

# A Review on the Internationalization of Technical Standards

Kaiyu Zhi\*

Xi'an International Students University, Xi'an 710128, Shaanxi, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** The internationalization of technical standards is a crucial means to promote high-quality economic development, enhance corporate competitiveness, and participate in global economic governance. Drawing widespread academic attention, this paper systematically reviews existing research on the internationalization of technical standards, covering aspects such as the concept of technical internationalization, challenges and countermeasures, influencing factors, and the relationship between technological innovation and technical standards. The aim is to advance the refinement of related technical fields and provide theoretical support and guidance for practical activities in the internationalization of technical standards.

**Keywords:** Internationalization of technical standards; Technological innovation; Technical standards

**Online publication:** April 28, 2025

## 1. Research background

The internationalization of technical standards is pivotal for driving high-quality economic growth, boosting corporate competitiveness, and engaging in global economic governance. Developed countries such as the United States, Germany, and Japan recognized the importance of standards competition early on. In contrast, China's development in this area lags by approximately 10–15 years. With first-mover advantages, developed countries dominate 90% of global international standards, wielding significant influence, while China accounts for only 2% <sup>[1]</sup>, reflecting its relatively weak voice in international standardization. China's lack of mature coordination mechanisms has resulted in weak interactive effects between innovation and standards, hindering their mutual advancement <sup>[2]</sup>.

Scholars have explored the internationalization of technical standards through conceptual definitions, challenges and countermeasures, influencing factors, and the interplay between innovation and standards. These studies lay the groundwork for future research and offer theoretical guidance for enterprises. Therefore, a comprehensive review of existing research is necessary to provide a robust theoretical foundation for enterprises to advance standard internationalization through innovation-standard synergy.



## **2. Concept of internationalization of technical standards**

### **2.1. Technical standards**

Standards serve as the technical backbone of a nation's economic activities and social development, vital for industrial technological progress, market expansion, and corporate internationalization. China initiated standardization work in 1949, establishing government-mandated standards to stabilize the chaotic post-founding era. Post-reform, China aligned its standards with international norms, joining the International Organization for Standardization (ISO) in 1978. ISO defines standards as technical specifications or public documents developed through consensus among stakeholders to enhance public welfare. China's Basic Terminology for Standardization (1983) describes standards as unified norms for homogeneous entities or concepts within a field grounded in science. ISO emphasizes that technical standards, whether mandatory or advisory, include technical requirements and solutions to ensure product/service safety or market access. By 2003, China elevated technical standards to one of its three core strategies for technological development, alongside talent and patents.

### **2.2. Internationalization of technical standards**

The internationalization of technical standards represents a specialized form of standardization globalization, characterized by their technical nature and the incorporation of specifications governing technical pathways <sup>[3]</sup>. To date, the concept of "internationalization of technical standards" lacks a clear definition. Over 40 years of reform, China's understanding has evolved: in the 1980s–1990s, it focused on aligning with international standards; by the 2000s, it expanded to participating in international standardization and enhancing China's influence. Since 2013, the vision has shifted toward globalizing Chinese standards and transitioning from participant to leader in international standard-setting. Current research also categorizes corporate internationalization of technical standards into stages. Zhou *et al.* divide it into "alignment," "followership," and "leadership" phases <sup>[4]</sup>. Policy documents further classify stages as "adopting international standards," "developing international standards," and "promoting China-led standards." Regardless of classification, the internationalization of technical standards is a dynamic, evolving process intertwined with technological innovation.

## **3. Challenges and countermeasures for the internationalization of technical standards**

Existing research examines challenges at macro (national), meso (industry), and micro (corporate) levels. National challenges include an incomplete standardization system, suppression by developed countries, etc. Industry-level challenges involve limited secretariat seats in international organizations and internal interest conflicts. Corporate challenges are fragmented and complex, encompassing weak innovation, inadequate standard-setting experience, and talent shortages. Scholars propose targeted countermeasures.

### **3.1. National level**

At the national level, around 2000, China had minimal involvement in setting international technical standards. The primary national task was to align domestic standards with international norms as quickly as possible. Scholars at the time advocated strategies for the internationalization of technical standards centered on actively adopting international and advanced foreign standards <sup>[5]</sup>. By 2020, China had achieved progress in standardizing technologies in aerospace, telecommunications, and high-speed rail. Scholars' focus on countermeasures shifted, emphasizing the need for China to strengthen interaction and cooperation with global and regional standards organizations, actively participate in drafting international standards, and encourage leading enterprises to integrate technological innovation with standard creation. This approach aims to align Chinese standards with the needs of Belt and Road Initiative (BRI) partner countries. Domestically, the government must first recognize the

importance of the internationalization of technical standards and elevate it to a national strategic priority. However, Xie *et al.* argued that the government should reduce direct intervention in standardization processes and allow market mechanisms to play a greater role <sup>[6]</sup>. In contrast, some scholars emphasized that both government and market should fulfill their respective roles. Government-led standards should focus on safeguarding baselines and ensuring safety, while market-driven standards should prioritize strengthening advantages and expanding markets.

### **3.2. Industry level**

Industry associations serve as intermediaries between enterprises and governments, as well as between industries and markets. They articulate the demands and expectations of enterprises to governments while disseminating national policies to enterprises on behalf of governments. Additionally, they relay international market information to domestic enterprises and showcase the achievements of Chinese enterprises globally. Therefore, industry associations should strengthen collaboration with standardization organizations, actively seek underrepresented seats in technical committees of international standards bodies (e.g., ISO, IEC), and assume more roles as conveners or secretaries. Grounded in market needs, they must conduct in-depth research on international norms—such as EU standards, German standards, British standards, French standards, Japanese standards, and specialized technical standards—as well as analyze international market responses. The timely adoption and localization of international standards and advanced standards from developed countries will expand channels for Chinese standards to go global.

### **3.3. Enterprise level**

Enterprises should adopt a market-oriented approach to establish market-driven standard-setting systems, conduct technological R&D, and prioritize niche markets lacking dominant standards but possessing certain technological foundations to leverage their competitive advantages. Enterprises should also build standard innovation systems, create dedicated standardization departments, and integrate technical standards with technological innovation and intellectual property to enhance independent innovation capabilities. Additionally, as latecomers, Chinese enterprises must strategically utilize China's vast user resources and information resources, leveraging market advantages to offset technological gaps. Prioritizing market preemption over immediate profit returns is a critical influencing factor for the internationalization of technical standards.

## **4. Influencing factors in the implementation of AI in management accounting**

### **4.1. Stakeholder perspectives**

From the perspective of stakeholder roles, influencing factors can be categorized into governments, industry associations, enterprises, and others. First, the internationalization of technical standards is not only market competition but also intergovernmental rivalry. Consequently, governments worldwide act as drivers, promoting their domestic enterprises to internationalize technical standards, enabling their technologies to expand globally and capture larger international market shares. Governments support this through policy measures—such as funding support and qualification support—by understanding the current state of national standard internationalization and acting as coordinators <sup>[7]</sup>. Second, industry standards associations play a critical role by acquiring timely international standards information and securing seats in international standards organizations, which safeguards enterprises' participation in global standardization activities. Finally, enterprises themselves are the primary executors of the internationalization of technical standards, serving as the frontline actors in technological innovation and international standard-setting. Their R&D capabilities, synergy between innovation and standards, and capacity to build standard innovation systems directly impact the success of standard

internationalization. Generally, enterprises with stronger capabilities wield greater standards influence, which further accelerates the development of their internationalization of technical standards.

## **4.2. Factor characteristics**

From the perspective of influencing factor characteristics, there are two main dimensions: innovation-related capabilities and standard-related capabilities. First, innovation-related capabilities encompass corporate R&D investment, technology absorption capacity, and collaborative R&D capabilities. The process of formulating technical standards is inherently a process of technological innovation. Enterprises with advanced R&D capacities can complete technical standard development more efficiently, accelerate product updates, and maintain the advancement and utility of new standards, thereby gaining a competitive edge in standards competition. However, for enterprises lacking independent innovation capabilities, their capacity for technology absorption and collaborative R&D becomes critical. An increasing number of firms are building proprietary R&D systems through technology acquisition and partnerships, thereby gaining standard-setting capabilities and advancing the internationalization of their technical standards <sup>[8,9]</sup>. Thus, higher innovation-related capabilities accelerate the internationalization of technical standards. Second, standard-related capabilities include opportunity identification capacity, resource integration capacity, and standardization talent. Opportunity identification is the prerequisite for standard internationalization, enabling enterprises to seize momentum and initiate internationalization efforts. Resource integration capacity ensures the efficiency of standard development by aligning corporate resources with internationalization goals. Standardization talent serves as a critical pillar for the internationalization of technical standards. Due to domestic enterprises' lack of familiarity with international standards, project costs and risks escalate. To address this, enterprises must establish a high-caliber talent system by recruiting professionals with international standardization expertise through internal training, external hiring, industry-academia collaboration, or international recruitment. Additionally, hiring locals or overseas Chinese familiar with target countries' contexts can further strengthen capabilities in navigating the internationalization of technical standards.

## **5. Relationship between technological innovation and technical standards**

Throughout the entire innovation process, one of the primary goals of innovation is to establish influential standards, while the main purpose of developing standards is to elevate innovation capabilities. Through empirical analysis, some scholars demonstrate a strong bidirectional influence between technological innovation systems and technical standard systems. Some scholars argue that standards within a specific technical category may negatively impact innovation performance in that field. In other words, the existence of standards can suppress innovation due to the inherent contradiction between the monopolistic nature of technical standards and the public-sharing nature required for innovation, necessitating government intervention to mitigate this adverse effect. Conversely, other scholars highlight the positive role of technological innovation in shaping standards: technical standards guide the direction of innovation activities and enhance R&D efficiency, while technological innovation drives the formation of new standards. Thus, in the context of corporate internationalization of technical standards, technological innovation and technical standards exhibit a mutually influential relationship.

## **6. Literature review**

In recent years, scholars have conducted extensive research and in-depth exploration on the internationalization of technical standards from various perspectives, providing both theoretical support and practical guidance for addressing related challenges.

### **6.1. Challenges and countermeasures for the internationalization of technical standards**

Existing studies analyze the challenges and countermeasures for the internationalization of technical standards from macro (national), meso (industry), and micro (corporate) perspectives. Governments, industry associations, and enterprises each have distinct roles: governments can provide multi-level support based on industry standard development; industry associations can undertake international standardization tasks aligned with domestic industry conditions; enterprises can engage in industry-specific standardization based on their technological innovation and technical standard capabilities. The interplay among governments, industry associations, and enterprises highlights the limitations of single-dimensional research. Future studies should explore how these three stakeholders can synergize to advance the internationalization of technical standards.

