment, promotion, and performance appraisal. Training content must extend beyond technical application to strengthen understanding of algorithmic bias detection, evidence-based reasoning, and the boundaries of learning analytics—preventing two extremes: "technology available but unused" and "technology convenient but misused." Only when technological empowerment consistently serves value

guidance and competency development can AI integration genuinely advance the educational mission of moral cultivation and ideological enrichment.

5.5. Improvement of Institutional Norms and Compliance Safeguards

The integration of AI into education inevitably introduces challenges related to data security, privacy protection, and ethical governance. Policies and regulations should clearly define the scope of data collection, storage methods, and purposes of use, strictly enforcing principles such as data minimization, purpose limitation, informed consent, de-identification, and lifecycle management. A cross-departmental mechanism for supervision, risk assessment, and accountability tracing should be established to achieve comprehensive, element-wide, and scenario-based compliance oversight. At the same time, the principles of interpretability, traceability, and accountability must serve as baseline requirements for educational platforms and course quality assurance systems. These safeguards prevent the instrumentalization of evaluation and data utilitarianism, ensuring that technological applications remain consistent with both educational principles and political requirements. Within such a governance framework, the vitality of IP education can develop steadily and sustainably, maintaining its moral and intellectual integrity amid the rapid evolution of artificial intelligence.

6. Conclusions

The widespread adoption of artificial intelligence (AI) signifies the transition of education from digitalization to intelligentization. Its deep integration not only reshapes knowledge delivery and learning methods, but also introduces new imperatives for educational governance and value formation. As a core course dedicated to cultivating virtue and shaping character, ideological and political (IP) education serves both as a carrier of this transformation and a benchmark for evaluating its effectiveness. AI brings not only methodological and instrumental innovation but, more profoundly, drives a reconstruction of educational logic. The central challenge for IP education in the new era lies in integrating technological advantages while preserving a firm value orientation.

From a holistic perspective, the AI-enabled reconstruction of IP education unfolds across three interrelated dimensions. Cognitively, it promotes a transition from indoctrination and memorization to problem-driven inquiry and evidence-based reasoning, thereby strengthening the integration of knowledge transmission and value generation. Relationally, it transforms teachers from knowledge mediators into interpreters of value and constructors of meaning, reaffirming their irreplaceable professionalism within a human–machine collaborative framework. Institutionally, it calls for the establishment of a systemic architecture encompassing value leadership, resource co-construction, data governance, and compliance regulation, ensuring that technological applications consistently serve the moral mission of education rather than diverge from it.

Therefore, artificial intelligence does not diminish ideological and political education. Instead, through the productive tension it introduces, AI compels conceptual renewal and structural optimization. Only through the synergistic advancement of theoretical self-awareness, practical

innovation, and institutional safeguards can IP education sustain its vitality in the intelligent era and continue to fulfill its strategic mission of nurturing minds and shaping values.

Author Contributions:

Conceptualization, Y.W.; methodology, Y.W.; software, Y.W.; validation, Y.W.; formal analysis, Y.W.; investigation, Y.W.; resources, Y.W.; data curation, Y.W.; writing—original draft preparation, Y.W.; writing—review and editing, Y.W.; visualization, Y.W.; supervision, Y.W.; project administration, Y.W.; All authors have read and agreed to the published version of the manuscript.

Funding:

Not applicable.

Institutional Review Board Statement:

Not applicable.

Informed Consent Statement:

Not applicable.

Data Availability Statement:

Not applicable.

Conflict of Interest:

The authors declare no conflict of interest.

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The Development of Humanities and Social Sciences, 2025, 1(3), 112-121
https://doi.org/10.71204/86y9zq65

Practical Dilemmas and Optimization Paths of Innovation and Entrepreneurship Education in Higher Vocational Colleges under the Background of New Quality Productive Forces

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Received: 24 October 2025/ Accepted: 10 November 2025/ Published online: 11 November 2025

Abstract

Driven by technological innovation, new quality productive forces place higher demands on the overall competence of the labor force, thereby assigning new contemporary connotations and missions to innovation and entrepreneurship education in higher vocational colleges. This paper examines the practical challenges confronted by such education within this emerging context. The findings indicate several prominent issues: a misalignment between curriculum design and industrial needs, insufficient innovation and entrepreneurship capabilities among faculty, inadequate depth in practical training platforms and industry-education integration, and a limited guiding function of existing evaluation mechanisms. To address these challenges, this paper proposes a set of systematic optimization strategies: reconstructing the curriculum system based on the integrated development of science–education–industry; cultivating "dual-qualified" faculty who possess both theoretical knowledge and practical experience; building collaborative practical training platforms that involve government, industry, academia, research, and application sectors; and establishing diversified evaluation mechanisms that emphasize innovative outcomes. The study concludes that higher vocational colleges must actively align with the development requirements of new quality productive forces, deepen the reform of innovation and entrepreneurship education, and cultivate high-quality technical and skilled talents who demonstrate innovative thinking, entrepreneurial awareness, and creative problem-solving capabilities.

Keywords: New Quality Productive Forces; Higher Vocational Colleges; Innovation and Entrepreneurship Education; Practical Dilemmas; Optimization Paths

1. Introduction

At present, the world is experiencing a new wave of scientific and technological revolution and industrial transformation. Breakthroughs in artificial intelligence, big data, quantum information, and other frontier technologies are accelerating, giving rise to new quality productive forces—an economic paradigm driven by technological innovation, grounded in the enhancement of labor competence, and supported by emerging production factors such as data. During an inspection tour in Heilongjiang, President Xi Jinping first articulated this significant concept, emphasizing the need to "integrate scientific and technological innovation resources, lead the development of strategic emerging industries and future industries, and accelerate the formation of new quality productive forces" (Xinhua News Agency, 2024). The emergence and evolution of new quality productive forces signify a transition from traditional productivity to advanced productivity. Their core driving force lies in technological innovation, their key carrier is a modern industrial system, and their fundamental guarantee is the cultivation of a high-quality labor force.

As a vital component of China's higher education system, higher vocational colleges undertake the mission of cultivating high-caliber technical and skilled talents, exemplary craftsmen, and master-level artisans. They function as an essential "talent incubator" for regional economic development and industrial upgrading. In the context of the rapid development of new quality productive forces, societal demand for talent has shifted from traditional skill-based, execution-oriented roles to roles requiring innovation, interdisciplinarity, and developmental capacity. Innovation and entrepreneurship education (hereafter referred to as "dual-innovation" education) is a critical means to foster innovative thinking and entrepreneurial competence, and it directly influences whether higher vocational colleges can effectively support the talent needs associated with new quality productive forces.

However, current practices of dual-innovation education in many higher vocational colleges still face multiple challenges concerning educational philosophy, instructional models, curriculum content, and teaching methods, which are misaligned with the demands of new quality productive forces. Therefore, analyzing these practical dilemmas and exploring scientifically grounded and feasible optimization strategies is not only necessary for deepening educational reform in higher vocational colleges, but also an urgent task for serving national strategic goals and promoting high-quality economic and social development. This paper will conduct a systematic investigation centered on these core issues.

2. The Intrinsic Logical Connection Between New Quality Productive Forces and Innovation and Entrepreneurship Education in Higher Vocational Colleges

There is a profound internal logical relationship between new quality productive forces and innovation and entrepreneurship education in higher vocational colleges, with the two mutually reinforcing and promoting each other.

First, new quality productive forces provide a new direction and value orientation for innovation and entrepreneurship education. They emphasize high-tech, high-efficiency, and high-quality industrial sectors such as artificial intelligence, biomanufacturing, and commercial

aerospace. This requires higher vocational colleges to break away from traditional models of innovation and entrepreneurship education, shifting the focus from general entrepreneurial knowledge dissemination to fostering technological innovation and the commercialization of scientific achievements, particularly in strategic emerging and future-oriented industries. As Zhou Wenqing argues, vocational education must adapt to industrial transformation: "Program offerings, curriculum content, and instructional methods require systematic restructuring to meet the new demands on talent knowledge structures and competencies brought about by the development of new quality productive forces" (Zhou, 2025). Therefore, innovation and entrepreneurship education is no longer a peripheral "supplement," but a core component in cultivating the talent structure required by new quality productive forces.

Second, innovation and entrepreneurship education injects vitality into the development of new quality productive forces. Since the essence of new quality productive forces is "innovation," and innovation ultimately relies on human initiative and creativity, cultivating innovative talent is crucial. Through innovation and entrepreneurship education, higher vocational colleges can stimulate students' innovative thinking, strengthen their ability to identify and solve practical problems, and enable them to become not only users of technology, but also improvers, innovators, and even creators of technology. These technically skilled talents with "dual-innovation" capabilities form the frontline force in promoting technological progress, process optimization, and business model innovation in enterprises. They act as "catalysts" for transferring scientific and technological achievements from laboratories to industrial production, integrating professional knowledge with market needs, conducting micro-innovations and small-scale inventions, and even establishing technology-based enterprises—thereby directly contributing to the formation and enhancement of new quality productive forces (Lü and Liang,2025).

Finally, both are aligned with the broader goal of promoting high-quality development. Whether advancing the formation of new quality productive forces or deepening innovation and entrepreneurship education, the ultimate purpose is to support high-quality economic and social development. Through high-standard innovation and entrepreneurship education, higher vocational colleges can cultivate talent more closely aligned with industrial upgrading needs, enhance employment quality, create new forms of work opportunities, and promote the comprehensive development of individuals at the micro level while improving national innovation capacity and core competitiveness at the macro level (Ma and He, 2024).

3. Practical Dilemmas of Innovation and Entrepreneurship Education in Higher Vocational Colleges under the Background of New Quality Productive Forces

Under the high requirements of new quality productive forces, the shortcomings of the traditional innovation and entrepreneurship education model in higher vocational colleges are becoming increasingly apparent, mainly facing the following four dilemmas.

3.1. Disconnect Between Curriculum System and Industrial Needs, Outdated and Rigid Content

The curriculum serves as the primary vehicle for talent cultivation. However, the current innovation and entrepreneurship curriculum systems in many higher vocational colleges exhibit evident delays and fragmentation. On one hand, course content still centers on general knowledge modules such as Entrepreneurship Fundamentals, Marketing, and Company Law, lacking substantive integration with specialized disciplines and emerging technologies (Gan et al, 2025). As a result, the curriculum fails to reflect the demands of new quality productive forces for digital, intelligent, and green competencies. The knowledge students acquire is thus disconnected from real-world industrial scenarios and technological frontiers.

On the other hand, the curriculum structure remains compartmentalized, with innovation and entrepreneurship courses and professional courses often operating independently of one another. As Huang Hui, Deputy Director of the Ministry of Education's Vocational Education Development Center, has noted, "In some vocational colleges, innovation and entrepreneurship education exists externally to the professional talent training system, lacking organic integration with professional education, which significantly diminishes educational effectiveness." This separation makes it difficult for students to internalize innovative thinking within their disciplinary learning processes, and prevents them from applying their professional skills meaningfully in innovation and entrepreneurship practices.

3.2. Insufficient "Innovation and Entrepreneurship" Capability of Teaching Staff, Homogeneous Structure

Teachers are the foundation and source of vitality for education. The success of innovation and entrepreneurship education in higher vocational colleges hinges on the teachers. However, the current teaching staff faces the dilemma of being "dual-qualified" but not proficient in "innovation and entrepreneurship." While most professional teachers possess solid theoretical expertise in their fields, they lack enterprise work experience and real entrepreneurial experience. Their understanding of practical knowledge such as market dynamics, business models, and financing channels is often superficial, leading to "armchair theorizing" in teaching. Conversely, the few teachers dedicated to innovation and entrepreneurship education often lack professional backgrounds in specific industrial fields, making it difficult for them to guide students in high-tech innovation projects (Tian and Ma, 2025). This structural contradiction renders the teaching staff inadequate for the compound teaching tasks combining "technology + innovation" required under the background of new quality productive forces. Research by numerous scholars also confirms that "insufficient enterprise practical experience and the need for improvement in technological R&D and innovation capability are key bottlenecks constraining the quality of the 'dual-qualified' teaching staff in vocational colleges."

3.3. Insufficient Depth of Practical Platforms and Industry-Education Integration, Weak Collaborative Education

Practice is the sole criterion for testing truth and the lifeblood of innovation and entrepreneurship education. Although most higher vocational colleges have established practical

platforms such as business incubators and maker spaces, most of these platforms have singular functions, primarily providing basic office space and simple policy consulting, and lack high-value-added services such as technical support, pilot-scale testing, and market connection. More importantly, industry-education integration and school-enterprise cooperation often remain at a superficial level, such as "signing agreements," "hanging plaques," and "short-term internships," failing to form a "community of shared future with intertwined interests." The lack of motivation and clear channels for enterprises to participate in innovation and entrepreneurship education results in students having limited exposure to real enterprise R&D processes and business environments (Yu and Zhang, 2024). Consequently, their innovation projects often "operate in isolation" and have very low market conversion rates. This "hollowing out" of practical platforms and "superficiality" of industry-education integration deprive innovation and entrepreneurship education of a solid practical foundation.