### **6.2. Influencing factors for the internationalization of technical standards**

Existing literature thoroughly examines the influencing factors for corporate internationalization of technical standards, analyzing government policies, market environments, standards organizations, and internal corporate capabilities. These factors can be categorized into innovation-related capabilities (e.g., R&D investment, technology absorption) and standard-related capabilities (e.g., opportunity identification, resource integration). The corporate internationalization of technical standards is a complex, dynamic process shaped by the interplay of these factors. Isolated analysis of individual factors is insufficient. Future research should integrate external factors (e.g., government policies, industry associations) with internal corporate factors to better understand their combined impact.

### **6.3. Research on the relationship between technological innovation and technical standards**

Current studies on the synergy between technological innovation and technical standards only outline basic collaboration forms without specifying how these forms and their depth vary across different stages of corporate internationalization of technical standards. As this process evolves, the synergy between innovation and standards should dynamically adapt, with varying forms and depths exerting distinct effects at each stage. Further exploration is needed to clarify how synergy models (e.g., government-led vs. market-led collaboration) and synergy depth (e.g., strategic alignment, resource integration) influence outcomes at different phases of internationalization.

## **Disclosure statement**

The author declares no conflict of interest.

## **References**

- [1] Dong Q, 2022, From a Large Manufacturing Country to a World Manufacturing Power: New Mission and Strategic Adjustment of China's Standardization Strategy. *Economist*, (01): 86–95.
- [2] Han S, Wang T, 2024, Blazing the Path through Legitimacy: Process Mechanisms of Latecomer Enterprises' Standard Catch-up from a Legitimacy Perspective. *Science & Technology Progress and Policy*, (17): 64–75.
- [3] Robert H, Ram D, 2000, The Role of Standards in Innovation. *Technological Forecasting and Social Change*, 64(2–3): 171–181.
- [4] Zhou Q, Chen J, Yang W, et al., 2023, How Can Latecomer Enterprises Broaden Their Influence on International Technical Standard Setting: An Exploratory Case Study of CRRC Zhuzhou Institute. *Journal of Management World*, 39(07): 82–100.
- [5] Cui S, 2022, The Global Clean Energy Transition and the Construction of China's Discourse Power in Technology

Standards. People's Tribune, (09): 50–54.

- [6] Xie Z, An X, Ling H, et al., 2022, Exploring a National Innovation System of Innovation Driven Standardization in The Manufacturing Industry of China: A Study based on International Comparison. Journal of Chongqing University (Social Science Edition), (03): 142–154.
- [7] Gu X, Wei H, 2022, The Influencing Factors of Promoting International Right of Speech of Standard-multi-case Exploration Based on Grounded Theory. Social Scientist, (05): 80–87.
- [8] Blind K, Lorenz A, Rauber J, 2021, Drivers for Companies' Entry into Standard-Setting Organizations. IEEE Transactions on Engineering Management, (68): 33–44.
- [9] Zhang L, Jiang B, Zhang J, 2024, The Key Elements of Technology Standard Internationalization-An Empirical Analysis Based on Global Communication Enterprises. China Science and Technology Forum, (03): 168–176.

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



# DeepSeek and Academia Impact on Higher Education Assessments: Taking “Management Accounting” Course as an Example

Minying Tan\*, Shuze Tang

Guangzhou Huali College, Guangzhou 511325, Guangdong, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** This essay explores the intersection of AI-driven tools like DeepSeek and its impact on academic assessments in accounting education. Using the Management Accounting course as an example, this research examines how AI technologies are influencing the nature of student assessments, particularly in terms of their effectiveness and accuracy. The study also investigates how DeepSeek serves as both an educational aid and a potential threat to traditional accounting assessment methods. By analyzing multiple choice questions (MCQs) from 22<sup>nd</sup>–23<sup>rd</sup>, the second semester’s final exam performance for the Management Accounting course, the research evaluates the AI’s ability to solve numerical and narrative-based questions correctly, comparing its performance against traditional student responses. Findings suggest that while AI can achieve high performance on simpler tasks, it struggles with complex accounting concepts that require critical thinking and deeper understanding. Furthermore, the paper discusses the implications of these findings for both lecturers and students, highlighting the need for a balance between technological innovation and traditional academic integrity. Ultimately, it calls for a re-evaluation of assessment frameworks to incorporate AI as a tool for learning enhancement while safeguarding against misuse in academic environments.

**Keywords:** DeepSeek; Tutor-DeepSeek-student “Three-way Inter-connection”; AI in academia; Higher education; Management accounting

**Online publication:** April 28, 2025

## 1. Introduction

The rapid advancement of artificial intelligence (AI) has led to significant transformations across various industries, with accounting education being no exception. As an AI technology, ChatGPT continues to evolve and reshape the landscape of academic assessments in accounting courses. Now, the newborn DeepSeek provides one more choice for educators to utilize those AI tools in lecturing and assessment. With the rapid integration and deployment by educational intelligence units, educational technology companies, and universities, DeepSeek is advancing from the periphery to the core of education. It will accelerate the technological revolution driven by artificial intelligence, thereby promoting educational transformation <sup>[1]</sup>. This research tries to enhance the



efficiency of traditional exam assessment methods.

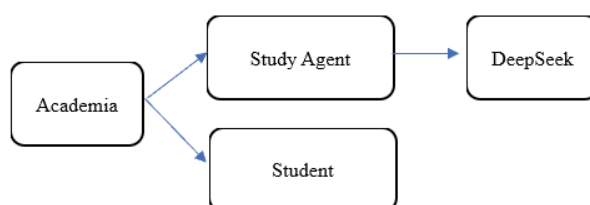
Financial intelligence powered by AI has altered the roles and functions of accounting professionals, necessitating a shift in the way accounting education and assessments are approached <sup>[2]</sup>. Management accounting, being a critical tool for internal business management, is undergoing a profound transformation through the integration of AI technologies. Meanwhile, artificial intelligence can also transform curriculum structures to create new hybrid teaching models, which can reshape training programs to achieve fully personalized learning pathways, thereby enhancing the quality of talent cultivation in higher education <sup>[3]</sup>. In recent years, AI technologies have integrated a trend of “human-machine collaboration” in which AI systems assist accountants by providing accurate data models and cost and profit forecasts with greater efficiency <sup>[4]</sup>. So, how do these tools also assist in the course assessment? As of January 2025, DeepSeek had 33.7 million monthly active users worldwide, while China, India, and Indonesia are the largest markets for DeepSeek, accounting for 51.24% of DeepSeek monthly active users. DeepSeek website unique visitors per week amounted to 15.9 million <sup>[5]</sup>.

Given the increasing use of AI in business settings, there is a growing need for academic institutions to rethink their teaching models and content in light of these technological advancements. AI’s application in management accounting offers both opportunities and challenges for instructors and students alike. While AI tools can enhance learning and assessment experiences by providing faster and more accurate solutions to financial problems, they can also raise questions about the validity and integrity of student assessments <sup>[6]</sup>. This essay explores how DeepSeek, as an AI tool, influences the assessment practices within Management Accounting courses. By analyzing its performance in multiple-choice questions and comparing it to traditional student responses, this study aims to investigate both the potential of AI in educational settings and the concerns it raises in terms of academic integrity and assessment accuracy.

## 2. Apply DeepSeek in Management Accounting course assessments

### 2.1. Theoretical framework

The agency framework employed below delineates the dynamic interplay between DeepSeek and the course lecturer in the co-creation of academic outputs in the final assessments of the Management Accounting course. Within this framework, the lecturer comprises two primary stakeholder groups: academics (lecturer) and students. The interaction between academia and DeepSeek is conceptualized as a form of humanlike interaction, thereby enabling a quasi-human-to-human engagement with academic stakeholders. This framework underscores the collaborative and interdependent nature of the relationship, wherein DeepSeek serves as a co-creative agent alongside traditional academic participants in assessment marking, as shown below in **Figure 1**.

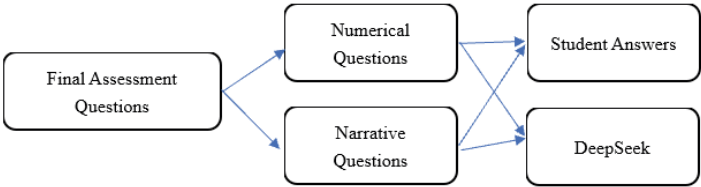


**Figure 1.** Framework on academia and DeepSeek interaction

### 2.2. Methodology

The methodological framework employed in this study is structured around the evaluation of two distinct users: Students and DeepSeek. Each user is assessed through a set of 10 questions from management accounting final assessments, evenly divided into five narrative (qualitative) and five numerical (quantitative) questions. To ensure

methodological rigor, each question is independently tested by two distinct platforms: Student and DeepSeek. Artificial intelligence can transform curriculum structures to create new hybrid teaching models, and it can reshape training programs to achieve fully personalized learning pathways, thereby enhancing the quality of talent cultivation in higher education. This approach aligns with established accounting research methodologies, emphasizing the systematic evaluation for assessment, as shown in **Figure 2**.



**Figure 2.** Methodological framework on user interaction

### 2.3. Performance comparison

According to **Table 1**, questions with higher accuracy rates (e.g., Questions 1, 8, and 10) typically involve basic concepts or theories, indicating better student comprehension. Questions with lower accuracy rates (e.g., Questions 5, 7, and 9) may involve calculations or more complex accounting treatments, requiring students to strengthen their understanding and practical skills. Meanwhile, for numerical questions, DeepSeek performed better than the student, and vice versa for narrative questions. However, the overall performance from DeepSeek is appreciated, which can meet the requirement to act as an assessment checker.

**Table 1.** Performance summary and comparison between students and DeepSeek

ID	Question type	Check point	Correct answer/ DeepSeek answer	DeepSeek performance	Student performance
1	Narrative	Conceptual	A/A	Correct	85%
2	Numerical	Bond	B/B	Correct	70%
3	Narrative	IRR	C/C	Correct	65%
4	Narrative	Contribution	B/B	Correct	75%
5	Numerical	Inventory	B/D	Incorrect	60%
6	Narrative	Cost center	D/C	Incorrect	80%
7	Narrative	Job costing	B/B	Correct	55%
8	Narrative	Performance management	C/C	Correct	90%
9	Narrative	Reporting	A/A	Correct	50%
10	Narrative	Conceptual	B/B	Correct	95%
Correct rate	Numerical			50%	65%
	Narrative			87.5%	74%

### 2.4. Advantages to adapting the framework

#### 2.4.1. Enhanced efficiency in assessment marking

AI can handle time-consuming tasks such as the accounting entry, classification, and review of accounting records automatically, thereby enhancing the accuracy and efficiency of financial management <sup>[7]</sup>. Hence, Thanks to DeepSeek, workload and errors in course grading objective questions, checking calculations, or identifying key concepts in student’s assessments may be reduced, which allows tutors to focus on higher-value tasks like

providing qualitative feedback or engaging with students.

#### **2.4.2. Improved consistency and fairness**

DeepSeek applies consistent criteria across all assessments, minimizing human biases or inconsistencies during making judgments.

#### **2.4.3. Quasi-human interaction for engagement**

DeepSeek's interactions as a quasi-human allow students to perceive the AI as a supportive and approachable tool rather than a cold, mechanical system. This fosters a more engaging learning environment.

#### **2.4.4. Collaborative co-creation of academic outputs**

DeepSeek can complement the lecturer's expertise under the framework. For example, DeepSeek can handle quantitative or data-heavy tasks, while the lecturer focuses on qualitative insights and critical thinking.

#### **2.4.5. Alignment with modern educational trends**

The framework aligns with the growing trend of incorporating AI tools into education, preparing students and lecturers for a future where human-AI collaboration is commonplace.

### **3. Implications for academia**

#### **3.1. Implications for knowledge**

By making knowledge more accessible, DeepSeek has elevated the benchmark of assumed knowledge for all stakeholders, including the scholarly community comprising of academics and students. The automated assistance provided by DeepSeek has challenged the traditional assessment methods.

Education is one of the core scenarios for the application of AI. Through cost reduction and efficiency improvement, DeepSeek has the potential to empower the education industry <sup>[8]</sup>. Since there is no universally accepted definition of originality, it is essential to contextualize it within specific academic disciplines and course structures. For instance, originality in accounting courses differs significantly from medical courses. Even within accounting, subfields - such as management accounting, financial accounting, and accounting theory demand may vary.

#### **3.2. Implications for DeepSeek**

Strategic decision-making is a critical component of the business model. Such reflections are not aimed at reducing revenue but rather at optimizing it. However, these reflections can offer scenario-based solutions on how to generate the desired revenue while contributing differently to the business. DeepSeek can champion business by increasing opportunities for lecturers to optimize resources, thereby reducing the costs associated with acquiring and disseminating knowledge. This would allow the lecturer to allocate more funds toward developing students' skills. Furthermore, DeepSeek can also champion AI businesses to share information and develop co-patented software, enhancing student learning within academic institutions.

#### **3.3. Challenges to using DeepSeek in assessment**

##### **3.3.1. Accuracy and contextual understanding**

While DeepSeek can efficiently process numerical data and solve routine accounting problems, it often struggles with the deeper contextual understanding required in management accounting. Many accounting problems require

not only technical calculations but also interpretation of data within specific business contexts, such as cost behavior analysis or strategic decision-making. AI tools may misinterpret underlying assumptions or fail to grasp nuanced business scenarios, leading to incorrect solutions or inappropriate recommendations.

### **3.3.2. Threat to academic integrity**

DeepSeek usually raises concerns about academic integrity and the potential for students to rely too heavily on automated solutions rather than engaging in critical thinking. Students might misuse the technology to bypass learning or submit AI-generated responses as their own, undermining the purpose of assessments. This presents a challenge for educators in ensuring that AI does not replace the essential cognitive processes involved in learning management accounting.

### **3.3.3. Lack of adaptability to complex or evolving assessment criteria**

Management Accounting course assessments often involve complex problem-solving that may change over time based on new theories, emerging trends, or real-world scenarios. DeepSeek is typically trained on historical data and may struggle to adapt quickly to evolving coursework, new methods, or unique questions that require creative solutions. As accounting practices evolve, so too must assessment methods, posing a challenge for AI tools that cannot keep pace with the dynamic nature of the field.

## **4. Future development**

The integration of DeepSeek into management accounting assessments has shown promising results. Even significant potential for further development is foreseeable. Future advancements can focus on enhancing the DeepSeek's ability to handle complex, context-driven problems, improving its adaptability to evolving assessment criteria and addressing ethical concerns related to academic integrity. Below are key areas for further development, supported by relevant literature:

Firstly, enhancing contextual understanding and critical thinking. DeepSeek's current capabilities are limited in interpreting business scenarios and applying critical thinking to solve complex accounting problems, which means it can't be used to check opening questions. Future research should focus on improving the DeepSeek's ability to understand contextual factors, such as accounting gaps, industry-specific regulations, organizational structures, and strategic decision-making processes. This can be achieved by establishing a platform like Huawei's AIDC center to train AI on a larger database that includes diverse business cases and real-world scenarios <sup>[9]</sup>.

Secondly, adapting to evolving assessment criteria. Management accounting is a dynamic field that continuously evolves with new theories, practices, and technologies. DeepSeek must be designed to adapt to these changes by incorporating real-time updates and learning from emerging trends. For instance, integrating machine learning algorithms that can analyze and adapt to new assessment frameworks will ensure that AI can remain relevant and effective <sup>[10]</sup>.

Thirdly, ensure academic integrity. To address concerns about academic integrity, future developments should include robust mechanisms to detect and prevent misuse of DeepSeek by students. To address these concerns, future studies can prioritize user trust and integrity through transparent communication, robust privacy safeguards, and the mechanisms to mitigate plagiarism risks by using AI tools (e.g., PICO frameworks) <sup>[11,12]</sup>.

Fourthly, collaborative learning and co-creation. Colleges can facilitate a cross-domain knowledge exchange platform involving DeepSeek can be further developed to facilitate collaborative learning between students and educators <sup>[13]</sup>. For example, the AI could be used to generate personalized feedback for students, helping them identify areas for improvement and encouraging active engagement with course materials. Additionally, DeepSeek

could support the co-creation of assessments by providing lecturers with insights into student performance and suggesting tailored questions based on learning outcomes.

Finally, ethical and inclusive AI development. As DeepSeek becomes more integrated into education, it is crucial to ensure that its development aligns with ethical principles and promotes inclusivity. This includes addressing biases in AI algorithms, ensuring transparency in decision-making processes, and making the technology accessible to students or business users from diverse backgrounds <sup>[14]</sup>.

## 5. Conclusion

DeepSeek's superior performance in numerical questions compared to students, while students outperform AI in narrative-based questions. We believe that, although there may be associated risks and integrity issues. However, enhancing contextual comprehension, adapting to dynamic assessment criteria, ensuring academic integrity, and promoting collaborative learning can assist artificial intelligence tools in improving and ultimately revolutionizing the quality and efficiency of course assessments in college. Furthermore, this will help to construct a top-notch innovative talent cultivation system that meets the demands of future technological and societal development needs, to equip students with interdisciplinary knowledge integration, critical thinking, and self-directed learning capabilities with a global perspective, thereby satisfying the nation's talent requirements in critical fields <sup>[15]</sup>.

## Disclosure statement

The authors declare no conflict of interest.

## References

- [1] Lu D, 2025, Disruption and Reconstruction: The “Butterfly Effect” in Education Triggered by DeepSeek and Strategies for Response. *Journal of Xinjiang Normal University*, (04): 1–9.
- [2] Hu Y, 2023, Analysis of Enterprise Financial Intelligence in the Digital Economy. *Modern Accounting*, 6: 22–25.
- [3] Yu Q, 2025, When 80% of the Homework Can be Correctly Completed by DeepSeek. *China University Teaching*, (1–2): 4–55.
- [4] Liu Z, 2023, Embracing Management Accounting in the Era of Artificial Intelligence. *China Management Accounting Review*, (3): 5–10.
- [5] Team B, 2025, DeepSeek AI usage stats, Backlinko, viewed March 10, 2025, <https://backlinko.com/DeepSeek-stats>
- [6] Indra A, 2024, ChatGPT and Academia on Accounting Assessments. *Journal of Open Innovation: Technology, Market, and Complexity*, (1): 100213.
- [7] Wei M, 2023, A Brief Discussion on the Impact of Large-scale AI Application on Financial Management and Accounting Practices. *Money China*, (19): 111–113.
- [8] Meng P, 2025, AI Deeply Empowers the Education Industry. *China Securities Journal*, A06.
- [9] Qi X, Wang T, 2025, An Exploration of the Path to Digital Upgrade in Management Accounting: A Case Study of Huawei AI DC. *Finance and Accounting for International*, (2): 13–16.
- [10] Samuele B, Ilaria B, 2025, Fundamental Rights and Artificial Intelligence Impact Assessment: A New Quantitative Methodology in the Upcoming Era of AI Act. *Computer Law & Security Review*, (56): 106101.
- [11] Maria I, Elaheh Y, 2024, ChatGPT in the Higher Education: A Systematic Literature Review and Research Challenges. *International Journal of Educational Research*, (127): 102411.
- [12] Himendra B, Sachini P, 2025, Reassessing Academic Integrity in the Age of AI: A Systematic Literature Review on

AI and Academic Integrity. *Social Sciences & Humanities Open*, (11): 101299.

- [13] Lemuria C, Liu D, 2025, How Was My Performance? Exploring The Role of Anchoring Bias in AI-assisted Decision Making. *International Journal of Information Management*, (82): 102875.
- [14] Elizabeth I, Dian T, Carla R, et al., 2024, Co-creation in Action: Bridging the Knowledge Gap in Artificial Intelligence Among Innovation Champions. *Computers and Education: Artificial Intelligence*, 7: 100272.
- [15] Xu Z, Qiu S, 2025, The Theoretical Logic and Practical Pathways of DeepSeek Empowering the Cultivation of Top-Notch Innovative Talents. *Journal of Chongqing University (Social Science Edition)*, (2): 2–12.

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



# The Impact of the Digital Economy on Urban Energy-Environment Efficiency

Menghao Tian\*

Hebei GEO University, Shijiazhuang 050030, Hebei, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** This study takes the panel data of 278 prefecture-level cities in China from 2011 to 2022 as samples, constructs a super-efficiency SBM model to measure urban energy-environment efficiency, uses the entropy method to synthesize the digital economy composite index, and introduces the green innovation index as a mediating variable. Breaking through the traditional analysis framework in the empirical method: Firstly, through the fixed-effects model and mediating-effect test, it reveals the direct impact of the digital economy on energy-environment efficiency and the transmission path of green innovation. Secondly, it divides the eastern, central, and western regions and low-carbon pilot cities for heterogeneity tests to identify the moderating effect of policy intervention. Thirdly, it strengthens the robustness of the conclusions by replacing the super-efficiency CCR model, shortening the sample period, and performing winsorization. The study finds that the digital economy significantly improves energy-environment efficiency through green technology innovation. These conclusions provide an empirical basis for optimizing the layout of digital infrastructure and improving the regional collaborative emission-reduction mechanism.

**Keywords:** Digital economy; Energy-environment efficiency; Super-efficiency SBM; Green development

**Online publication:** April 28, 2025

## 1. Introduction

Against the backdrop of global climate governance and the accelerated advancement of the “dual-carbon” goals, the digital economy, as the core driving force of the new round of scientific and technological revolution, is profoundly reshaping the operating logic of the urban energy-environment system through technological penetration, factor recombination, and model innovation<sup>[1]</sup>.