3.4. Weak Guidance of Evaluation Mechanisms, Lack of Incentive Effect

Evaluation functions as the “baton” that guides the direction of education. However, the current evaluation mechanisms for innovation and entrepreneurship education in higher vocational colleges still present several shortcomings. First, evaluation criteria remain overly singular, relying primarily on quantitative indicators such as course grades and competition awards, while placing insufficient emphasis on process-oriented and outcome-based dimensions—including students’ innovative thinking, practical application abilities, and the effectiveness of project incubation. Second, evaluation stakeholders are relatively homogeneous, with assessments mainly conducted within the institution. The absence of participation from external entities such as industry enterprises, entrepreneurship mentors, and investment institutions limits the validity and market relevance of evaluation results, making it difficult for them to reflect true societal and industrial recognition. Third, the utilization of evaluation results is inadequate. Evaluation outcomes are not effectively integrated into teachers’ professional title assessment, performance appraisal, or students’ credit recognition, awards, and honor systems. Consequently, both teachers and students lack strong intrinsic motivation to engage deeply in innovation and entrepreneurship activities. This evaluation mechanism, which tends to “emphasize form over substance,” significantly weakens the incentive and guiding functions of innovation and entrepreneurship education, thereby hindering its role in cultivating high-quality technical and skilled talent that meets the requirements of new quality productive forces.

4. Optimization Paths for Innovation and Entrepreneurship Education in Higher Vocational Colleges under the Background of New Quality Productive Forces

To address the aforementioned dilemmas, higher vocational colleges must orient themselves towards the development needs of new quality productive forces and undertake systematic and deep-seated reforms and innovations.

4.1. Restructuring the Curriculum System Centered on the Integration of "Science-Education-Industry"

Curriculum reform is the breakthrough point. Higher vocational colleges should break down disciplinary barriers and construct an integrated "science-education-industry" curriculum system that deeply merges technological innovation, professional education, and industrial needs.

(1) Content Update: Integrate knowledge, technologies, and case studies related to new quality productive forces, such as artificial intelligence, industrial internet, and green low-carbon development, into innovation and entrepreneurship courses. Develop modular course packages combining "major + innovation and entrepreneurship." For example, offer courses like "Innovative Design and Entrepreneurship of Intelligent Equipment" for mechatronics majors and "Data-Driven Business Model Innovation" for e-commerce majors.

(2) Model Innovation: Fully implement Project-Based Learning (PBL) and case teaching methods. Use real enterprise technical challenges or market pain points as project sources. Form interdisciplinary student teams who, under the joint guidance of teachers and enterprise mentors, complete the entire process from market research and technical solution design to prototype development and business plan writing.

(3) System Integration:Fully integrate innovation and entrepreneurship education into the talent training plan, achieving coherence from the "first classroom" to the "second classroom." Clearly define the cultivation objectives for innovative thinking and entrepreneurial ability within professional courses. Set innovation tasks during practical training and internships. Strengthen innovation and entrepreneurship practice through club activities, social practice, and skills competitions, forming an educational pattern involving all individuals, throughout the entire process, and across all aspects.

In response to the demands of new quality productive forces for intelligent technologies, Shenzhen Polytechnic took the lead in implementing the "AI + Majors" innovation and entrepreneurship curriculum reform. It integrated artificial intelligence and industrial internet into majors such as mechatronics and e-commerce, developing modular courses like "Innovative Design of Intelligent Equipment" and "Data-Driven E-Commerce Operations." The college adopted a "real-world enterprise projects + interdisciplinary teams" model—collaborating with Huawei and JingDong on themes such as "optimization of smart factory equipment" and "user growth for cross-border e-commerce platforms." These projects were jointly guided by academic instructors and enterprise engineers.

Over the past three years, students have developed 12 innovative outcomes based on course projects, three of which won provincial "Internet Plus" competition awards, and two projects were incubated in the college’s pilot base for technological commercialization. This case fully demonstrates how the integration of "science-education-industry" enhances students' innovation and practical capabilities.

4.2. Cultivating a "Dual-Qualified and Dual-Abled" Teaching Faculty

(1) Internal Cultivation and External Introduction: Implement a "Teacher Enterprise Practice Empowerment Plan," establish special funds to support professional teachers in undertaking posts for practical training or technical research for over six months in leading enterprises, high-tech firms, and research institutes, allowing them to personally participate in R&D and project incubation. Simultaneously, flexibly introduce a group of entrepreneurs, investors, technical experts, and outstanding alumni to serve as industry professors or entrepreneurship mentors, deeply involved in curriculum teaching and project guidance.

(2) Team Building: Establish "tripartite structure" teaching teams composed of professional teachers, innovation/entrepreneurship teachers, and industry mentors to jointly develop courses, guide projects, and evaluate outcomes. Through teamwork, compensate for the knowledge gaps of individual teachers and achieve complementary advantages.

(3) Incentive Mechanisms: Reform teacher evaluation and promotion systems. Incorporate teachers' contributions in guiding student innovation and entrepreneurship projects, commercializing technological achievements, and serving enterprise innovation into important indicators for performance assessment and professional title evaluation, thereby stimulating teachers' enthusiasm and creativity in engaging with innovation and entrepreneurship education.

Zhejiang Financial College implemented the "Financial Craftsman Cultivation Program." On one hand, it dispatched faculty from FinTech and Accounting majors to undertake practical training at Ant Group and Pan-China Certified Public Accountants, participating in projects such as blockchain-based financial product design and corporate financial digital transformation. On the other hand, the college flexibly recruited 15 industry mentors, including blockchain experts from Ant Group and CPAs from Pan-China, to form tripartite teams comprising "professional instructors, innovation/entrepreneurship teachers, and industry mentors."

Over the past two years, these teams have guided students in completing eight innovation projects, including "Blockchain-based Supply Chain Finance for SMEs" and "Intelligent Financial Robots." Two of these projects were approved at the provincial-level Innovation and Entrepreneurship Training Program. Additionally, faculty members were honored with the "Zhejiang Technical Expert" award, effectively addressing the challenge of "dual-qualified teachers lacking innovation and entrepreneurship capabilities."

4.3. Building Collaborative "Government-Industry-University-Research-Application" Practical Platforms

Platforms serve as foundational support. Higher vocational colleges should take proactive measures and collaborate with government, industry, and research institutions to construct comprehensive and efficiently operated “government–industry–university–research–application” collaborative platforms for talent cultivation.

(1) Substantive Construction: Existing on-campus makerspaces and incubators should be upgraded by introducing small-scale pilot production lines, testing equipment, and other facilities, thereby forming integrated, full-chain incubation systems that connect makerspace → incubator

→ accelerator. Meanwhile, colleges should jointly establish “Industry Colleges” or “Future Technology Colleges” with local governments and industrial parks, promoting the organic alignment of the education chain, talent chain, industrial chain, and innovation chain.

(2) Project-Based Operation: A project-driven operation mechanism should be implemented under the principle of “enterprises propose problems, universities explore solutions, and the market evaluates outcomes.” The college should regularly collect enterprises’ technological demands and innovation topics and publicly release them for faculty and students to undertake. The college provides space, equipment, and seed funding; enterprises offer technical mentorship and market resources; achievements are jointly shared and risks are co-managed, thereby enhancing the practicality and application value of innovation outcomes.

(3) Ecological Cultivation: Financial resources such as angel investment and venture capital should be actively introduced. Regular project roadshows and investment-matching events should be organized to create financial support pathways for student innovation projects. Additionally, partnerships with professional service institutions in intellectual property, law, and finance should be strengthened to provide one-stop support for student entrepreneurship, thereby fostering a robust innovation and entrepreneurship ecosystem.

Jiangsu Vocational College of Economics and Trade collaborated with the Nanjing Jiangning High-Tech Zone Management Committee and the Jiangsu Association of Artificial Intelligence to establish the "Smart Industry Innovation and Entrepreneurship Park." They created an integrated platform spanning "makerspace-incubator-accelerator," equipped with an IoT pilot line and intelligent product testing facilities. The platform implements a mechanism where "enterprises pose challenges, and the college devises solutions." For instance, in partnership with Suning Tesco, it identified the need to "optimize intelligent retail terminals." Student teams conducted research and designed a "vision recognition-based restocking system for unmanned smart cabinets." Simultaneously, angel investment institutions were introduced to provide seed funding for outstanding projects, achieving deep integration of the educational and industrial chains.

4.4. Establishing a Diversified Evaluation Mechanism Guided by Innovative Outcomes

Evaluation serves as an essential guarantee, and higher vocational colleges must reform their evaluation mechanisms to ensure that this “baton” plays its proper guiding role.

(1) Diversified Evaluation Criteria: A comprehensive evaluation system should be established that integrates the dimensions of knowledge, ability, and outcomes. On the basis of assessing students’ mastery of theoretical knowledge related to innovation and entrepreneurship, greater emphasis should be placed on evaluating their innovative thinking, teamwork skills, and practical application abilities. Meanwhile, tangible innovative outcomes—such as patent applications, academic publications, project implementation, company establishment, and acquisition of investment—should be used as core evaluation indicators.

(2) Diversified Evaluation Subjects: A multi-stakeholder evaluation committee should be formed, consisting of university instructors, enterprise mentors, industry experts, and representatives from investment institutions. This committee should conduct multi-perspective

and comprehensive evaluations of students' innovation and entrepreneurship projects to enhance the objectivity, professionalism, and market orientation of evaluation results.

(3) Diversified Utilization of Evaluation Results: The outcomes of innovation and entrepreneurship evaluations should be closely linked to students' credit recognition, scholarship selection, and postgraduate recommendation opportunities. Meanwhile, they should also be integrated into teachers' performance assessments, commendation systems, and professional title promotions. In addition, establishing a "Innovation and Entrepreneurship Achievement Commercialization Award" can provide strong recognition and incentives to teacher-student teams that achieve significant accomplishments, thereby fostering a clear value orientation that respects innovation and emphasizes value creation.

5. Conclusion

The rise of new quality productive forces has created unprecedented development opportunities for higher vocational colleges, while also posing significant challenges. As a critical link between education and the economy, as well as between theory and practice, the reform and enhancement of innovation and entrepreneurship education has become an essential pathway for higher vocational colleges to respond to these evolving demands. In the face of practical difficulties—such as misalignment between curriculum and industry needs, insufficient faculty capacity, weak practical training platforms, and outdated evaluation systems—higher vocational colleges must adopt systematic and holistic reform strategies. Specifically, advancing reform requires restructuring the curriculum around the integrated development of science–education–industry, cultivating a "dual-qualified and dual-capable" faculty with both theoretical literacy and practical expertise, constructing collaborative practical training platforms across government–industry–university–research–application sectors, and establishing diversified, outcome-oriented evaluation mechanisms. Through these measures, higher vocational colleges can build a new ecosystem for innovation and entrepreneurship education that aligns with the developmental logic and talent demands of new quality productive forces. Only by doing so can higher vocational colleges effectively fulfill their mission of cultivating high-quality technical and skilled professionals equipped with innovative awareness, entrepreneurial capability, and creative potential, thereby contributing the vital "strength of vocational education" to accelerating the formation of new quality productive forces and advancing Chinese modernization.

Author Contributions:

Conceptualization, L. L. and X. C.; methodology, L. L. and X. C.; software, L. L. and X. C.; validation, L. L. and X. C.; formal analysis, L. L. and X. C.; investigation, L. L. and X. C.; resources, L. L. and X. C.; data curation, L. L. and X. C.; writing—original draft preparation, L. L. and X. C.; writing—review and editing, L. L. and X. C.; visualization, L. L. and X. C.; supervision, L. L. and X. C.; project administration, L. L. and X. C.; All authors have read and agreed to the published version of the manuscript.

Funding:

Not applicable.

Institutional Review Board Statement:

Not applicable.

Informed Consent Statement:

Not applicable.

Data Availability Statement:

Not applicable.

Conflict of Interest:

The authors declare no conflict of interest.

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The Development of Humanities and Social Sciences, 2025, 1(3), 122-134
https://doi.org/10.71204/y4zs4259

Internationalization Strategies in Chinese Higher Education: Balancing Global Integration and National Identity

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Received: 2 Novembe 2025 / Accepted: 15 Novembe2025 / Published online: 16 November 2025

Abstract

China′s higher education system has rapidly expanded and pursued vigorous internationalization since the late 20th century, aiming to enhance global competitiveness while preserving national identity. This study examines the strategies employed by Chinese universities to integrate into the global academic community and the measures taken to maintain China′s cultural and ideological integrity. The analysis, grounded in policy review and literature, finds that Chinese higher education institutions have adopted a multifaceted approach: aggressively promoting outbound and inbound student mobility, forging international research collaborations, establishing joint programs and branch campuses, and implementing English-medium instruction to achieve global integration. Simultaneously, authorities emphasize national identity through curricula infused with Chinese culture and socialist values, tightened ideological oversight, and policies branding "internationalization with Chinese characteristics." The results reveal a dynamic balancing act – Chinese universities are largely pragmatic and eclectic in learning from Western models while adapting them to local contexts. The discussion highlights successes (e.g. improved world rankings, increased foreign enrollment) and tensions (e.g. balancing academic openness with ideological guidance, "brain drain" versus "brain gain") in this balancing process. The conclusion reflects on how China′s global engagement in higher education can coexist with its desire to safeguard national sovereignty and cultural heritage. This study contributes to understanding the Chinese model of internationalization, offering insights for policymakers and academic leaders on managing the interplay between global forces and national priorities in higher education reform.