Data from the China Academy of Information and Communications Technology shows that from 2016 to 2022, China’s digital economy scale increased from 22.4 trillion yuan to 50.2 trillion yuan, and its proportion in GDP rose from 30.3% to 41.5%, with a growth rate far exceeding that of traditional economic sectors. At the same time, the United Nations’ “Digital Economy Report 2019” points out that China and the United States account for 90% of the global digital platform market value. Chinese “super-platforms” represented by Tencent and Alibaba are accelerating the digital transformation of energy consumption, production, and governance<sup>[2]</sup>. However, with

the exponential expansion of the digital economy, there are still significant controversies regarding its synergistic relationship with urban energy-environment efficiency. On the one hand, digital technologies may improve energy-environment efficiency and reduce environmental loads through smart grid optimization, real-time carbon emission monitoring, and green supply chain management <sup>[3]</sup>. On the other hand, the expansion of high-energy-consuming infrastructure, such as data centers and the “rebound effect,” may also exacerbate energy consumption and carbon emissions <sup>[4]</sup>. In this contradictory context, clarifying the mechanism of action and spatial spillover effect of the digital economy on urban energy-environment efficiency has become a key proposition for achieving the coordinated development of the “dual-carbon” goals and high-quality digital economy.

Existing research has conducted preliminary explorations on the relationship between the digital economy and energy-environment efficiency. At the theoretical level, scholars generally recognize the “technology-enabling” effect of the digital economy; that is, it optimizes energy allocation efficiency through the Internet of Things, big data, and artificial intelligence <sup>[5]</sup>. However, there are two limitations in the existing literature: First, the spatial scale mostly focuses on provincial panels or specific urban agglomerations, lacking a systematic test of the heterogeneous characteristics of 278 prefecture-level cities. Second, the mechanism analysis is mostly limited to industrial structure or human capital, with insufficient discussion on the mediating path of green technology innovation.

## 2. Research design

### 2.1. Research hypotheses

As a key engine for promoting the green development of the economy and society, the digital economy is providing innovative paths for low-carbon transformation through multi-dimensional technological integration. After digital technologies are embedded in the industrial production process, intelligent algorithms can be used to optimize production process parameters, reducing the energy consumption intensity per unit of output <sup>[6,7]</sup>. In terms of industrial upgrading, the digital economy drives the transformation of traditional manufacturing industries to intelligent manufacturing and constructs a green industrial system covering the entire industrial chain by cultivating emerging industries such as smart energy and environmental protection technology. Therefore, the following hypotheses are proposed:

- (1) The digital economy can promote urban energy-environment efficiency.

The promoting effect of the digital economy on urban energy-environment efficiency can be achieved through its impact mechanism on the level of green innovation. Empirical research shows that in cities with a high level of digital economy development, the increase in green total factor productivity can be more than 1.3 times that of traditional cities <sup>[8]</sup>. The high permeability and network externality of digital technologies break geographical barriers and promote the diffusion of green innovation technologies through the cross-regional flow and sharing of data factors <sup>[9,10]</sup>. The improvement of green innovation capabilities strengthens the regional synergy effect <sup>[11]</sup>. The digital economy optimizes the efficiency of regional resource allocation through big data analysis and cloud computing, achieving accurate matching of energy supply and demand and reducing the overall carbon emission intensity <sup>[12]</sup>. Therefore, the following hypothesis is proposed:

- (2) The digital economy can promote urban energy-environment efficiency by influencing the level of urban green innovation.

### 2.2. Model specification

Mediating-effect model: This paper refers to the mediating-effect model proposed by Wen *et al.* to examine whether the level of the digital economy has an indirect impact on the improvement of urban energy-environment

efficiency by promoting the level of urban green innovation <sup>[13]</sup>. The specific models are as follows:

$$\begin{aligned} NC_{it} &= \beta DIG_{it} + \sum \delta ControlV_{it} + \alpha_t + \epsilon_{it} \\ GC_{it} &= \beta DIG_{it} + \sum \delta ControlV_{it} + \alpha_t + \epsilon_{it} \\ NC_{it} &= \rho wIR_{it} + \beta DIG_{it} + \gamma GC_{it} + \sum \delta ControlV_{it} + \alpha_t + \epsilon_{it} \end{aligned}$$

Among them,  $GC_{it}$  represents the green innovation level of the  $i$ -th region at time  $t$ .  $\gamma$  is the impact coefficient of the mediating variable  $GC_{it}$  on the explained variable  $NC_{it}$ , and  $ControlV_{it}$  represents the control variables of the  $i$ -th region at time  $t$ .

### 2.3. Variable selection

According to Shi *et al.*, this paper draws on and uses the super-efficiency SBM method <sup>[14]</sup>. Taking labor, capital, and energy as inputs, regional GDP as the desired output, and industrial sulfur dioxide, industrial smoke and dust, and industrial wastewater as the undesired outputs, it measures the energy-environment efficiency. It also refers to Zhao *et al.*, taking the logarithmic digital economy index as the explanatory variable <sup>[15]</sup>, the logarithm of the number of green patent authorizations as the mediating variable, and the financial development level, environmental regulation, industrial structure upgrading, foreign direct investment, and scientific and technological development level as control variables. Based on the panel data of 278 prefecture-level cities in China from 2011 to 2022, it explores the impact mechanism of the digital economy on energy-environment efficiency.

## 3. Empirical analysis

### 3.1. Baseline regression

The results of the baseline regression after adding all control variables show that the regression coefficient of the digital economy level on urban energy-environment efficiency is 0.0769, which is significant at the 1% level. This indicates that for every one unit increase in the digital economy, urban energy-environment efficiency increases by 0.0769 units. After adding the fixed-effects and random-effects models, the direction and significance of the regression coefficient remain unchanged, but the value decreases, indicating that the control variables can more accurately reflect the impact of the digital economy. The results show that the digital economy has a significant promoting effect on industrial carbon emission efficiency, verifying hypothesis 1. (1) The sample period of the study is adjusted to 2015–2022 after the implementation of the “Broadband China” pilot policy for testing. The results show that the regression coefficient of the digital economy on industrial carbon emission efficiency is still significantly positive, verifying the robustness of the conclusion. (2) The super-efficiency CCR model is used to remeasure the energy-environment efficiency. The regression results show that the digital economy coefficient is significantly positive at the 1% level, and the test results remain robust. (3) The variables are winsorized at the 1% level to eliminate the influence of extreme values. The promoting effect of the digital economy on energy-environment efficiency remains significant, indicating the reliability of the conclusion.

### 3.2. Mediating-effect

The results of the mechanism test of the digital economy on urban energy-environment efficiency show that the regression coefficient of the digital economy on the level of green innovation is 1.9702, which is significant at the 1% level, indicating that the digital economy significantly promotes green innovation and drives urban green development. Improving green innovation capabilities is the key to improving energy efficiency. By greening technologies and industries, it can reduce undesired outputs and increase desired outputs, thereby improving

energy-environment efficiency.

3.3. Heterogeneity test

(1) The results of the regional heterogeneity regression show that the digital economy in the eastern, central, and western regions can all promote urban energy-environment efficiency. However, the total effects in the central and western regions did not pass the 1% significance test, while the mechanism of the digital economy in the eastern region promoting energy-environment efficiency through green technology innovation is significant. (2) The results of the policy heterogeneity regression show that the digital economy in both low-carbon economic policy pilot cities and non-pilot cities can promote energy-environment efficiency. However, the significance of the total effect of the digital economy in non-pilot cities indirectly promoting energy-environment efficiency through green innovation has decreased, as shown in **Table 1**.

Table 1. Heterogeneity test

Usage method	Variable	Direct effect	Indirect effect	Total effect
All samples	Indig	0.0817***	1.9702***	0.0291***
	Ingc			0.0270***
The east	Lndig	0.1051***	1.9202***	0.0557***
	Gc			0.0257***
Middle part	Lndig	0.0257***	1.7940***	0.0166
	Gc			0.0241***
West	Lndig	0.0358***	1.9474***	-0.0053
	Gc			0.0218***
Low-carbon economic policy pilot city	Lndig	0.0829***	2.0001***	0.0257***
	Gc			0.0293***
Non-low-carbon economic policy pilot cities	Lndig	0.0794***	1.9957***	0.0278*
	Gc			0.0255***

4. Conclusions and suggestions

4.1. Conclusions

Based on the panel data of prefecture-level cities from 2011 to 2022, this paper uses methods such as mediating-effect tests to empirically analyze the impact and mechanism of the digital economy on urban energy-environment efficiency. The results show that the digital economy significantly promotes energy-environment efficiency; the level of green innovation plays a mediating role in the impact of the digital economy on energy-environment efficiency, and this effect is more significant in the eastern region and low-carbon pilot cities.

4.2. Suggestions

First, accelerate the development of the digital economy, optimize the construction of digital infrastructure, promote the application of digital technologies in energy and environmental management, and improve urban energy-environment efficiency.

Second, strengthen policies to support green innovation, encourage enterprises to increase investment in green technology research and development, especially in the eastern region and low-carbon pilot cities, and give full

play to the mediating role of green innovation between the digital economy and energy-environment efficiency.

Third, improve the regional coordinated development mechanism, promote the in-depth integration of the digital economy and green innovation, realize inter-regional technology sharing and experience exchange, and promote the overall improvement of energy-environment efficiency.

Fourth, strengthen policy guidance, combine the development of the digital economy with low-carbon economic pilot projects, explore effective paths for the digital economy to drive green transformation, and help achieve the “dual-carbon” goals.

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Wu H, Cheng C, 2024, The Impact of Digital Economy Development on Urban Energy Efficiency — An Empirical Analysis Based on 108 Cities in the Yangtze River Economic Belt. *Journal of Xinyang Normal University (Philosophy and Social Sciences Edition)*, 44(05): 53–57.
- [2] Xia W, Ruan Z, Ma S, et al., 2025, Can the Digital Economy Enhance Carbon Emission Efficiency? Evidence from 269 Cities in China. *International Review of Economics and Finance*, 97: 103815.
- [3] Luo X, 2022, Research on the Impact of Digital Economy Development on Energy Utilization Efficiency, dissertation, Fuzhou University.
- [4] Gao W, Peng Y, Hu X, 2023, Research on the Impact of the Digital Economy on Urban Energy Conservation and Emission Reduction under the “Dual-carbon” Goals. *Urban Problems*, (03): 25–37.
- [5] Wang J, 2024, Research on the Impact of the Digital Economy Development of Prefecture-level Cities in China on Carbon Emissions, Dissertation, Shandong Normal University.
- [6] Wang J, Zhu J, Luo X, 2021, Measurement of the Development Level and Evolution of China’s Digital Economy. *The Journal of Quantitative & Technical Economics*, 38(07): 26–42.
- [7] Meng X, Zhu P, 2025, Research on the Effects and Mechanisms of Digital Infrastructure Driving Green Innovation based on the Policy Experiment of the “Broadband China” Strategy. *Research on Economics and Management*, 46(01): 90–108.
- [8] Zhu Q, Jin C, Li Z, 2025, Can the Integration of the Digital and Real Economies Promote the Synergistic Improvement of Industrial Pollution Reduction and Carbon Emission Reduction? — An Investigation Based on the Forward and Backward Linkages between the Information Industry and Industry. *South China Journal of Economics*, (02): 68–96.
- [9] Yang M, Liang Q, 2024, Analysis of the Correlation between the Spatial Spillover Effect of the Digital Economy and Urban Green Development. *Journal of Xingtai University*, 39(03): 51–56.
- [10] Qu H, Fan Q, Liu H, 2024, The Digital Economy and Green Economic Efficiency: Mechanisms and Spatial Spillovers. *Journal of China University of Petroleum (Edition of Social Sciences)*, 40(05): 69–78.
- [11] Xue Y, Zhao H, Feng Y, 2024, Analysis of the Spatial Spillover Effect of the Digital Economy on Carbon Emissions. *Journal of Nanjing University of Posts and Telecommunications (Social Science Edition)*, 26(05): 95–106.
- [12] Zuo X, Qian P, 2024, Research on the Impact of Digital Economy Development on Carbon Emission Reduction. *Taxation and Economy*, (05): 54–63.
- [13] Wen Z, Ye B, 2014, Analysis of Mediating Effects: Methodological and Model Developments. *Advances in Psychological Science*, 22(05): 731–745.