Keywords: Internationalization; Chinese Higher Education; Global Integration; National Identity; Education Policy; Cultural Identity

1. Introduction

Higher education internationalization is commonly defined as the process of integrating an international and intercultural dimension into teaching, research, and service functions of universities (Knight, 2004). Over the past four decades, China′s higher education system – now one of the world′s largest – has undergone dramatic internationalization as part of the nation′s broader "reform and opening-up" policy initiated in 1978 (Huang, 2003; Yang, 2014). Chinese universities today actively pursue global engagement to enhance their academic quality and prestige, reflecting the worldwide trend of globalization in higher education (Altbach & Knight, 2007; Mok, 2007). At the same time, the Chinese university leaders stress the importance of maintaining a strong national identity and socialist values within this internationalization process (Yang, 2010; Zhou, 2016). The interplay between global integration and national identity has therefore become a defining feature of China′s higher education strategy.

In the decades following the launch of economic reforms, China prioritized higher education as a vehicle for national development and global competitiveness (State Council, 2010). Policies such as the "211 Project" and "985 Project" in the 1990s–2000s, and the more recent "Double First-Class" initiative, explicitly aim to cultivate world-class universities and research programs (Mohrman, 2008; Liu & Cheng, 2005). Internationalization has been a key means to this end – Chinese universities have been encouraged to adopt international curricular standards, publish in international journals, host and attend global conferences, and attract foreign talent (Altbach & Knight, 2007; Luo & Welch, 2021). By 2020, China was sending hundreds of thousands of students overseas annually and had become Asia′s top destination for international students, reflecting deliberate policy efforts to increase academic mobility (Ministry of Education, 2016; Zha, Wu, & Hayhoe, 2019). These trends underscore China′s integration into the global knowledge network and its ambition to be a leading higher education power.

Pursuing global integration raises questions about how Chinese higher education can simultaneously uphold national character, including language, culture, and political ideology (Tian & Lowe, 2014; Yang, 2014). Chinese leaders emphasize that universities must "remain socialist in orientation" even as they internationalize, guarding against what they perceive as undue Western influence or erosion of socialist ideals (Zhou, 2016). This balance between openness and safeguarding national interests represents a strategic dilemma: How can Chinese universities achieve world-class status and global integration without compromising the country′s educational sovereignty and cultural identity?

Existing research offers insight into this dilemma. Knight (2012) categorizes rationales for internationalization (academic, economic, political, socio-cultural), all of which are evident in China′s case: academically, China seeks improved quality and innovation; economically, skilled human capital and global reputation; politically, soft power and diplomatic influence; and socio-culturally, exposure to global ideas (Knight, 2012; Qiang, 2003). Studies also note the Chinese strong steering role in internationalization, ensuring that initiatives serve national goals (Yang, 2014; Shen & Wu, 2018). As a result, China′s approach may differ from Western

paradigms – some scholars speak of "internationalization with Chinese characteristics," wherein global best practices are adopted selectively and blended with indigenous elements. This article builds on such literature by examining the concrete strategies Chinese higher education employs to navigate the dual imperatives of global engagement and national identity preservation.

The aim of this study is to analyze how Chinese higher education institutions balance the drive for global integration with the mandate to uphold national identity. We review major internationalization strategies in Chinese universities and discuss their implementation against the backdrop of cultural and policy constraints. Section 2 outlines the methodology, including data sources and analytical approach. Section 3 presents results, categorizing key internationalization strategies and identity-preservation measures. Section 4 provides a discussion, interpreting the findings in light of theoretical and practical implications. Section 5 concludes with reflections on future prospects for Chinese higher education amid global and national forces. By elucidating China's experience, this analysis can inform other countries and stakeholders interested in how higher education systems might globalize on their own terms.

2. Methodology

This article is based on a qualitative policy analysis and literature review. The research process involved two primary methods: document analysis of official policies and university strategies related to internationalization, and systematic literature review of scholarly studies on Chinese higher education internationalization.

2.1. Document Analysis Method

Key policy documents from the Chinese were examined to identify stated goals and regulations regarding internationalization. These included the Outline of China's National Plan for Medium- and Long-Term Education Reform and Development (2010–2020) (State Council, 2010), the Education Action Plan for the Belt and Road Initiative (Ministry of Education, 2016), and various directives on Sino-foreign cooperative universities, study-abroad scholarship programs, and curriculum guidelines. University-level strategic plans from a selection of leading Chinese universities (e.g., Peking University, Tsinghua University) were also reviewed to see how institutions interpret and implement internationalization goals. The document analysis focused on identifying recurring themes: initiatives to promote global integration (such as partnerships, international student recruitment, faculty exchanges) and mandates to reinforce national identity (such as ideological education requirements, use of Chinese language, cultural programs).

2.2. Literature Review Method

To contextualize and critique the policy intentions, a review of English and Chinese-language To contextualize and critique the policy intentions, a review of English- and Chinese-language scholarly literature was conducted. We surveyed over 40 academic sources, including journal articles, books, and research reports, on topics such as the internationalization of Chinese higher education, comparative education policy, transnational education, and cultural/ideological aspects of education (Huang, 2003; Yang, 2014; Zha et al., 2019). Both qualitative studies (e.g., case

studies of specific universities or programs) and quantitative studies (e.g., enrollment statistics, ranking outcomes) were included to gain a comprehensive picture. Special attention was given to literature addressing the tension or interplay between global and local dimensions – for instance, works that discuss whether internationalization in China equals Westernization (Tian & Lowe, 2014), how China projects soft power through education (Pan, 2013; Yang, 2010), and how Chinese cultural/ideological elements are preserved in an era of globalization (Zhou, 2016).

This combined methodology is appropriate for the exploratory and interpretive nature of the research question. Rather than testing a hypothesis, the goal is to synthesize evidence from policy and practice to understand a complex phenomenon. The document analysis grounds the study in concrete measures and official stances, while the literature review provides multiple perspectives and critiques, helping to identify gaps between policy and implementation ("enactment gap") noted by some scholars (Rizvi, 2011). No human subjects were involved, so ethical review was not required (thus sections on IRB and consent are not applicable). Instead, reliability was sought through triangulation of sources – corroborating findings across policy documents, statistical data, and independent academic analyses.

The analysis procedure was iterative. Policy documents were first coded for major themes (e.g., academic partnerships, curriculum internationalization, political education). Next, literature findings were mapped onto these themes to see how they reinforce or challenge the official narrative. For instance, if a policy touted increasing foreign student enrollment for cultural exchange, we checked enrollment data and studies on international student experiences in China (Wen & Hu, 2019) to assess outcomes and challenges. This approach allowed us to construct a layered understanding of each strategy: the intended goals, the practical implementation, and any tensions observed by researchers. The results (Section 3) are organized around the main clusters of strategies identified, each discussed with support from both policy evidence and scholarly research. While not a statistical analysis, this method provides depth and context, yielding insights into how and why Chinese higher education is attempting to balance global and national demands.

3. Results

3.1. Strategies for Global Integration

(1) International Student and Scholar Mobility

One of China's foremost internationalization strategies is promoting mobility of students and scholars. China has massively expanded study-abroad programs for its citizens and concurrently developed schemes to attract foreign students to Chinese campuses. Outbound mobility is encouraged through government scholarships like the China Scholarship Council programs, which fund tens of thousands of Chinese students and academics to study or train abroad (Pan, 2011). This is driven by the belief that international experience will produce globally competent talent and foster knowledge transfer upon return (Qiang, 2003). At the same time, inbound mobility has surged – by the late 2010s China was hosting over 490,000 international students

annually, making it the third-largest host country globally (Ministry of Education, 2019). Policies such as Study in China 2020 set targets for recruiting foreign students, especially in science and engineering fields, and universities established international colleges to offer programs in English (Wen & Hu, 2019). This two-way flow is intended to integrate Chinese higher education into global academic networks and enhance cultural exchange. However, managing quality and integration for the growing international student body remains a challenge; researchers have noted issues such as language barriers, limited cross-cultural interaction on campuses, and a need for better support services (Wen & Hu, 2019; Wu & Zha, 2018).

(2) Transnational Partnerships and Branch Campuses

Chinese universities have actively pursued partnerships with foreign institutions as a fast track to global engagement. Since the 1990s, China enabled Sino-foreign cooperative education ventures, wherein domestic and overseas universities jointly establish programs or even independent joint campuses (Ministry of Education, 2016). Notable examples include University of Nottingham Ningbo China and NYU Shanghai – fully accredited universities in China operated in partnership with UK or US counterparts. By 2020, there were more than 2,300 joint programs or institutes in China (Wang & Zhou, 2015), ranging from dual-degree programs to extensive branch campuses. These partnerships bring international curricula, pedagogies, and faculty into Chinese settings, aiming to "internationalize at home" for those students who do not go abroad (Galloway et al., 2020). They also signal China's openness and ability to collaborate within global higher education. The Chinese supports high-profile collaborations as a way to benchmark against world-class standards and to internationalize its talent pool (Yang, 2014; Shen & Wu, 2018). Nonetheless, managing these partnerships involves balancing differing educational cultures and expectations. Both sides must negotiate governance approaches to meet each partner's standards while aligning with regulatory requirements.

(3) Curriculum Internationalization and EMI

Another strategy is the internationalization of curriculum and adoption of English-Medium Instruction (EMI) in Chinese universities. To prepare graduates for global careers and attract international students, many institutions have introduced English-taught degree programs, especially at the master's and doctoral levels (Galloway et al., 2020). For example, leading universities now offer MBA programs, engineering courses, and even some undergraduate majors entirely in English. The use of English as a lingua franca in academia is seen as essential for integrating into global scholarly discourse and improving university rankings. Alongside EMI, universities are revising curricula to include more global content – such as courses on international law, global business, or comparative studies – and using internationally recognized textbooks and teaching materials (Huang, 2003; Knight, 2012). Faculty development programs encourage Chinese professors to improve their English proficiency and incorporate international perspectives in teaching (Luo & Welch, 2021). These efforts have yielded results: an increase in internationally co-authored publications and a growing presence of Chinese institutions in world university rankings indicate better global academic integration (Liu & Metcalfe, 2016; Shen & Li, 2015). However, researchers caution about the "Englishization" phenomenon – while EMI can

enhance competitiveness, it may also sideline the Chinese language in advanced education and pose learning difficulties for domestic students (Galloway et al., 2020). Some faculty and students report challenges in fully engaging with content in a non-native language, suggesting a need to balance English use with bilingual support to maintain teaching effectiveness.

(4) Research Collaboration and Talent Programs

China has invested heavily in global research collaboration as part of its internationalization toolkit. Top universities have established international joint research centers and laboratories with partners abroad, focusing on areas from nanotechnology to climate change. Participation in international research projects and consortia (e.g., CERN, large-scale STEM collaborations) has increased markedly (Liu & Metcalfe, 2016). Furthermore, national talent recruitment initiatives like the "Thousand Talents Plan" (launched in 2008) aggressively recruit foreign experts and overseas Chinese scholars to work in China's universities and research institutes. These programs offer generous funding and prestigious appointments to attract global talent in support of China's innovation drive. The inflow of returnee scholars (haigui) and foreign faculty has helped Chinese universities internationalize their research culture and PhD training, leading to a rise in high-impact publications (Luo & Welch, 2021). Collaborations are evident in the steady growth of internationally co-authored papers involving Chinese scientists, which reflects deeper integration into global knowledge production (Marginson, 2011; Shen & Wu, 2018). On the flip side, concerns about a "brain drain" – the loss of top Chinese students and scholars who remain abroad – have driven policies to incentivize returnees through grants, housing, and career opportunities (Qiang, 2003; Pan, 2011). Recent assessments suggest China is making progress in turning "brain drain" into "brain circulation" or even "brain gain," as many Western-trained Chinese academics come back to take up roles in domestic universities (Chen & Huang, 2013). Nonetheless, integrating foreign faculty into Chinese campuses can pose cultural and institutional challenges, including language barriers and differences in administrative processes (Luo & Welch, 2021).

(5) Participation in Global Networks and Benchmarking

Chinese higher education's global integration is also pursued through active participation in international consortia and adoption of global benchmarks. Many Chinese universities have joined international networks (such as the Association of Pacific Rim Universities, APRU, or the International Association of Universities) to share best practices and increase visibility. China hosts and attends major global higher education forums and uses these platforms to project a more international image of its universities (Yang, 2014). Additionally, global rankings and accreditation systems serve as yardsticks for Chinese institutions. The pursuit of AACSB or ABET accreditation for certain programs, for instance, has been used to signal quality by international standards. TheDouble First-Cl ass initiative explicitly uses global rankings metrics and peer review to identify and fund elite institutions (Shen & Jiang, 2019). This benchmarking has spurred Chinese universities to emulate top global universities in governance and output (Liu & Cheng, 2005; Mohrman, 2008). While this can drive improvement, critics argue it also creates pressure to conform to Western criteria of excellence, potentially at the expense of attention to

local needs (Rizvi, 2011). China's policymakers appear aware of this and have called for "building world-class universities with Chinese characteristics," indicating a desire to not simply replicate Harvard or Oxford, but to develop globally competitive institutions rooted in Chinese context (Yang, 2014).

3.2. Measures to Preserve National Identity

Despite the strong push for internationalization, Chinese higher education has simultaneously implemented measures to reinforce national identity, ideology, and cultural heritage within the sector. These measures ensure that global engagement does not lead to what some in China fear as "Westernization" or loss of socialist orientation (Tian & Lowe, 2014; Yang, 2010).