- [14] Shi D, Li S, 2020, Emission Trading System and Energy Utilization Efficiency Measurement and Empirical Analysis of Prefecture-level and Above Cities. *China Industrial Economics*, (09): 5–23.
- [15] Zhao T, Zhang Z, Liang S, 2020, Digital Economy, Entrepreneurial Activity, and High-quality Development-empirical Evidence from Chinese Cities. *Management World*, 36(10): 65–76.

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



# The Application of Blockchain Technology in the Financial Field

Yanling Liu\*, Yun Li

Hainan Vocational University of Science and Technology, Haikou, Hainan 570100, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** Blockchain technology, as a revolutionary tool, is profoundly changing the way the financial field works. Its application has expanded from digital currency to many fields, such as smart contracts, cross-border payments, trade finance, and digital identity management, providing important support for simplifying financial service processes, reducing costs, and improving efficiency. However, the widespread application of blockchain technology still faces challenges such as scalability, regulatory compliance, and cybersecurity, limiting its full integration in the financial industry. This study systematically reviews the status quo, development history, and future trends of blockchain technology application in the financial sector, analyzes its key role in capital markets, decentralized finance (DeFi), and other fields, and explores the potential of emerging solutions such as hybrid blockchain and dynamic regulatory frameworks.

**Keywords:** Blockchain; Decentralized finance; Smart contracts; Cross-border payments

**Online publication:** April 28, 2025

## 1. Introduction

The financial sector has been at the forefront of technological innovation, driven by increased transaction and operational efficiency, transparency, and security. The decentralized and secure nature of blockchain technology offers powerful solutions to many of the challenges faced by the traditional financial system<sup>[1]</sup>. The technology allows for secure and transparent record-keeping, which can significantly reduce fraud and errors in financial transactions. During this phase, the operation of Bitcoin demonstrated the potential of blockchain to provide a secure, transparent, and immutable record of transactions, gradually attracting the attention of global financial institutions. With the deepening of people's awareness of blockchain's advantages, various banks and financial entities began to actively explore its application possibilities<sup>[2]</sup>.

In the years since Bitcoin's launch, financial use cases for blockchain have continued to emerge. The introduction of a new generation of blockchain platforms, such as Ethereum, has expanded the application possibilities of blockchain through smart contracts. These technological developments demonstrate the great potential of blockchain in streamlining all kinds of financial processes, from transaction settlement to fraud prevention to compliance management, with significant optimization. Major international banks such as JPMorgan

Chase and Goldman Sachs have successively announced strategic partnerships and developed proprietary blockchain solutions, marking the mainstream development of the application of blockchain technology in the financial sector. At the same time, there is growing research interest in tokenized assets and digital currencies, and these innovations are expected to significantly improve the liquidity and accessibility of financial markets <sup>[3]</sup>.

As blockchain technology continues to mature, the need for a comprehensive regulatory framework becomes even more urgent. Regulators around the world are beginning to develop guidelines to address the many challenges posed by blockchain technology. These regulatory efforts play a key role in ensuring that blockchain solutions are aligned with international standards and securely integrated into the existing financial ecosystem.

## **2. Status of application**

### **2.1. Smart contract**

Smart contracts represent a significant advance in the way agreements are formed and enforced in the digital age. As self-executing contracts, their terms are written directly into computer code and automatically trigger execution when certain conditions are met. This innovation eliminates the reliance on third-party verification and significantly streamlines business processes across multiple industries, including finance, real estate, and supply chain management. In the logistics sector, for example, companies can set up smart contracts to automatically trigger payments when goods arrive at their designated destinations, thus ensuring the timely completion of transactions and the establishment of trust between the two parties.

### **2.2. Cross-border payments and asset management**

Blockchain simplifies international money transfers by eliminating intermediaries, reducing transaction costs, and increasing processing speed while maintaining security through its decentralized nature. The tokenization of assets on the blockchain allows for partial ownership and easier transferability while providing a transparent record of ownership to reduce the risk of fraud <sup>[4]</sup>.

### **2.3. Trade finance**

In the field of trade finance, blockchain technology has significantly improved the efficiency and security of international trade transactions. By providing necessary financial instruments such as letters of credit and trade letters of credit, blockchain has effectively reduced risks such as currency fluctuations and payment defaults in cross-border transactions. Such technological integration not only optimizes cash flow management but also improves cooperation among all parties in the supply chain, providing strong support for global business operations.

### **2.4. Cryptocurrency management**

Blockchain technology provides a revolutionary infrastructure for the management of cryptocurrencies, enabling a truly decentralized transaction system. As the first and most influential cryptocurrency, Bitcoin's operation on the blockchain network demonstrates an entirely new mode of value transmission. In this system, participants can conduct peer-to-peer transactions directly, while the mining process validates transactions by solving complex mathematical problems and rewards miners with newly generated digital currency, thus maintaining the healthy functioning of the entire cryptocurrency ecosystem.

### **2.5. Supply chain management**

The application of blockchain technology in the field of supply chain management is significantly improving

operational transparency and efficiency. Through blockchain technology, organizations can optimize the whole process of management from procurement to distribution, effectively reducing operational costs and improving customer satisfaction. Especially in the collaborative application of trade finance and supply chain management, this advantage is more obvious, enabling enterprises to establish a more stable supplier relationship network and ensure the timeliness and reliability of capital flow.

These applications can reduce transaction costs and improve operational efficiency across the financial sector <sup>[5]</sup>.

### **3. The advantages of blockchain in finance**

Blockchain technology has brought many innovative advantages to the financial field. Its decentralized nature effectively eliminates the need for traditional intermediaries, which not only significantly reduces operating costs but also significantly improves transaction efficiency <sup>[6]</sup>. At the same time, blockchain's inherent immutability and transparency features further enhance system security and promote trust-building among participants, making it a powerful tool for preventing financial fraud.

#### **3.1. Reduced costs and improved efficiency**

One of the most significant advantages of blockchain technology in the financial sector is the significant reduction of transaction costs. By enabling a true peer-to-peer transaction mechanism, blockchain enables users to bypass the traditional banking system and enables faster and more economical international remittance services.

#### **3.2. Enhanced security and transparency**

Every transaction recorded on the blockchain is immutable and fully transparent, meaning that transactions cannot be changed or deleted once confirmed. This transparency significantly increases the level of trust between users, as all participants can independently verify transactions recorded on the public ledger, significantly reducing the probability of fraud. In addition, the decentralized nature of blockchain effectively reduces the risk of a single point of failure, making the financial system more resilient in the face of cyber threats.

#### **3.3. Innovative applications in trade finance**

Blockchain technology is profoundly transforming how the trade finance sector operates. For example, blockchain-based letters of credit and trade loans enable more efficient management and significantly streamline the flow of funds within the supply chain by providing greater control and accessibility. The computational logic and data mining capabilities of blockchain technology can not only effectively verify the authenticity of transaction data but also further enhance the overall operational efficiency of trade finance and provide more reliable financial support for international trade <sup>[7]</sup>.

#### **3.4. Positive impact on the capital market**

The capital market has become one of the important areas to benefit from the application of blockchain technology. By facilitating seamless peer-to-peer communication and collaboration among participants, blockchain technology has significantly simplified the transaction process of the capital market and promoted the efficiency of the entire financial market. Especially in the clearing and settlement process, the application of blockchain technology can shorten the process that traditionally takes days to a few hours or less while significantly reducing the associated operating costs.

## **4. Challenges and limitations**

Despite the transformative potential of blockchain technology for the financial industry, there are still several significant challenges and limitations to its practical application, which to some extent limit its wider adoption and effectiveness.

### **4.1. Scalability**

Scalability has always been a core technical challenge for blockchain applications, especially in high-volume financial environments <sup>[8]</sup>. Traditional public blockchains are plagued by transaction throughput limitations and processing delays that can seriously impact the overall performance of the financial system, especially when it comes to processing massive amounts of data generated by a rapidly growing user base.

### **4.2. Regulatory uncertainty**

One of the biggest obstacles to blockchain adoption is the lack of regulatory transparency. Financial institutions operate in a heavily regulated environment, and the murky legal status of blockchain technology can create uncertainty. Regulators are still developing frameworks to govern blockchain applications, raising concerns about compliance and potential legal consequences. This uncertainty could deter financial institutions from investing in blockchain initiatives for fear of non-compliance or future regulatory changes that could affect their operations <sup>[9,10]</sup>.

### **4.3. Privacy and security**

In financial services, privacy and security are always the most important considerations. The transparency features of blockchain can conflict with certain privacy protection requirements, a problem that is particularly acute in industries such as healthcare or financial services that require strict protection of sensitive information. Although blockchain offers advanced encryption and decentralized data management mechanisms, security vulnerabilities remain, especially in networks that employ sharding technology, where smaller groups of nodes may be more vulnerable to security threats.

### **4.4. Technical limitations and energy consumption**

The technical framework of blockchain also presents its own set of challenges, especially in terms of energy consumption and consensus mechanisms. The shift from a proof-of-work (PoW) to a proof-of-stake (PoS) model represents an important step in reducing the environmental impact of blockchain operations. However, the continued demand for software upgrades and innovative architectures shows that scalability and sustainability remain key areas where significant R&D resources need to be invested.

### **4.5. Adaptability of the regulatory framework**

The rapid pace of fintech innovation needs to be underpinned by a more adaptive regulatory framework. The volatility of the initial coin offering (ICO) market in 2017 is a reminder of the risks posed by the inability of static regulatory frameworks to effectively keep pace with technological advances. The imperative is to establish dynamic regulatory approaches that can evolve alongside emerging blockchain technologies to effectively reduce systemic risk and protect the interests of market participants.

Addressing these challenges is critical to realizing the full potential of blockchain in the financial sector <sup>[11]</sup>.

## **5. Future trends**

### **5.1. Hybrid blockchain**

The development of hybrid blockchains represents an important trend for the future, and it aims to combine the advantageous features of public and private blockchains <sup>[12]</sup>. This hybrid scheme provides organizations with the transparency and accessibility of a public blockchain while maintaining effective control over data and operations through private blockchain functionality. These types of systems significantly increase the flexibility and practicality of blockchain applications in the financial sector, with the ability to provide customized solutions tailored to the specific needs of different organizations.

### **5.2. Interoperability**

Interoperability between different blockchain networks has become another key development direction <sup>[13]</sup>. As blockchain and distributed ledger technologies continue to emerge, it is becoming increasingly important to ensure that these platforms can communicate and interact seamlessly. The development of solutions that facilitate cross-chain transactions is expected to further unlock the potential of blockchain technology, making it easier for financial institutions to integrate and collaborate their systems.

### **5.3. Regulatory framework**

The regulatory environment related to blockchain technology is undergoing significant change. Governments and regulatory bodies across the globe increasingly recognize the need for dedicated frameworks to address the unique challenges presented by blockchain, including issues such as data privacy and security. Future regulatory policies are expected to actively promote the innovative development of blockchain solutions in the financial sector while protecting the rights and interests of consumers. In addition, a unified global standard for cryptocurrency regulation is expected to be gradually established, which will effectively boost market confidence and promote the development of international transactions.

### **5.4. Decentralized finance**

The rise of decentralized finance (DeFi) represents another important transformative trend in the financial industry <sup>[14,15]</sup>. DeFi makes full use of blockchain technology to provide financial services without the involvement of traditional intermediaries, thus achieving the dual goals of reducing costs and improving accessibility. The potential that DeFi has demonstrated in reshaping the financial services landscape deserves in-depth study, especially its potential impact on the traditional banking system.

### **5.5. Security and compliance challenges**

Despite the promising applications of blockchain in the financial sector, challenges in cybersecurity and regulatory compliance remain. Financial institutions and innovative enterprises need to take effective measures to address these challenges to fully realize the potential of blockchain technology. Ensuring strong security safeguards and making blockchain applications compliant with regulatory requirements will be key factors driving the widespread adoption of the technology in the financial sector.

## **6. Summary and outlook**

Blockchain technology holds transformative potential for the financial industry by increasing security, transparency, and efficiency. From its initial cryptocurrency experiments to today's widespread application scenarios, blockchain has proven its potential to transform the way financial services are delivered. While



many challenges remain, blockchain is expected to play a bigger role in driving financial innovation, improving operational efficiency, and enhancing security as the technology continues to mature and the regulatory framework gradually improves. In the future, as new application scenarios continue to emerge and existing solutions continue to be optimized, blockchain technology will continue to drive the digital transformation of the financial industry and contribute to building a more efficient, transparent, and inclusive financial system.

## Funding

Exploration and Practice of the Application of Blockchain Technology to the Cultivation of Compound Talents under the Background of Free Trade Port (HKJG2023-18)

## Disclosure statement

The authors declare no conflict of interest.

## References

- [1] Polyviou A, Velanas P, Soldatos J, 2019, Blockchain Technology: Financial Sector Applications Beyond Cryptocurrencies. *Proceedings of the 10th International Conference on Digital Technologies*, 28(1): 7.
- [2] Hashimzai IA, Ahmadzai MZ, 2024, Navigating the Integration of Blockchain Technology in Banking: Opportunities and Challenges. *International Journal of Software Engineering and Computer Science (IJSECS)*, 14(2): 45–56.
- [3] Han Y, 2025, Blockchain Technology Promotes the Innovation and Development of Asset Transaction Modes. *Fintech Times*, 33(01): 112–125.
- [4] Lu M, 2025, Application Research of Blockchain-Based Digital RMB in Patient Capital Risk Management. *Lanzhou Academic Journal*, (1): 88–99.
- [5] Roucheet B, Bhavish J, Tosina D, 2023, Evolution of Blockchain Technology in the Financial Sector: An Empirical Analysis. *Tuijin Jishu/Journal of Propulsion Technology*, 12(1): 67–80.
- [6] Wang X, 2025, Analysis of Follow-up Management of Corporate Venture Capital Based on Blockchain. *Business and Management*, (01): 55–70.
- [7] Ni N, 2023, The Application of Blockchain Technology in Digital Asset Security Transactions. *Digital Technology and Application*, (10): 88–101.
- [8] Shorman AA, Eddin K, Sabri MA, et al., 2020, Blockchain for Banking Systems: Opportunities and Challenges. *Journal of Financial Technology*, 21(3): 102–118.
- [9] Suyanto S, Astuti I, Duryana D, 2024, Exploring Blockchain Technology for Transparency and Efficiency in Indonesia's Financial Sector. *Nomico*, 45(2): 112–123.
- [10] Noch MY, 2024, The Application of Blockchain Technology in International Financial Management: Opportunities and Challenges. *Golden Ratio of Mapping Idea and Literature Format*, 19(3): 25–38.
- [11] Kumar N, 2024, A Systematic Review of Fintech Development. *International Journal of Scientific Research in Engineering and Management*, 7(4): 29–42.
- [12] Abeysekera MC, Kumarawadu P, 2022, Analysis of Factors Influencing Blockchain Implementation in the Finance Sector in Sri Lanka. *Ho Chi Minh City Open University Journal of Science — Economics and Business Administration*, 12(4): 220–231.
- [13] Agyapong K, Boakye I, 2024, The Role of Blockchain Technology in Securing Banking Transactions in Africa. *European Journal of Economic and Financial Research*, 9(2): 77–89.



- [14] Tambe MT, 2024, Blockchain's Role in Finance Beyond Cryptocurrency. *International Journal for Research in Applied Science and Engineering Technology*, 12(5): 78–91.
- [15] Akindotei O, Emmanuel I, Awotiwon BO, et al., 2024, Blockchain Integration in Critical Systems Enhancing Transparency, Efficiency, and Real-Time Data Security in Agile Project Management, Decentralized Finance (DeFi), and Cold Chain Management. *International Journal of Scientific Research and Modern Technology (IJSRMT)*, 10(1): 134–150.

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# ACF Artificial Cartilage Biomimetic Energy-Absorbing Materials: Research and Development Journey, Transformation Practices, and Deep Insights and Paradigm Construction for Technological Innovation Ecosystems

Bowei Wang\*

Foshan Linzhi Polymer Material Technology Co, Ltd, Foshan 528253, Guangdong, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** This paper focuses on ACF artificial cartilage biomimetic energy-absorbing materials, exploring the entire process from fundamental research to industrial transformation. By analyzing the key nodes and technological breakthroughs in the research and development journey, as well as the market strategies and collaboration models in the transformation practices, this study reveals the profound insights ACF provides to the technological innovation ecosystem in terms of concepts, mechanisms, and resource integration, and constructs a universally applicable and forward-looking paradigm for technological innovation. Aiming to provide comprehensive and in-depth case studies for materials science and the entire technological innovation system, facilitating the innovative development and progress in related areas.

**Keywords:** Material science; Bionic energy absorption; Scientific and technological innovation; Organizational innovation; Interdisciplinary integration; Industry-university-research cooperation

**Online publication:** April 28, 2025

## 1. Introduction

In today's era of rapid technological advancement, materials science, as the cornerstone of numerous technological breakthroughs, remains at the forefront of innovation. The emergence of ACF artificial cartilage biomimetic energy-absorbing materials not only represents an outstanding achievement in the field of biomimetic materials science but also serves as a typical example for studying the technological innovation ecosystem and paradigm due to its unique research and transformation trajectory. This paper will systematically outline the development trajectory of ACF, deeply exploring the innovative value and insights contained within, contributing to the construction of a more efficient and sustainable technological innovation system.

## **2. The research and development journey of ACF**

### **2.1. Inspiration and fundamental research**

The research journey of ACF began with an in-depth observation and contemplation of the excellent energy-absorbing performance of biological cartilage. In nature, biological cartilage has developed intricate microstructures and unique mechanical characteristics through long-term evolution, enabling it to effectively buffer and absorb energy in complex and variable mechanical environments while maintaining structural integrity and functionality. The research team keenly captured the potential application value behind this biological phenomenon, initiating a journey of interdisciplinary fundamental research. At this stage, researchers integrated knowledge systems from multiple disciplines, including biology, materials science, and mechanics, employing advanced micro-characterization techniques such as scanning electron microscopy (SEM) and atomic force microscopy (AFM) to conduct a detailed analysis of the microstructure of biological cartilage. The research found that the fibrous network structure, pore distribution, and the composition and arrangement of the extracellular matrix of biological cartilage collectively constitute the material basis for its excellent energy-absorbing performance. Based on these in-depth understandings, the research team proposed the concept of constructing artificial materials with similar microstructures and mechanical characteristics and began preliminary material design and synthesis attempts. For example, when mimicking the fiber arrangement of biological cartilage, researchers attempted to use different fiber materials and weaving techniques to achieve a similar distribution of mechanical properties <sup>[1,2]</sup>.

### **2.2. Technological breakthroughs and material optimization**

As the research progressed, ACF R&D faced a series of critical technological challenges, such as how to precisely control the microstructure of the materials, achieve designability and controllability of material properties, and improve the stability and durability of the materials while ensuring energy-absorbing performance. To tackle these challenges, the research team conducted extensive experimental studies and theoretical explorations. In terms of material design, an innovative strategy of organic-inorganic hybridization was adopted, successfully achieving fine control over the material's microstructure by introducing nanoscale inorganic fillers, such as silica and calcium carbonate, into a polymer matrix <sup>[3]</sup>. By utilizing computational simulation techniques, such as molecular dynamics simulations and finite element analysis, the mechanical properties of the materials were predicted and optimized, providing strong theoretical guidance for experimental research <sup>[4]</sup>. For example, through molecular dynamics simulations, researchers can observe the microstructural changes of materials at the atomic scale during the stress process, thereby providing a basis for adjusting material formulations. In terms of material synthesis processes, the R&D team developed a unique preparation process through repeated experiments and optimizations, including key steps such as solution blending, in-situ polymerization, and hot pressing <sup>[5]</sup>. By precisely controlling reaction conditions such as temperature, pressure, reaction time, and catalyst dosage, they achieved accurate control over the chemical composition, crystal structure, and micro-morphology of the materials, thus producing ACF materials with high consistency and stability <sup>[6]</sup>. Taking the hot pressing molding process as an example, by precisely controlling the temperature and pressure curves, it is possible to achieve a uniform distribution of fibers and fillers within the material, thereby enhancing the overall performance of the material <sup>[7]</sup>. In addition, to improve the performance of ACF materials, the research team has also conducted a series of post-treatment studies, such as surface modification, cross-linking curing, and heat treatment. These post-treatment processes further optimized the microstructure of the material, enhanced the chemical bonding strength, and significantly improved the energy absorption efficiency, mechanical strength, fatigue resistance, and environmental stability of ACF materials. For example, surface modification can improve the hydrophilicity or hydrophobicity of the material, making it more suitable for specific application environments.