(1) Ideological Education and Curriculum Content

A prominent feature of China's universities is the required curriculum in ideological and political theory. All students, including those in joint venture universities and foreign students studying in China, are generally expected to take courses on Marxism, Mao Zedong Thought, Deng Xiaoping Theory, and Xi Jinping's Thought on Socialism with Chinese Characteristics (Zhou, 2016). The Ministry of Education mandates these courses to instill core socialist values and patriotic education. In recent years, these requirements have been strengthened rather than relaxed, indicating the state's commitment to ideological consistency even as campuses internationalize (Zhou, 2016; Yang, 2014). For example, new textbooks and online courses have been developed to make ideological content more appealing to youth, and top universities have Communist Party secretaries overseeing that teaching and research align with approved political values. Some joint programs initially struggled with how to incorporate these modules, but they have since complied by offering such classes (often in Chinese with translation for non-Chinese students) to fulfill national regulations. Scholars note that this intertwining of academia and ideology is a distinctive aspect of Chinese higher education; it is one way the system balances global academic norms with local political culture (Yang, 2010). While it sometimes clashes with Western notions of institutional autonomy, from the Chinese perspective it is seen as necessary to "guide the direction" of higher education and prevent the erosion of socialist ideals (Zhou, 2016).

(2) Chinese Language and Culture Promotion

To counterbalance the increased use of English and imported curricula, Chinese universities have taken steps to promote Chinese language and culture both at home and abroad. Domestically, even as EMI programs grow, institutions often require international students to learn Chinese language and encourage them to take courses in Chinese history or culture as part of their experience (Chen & Huang, 2013). The idea is to ensure foreigners engaging with China's academia also gain an appreciation of Chinese civilization and contemporary society, strengthening cultural exchange on China's terms. Internationally, China's well-known Confucius Institute initiative – while not a higher education program per se – exemplifies efforts to project Chinese culture and language globally as part of educational outreach (Pan, 2013). Confucius Institutes (CIs), which are often hosted on foreign university campuses, teach Chinese language and cultural subjects, and thus serve as a soft power tool complementing the international

activities of Chinese universities (Yang, 2010; Pan, 2013). By 2020, over 500 Confucius Institutes existed worldwide. Chinese universities often partner with CIs, sending teachers and materials abroad, which reinforces their international profile while promoting Chinese cultural heritage. This dual mission of the CIs ("global presence, national essence") mirrors the balancing act at home – it is an assertion that China can engage globally without losing its cultural core. However, the CI program has faced differing perceptions in some host countries, reflecting the challenges of cultural outreach in diverse contexts (Pan, 2013). Nonetheless, it remains a pillar of China's strategy to craft a positive national identity in the international educational sphere.

(3) Selective Adaptation of Foreign Models

In implementing internationalization initiatives, Chinese educators often practice selective adaptation, accepting aspects of foreign models that fit local values and rejecting those that conflict. For instance, Chinese universities have embraced Western pedagogy like interactive learning, but they still usually maintain a hierarchical professor–student relationship and exam-centric evaluation that align with domestic traditions (Huang, 2003). Similarly, while Western-style liberal arts education has influenced some reforms (a few elite universities created general education curricula inspired by U.S. colleges), these are tailored to include Chinese classics and moral education consistent with the national ethos (Li & Chen, 2005). University governance reforms offer another example: many institutions created boards of trustees and other structures seen in global practice, yet the Communist Party Committee remains the ultimate decision authority on campuses, ensuring alignment with national policy (Yang, 2014; Marginson, 2011). This dual structure – modern university administration alongside Party leadership – illustrates how China's identity and political system are woven into the fabric of even the most "international" universities. Researchers describe this as a "hybrid model" of governance (Yang, 2014), one that keeps the university responsive to state and societal expectations in China while also allowing flexibility to interact with global partners. Such selective adaptation is supported by a narrative among Chinese officials that internationalization is not the same as Westernization: "We can internationalize and still do things the Chinese way" (Tian & Lowe, 2014). The extent to which this holds true is debated, but it is clear that deliberate choices are made to preserve elements of Chinese identity in campus life, governance, and academic norms.

(4) Regulatory Oversight and Academic Sovereignty

The Ministry of Education approves each Sino-foreign joint program or institution, requiring that a Chinese party holds academic control and that programs do not teach content violating Chinese law or policy (Ministry of Education, 2016). For example, subjects like law, politics, or history offered in joint ventures must adhere to approved curricula, and foreign textbooks undergo vetting for appropriateness. There have been instances where proposed joint programs were altered or halted due to concerns they might introduce undesirable ideologies (Wang & Curdt-Christiansen, 2016). This oversight ensures "education sovereignty" – China's term for retaining ultimate control over educational content and values (Yang, 2014). In addition, foreign faculty hiring is subject to background checks, and international conferences in China often require permission to discuss sensitive topics. While such controls differ from the more

autonomously governed academic practices in Western academia, they reflect the priority placed on national stability and identity. China's leaders have explicitly stated that "universities are under the leadership of the Party" and must serve the socialist cause (Zhou, 2016). Therefore, even as universities gain greater autonomy in areas like international partnerships or financial management compared to the past, that autonomy has clear limits where national ideological security is concerned (Yang, 2010). The balance is delicate: policymakers aim to maintain strong oversight without discouraging international engagement. In recent years, China has strengthened governance measures to ensure that internationalization proceeds on its own terms (Marginson, 2011).

3.3. Balancing Outcomes and Challenges

The combined effect of the above strategies is a nuanced balance – Chinese higher education has undeniably become more global in its outlook and operations, yet it retains distinct characteristics rooted in national context. Outcomes of this balancing act include the rise of Chinese universities in global rankings and research output, indicating success in integration (Liu & Cheng, 2005; Shen & Li, 2015). Universities like Tsinghua and Peking University are now regularly listed among the world's top 50, thanks in part to international collaborations and talent recruitment. China also confers a growing number of degrees to international students and has become a hub for students from Asia and Africa, enhancing its soft power and cultural influence (Zha et al., 2019). Many Chinese universities have student bodies and faculty more international than ever before, creating more cosmopolitan campus environments than two decades ago (Luo & Welch, 2021). These are positive signs of global integration yielding tangible benefits.

However, challenges and tensions persist in balancing the dual goals. On the academic front, it is important to ensure that the drive for global rankings and prestige does not come at the expense of local educational needs and equity. Policymakers are aware that resources concentrated on elite international projects should not widen disparities between top-tier universities and less-funded local institutions, as educational equality is also a national priority.

Culturally, while China aims to avoid "Westernization," the widespread use of English and foreign frameworks could inadvertently overshadow Chinese scholarly discourse. For example, faculty hiring and promotion criteria sometimes emphasize publishing in English-language journals, which may undervalue research on local issues published in Chinese. There is also a personal dimension: Chinese students who study abroad may experience a cultural adjustment upon returning, which can pose reintegration challenges (Pan, 2011).

Moreover, geopolitical factors increasingly influence the balance. Geopolitical Shifts: Internationalization does not occur in isolation from world affairs. In the current global climate of rising nationalism and geopolitical tension, international academic engagement can face new constraints. Chinese universities may need to diversify their partnerships; for instance, if certain traditional avenues narrow, they can deepen ties with institutions in Asia, Africa, and Latin America in line with the Belt and Road Initiative (Yang, 2010). Such diversification would make China's internationalization less West-centric and more broadly based. Maintaining mutual trust

and open communication will be important to ensure that academic collaboration continues smoothly. By continuing to uphold transparency and build confidence with global partners, China can remain firmly embedded in the international academic community.

Balancing Innovation and Ideology: Internally, a major ongoing challenge is fostering an environment of critical inquiry and innovation while under an ideology-focused framework. China′s leadership places great importance on ideological guidance within universities. Some educators suggest that encouraging a culture of open inquiry and academic freedom can spur innovation and global impact, especially in fields like the social sciences and international relations. The challenge is to find a balance that allows intellectual creativity while upholding core values. One approach has been to encourage innovation in technical and applied fields, where political sensitivities are lower, while providing guidance in humanities and social sciences to ensure alignment with national objectives. This approach, already visible in practice, reflects a pragmatic strategy to foster excellence across disciplines. As global integration deepens and ideas circulate more freely, maintaining this balance will likely require continual adjustment.

4. Conclusion

China′s experience in higher education internationalization underscores that globalization and national identity need not be mutually exclusive; rather, they can be dynamically balanced through deliberate policy and practice. This article has shown that Chinese universities, under strong state guidance, have adopted comprehensive global integration strategies – from mobilizing student flows and forging international partnerships to modernizing curricula and research – that have propelled them onto the world stage. Concurrently, a suite of measures aimed at preserving national identity – including ideological education, cultural promotion, selective adaptation of external models, and regulatory control – ensures that international engagement unfolds within the bounds of China′s sociopolitical values. The result is a higher education system striving to be "globally competitive and distinctly Chinese" at the same time.

Several key conclusions emerge from this study. First, the pragmatic eclecticism of China′s approach is evident: policymakers and university leaders are willing to learn from anywhere (be it the West or other Asian neighbors) if it benefits their development, but they also exhibit the confidence to modify or reject external ideas that clash with local priorities. This pragmatism has enabled rapid gains in capacity and quality – Chinese universities are increasingly publishing influential research, attracting international talent, and contributing to global knowledge networks. Second, the Chinese case highlights that state involvement and national ideology can be deeply intertwined with internationalization, contrary to theories that predict a weakening of national control in the face of globalization. In China, the state has not retreated; it has recalibrated its role to foster international links while simultaneously embedding a nationalist mission in higher education. This challenges the universality of certain Western assumptions about the evolution of universities, suggesting alternative pathways are viable.

However, the concluding analysis also notes ongoing tensions and uncertainties. The delicate balance China has maintained could be tested by internal and external pressures: rising geopolitical frictions, generational shifts in student attitudes, and the inherent creative ferment of global academia might all require adjustments in China′s strategy. There is a recognition in China that true educational power comes not just from emulating others, but from contributing original ideas and models. Thus, a future aspiration is that China not only participates in internationalization but helps redefine it in a more multipolar, culturally inclusive manner. If China can reconcile its global ambitions with openness in intellectual inquiry – in short, if it can solve the riddle of how to be both fiercely Chinese and fully global – it may offer a blueprint for other countries navigating similar waters.

In closing, the story of internationalization in Chinese higher education is still being written. This study contributes a chapter by detailing the strategies and balancing acts up to the mid-2020s. For scholars and practitioners, China′s case is a reminder that internationalization is not a neutral, technical process; it is deeply political and cultural. The "traffic" in international education is not one-way – China has shown it is not only receiving global influences but also shaping the global education landscape with its own ideas. Whether one views certain aspects critically or favorably, the scale and intentionality of China′s efforts demand attention. As global higher education enters a new era of uncertainty and interconnectedness, understanding the Chinese approach enriches the dialogue on how universities can adapt to globalization while honoring their unique identity. It is a balancing act many will seek to master, and China′s evolving model provides both inspiration and caution in that quest.

Author Contributions:

Conceptualization, J. L.; methodology, J. L.; software, J. L.; validation, J. L.; formal analysis, J. L.; investigation, J. L.; resources, J. L.; data curation, J. L.; writing—original draft preparation, J. L.; writing—review and editing, J. L.; visualization, J. L.; supervision, J. L.; project administration, J. L.; funding acquisition, J. L. All authors have read and agreed to the published version of the manuscript.

Funding Statement:

Not applicable.

Institutional Review Board Statement:

Not applicable.

Informed Consent Statement:

Not applicable.

Data Availability Statement:

Not applicable.

Acknowledgments:

Not applicable.

Conflict of Interest:

The author declared no potential conflicts of interest with respect to the research, authorship, or publication of this article.

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The Development of Humanities and Social Sciences, 2025, 1(3), 135-143
https://doi.org/10.71204/k3tnna91

An Analysis and Research on the Investment Issues of Holiland Company

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Received: 31 October 2025/ Accepted: 13 November 2025/ Published online: 15 November 2025

Abstract

With China's economy entering a stage of high-quality development, the investment decisions and management of listed companies are crucial to their market competitiveness and sustainable development. This paper takes Holiland (China) Co., Ltd., a well-known listed enterprise in China's baking industry, as a case study to conduct an in-depth exploration of its investment status, problems, and optimization strategies. The research shows that through investment activities such as direct chain expansion, modern industrial park construction, and product line diversification, Holiland has achieved steady growth in asset scale and consolidated its market position, demonstrating good profitability. However, the company also faces multiple internal and external risks, including relatively concentrated investment areas, intensified market competition, rising raw material and labor costs, and pressure for product innovation. These issues highlight potential shortcomings in its investment risk management and control. Based on this, this paper proposes targeted investment optimization suggestions for Holiland from the perspectives of strengthening market research, optimizing cost control, increasing product innovation, improving internal control systems, and focusing on talent cultivation, aiming to provide reference for enhancing its investment efficiency and risk resistance ability, and offer practical insights for investment decisions of similar enterprises.

Keywords: Holiland; Investment Decision-Making; Risk Management; Optimization Strategies

1. Introduction

Investment activities are the core means for enterprises to allocate resources, drive growth, and achieve strategic goals (Brealey, Myers, & Allen, 2017), The scientificity of decision-making and the effectiveness of management are directly related to an enterprise's market competitiveness and

sustainable development capabilities. Against the backdrop of China's economy stepping into a high-quality development stage, how listed companies carefully assess investment risks, optimize investment structure, and improve investment efficiency has become an important topic of common concern in both theoretical and practical circles (Porter, 2008). As a field closely linked to mass consumption, the baking food industry has seen continuous expansion in market capacity in recent years, but it also faces multiple challenges such as changing consumer demands, increasingly fierce industry competition, and frequent fluctuations in raw material costs, making the investment decision-making environment for enterprises increasingly complex.

Holiland (China) Co., Ltd., as a well-known listed enterprise in China's baking industry, its development history and investment layout are typically representative in the industry. Since its establishment, the company has laid a solid market position through a series of investment activities, including direct chain expansion, modern industrial park construction, and product line diversification. However, behind the impressive performance, the company also faces investment management issues such as market risks brought about by relatively concentrated investment areas, profit squeeze from rising raw material and labor costs, and higher requirements for product innovation and operational efficiency in the new consumption environment (Kotler& Keller, 2015).

Therefore, this paper takes Holiland as a specific research object. On the basis of systematically sorting out its basic situation and investment status, it deeply analyzes the internal and external risks and key issues faced in the investment process, and then puts forward constructive countermeasures to optimize investment strategies and strengthen risk management and control. This study aims to provide reference for Holiland to improve its investment management level and avoid investment traps, and also offer useful lessons and enlightenment for similar listed companies to make scientific investment decisions and achieve steady development in a complex market environment.

2. Analysis of Holiland's Investment Status

2.1.Current Situation

Holiland has always been committed to providing consumers with high-quality and uniquely flavored baked products. In terms of market positioning, Holiland mainly targets mid-to-high-end consumer groups, focusing on brand image building and product quality improvement. Therefore, most of Holiland's investments are in the continuous innovation and improvement of the brand. Holiland has established a good reputation and brand image in the baking market, becoming a trusted baking brand among consumers.

Holiland's investment scale has maintained steady growth over the past few years. According to the latest data, the company's total assets have reached 470.2106 million yuan, an increase from 415.8743 million yuan in the previous year (Holiland, 2021 Financial Report). This growth is mainly due to the steady development of the company's business and the gradual increase in market share. With the continuous expansion of asset scale, Holiland will have more funds for product research and development, market expansion, and brand building to further consolidate

its market position. From Holiland's recent asset returns, it can be seen that although the overall sales volume has grown steadily, the profit growth rate has slowed down. This is mainly due to the intensification of market competition and the rise in raw material costs. In terms of investment, Holiland needs to more carefully evaluate the market environment and its own strength to avoid fund chain tension caused by blind expansion.

From the perspective of asset returns, although Holiland's overall sales volume has grown steadily, its profit growth rate has slowed down ─ this is mainly due to the intensification of market competition and the rise in raw material costs (China Baking Industry Development Report, 2021). In terms of profitability, Holiland's net profit was 10.7846 million yuan, a year-on-year increase of 50.09% (Holiland, 2020 Annual Report).This data indicates that Holiland's profitability is increasing year by year, and its operating efficiency is steadily improving. The growth of net profit is mainly due to the company's continuous investment in product research and development, market expansion, and brand building, as well as the effective implementation of refined management and cost control.

Facing market changes, Holiland is actively making transformation attempts to seek new development opportunities. First, the company is increasing investment in product research and development to launch more new products that meet consumers' tastes, so as to enhance brand competitiveness. Second, Holiland is actively expanding online sales channels, using e-commerce platforms and social media platforms to expand brand influence. In addition, the company is exploring diversified operations, such as opening coffee shops and dessert stores, to enrich the product line and meet consumers' diverse needs (Kaplan & Norton, 2001)

2.2. Investment Areas

Holiland has always been committed to providing consumers with high-quality and uniquely flavored baked products. In terms of market positioning, Holiland mainly targets mid-to-high-end consumer groups, focusing on brand image building and product quality improvement. Through continuous innovation and improvement, Holiland has established a good reputation and brand image in the baking market, becoming a trusted baking brand among consumers.

Holiland has invested in nearly a thousand direct chain stores, distributed in more than 70 large and medium-sized cities nationwide, including Beijing, Tianjin, and Shenyang. Holiland's investments mainly focus on the development and production of products such as cakes, bread, western pastries, Chinese pastries, mooncakes, glutinous rice balls, and zongzi. At the same time, Holiland has established many food industrial parks, which are first-class large-scale modern food industrial parks in China. The industrial parks are invested and built in accordance with the GMP standards of the international pharmaceutical industry, and are the largest large-scale modern sterile food factories in the industry. The industrial parks absorb and adopt world-class advanced technologies, hardware facilities, and production concepts, innovating the originally labor-intensive baking food industry into a capital and technology-intensive industry. In order to ensure the taste and quality of products, Holiland has also introduced German bread production lines, French cake production lines, and the most advanced mooncake production lines in China for product processing (Hitt, Ireland& Hoskisson, 2016). In summary, in terms of investment projects

and areas, Holiland not only focuses on the expansion of direct chain stores and the improvement of product quality, but also pays attention to the innovation of food industrial technology, the assumption of social responsibilities, and the development of franchise projects.

Holiland has shown a steady development trend and good operating benefits in investment. The company has achieved remarkable results in terms of asset scale, liabilities and asset-liability ratio, operating income, net profit, etc. At the same time, Holiland also has obvious advantages in market positioning and competitive edge, laying a solid foundation for the company's long-term development. However, facing increasingly fierce market competition and changing market environment, Holiland still needs to maintain the spirit of innovation and enterprise, and continuously improve its competitiveness and market share (Hitt, Ireland& Hoskisson, 2016).

3. Analysis of Holiland's Investment Problems

3.1. Investment Risk Issues

In the current fiercely competitive market environment, Holiland is faced with a series of investment problems. The existence of these problems may not only affect the normal operation of the enterprise, but also have an adverse impact on its long-term development. These risks can be categorized into four core types: market risk, cost risk, innovation risk, and management risk.

3.1.1. Market Risk

This type of risk mainly includes three sub-risks: changing consumer demands, intensified market competition, and inaccurate market trend prediction.

Consumer demand change risk: With the increasing diversification of consumers' demands for health and taste, the dessert market is also facing the risk of changing consumer demands. If Holiland cannot timely grasp the changes in market demands, it may face problems such as poor product sales and inventory backlogs.

Market competition pressure risk: The dessert industry is highly competitive, with numerous competitors in the market. The continuous emergence of new brands and the continuous innovation of existing brands make it more difficult for Holiland to gain a foothold in the market. In investment, Holiland needs to consider how to stand out in the fierce market competition.

Inaccurate market trend prediction: The development trend of the dessert market is affected by many factors, including economic situation, policies and regulations, social culture, etc. If Holiland's prediction of market trends is inaccurate, it may lead to wrong investment decisions and losses for the enterprise.

3.1.2. Cost Risk

Raw material price fluctuation risk: The main raw materials of desserts include flour, sugar, oil, etc. The price fluctuations of these raw materials may have a significant impact on Holiland's cost control. The rise in raw material prices may lead to an increase in Holiland's production costs, thereby affecting its profitability.

Labor cost increase risk: With the rise of labor costs, the labor costs of dessert enterprises are also increasing. Holiland needs to rationally allocate human resources and improve production efficiency to reduce the impact of labor costs on the enterprise's profitability (Becker, 1964)

Operating cost increase risk: In the operation process, Holiland also needs to bear operating costs such as rent, water and electricity fees, and advertising fees. The increase of these costs may lead to a decline in Holiland's profits, bringing pressure to the enterprise.

Product quality problem risk: As a kind of food, the quality and safety of desserts are crucial. If product quality problems occur, it may not only lead to customer complaints and returns, but also damage Holiland's brand image. Therefore, Holiland needs to attach great importance to product quality control in investment.

3.1.3. Innovation Risk

Product innovation insufficiency risk: In the context of fierce market competition, dessert enterprises need to continuously innovate to meet consumers' demands. If product innovation is insufficient, it may lead to Holiland's products losing market competitiveness (Teece, Pisano& Shuen, 1997).

3.1.4. Management Risk

Internal control deficiency risk: In the investment process, dessert enterprises need to establish a sound internal control system to ensure the compliance and effectiveness of investment decisions. If internal control is lacking or insufficient, it may lead to wrong investment decisions or irregular behaviors (Jensen & Meckling, 1976).

Talent training and introduction insufficiency risk: The development of dessert enterprises is inseparable from a high-quality talent team. If Holiland invests insufficiently in talent training and introduction, it may lead to a shortage of enterprise talents, affecting the enterprise's operation and innovation capabilities (Becker, 1964).

Incomplete corporate culture risk: Corporate culture is of great significance for the long-term development of enterprises. If the corporate culture is incomplete or lacks cohesion, it may lead to problems such as low employee morale and low work efficiency in Holiland.

Competition risk: The dessert market is highly competitive, with many brands and players competing for market share. How to stand out in the fierce market competition and attract more customers is a major challenge for Holiland (Dess& Beard, 1984).

Market demand fluctuation risk: Consumers' tastes and demands may change over time, leading to fluctuations in market demand and affecting the sales volume of dessert enterprises. Holiland needs to constantly monitor market dynamics and flexibly adjust products and marketing strategies to cope with market changes (Dess& Beard, 1984).

Price risk: Market prices fluctuate greatly, especially changes in raw material prices and labor costs, which will directly affect the profitability of dessert enterprises. Holiland needs to rationally formulate pricing strategies, improve management efficiency and cost control capabilities, and reduce operational risks.

Personnel management risk: High employee turnover and uneven quality may have an adverse impact on the business operation of the enterprise. Holiland needs to establish a sound human resource management system, strengthen employee training and motivation, and improve employee loyalty and performance.

Supply chain risk: The supply of raw materials for dessert stores is affected by factors such as region and season, which may lead to unstable supply and quality problems. Holiland needs to establish a stable supply chain system and establish long-term cooperative relationships with reputable suppliers to ensure the quality and stability of raw material supply.

Financial management risk: Improper financial management may lead to the breakage of the enterprise's capital chain, affecting the normal operation of the enterprise. Holiland needs to establish a sound financial management system, including the formulation and analysis of budgets and financial statements, to ensure the transparency of the store's financial status and operation.

Policy and regulatory risk: The operation of dessert stores needs to comply with various government regulations, including food safety, environmental protection, labor law and other aspects. If Holiland fails to comply with relevant regulations, it may face risks such as fines and suspension of business for rectification.

Pandemic and other emergency risks: Global pandemics and other emergencies may have a significant impact on the dessert industry, leading to changes in consumer demands and consumption habits, and affecting the normal operation of enterprises. Holiland needs to closely monitor changes in the external environment and formulate response measures to address potential risks.

Holiland's financial situation is relatively stable, and the debt level is within a controllable range. A lower asset-liability ratio helps the company maintain lower financial costs and improve profitability. At the same time, the company also has sufficient solvency to cope with potential market risks. Data shows that in 2020, Holiland's operating income reached 169.195 million yuan, a year-on-year increase of 4.99%. This reflects that Holiland's market share is gradually expanding and its brand influence is also continuously enhancing. Holiland has maintained stable revenue growth, showing strong market competitiveness and risk resistance ability.

In short, Holiland needs to pay attention to issues such as performance and investment, transformation attempts, market risks, financial risks, and strategic planning in the investment process. By formulating feasible strategic plans and taking effective measures, Holiland can cope with market challenges and achieve steady development (Miller & Friesen, 1984)

4. Suggestions and Countermeasures for Holiland's Investment

In response to the above problems, Holiland needs to pay attention to market risks, cost risks, quality risks, and management risks in investment. To reduce investment risks, enterprises should strengthen market research and forecasting capabilities to timely grasp changes in market demands; optimize cost control to reduce the impact of raw material price fluctuations and rising labor costs on enterprises; strengthen product quality control and improve product innovation

capabilities; establish a sound internal control system, strengthen talent training and introduction, and shape a positive corporate culture. Through comprehensive measures, dessert enterprises can achieve steady development in investment (Berman, Wicks, Kotha & Jones, 1999).

Holiland needs to formulate feasible strategic plans (Mintzberg, 1994). First, the company needs to clarify its positioning and development direction and formulate long-term development plans. Second, strengthen brand building and market promotion to enhance brand awareness and reputation. At the same time, increase investment in research and development to promote product innovation and technological upgrading. In addition, it is also necessary to strengthen talent team building to improve employee quality and management level. In terms of investment, Holiland needs to carefully evaluate the market environment and its own strength, and select projects with development potential for investment to achieve the company's sustainable development.

At the same time, Holiland should strengthen market research to timely understand market changes and consumer demands, ensuring the market prospects of investment projects. Optimize product structure, improve product quality, enhance brand influence, and reduce operational risks. Establish a sound financial management system, strengthen cost control and fund management, and reduce financial risks (Huber, 1991).

Risk is a key issue that Holiland needs to focus on in the investment process. First, the baking market is highly competitive, and major brands have increased their marketing efforts to compete for market share. Holiland needs to closely monitor market dynamics to understand market risks and analyze the impact of market changes on project returns, such as changes in consumer demands and intensified competition. At the same time, it is also necessary to pay attention to operational risks, considering potential risks in the store operation process, such as fluctuations in raw material prices and rising labor costs. Holiland should also comply with relevant national laws and regulations to ensure project compliance, reduce legal risks, and formulate effective competition strategies (Simons, 1995).

Second, consumers' tastes change rapidly, and Holiland needs to continuously introduce new products to meet consumers' demands. In addition, factors such as the policy environment and raw material prices may also have a significant impact on the market. Holiland needs to closely monitor changes in these factors and complete risk prevention and control.