### 2.3. Exploration and validation of multi-domain applications

During the gradual optimization of ACF material performance, the research team actively conducted exploration and validation of applications across multiple domains, aiming to integrate this innovative material with actual engineering needs and expand its application scope and market potential. In the field of automotive safety, ACF materials are applied in the design and manufacturing of key components such as automotive bumpers, airbags, and body structural parts. Through simulating automotive collision tests, the significant advantages of ACF materials in absorbing collision energy, reducing vehicle deformation, and protecting the safety of passengers have been validated. Compared to traditional energy-absorbing materials, ACF materials can absorb more energy in a shorter time, effectively reducing the peak impact force during collisions, greatly enhancing the passive safety performance of vehicles<sup>[8]</sup>. For example, in the field of sports protection, ACF materials are used to develop high-performance sports protective gear, such as helmets, knee pads, elbow pads, and insoles<sup>[9]</sup>. In response to the characteristics and needs of different sports<sup>[10]</sup>, the research team optimized the design of parameters such as the thickness, hardness, and shape of ACF materials, enabling them to provide effective protection while minimizing the burden on athletes, thereby enhancing comfort and flexibility during sports<sup>[11,12]</sup>. Practical usage tests have shown that ACF sports protective gear and sports insoles gear excels in absorbing impact energy and reducing the risk of sports injuries, receiving widespread acclaim from professional athletes and sports enthusiasts<sup>[13,14]</sup>. For example, the application of ACF materials in ski helmets can effectively absorb the impact force generated during falls at high speeds, reducing the risk of head injuries. For example, in badminton and basketball<sup>[15]</sup>, it reduces the damage caused by the intense impact on the ankles, knees, lumbar vertebrae, and even the whole body<sup>[16–19]</sup>. In the aerospace field, ACF materials are being explored for use in aircraft landing gear buffering systems, energy-absorbing components in cabin interiors, and vibration and noise reduction in aerospace structural components. Due to the extremely high performance requirements for materials in the aerospace sector, the lightweight, high energy absorption, and high-temperature resistance characteristics of ACF materials make them one of the ideal candidate materials<sup>[20,21]</sup>. Through a series of ground simulation tests and flight tests, ACF materials have demonstrated good reliability and stability in aerospace environments, providing new technical solutions for improving the safety, comfort, and economy of aircraft. For example, after using ACF materials in the buffering system of a certain model aircraft's landing gear, the impact force during landing was effectively cushioned<sup>[22]</sup>, reducing damage to the landing gear structure and extending its service life.

## 3. Transformation practices of ACF

### 3.1. Insights into market demand and product positioning

In the process of transitioning ACF materials from the laboratory to the market, precise insights into market demand and clear product positioning have become the crucial first steps for successful transformation. The research team gained a deep understanding of the potential demands and pain points for energy-absorbing materials across different industries through extensive market research, in-depth interviews with industry experts, and continuous tracking of global market trends. Based on these market insights, ACF products are positioned as high-performance, customized, and multifunctional energy-absorbing solution providers. In response to the urgent demand for improved automotive safety performance in the automotive industry, a series of ACF energy-absorbing components suitable for different parts of vehicles have been developed, such as ACF automotive bumper cushioning modules and ACF airbag reinforcement materials; In response to the pursuit of lightweight and high protective performance sports protective gear in the sports protection market, the ACF professional sports protective gear series products have been launched; In response to the stringent requirements for material lightweighting and high reliability in the aerospace field, ACF aerospace-specific energy-absorbing materials and

components have been developed. Through this precise market positioning, ACF products can quickly penetrate the target market, meet specific customer needs, and lay a solid foundation for subsequent market promotion and commercial success. For example, in the sports protection market, protective gear designed with targeted protective structures is developed based on the injury risk areas and impact forces of different sports. For instance, the knee pad designed for basketball incorporates a special ACF cushioning layer at the knee joint, enhancing protection for the knee.

### **3.2. Innovation in business models and construction of collaborative networks**

To maximize the commercial value of ACF materials, the research team innovatively designed a diversified business model and actively built a broad cooperation network.

In terms of business models, in addition to the traditional product sales model, various profit avenues such as technology licensing, joint research and development, and customized production services have also been explored. Through technology licensing, the core ACF technology is licensed to other enterprises for use, collecting technology licensing fees to maximize the value of the technology; By conducting joint research and development projects with downstream enterprises, new products and technologies based on ACF materials are developed collaboratively, sharing research and development results and market profits; In response to the special needs of customers, we provide customized production services, designing and producing ACF products according to the specific requirements of clients, thereby enhancing customer satisfaction and loyalty. For example, a sports equipment manufacturer obtained ACF technology through a technology licensing agreement, applying it to its high-end sports protective gear series, with both parties sharing product sales profits according to the agreement.

In terms of building cooperative networks, we actively establish strategic partnerships with leading global automotive manufacturers, sports brands, aerospace enterprises, medical device companies, and research institutions. Collaborating with automotive manufacturers to jointly carry out research and development of automotive safety technologies and product innovations, promoting the widespread application of ACF materials in the automotive industry; Collaborating with sports brands to create a high-performance sports protection product series, enhancing brand image and market competitiveness; Collaborating with aerospace enterprises to participate in the research and development and production of aerospace projects, contributing to the development of our country's aerospace industry; Collaborating with research institutions to conduct cutting-edge technology research and talent development, maintaining the continuous innovation and leading position of ACF technology.

Through these extensive and close cooperation networks, we have achieved resource sharing and complementarity, accelerating the research and development, production, market promotion, and after-sales service processes of ACF products, forming a mutually beneficial and win-win innovation development pattern. For example, collaborating with a well-known research institution to establish a joint laboratory to jointly conduct research on new applications of ACF materials, while providing internship and practical opportunities for students of the research institution, has cultivated a group of professionals.

### **3.3. Addressing industrialization challenges and supply chain management**

The industrialization process of ACF materials is not smooth sailing, facing numerous challenges in technology, funding, production scale, and supply chain management.

In terms of technology, although a series of key technological breakthroughs have been achieved during the research and development phase, issues of technological stability and consistency in large-scale production still need to be addressed during the industrialization process. In response to this challenge, the research team established a rigorous quality control system, introducing advanced production process monitoring and control



technologies, such as automated production lines and online inspection equipment, to ensure that each batch of ACF products meets the same high-quality standards. At the same time, continuous investment in research and development resources has been made to constantly optimize and improve production processes, enhancing production efficiency and product quality stability. For example, after adopting automated production lines, the production efficiency of ACF products increased by 53%, and the consistency of product quality was significantly improved.

In terms of funding, industrialization requires substantial financial investment, including the purchase of production equipment, the construction of factories, the procurement of raw materials, and market promotion. To address the issue of funding shortages, the research team actively seeks multi-channel financial support. On one hand, by striving for government research project funding, industrial support funds, and tax incentive policies, they aim to reduce the costs and risks of industrialization. On the other hand, they actively introduce venture capital, bank loans, and other social capital to provide sufficient financial assurance for industrialization projects. In addition, they also ensure the smooth advancement of industrialization projects by reasonably planning the use of funds, optimizing the financial structure, and improving the efficiency of fund utilization. For example, after obtaining a certain industrial support fund from the government, it was used to purchase advanced production equipment, thereby enhancing production capacity and accelerating the industrialization process.

In terms of production scale, with the rapid growth of market demand, the production scale of ACF products needs to be continuously expanded. To achieve the transition from small-batch production in the laboratory to large-scale industrial production, the research team has gradually established automated and intelligent production lines, utilizing advanced production management systems such as Enterprise Resource Planning (ERP) and Manufacturing Execution Systems (MES), thereby realizing refined management and efficient operation of the production process. At the same time, strengthening the training of production personnel and the construction of the technical team, improving employees' production skills and quality awareness, ensures the smooth progress of large-scale production. For example, through training, production personnel have become more proficient in mastering the production process, resulting in a reduction in the defect rate of products by 6 %.

In terms of supply chain management, the production of ACF materials involves the procurement and supply of various raw materials, as well as the sales and logistics distribution of products. To ensure the stable and efficient operation of the supply chain, the research team has established long-term stable cooperative relationships with globally reputable raw material suppliers, signing long-term supply contracts to guarantee the stability of raw material supply and quality control. At the same time, we optimize the logistics distribution network, select professional logistics partners, and adopt advanced logistics management technologies, such as logistics information systems and intelligent warehousing management, to ensure that ACF products can be delivered to customers in a timely and accurate manner. In addition, a supply chain risk early warning and emergency response mechanism has been established to address potential disruptions in raw material supply, logistics delays, and other emergencies, ensuring the safety and stability of the supply chain. For example, in terms of raw material supply, dual supply channels have been established with major suppliers, allowing for a timely switch to backup channels when issues arise in one channel, ensuring that production is not affected.

## **4. Deep insights of ACF on technological innovation ecology**

### **4.1. Interdisciplinary integration: The source and driving force of innovation**

The research and development journey of ACF fully demonstrates the immense power of interdisciplinary integration in technological innovation. The traditional division of disciplines often limits the perspectives and thinking methods of research personnel, while the successful development of ACF is the result of the mutual

integration and inspiration of knowledge from multiple disciplines such as biology, materials science, mechanics, and chemistry. In the ACF project, biologists provided information on the structure and function of biological cartilage, materials scientists were responsible for designing and synthesizing artificial materials with similar properties, mechanics experts analyzed and optimized the mechanical behavior of the materials, and chemists achieved precise control of material properties by regulating the chemical composition and reaction processes. This interdisciplinary collaboration model breaks down barriers between disciplines, promotes the flow and sharing of knowledge, stimulates more sources of innovation, and gives rise to groundbreaking technological innovation achievements.

For the technological innovation ecology, this suggests that we should actively encourage the formation of interdisciplinary research teams, break down disciplinary boundaries, and promote communication and collaboration among research personnel from different fields. Higher education institutions and research institutions should strengthen interdisciplinary education and talent development, offering interdisciplinary courses and programs to cultivate composite talents with multidisciplinary knowledge backgrounds and innovative capabilities. For example, a major in biomaterials engineering could be established, integrating knowledge from biology, materials science, and engineering into the curriculum. At the same time, the government and society should increase support for interdisciplinary research, establishing interdisciplinary research funds and projects to provide a favorable policy environment and financial guarantees for interdisciplinary research. For example, the government can specifically establish special funds for interdisciplinary innovation to encourage research teams to carry out interdisciplinary research projects.

#### **4.2. Market-oriented innovation: The deep integration of science and technology with the economy**

In the process of achieving results, ACF materials have consistently adhered to the innovation concept of being market-oriented, making market demand the primary driving force for technology research and development as well as product design. During the early stages of research and development, in-depth market research was conducted to understand the demand characteristics and pain points of different industries regarding energy-absorbing materials, thereby determining the research direction and application fields of ACF materials. In the process of product design and development, product performance and functionality are continuously optimized based on market feedback to meet the personalized needs of customers. This market-oriented innovation concept ensures that ACF products can quickly gain market recognition and achieve commercial success after entering the market.