In terms of financial risks, Holiland needs to pay attention to the following aspects. First, fund chain management is crucial for the company's steady development. Holiland needs to rationally plan the use of funds to ensure sufficient funds and avoid fund chain breakage. Second, the debt structure needs to be optimized to reduce financial costs. Holiland needs to formulate reasonable financing strategies according to its own operating conditions and market environment to avoid the pressure of high debt on the company's operations. In addition, it is also necessary to strengthen cost control and reduce operational risks.

5. Conclusion

The current dessert market shows a steady growth trend, and consumers' demands for healthy, delicious, and innovative desserts are increasing day by day. With consumption upgrading and diversified tastes, the dessert industry has huge market potential, but it also faces fierce market competition.

With years of industry experience and market accumulation, Holiland has become one of the well-known brands in the domestic dessert market. Holiland has a professional R&D team and an efficient production line, committed to providing consumers with high-quality, healthy, and delicious dessert products.

Holiland's dessert products are loved by consumers for their unique taste, exquisite appearance, and rich nutrition. Holiland attaches great importance to product R&D and innovation, constantly launching new varieties and flavors to meet consumers' diverse needs. At the same time, Holiland adheres to the use of high-quality raw materials to ensure product quality and taste.

In the investment process, Holiland needs to pay attention to issues such as asset structure adjustment, investment strategies, investment benefits, investment risks, internal control management, compliance with regulations, and capital liquidity. To optimize investment results, Holiland should strengthen market research and risk assessment, formulate reasonable investment strategies and risk control measures; at the same time, Holiland should establish a sound internal control management system, strengthen auditing and supervision, and ensure the compliance and effectiveness of investment activities.

In summary, as one of the well-known brands in the domestic dessert market, Holiland has good market prospects and a stable financial situation. Holiland has strong product R&D capabilities and can meet consumers' diverse needs. At the same time, Holiland also faces risks such as market competition and fluctuations in raw material prices. When choosing to invest in dessert companies, investors should pay attention to the company's brand influence, R&D capabilities, financial status, and profitability, and formulate appropriate investment strategies to reduce investment risks and achieve long-term stable investment returns.

Author Contributions:

Conceptualization, S. L., S. P.; formal analysis, S. L., S. P., Y.Z.; writing—original draft preparation, S. L., S. P., Y.Z.; All authors have read and agreed to the published version of the manuscript.

Funding:

Not applicable.

Institutional Review Board Statement:

Not applicable.

Informed Consent Statement:

Not applicable.

Data Availability Statement:

Not applicable.

Conflict of Interest:

The authors declare no conflict of interest.

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The Development of Humanities and Social Sciences, 2025, 1(3), 144-161
https://doi.org/10.71204/bngj5358

Quality Assurance in Chinese Higher Education: Policy Reforms and Institutional Challenges

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Received: 3 Novembe 2025 / Accepted: 15 Novembe2025 / Published online: 16 November 2025

Abstract

Quality assurance (QA) has become a central concern in Chinese higher education amid rapid expansion and reforms. This paper examines the evolution of QA policies in China and analyzes the institutional challenges that universities face in implementing these policies. The study situates China's QA development in the broader context of global trends toward accountability and quality improvement. It reviews major policy initiatives ─ from the massification of higher education and early evaluation schemes to recent audit-based approaches ─ and evaluates their impact on university governance, educational quality, and stakeholder involvement. The findings indicate that China has made significant strides in building a comprehensive QA system, including national evaluation agencies and internal quality monitoring mechanisms, which have improved baseline educational standards. However, challenges persist in fostering a genuine "quality culture" within institutions, balancing government control with university autonomy, and ensuring that QA processes lead to substantive improvements in teaching and learning. The paper concludes with recommendations to enhance stakeholder engagement, strengthen internal quality management, and align QA practices with educational outcomes. These insights contribute to understanding how policy reforms can effectively support quality improvement in the context of China's dynamic higher education system.

Keywords: Quality Assurance; Higher Education; Policy Reform; Quality Culture; Institutional Evaluation; Educational Quality

1. Introduction

In recent decades, quality assurance (QA) in higher education has emerged as a global priority, driven by the demands of a knowledge-based economy and the pressures of international competition. Around the world, universities are expected to produce skilled graduates and cutting-edge research, prompting governments to implement QA mechanisms to monitor and improve

educational standards (Osborne & Gaebler, 1992; Rhoades & Sporn, 2002). In China, these global trends have intersected with domestic imperatives. Since the late 1990s, Chinese higher education has undergone a dramatic transformation from an elite to a mass system. Enrollments expanded rapidly after 1999, when a government policy initiative led to an unprecedented surge in admissions (Zha, 2011). Annual undergraduate enrollment grew from about 1 million in 1998 to over 9 million by 2020, propelling China′s gross higher education enrollment rate to 54.4% in 2020 (Ministry of Education, 2021). This massification improved access but also intensified concerns about educational quality (Dahlman & Aubert, 2001; Trow, 1973). Institutions faced overcrowded classrooms, strained facilities, and uneven faculty qualifications, leading observers to warn of a potential decline in academic standards (Zha, 2011; Mok & Jiang, 2018).

The Chinese government responded to these challenges by making quality improvement a core focus of higher education policy (Ministry of Education, 2010). Over the past two decades, China has developed an extensive QA framework that draws on international models while aligning with national conditions (Liu, 2018). Early efforts in the 2000s emphasized accountability and evaluation, reflecting a state-led approach to reform. A national undergraduate teaching evaluation project was implemented between 2003 and 2008, in which teams of experts assessed each university′s teaching quality against set criteria. This top-down evaluation system was intended to ensure that rapid expansion did not come at the expense of academic standards. At the same time, China launched excellence initiatives such as the "211 Project" and "985 Project," funneling resources to select universities to build world-class status (Salmi, 2009). These initiatives underscored the government′s dual strategy of expanding capacity and enhancing quality at the pinnacle of the system (Altbach & de Wit, 2018; Mohrman, Ma, & Baker, 2008).

By the 2010s, Chinese higher education entered a new phase where quality assurance and improvement overtook expansion as the primary policy goal. The *Outline of China′s National Plan for Medium- and Long-Term Education Reform and Development (2010–2020)* explicitly prioritized quality, calling for a "quality-centered" growth model (Ministry of Education, 2010). Reforms in this period introduced more nuanced QA mechanisms. The Ministry of Education established the Higher Education Evaluation Center (HEEC) as a semi-autonomous body to oversee evaluations and shifted from one-off inspections to a combination of periodic assessments and continuous monitoring (Shi, 2009; Liu et al., 2025). New QA philosophies and methods were adopted from international best practices, including *student-centered learning, outcome-based education (OBE), and continuous quality improvement (CQI)* principles. For example, program accreditation in engineering and other disciplines was strengthened to meet global standards; by 2016 China had joined the Washington Accord for engineering education, signaling that its accreditation processes achieved international equivalence (Xu & Li, 2019). At the institutional level, universities were encouraged to conduct internal self-evaluations and establish quality management offices, embedding QA into their governance structures (Chen & Li, 2022; Zhou & Gao, 2017). These shifts represent a move from a singular reliance on external supervision to a more complex QA system combining external *and* internal measures.

Despite these extensive reforms, Chinese higher education still grapples with significant institutional challenges in quality assurance (Wang, 2014; Yang, 2015). Tensions exist between a centralized accountability-driven QA approach and the need for genuine improvement on the ground (Harvey & Stensaker, 2008). Many academics perceive QA exercises as bureaucratic and compliance-oriented, which can limit their effectiveness in improving teaching and learning (Zhou & Gao, 2017). Additionally, the sheer scale and diversity of China′s higher education sector—from elite research universities to local teaching colleges—make it difficult to design one-size-fits-all QA policies (Mok & Jiang, 2018; Gao & Guo, 2018). As China strives to build world-class universities and cultivate innovative talent, addressing these challenges has become ever more critical.

This paper provides a comprehensive analysis of quality assurance in Chinese higher education, focusing on policy reforms and institutional challenges. Drawing on policy documents, national reports, and existing research, we trace the evolution of China′s QA system and evaluate its impact on university practices. We then discuss the ongoing challenges in implementing QA at the institutional level, including issues of governance, culture, and stakeholder participation. The goal is to shed light on how China can further strengthen its QA mechanisms to support sustainable improvement in higher education quality. Insights from China′s experience will also be relevant to other higher education systems undergoing rapid expansion and reform.

2. Methodology

This study adopts a qualitative approach, using document analysis and literature review to examine quality assurance policies and practices in Chinese higher education. We reviewed a wide range of primary policy documents and regulations issued by the Chinese government and Ministry of Education (e.g., the 2010 National Education Reform Plan and subsequent QA guidelines), as well as reports from national QA agencies such as the HEEC. These sources provide insight into the intended objectives, structures, and evolution of China′s QA system. In addition, we analyzed statistical communiqués and official data on higher education development (e.g., enrollment figures, numbers of evaluated programs) to understand the broader context of QA reforms (Ministry of Education, 2021).

The document analysis was supplemented by a systematic review of the scholarly literature on Chinese higher education quality assurance. We surveyed academic articles, books, and conference papers in both English and Chinese that address QA policies, evaluation outcomes, and quality improvement challenges in China. Key sources include comprehensive overviews of QA developments (Liu, 2018), case studies of university QA practices (Chen & Wu, 2020; Zhou & Gao, 2017), and comparative analyses situating China′s experience in global context (Marginson, 2011; Hazelkorn, 2015). We paid special attention to research by Chinese scholars and practitioners (often published in translation) to capture on-the-ground perspectives. For example, the work of Wu Yan (the Director-General of HEEC) and colleagues provides authoritative insights into China′s QA philosophy and criteria. We also included recent studies that highlight current challenges and criticisms of QA implementation, such as the engagement of

faculty and students in QA processes (Zhou & Gao, 2017) and the role of new data-driven evaluation tools (Zhang et al., 2022).

By triangulating policy analysis with literature review, we aimed to develop a well-rounded understanding of both the formal QA system and its practical effects. The methodology is exploratory and interpretive: instead of testing hypotheses, we identify patterns and themes in QA reforms and their outcomes. Given that this research does not involve human subjects or confidential data, no institutional ethics approval was required (and hence no survey or interview data were collected). The analysis is informed by theoretical concepts from higher education studies—such as accountability vs. improvement, centralization vs. decentralization, and quality culture (Harvey & Stensaker, 2008; Rhoades & Sporn, 2002)—which serve as lenses for interpreting China′s QA trajectory.

Several strategies were used to enhance the reliability and validity of our findings. First, multiple sources were consulted for each aspect of QA policy (for instance, both official policy texts and independent evaluations of their impact), to ensure that conclusions do not rely on a single viewpoint. Second, where possible, we cross-referenced Chinese-language and English-language literature to capture a broad spectrum of analysis. Third, we contextualized China′s QA developments within international trends by referencing comparative studies and global QA guidelines (Altbach & de Wit, 2018; Salmi, 2009). This approach helps distinguish which features of China′s QA system are unique and which reflect common global patterns. Overall, the methodological approach is appropriate for a policy-focused analysis, providing depth and context rather than quantitative measurement. The next section presents the results of our analysis, detailing the chronological reforms in China′s QA system and their outcomes, followed by a discussion of ongoing challenges and implications.

3. Results

3.1. Evolution of Quality Assurance Policies in China

Quality assurance in Chinese higher education has evolved through distinct phases of policy reform, each introducing new mechanisms and priorities. Table 1 provides a timeline of major QA initiatives and their characteristics.

Early QA efforts were largely top-down. In the 2003–2008 nationwide undergraduate teaching evaluation, teams of experts visited every higher education institution (HEI) to conduct intensive reviews. Universities prepared elaborate self-study reports and underwent site inspections that examined inputs (faculty qualifications, facilities), processes (teaching and curriculum management), and outputs (graduate employment rates). This exercise, unprecedented in scale, instilled a baseline QA awareness across the system and identified shortcomings at many HEIs, leading to concrete improvements such as curriculum updates and faculty development programs (Liu & Hou, 2009). However, it also had drawbacks: because institutions were judged against uniform metrics, some critics argued it encouraged *"teaching to the test"*—universities might focus on the evaluation criteria (e.g., expanding library collections) rather than substantive

educational quality (Bao & Liu, 2019). Once virtually all universities passed the one-time assessment, its effectiveness in driving ongoing improvement diminished (Wang, 2014).

Table 1. Milestones in the Development of China's Higher Education QA System

Period	Policy Initiatives	QA Mechanisms Introduced	Key Features
Late 1990s	Expansion Era – "Massification" begins (1999 enrollment surge); Project 211 and 985 launched.	– Basic standards for HEIs; – Selective excellence funding.	**Focus:** Increase capacity; build elite universities. **QA:** Ad hoc evaluations; input controls (e.g., infrastructure).
Early 2000s	National Teaching Evaluation (2003–2008); Establishment of HEEC (2004).	–Comprehensive institutional evaluations by MoE/HEEC; – Ranking and classification of universities.	**Focus:** Accountability and oversight during rapid expansion. **QA:** One-time external reviews of teaching quality for all universities; quantitative indicators (faculty credentials, library size, etc.) widely used.
2010s	Quality Enhancement Era – Education Reform Plan (2010); "Quality Project" and Double First-Class Initiative (2017).	– Transition to audit-style evaluations (from 2013); – Program accreditation (e.g., engineering, medicine); – Annual quality reporting by HEIs.	**Focus:** Continuous improvement and global competitiveness. **QA:** Emphasis on outcomes (student learning, employment); introduction of student-centered and OBE approaches; internal QA systems strengthened within universities.
Late 2010s–2020s	Data-Driven & Differentiated QA – New national standards (Undergraduate Teaching Audit Evaluation 2018); Big data in QA (learning analytics).	– Regular quality audits of universities on a 5-year cycle; – National data platform for monitoring indicators (teaching load, graduation rates, etc.); – Independent QA agencies emerging in some provinces.	**Focus:** Fostering quality culture and transparency. **QA:** Mix of external evaluation and self-assessment; data-informed decision-making; greater public disclosure of quality information (e.g., annual quality reports published by MoE).

A significant shift occurred in the early 2010s, marked by the slogan "putting quality first" in national policy (Ministry of Education, 2010). The QA system transitioned toward a more regular and nuanced regime known as *audit evaluations*. Instead of pass/fail inspections, audit evaluations are lighter-touch reviews conducted on a 5-year cycle, focusing on whether an institution's *internal QA system* is functioning and on outcomes like student learning and development (Yang & Chen, 2016). The idea is to respect institutional diversity: each university is evaluated in light of its own mission and objectives (fitness for purpose), rather than against an identical checklist for all (Liu et al., 2025). This approach was first piloted in 2013–2014 and fully implemented by 2018. The audits shifted attention from simply meeting minimum standards to *continuous improvement*: universities now receive feedback on how to enhance quality rather than just a yes/no judgment. As a result, many institutions established or expanded their internal Quality Assurance Offices to conduct self-evaluations and close the quality loop (Chen & Li, 2022). By 2020, over 1000 Chinese HEIs had undergone the new audit evaluation, indicating a systemic move towards ongoing monitoring.

Alongside institutional audits, program-level accreditation has been strengthened in specific disciplines. For example, engineering programs are accredited through the China Engineering Education Accreditation Association (CEEAA) using international standards, and medical schools undergo accreditation aligned with the WFME (World Federation for Medical Education) guidelines (Liu & Hou, 2009; Xu & Li, 2019). These accreditations ensure that graduates in regulated professions meet industry and global benchmarks. China's membership in international agreements (like the Washington Accord in 2016 for engineering) signifies that its program QA processes have matured to global norms, facilitating international recognition of Chinese degrees (Xu & Li, 2019). By 2022, over 1,200 engineering programs in China had been accredited, reflecting this trend of professionalizing QA at the program level (Chen & Wu, 2020).

Another development in the late 2010s is the use of data analytics and transparency in QA. The Ministry of Education established a National Higher Education Quality Monitoring Platform, aggregating key performance indicators (KPIs) from all HEIs annually. Indicators include student-faculty ratios, graduation rates, research outputs, and student satisfaction survey results. Summaries are published in annual national quality reports (Wu et al., 2025). These data-driven measures enable continuous surveillance of quality across the system and help identify emerging problems (for instance, unusually low employment rates in certain majors can trigger a quality review). Chinese universities are also increasingly required to publicize information such as teaching conditions and graduate outcomes on their websites (Pan, 2015). This push towards greater transparency aims to involve the public and stakeholders in quality oversight and to incentivize institutions to improve through reputational pressures (Hazelkorn, 2015; Gao & Guo, 2018).

In summary, China's QA policies have progressed from a one-time evaluative mode to a dynamic and multi-layered system. The current QA architecture includes: (a) External periodic evaluations (institutional audits and specialized accreditations), led by or in cooperation with national agencies; (b) Internal quality assurance mechanisms at universities (self-assessment reports, teaching supervision committees, etc.); and (c) Outcome monitoring via data collection

and feedback loops (Ministry of Education, 2021; Zhang et al., 2022). This evolution reflects lessons learned over two decades of reforms. The policy intent is now to foster a culture of quality—where HEIs take proactive responsibility for quality—rather than relying solely on top-down enforcement (Harvey & Stensaker, 2008; Ministry of Education, 2010). The effectiveness of these reforms, however, depends on how they are received and enacted at the institutional level, which we examine in the next subsection.

3.2. Institutional Responses and Outcomes

Chinese universities have had to adapt rapidly to the changing QA landscape. The external evaluation cycles and new quality criteria prompted many institutions to undertake internal reforms. Common responses included:

Strengthening Internal Governance for QA: Nearly all universities now have a dedicated quality management office or Teaching Affairs Department responsible for coordinating QA activities (Chen & Li, 2022). These units compile data, prepare self-evaluation reports, and organize campus-wide efforts during audit evaluations. University leaders have also established QA committees that include academic staff to discuss continuous improvement. This represents a shift from the past, when QA was often seen as an external task disconnected from daily management. In some leading universities, institutional research (IR) teams analyze teaching and learning metrics to inform decision-making, indicating growing internal capacity for QA.

Curriculum and Teaching Reforms: Spurred by QA feedback, universities have revised curricula to enhance relevance and rigor (Wang, 2014). For instance, many introduced new general education courses and practical training components after the 2003–08 evaluations highlighted rote learning issues. More recently, outcome-based education principles have led to clearer articulation of learning outcomes for each program and alignment of assessment methods with those outcomes (Yang & Chen, 2016). Pedagogical improvements, such as interactive teaching and use of educational technology, have been piloted, sometimes in direct response to QA recommendations that called for student-centered learning (Zhang et al., 2022). These changes show QA′s influence in prompting academic innovations, although implementation depth varies by institution.

Faculty Development and Incentives: Recognizing that faculty engagement is crucial to quality, many institutions expanded training for teachers and linked QA to faculty evaluation. Teaching development centers have been established to offer workshops on instructional skills, often catalyzed by QA findings that teaching quality needed improvement (Long et al., 2024). Some universities incorporated student course evaluations and peer observations into faculty performance appraisals as part of internal QA. However, the effectiveness of these measures in truly improving teaching remains debated (Xiong & Yang, 2017). In research-intensive universities, research output still dominates faculty incentives, potentially undermining the QA focus on teaching (Yang, 2015). Nonetheless, there is evidence that institutions are striving to balance this by recognizing teaching excellence—for example, through teaching award programs and promotion criteria that consider teaching effectiveness (Jiang & Tam, 2019).

Quality Culture Initiatives: Leading universities have explicitly started talking about "quality culture," encouraging bottom-up participation in QA (Harvey & Stensaker, 2008). Some have set up platforms for students to give feedback on courses and campus facilities, beyond the mandatory end-of-term evaluations (Zhou & Gao, 2017). A few institutions involve student representatives in internal quality assurance committees, a practice aligned with international standards but still new in China. Faculty are also being engaged through departmental self-studies and annual teaching reviews where they reflect on their courses. These practices, while not yet universal, signal a gradual shift toward making quality assurance a shared value rather than a top-down mandate (Chen & Li, 2022). For example, Sun Yat-sen University reportedly organized "quality month" campaigns to promote awareness of continuous improvement among staff and students (Pan, 2015).

Resource Allocation and QA: The government's performance-based funding has provided financial incentives linked to quality metrics. Universities that performed well in evaluations or achieved accreditation of programs often received additional funding or were granted approval to expand programs (Salmi, 2009; Mok & Jiang, 2018). This has generally had positive effects, enabling those institutions to invest in hiring more qualified faculty, upgrading laboratories, and reducing student–teacher ratios, thereby further improving quality. On the other hand, lower-tier institutions that struggle with quality have sometimes faced enrollment caps or closer supervision by authorities (Bao & Liu, 2019). Such high-stakes consequences make QA a critical matter for institutional survival and development, spurring university leaders to prioritize QA efforts. However, it also raises a concern: if funding is too tightly tied to evaluation results, institutions might engage in short-term tactics to "score well" rather than pursuing deeper quality enhancement (Hazelkorn, 2015; Gao & Guo, 2018). This tension between genuine improvement and gaming the system has been observed by some researchers, especially during the era of one-off evaluations.

The outcomes of QA reforms in China can be observed in several dimensions of the higher education system:

Academic Quality and Student Outcomes: Overall, the quality of educational provision has improved in measurable ways. The proportion of faculty with higher degrees has increased significantly across Chinese universities, partly due to QA pressures to meet faculty qualification benchmarks (Ministry of Education, 2021). Curriculum renewal has kept programs more up-to-date with disciplinary developments and labor market needs (Wang, 2014). Importantly, student outcomes have shown gains: average graduation rates have risen, and graduate employment rates have remained relatively high (typically above 90% within six months of graduation for most universities in recent years) despite huge increases in the number of graduates (Ministry of Education, 2021). Some of this success is attributed to QA-driven improvements like strengthened practical training and closer monitoring of at-risk students (Mok & Jiang, 2018). However, challenges persist in aligning graduates' skills with rapidly changing economic demands, as discussed later in the paper.

Institutional Differentiation: QA policies have contributed to a clearer stratification in the higher education sector. Elite universities that receive excellence funding (Double First-Class universities) have used QA as a tool for competitive enhancement, adopting international best practices and benchmarking themselves against world-class standards (Hazelkorn, 2015; Marginson, 2011). Many of these top institutions now regularly undergo international reviews in addition to national QA, and they have climbed steadily in global university rankings, suggesting improvements in research and teaching quality (Altbach & de Wit, 2018). In contrast, some local colleges and private institutions have faced greater difficulties in meeting QA standards (Zhang & Wan, 2017). A number of private colleges underwent consolidation or program cuts after failing to achieve satisfactory evaluation results in the 2000s. The QA system thus acts as a mechanism of accountability that can weed out substandard providers, but it also means weaker institutions require more support to improve. Recent policy has acknowledged this, with targeted programs to help *"newly-established HEIs"* (often local colleges) build capacity (Pan, 2015). This differentiation aligns with the government's intent to have a diverse system with different tiers, but it raises equity concerns about students in lower-tier colleges (Yang, 2015).

Internationalization and Recognition: One clear outcome of enhanced QA is the greater international recognition of Chinese higher education credentials. Through alignment with global accreditation systems and demonstration of rigorous QA processes, Chinese universities have gained trust internationally. For instance, the acceptance of Chinese engineering and medical degrees abroad has improved post-accreditation (Liu & Hou, 2009; Xu & Li, 2019). Several Chinese universities have obtained accreditation from international bodies (e.g., AACSB or EQUIS for business programs), leveraging domestic QA improvements. Moreover, China's active participation in global QA networks (such as the Asia-Pacific Quality Network, APQN, and the International Network for Quality Assurance Agencies in Higher Education, INQAAHE) is both a cause and effect of its QA advancement. These engagements not only elevate the reputation of Chinese higher education but also continuously expose Chinese QA practitioners to new ideas and standards, creating a virtuous cycle of quality enhancement (Liu et al., 2025). On the flip side, the internationalization of higher education—such as the growth of Sino-foreign joint universities and programs—has tested China's QA system, which must coordinate with foreign QA agencies to accredit these joint initiatives (Huang, 2016). China has responded by issuing special QA guidelines for transnational programs and conducting joint evaluations, an area that still evolves as cross-border education expands.

In sum, the reforms in QA policy have led to notable improvements in the infrastructure and processes of quality assurance at Chinese universities, with positive impacts on educational quality in many cases. However, the experiences of institutions also reveal areas where QA practices have yet to achieve their intended effect, or have generated unintended consequences. The *Discussion* section will delve into these persistent challenges, offering a critical perspective on what obstacles remain and how they might be addressed to ensure that QA truly supports educational excellence across China's diverse higher education landscape.

4. Discussion

China's ambitious efforts to implement quality assurance in higher education have yielded both significant progress and ongoing challenges. In this section, we reflect on the implications of the findings, examining the tensions in China's QA system and the hurdles that institutions face in cultivating genuine quality improvement. Several interrelated themes emerge: the balance between accountability and improvement, the centralization of QA versus institutional autonomy, the development of a quality culture, and the capacity of stakeholders (faculty, students, third-party agencies) to engage in QA processes.

4.1. Accountability vs. Improvement

One of the classic debates in QA is whether evaluation systems primarily serve as accountability tools or as mechanisms for improvement (Rhoades & Sporn, 2002). China's experience encapsulates this tension. The early QA regime was firmly accountability-oriented – universities were held to uniform standards set by the government, and poor performance could lead to sanctions or loss of face. This had the advantage of establishing minimum quality thresholds across a vastly expanded system, a necessary step in the aftermath of rapid growth. However, a compliance-driven approach can engender a checklist mentality among institutions, where the focus is on satisfying the evaluator rather than innovating in teaching and learning (Bao & Liu, 2019). Indeed, some Chinese academics have criticized past evaluations as overly bureaucratic, consuming faculty time in preparing documentation and statistics that may not reflect actual learning quality (Wang, 2014; Zhou & Gao, 2017). While the newer audit model aims to pivot towards improvement by providing developmental feedback, it is still evolving. Universities often still perceive external audits as high-stakes "inspections" and may engage in short-term mobilization of resources (e.g., temporarily reducing class sizes or sprucing up facilities) before an audit, which can limit the authenticity of the exercise (Yang, 2015). The key challenge is to embed continuous improvement so that QA is not an event but a process. This requires reducing the punitive perception of QA and framing it as a collaborative effort to enhance quality. Chinese policy makers appear aware of this, as seen in recent guidelines that explicitly forbid excessive paperwork in evaluations and encourage expert panels to act more like consultants than judges (Pan, 2015). Moving forward, the effectiveness of QA in China will hinge on strengthening its formative aspects – helping institutions identify weaknesses and support improvement – rather than just its summative judgment function (Harvey & Stensaker, 2008).

4.2. Centralization and University Autonomy

China's QA system reflects the broader governance model often described as "centralized decentralization" (Marginson, 2011), wherein the government sets the agenda and framework, but implementation is devolved to universities. The state maintains tight control over QA criteria and processes through the Ministry of Education and its authorized agencies. For instance, even as audits replaced evaluations, the criteria for audits were still designed by national bodies and largely standardized (covering institutional mission, faculty, teaching conditions, student support, etc.), albeit assessed more flexibly (Shi, 2009; Yang & Chen, 2016). This centralization ensures a baseline consistency and aligns QA with national goals (like producing more STEM graduates or

promoting innovation). However, it can conflict with institutional autonomy and innovation. Some university leaders argue that they need greater freedom to define quality on their own terms and to experiment with new educational models without fearing negative evaluation results (Yang, 2015). The Double First-Class initiative, for example, pressures elite universities to excel in research and global rankings, which might incentivize practices (hiring star researchers, emphasizing publications) that do not directly translate to better undergraduate teaching quality (Hazelkorn, 2015; Mok & Jiang, 2018). In less prestigious institutions, strict adherence to government QA directives may stifle local adaptation – for example, a teaching-focused college in a poor region might be better served by qualitatively different QA metrics emphasizing community impact and practical training, rather than the same research indicators used for top universities (Zhang & Wan, 2017). The Chinese government has acknowledged the need to "respect institutional diversity" in QA (Ministry of Education, 2010), but in practice, achieving this remains difficult in a centralized system. A potential path forward is granting universities more autonomy in internal quality management, with the state shifting to a supervisory and capacity-building role. This could involve allowing institutions to set specific additional quality goals based on their mission (with state oversight ensuring these goals are credible), and accepting differentiated evaluation outcomes rather than assuming one hierarchy of quality for all (Liu et al., 2025). Such an approach would require trust in universities—a cultural shift from the traditional top-down control. Notably, some pilot reforms are testing greater autonomy: e.g., a few top universities have been allowed to undertake self-evaluation in lieu of a scheduled external audit, submitting their self-assessment to MoE for record (Pan, 2015). If successful, this could be expanded.

4.3. Building a Quality Culture

International QA experts emphasize that a sustainable quality system depends on cultivating a quality culture—shared values and commitments to quality within the academic community (Harvey & Stensaker, 2008; Green, 1994). Establishing such a culture is arguably the most persistent challenge in China. Historically, Chinese universities (especially during the expansion era) have been more accustomed to responding to government directives than engaging in collegial self-reflection on quality. Changing this mindset is a slow process. Our review indicates some positive trends: faculty awareness of teaching quality issues has risen, and there are more discussions at department and school levels about how to improve courses and academic support (Zhou & Gao, 2017; Long et al., 2024). The involvement of faculty in QA processes, however, is not uniform. In many institutions, QA is still seen as the domain of administrators, with academics participating only minimally, for instance by filling out evaluation forms or complying with new syllabus requirements (Zhou & Gao, 2017). For QA to truly lead to pedagogical enhancement, faculty need to take ownership. This could be encouraged by initiatives such as faculty-led quality circles, peer mentoring programs for teaching, and giving departments greater responsibility (and credit) for internal quality improvements (Chen & Li, 2022). The role of students is equally important. Chinese universities have begun to solicit student feedback more systematically, but students can be reluctant to voice criticism due to cultural norms and skepticism about whether feedback will bring change (Yang, 2015). Strengthening student

representation in QA committees and transparently acting on student feedback (e.g., publishing "you said, we did" reports) could gradually empower the student voice. A heartening development is that some quality evaluations now explicitly assess whether an institution has a positive quality culture – for example, audit teams might interview random faculty and students to gauge their understanding of and commitment to quality goals (Liu & Cheng, 2005; Liu et al., 2025). This sends a message that quality culture is not an abstract ideal but a tangible part of what "counts" in QA. Over time, recognition (through awards or commendations) of departments and universities that exemplify a strong quality culture could reinforce these values. As Harvey and Stensaker (2008) note, building quality culture is a long-term endeavor; China's QA evolution may need another decade of persistent effort in this direction for the cultural shift to fully take root.

4.4. Stakeholder Engagement and Third-Party Agencies

A robust QA system engages multiple stakeholders, including not just the university and government, but also independent agencies, employers, and society at large. In China, this aspect of QA is still developing. The creation of the HEEC and specialized accreditation committees has introduced elements of peer review and expert involvement beyond direct government officials, which is a positive step. However, truly independent QA agencies (like non-governmental accreditation bodies common in some countries) are rare. An attempt to pilot third-party QA agencies in a few provinces has encountered obstacles such as lack of authority, limited professional capacity, and unclear division of responsibility with government education departments (Chen & Wu, 2020). In Yunnan Province, for instance, a third-party QA agency struggled to gain the trust of universities, who still looked to the provincial education department for final judgments (Chen & Wu, 2020). Strengthening such agencies requires clear policy support that delineates their role and ensures their evaluations carry weight. Training of QA professionals is also needed so that there is an expert community outside the universities and government capable of carrying out evaluations objectively (Liu, 2018). Engaging employers and industry representatives in QA is another area for improvement. While many universities have industry advisory boards for their programs (as encouraged by accreditation standards), the extent to which employer feedback influences curriculum and QA decisions is not always evident (Hu & Vargas, 2015). Given China's focus on aligning higher education with economic needs, more systematic inclusion of labor market outcomes in QA (such as employer surveys, graduate tracking studies) would be beneficial (Jiang & Tam, 2019). The data systems established are starting to do this, but qualitative input from employers could enrich the understanding of quality beyond numerical indicators. Furthermore, transparency to the public remains a challenge. Chinese QA results are often not fully disclosed—typically, a list of evaluated institutions might be published with general comments, but detailed reports are internal (Pan, 2015). Increasing public access to quality information could enhance external pressure and incentives for improvement (Hazelkorn, 2015). However, it must be balanced with fairness, to avoid misinterpretation of data by rankings or media that might unduly stigmatize institutions in challenging contexts. Initiatives like publishing brief annual quality reports for each university (a practice some institutions have voluntarily adopted) can improve accountability to society (Ministry of Education, 2021). Internationally, China can also leverage cross-border external

reviews—for example, inviting foreign QA agencies to conduct reviews of certain programs or benchmarking exercises. This has been done on a limited basis (such as joint evaluations for Sino-foreign joint universities), and expanding it could further spur Chinese universities to meet global quality expectations.

4.5. Sustaining Improvement Amid Massification

Finally, it is important to acknowledge the scale-related challenges that persist. China now hosts the world's largest higher education system, and maintaining quality across such a vast and diverse array of institutions is a herculean task (Liu et al., 2025). Quality gaps between urban elite universities and rural local colleges are still pronounced. Faculty student ratios in some less-funded institutions remain high (e.g., above 25:1), and faculty qualifications and research opportunities lag behind, affecting the educational experience (Ministry of Education, 2021). QA mechanisms have identified these disparities, but addressing them requires resource allocation and capacity building, which extend beyond QA per se. The government has launched initiatives (like targeted support for universities in central and western China) to reduce inequities, yet the effects will take time to manifest (Pan, 2015; Wang & Liu, 2021). Additionally, academic pressure and employment competition influence perceptions of quality. With a record number of college graduates each year (over 9 million in 2021), students and families gauge quality partly by employability and career outcomes (Mok & Jiang, 2018). QA in China increasingly incorporates graduate employment rates as a metric, but there is debate about over-reliance on this indicator. If universities focus narrowly on employment statistics, they might neglect broader educational outcomes like critical thinking or civic education (Yang, 2015). Thus, QA must strike a balance in defining quality holistically, not just through easily quantifiable outcomes. The concept of "high-quality higher education" now being promoted in China's new policy rhetoric (as seen in the 14th Five-Year Plan for Education) suggests an orientation toward more well-rounded, inclusive, and innovative education (Huang, 2016; Zhang & Wang, 2024). QA standards will likely be revised in coming years to align with this expanded notion of quality, encompassing aspects like teaching innovation, student satisfaction, and contributions to society.

In conclusion, the discussion highlights that while China has built an impressive QA infrastructure in a short time—effectively underpinning the rapid expansion of its higher education system—the journey toward deeply embedded and effective quality assurance is ongoing. Key challenges such as nurturing a quality culture, fine-tuning the balance of control between the state and institutions, and engaging stakeholders more fully must be addressed to avoid QA becoming a mere formality. The Chinese experience reinforces lessons familiar in global higher education: quality assurance is not a one-time reform but a continuous process of learning and adjustment for all actors involved. As China continues to innovate and refine its QA approaches, it can offer valuable insights to other countries facing the twin demands of expanding access and ensuring quality in higher education.

5. Conclusion

Quality assurance has been at the forefront of China′s higher education reform agenda as the country seeks to transition from mass access to world-class quality. This study reviewed the trajectory of QA policy reforms in Chinese higher education and examined the institutional challenges that remain. Over the past two decades, China has succeeded in establishing a comprehensive QA system that includes national evaluations, program accreditations, data monitoring, and internal quality mechanisms. These measures have helped protect educational standards amid explosive enrollment growth and have driven improvements in areas such as curriculum design, teaching conditions, and outcomes assessment. The QA reforms are closely intertwined with China′s push for global competitiveness of its universities, reflected in initiatives like the Double First-Class plan. By aligning many QA practices with international norms and emphasizing accountability, Chinese policymakers have signaled that educational quality is as important as quantity in the country′s development of human resources.

However, the Chinese experience also underscores that implementing QA in a way that genuinely enhances educational quality is a complex endeavor. Many challenges identified in this paper are not unique to China—such as fostering a quality-oriented institutional culture rather than compliance behavior—but some are accentuated by China′s context and scale. The persistence of a top-down ethos means that universities often remain reactive to government mandates. To truly internalize quality improvement, institutions will need greater empowerment and encouragement to take initiative in QA, tailoring improvement strategies to their unique missions and student populations. Furthermore, while China′s QA system effectively identifies problems, addressing those problems requires ongoing investment in faculty development, student support, and infrastructure, especially for institutions in less-developed regions. The inequity in resources can translate into inequity in quality, a challenge that China′s QA and funding policies must tackle hand-in-hand.

The analysis leads to several recommendations for policy and practice. First, China could adopt a more risk-based and differentiated QA approach: institutions with strong track records might undergo lighter-touch reviews, whereas those with documented challenges receive more intensive mentoring and monitoring. This would allocate evaluative effort where it is most needed and reduce unnecessary burden on high-performing universities, allowing them to focus on innovation. Second, strengthening feedback loops is crucial. After evaluations or audits, actionable recommendations should be followed up, and universities should report on improvement actions taken; in turn, QA agencies should provide guidance or training to assist with those improvements. Creating communities of practice—networks where QA officers and faculty from different universities share effective practices—can also facilitate collective learning and dissemination of what works. Third, enhancing stakeholder engagement will improve legitimacy and effectiveness of QA. Incorporating student and employer input more systematically can help ensure that quality is defined in terms of real educational value added, not just administrative metrics. The move towards publishing annual quality reports is positive; expanding this transparency and

encouraging public dialogue about higher education quality will keep institutions responsive to societal needs.

For scholars and policymakers internationally, China′s QA journey offers valuable insights. It demonstrates the possibility of building QA systems relatively quickly through strong government initiative, but also highlights the risk that such systems may emphasize compliance over creativity. The Chinese case reinforces the idea that quality assurance must evolve: initial phases may rightly focus on establishing accountability and minimum standards, but mature systems should pivot to promoting a deep-seated culture of continuous improvement. As Chinese higher education moves into a new stage of consolidation and improvement, its QA system is likely to keep adapting. Future research could fruitfully examine, for example, the impact of QA on student learning outcomes more directly (beyond proxies like employment) and how new challenges—such as the rapid digitalization of education with online learning—are addressed by QA policies.

In conclusion, quality assurance in Chinese higher education has come a long way, reflecting and enabling the sector′s remarkable expansion and rising stature. The policy reforms have established structures and awareness that did not exist a generation ago, laying the groundwork for more substantive quality improvements. Yet, achieving the lofty goal of world-class education for a system serving tens of millions of students will require sustained commitment to refining QA practices. It entails trusting and supporting universities to innovate, engaging educators and students as partners in the quest for quality, and remaining vigilant that the ultimate purpose of QA is not the production of self-congratulatory reports, but the enhancement of student learning and development. The Chinese experience thus far illustrates both the opportunities and the challenges in using policy levers to drive educational quality. Other countries can learn from China′s successes in building QA capacity, while also heeding the caution that true quality is cultivated from within academic communities, not just engineered from above. As China continues to navigate this balance, its outcomes will be closely watched, offering lessons for the global higher education community in the shared pursuit of excellence.

Author Contributions:

Conceptualization, J. L.; methodology, J. L.; software, J. L.; validation, J. L.; formal analysis, J. L.; investigation, J. L.; resources, J. L.; data curation, J. L.; writing—original draft preparation, J. L.; writing—review and editing, J. L.; visualization, J. L.; supervision, J. L.; project administration, J. L.; funding acquisition, J. L. All authors have read and agreed to the published version of the manuscript.

Funding Statement:

Not applicable.

Institutional Review Board Statement:

Not applicable.

Informed Consent Statement:

Not applicable.

Data Availability Statement:

Not applicable.

Acknowledgments:

Not applicable.

Conflict of Interest:

The author declared no potential conflicts of interest with respect to the research, authorship, or publication of this article.

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