For the entire technological innovation ecology, this suggests that research personnel and corporate innovators should pay more attention to market demand research and analysis, establishing an efficient conversion channel from the laboratory to the market. Research institutions should strengthen cooperation with enterprises, establishing a collaborative mechanism between industry, academia, and research so that technological innovation achievements can truly meet societal needs and realize a deep integration of technology and economy. For example, research institutions can collaborate with enterprises to establish R&D centers and jointly carry out project development. The government should guide enterprises to increase their investment in market-oriented innovation by formulating relevant policies, encouraging them to engage in technological innovation and product upgrades, thereby enhancing their market competitiveness and innovation capabilities. For instance, the government can introduce tax incentive policies to provide tax reductions for enterprises engaged in market-oriented innovation.

### **4.3. Open innovation: Sharing resources and collaborative development**

The ACF project has achieved the sharing and optimal allocation of innovation resources globally by constructing a broad and diverse cooperation network. In this collaborative network, enterprises closely cooperate with research institutions, higher education institutions, suppliers, customers, and other stakeholders to jointly carry out technology research and development, product innovation, market promotion, and other activities. Through various cooperation methods, such as technology licensing, joint research and development, and collaborative production, resources among all parties can be fully shared and complemented, accelerating the research and development and industrialization process of ACF materials and enhancing the vitality and competitiveness of the entire innovation ecosystem.

In today's globalized technological competition environment, enterprises and research institutions should actively embrace the concept of open innovation and break away from traditional closed innovation models. By establishing strategic partnerships, participating in international scientific and technological cooperation projects, and building open innovation platforms, we can fully integrate innovative resources globally to achieve a mutually beneficial innovation development pattern. For example, companies can join international scientific and technological cooperation alliances to collaboratively conduct project research with global research institutions and enterprises. The government should actively promote international scientific and technological cooperation and exchanges, create a favorable environment for international innovation cooperation, and encourage enterprises and research institutions to 'go out and invite in,' thereby enhancing our country's position and influence in the global technological innovation landscape. For example, the government can organize technology exchange delegations to promote communication and cooperation between domestic and foreign enterprises and research institutions.

### **4.4. Cultivation of innovation ecology: Comprehensive support and assurance**

The success of ACF is closely linked to the support of a robust technological innovation ecosystem. The government's proactive measures in formulating technological innovation policies, investing in research funding, and backing industries provide strong policy guarantees for the ACF project. The efforts of higher education and research institutions in interdisciplinary talent development, fundamental research, and applied basic research have produced a significant number of high-quality innovative talents and cutting-edge technological achievements for the ACF project. Cultivating a social innovation culture that encourages risk-taking and fosters a tolerant atmosphere for failure creates fertile ground for the ACF project's innovative practices. A sound technological innovation ecosystem requires the collective efforts of the government, higher education institutions, research institutions, enterprises, and all sectors of society. The government should enhance the technological innovation policy system, increase investment in research funding, reinforce intellectual property protection, and optimize the allocation of innovation resources to provide comprehensive policy support and service guarantees for technological innovation. For example, the government can enhance the patent examination system and strengthen the protection of intellectual property rights for innovative achievements. Higher education and research institutions should bolster their development, elevate research standards, and enhance the quality of talent development while actively pursuing frontier scientific research and key technological breakthroughs to provide a solid knowledge base and technical support for technological innovation. Enterprises should strengthen their role as the primary drivers of innovation, boost investment in research and development, develop innovative talent teams, and enhance their independent innovation capabilities and market competitiveness. All sectors of society should work to foster an innovative cultural atmosphere, promote an innovative spirit, respect innovative achievements, and create an environment where the entire society supports and participates in innovation. For instance, society can conduct various technological innovation competitions to spark public enthusiasm for

innovation.

## **5. Construction of technological innovation paradigm based on ACF experience**

### **5.1. Multidimensional innovation-driven model**

Construct a multidimensional innovation-driven model encompassing technological, market, organizational, and cultural innovation <sup>[24]</sup>.

In terms of technological innovation, companies should continuously invest in R&D resources while encouraging interdisciplinary technological exploration and innovative breakthroughs. It is crucial to establish a technological innovation system that is enterprise-led, market-oriented, and deeply integrated with industry, academia, and research. This system should strengthen support for both fundamental and applied basic research, enhancing capabilities for original innovation. For example, organizations can set up internal interdisciplinary research and development laboratories to attract experts from diverse fields, such as biology, materials science, and mechanics, enabling them to collaboratively conduct research projects. These labs can regularly engage in academic exchanges and technical cooperation with higher education and research institutions, sharing cutting-edge research results and experimental equipment. Simultaneously, the government can incentivize companies to boost their investment in fundamental research through policy measures like research subsidies and tax incentives, promoting the continual emergence of forward-looking technological innovations such as ACF.

In terms of market innovation, it is essential to lead with keen market insights and accurately position products and services. In-depth exploration of the potential demands of different customer groups, combined with the characteristics of ACF materials, to develop diversified and personalized application solutions. For example, designing and producing ACF joint support braces to meet the joint protection needs of the elderly population and developing ACF flexible cushioning films for the protection of fragile screens in electronic devices. Moreover, actively expand into emerging market sectors, such as smart wearable devices and virtual reality equipment, to strategically position ourselves and seize market opportunities. Utilizing digital marketing strategies, such as social media promotion and online experience activities, to enhance product visibility and market share, achieving comprehensive expansion of market innovation.

At the organizational innovation level, construct an agile, flexible, and open organizational structure. Break down traditional departmental barriers and establish cross-departmental project teams to promote information flow and collaboration efficiency. For example, in the ACF product development project, form a project team composed of personnel from R&D, marketing, production, and after-sales departments to achieve full-process collaborative operation from product concept design to market feedback collection. At the same time, strengthen organizational collaboration with external partners by establishing strategic alliances, joint ventures, and other forms to integrate the advantages of various resources, jointly address market challenges and technological difficulties, and enhance the overall innovation effectiveness and adaptability of the organization.

In terms of cultural innovation, cultivate an enterprise culture that encourages bold innovation and embraces failure. Encourage employees to propose new ideas and concepts, establish an innovation reward mechanism, and provide both material and spiritual rewards for valuable innovative suggestions. For example, regularly hold innovation and creativity competitions within the company to provide employees with a platform to showcase their innovative achievements, thereby stimulating their enthusiasm for innovation. At the same time, I advocate for a spirit of teamwork, encouraging employees from diverse backgrounds to learn from and inspire each other, creating an innovative environment that integrates the collision and fusion of diverse cultures, thus providing a continuous cultural impetus for technological innovation.



## 5.2. Data-driven innovation decision-making mechanism

Utilizing big data and artificial intelligence technologies to establish a data-driven innovation decision-making mechanism. During the R&D process of ACF, a comprehensive database was constructed by collecting vast amounts of material performance data, market demand data, user feedback data, and industry trend data. By employing data mining and analysis techniques, the potential patterns and correlations behind the data were deeply explored. For example, analyzing users' focus and expectations regarding ACF product performance in different application scenarios provides precise directions for product optimization. Through the correlation analysis of microstructure data and macro performance data of materials, key factors affecting the energy absorption performance of ACF were identified, guiding improvements in material design and synthesis processes. Using artificial intelligence algorithms, such as machine learning and deep learning, to establish predictive models. Predicting the sales trends of ACF products in different market environments to plan production and marketing strategies; Simulating and predicting experimental results during the material development process to optimize experimental plans, reducing development cycles and costs. For example, using machine learning algorithms to predict the performance changes of ACF materials under different temperature and humidity conditions, providing a basis for the environmental adaptability design of the products. At the same time, establishing a data visualization platform to present complex data information in intuitive charts and images, facilitating decision-makers to quickly and accurately grasp key information, make scientifically sound innovation decisions, and improve the efficiency and success rate of technological innovation.

## 5.3. Global innovation resource integration platform

To build a global innovation resource integration platform that consolidates research personnel, technical patents, R&D facilities, market channels, and funding resources from around the world <sup>[25]</sup>. By establishing a combination of online innovation communities and offline cooperation and communication centers, we can break geographical limitations and promote the efficient circulation and sharing of resources. For example, on the online platform, research personnel can publish their research results and technical needs, while enterprises can showcase innovative projects and cooperation intentions, achieving technical docking and cooperation negotiations on a global scale; Offline, international innovation resource exchange conferences, technology transfer exhibitions, and other activities are regularly held to provide opportunities for face-to-face communication and cooperation among all parties. Establish a global innovation resource database to classify, organize, and evaluate innovative resources worldwide, facilitating access and use by enterprises and research institutions. For example, classify technical patents according to fields such as materials science, bioengineering, and electronic technology, marking key information such as technological innovation, application prospects, and authorization status. Conduct detailed records and evaluations of research talent based on professional fields, research achievements, and collaboration experiences. At the same time, strengthen the construction of international scientific and technological cooperation and exchange mechanisms to promote collaboration and coordination among countries in areas such as science and technology policy, research projects, and talent development, collectively addressing global scientific and technological challenges <sup>[26]</sup>. For example, establish an international joint research fund to support cross-border ACF-related research projects; Carry out international scientific and technological talent exchange programs to promote the international mobility of research personnel and collaborative research, facilitating the synergistic development of ACF technology and related technological innovations on a global scale <sup>[27]</sup>.

## 6. Conclusion

The development and transformation journey of ACF artificial cartilage biomimetic energy-absorbing materials



presents a successful example of technological innovation. From its multidisciplinary integration in research and development concepts to market-oriented practices in results transformation, and from the deep insights into the technological innovation ecology to the innovation paradigms constructed based on its experiences, it provides valuable reference experiences for technological innovation on a global scale. In the future journey of technological innovation, we should actively draw on the successful experiences of ACF, continuously explore innovative concepts and methods, and construct a more comprehensive technological innovation ecosystem and paradigm to address the increasingly complex and changing global technological challenges, promoting human society towards a more innovative, sustainable, and prosperous direction.

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Shu X, Xi H, Wang X, et al., 2024, Preparation and Energy Absorption of Flexible Polyurethane Foam with Hollow Glass. *Journal of Cellular Plastics*, 60(4): 201–219.
- [2] Chen S, Xi H, Huang S, et al., 2022, Study on Mechanical Properties and Multiple Impact Resistance of Soft Matrix Mixed Cellular Materials. *Explosion and Impact*, 42(06): 62–70.
- [3] Logesh S, Kazemi ME, Rao Z, et al., 2019, Enhanced Mode I Fracture Toughness of UHMWPE Fabric/Thermoplastic Laminates with Combined Surface Treatments of Polydopamine and Functionalized Carbon Nanotubes. *Composites Part B: Engineering*, 178: 1359–8368.
- [4] Chen S, 2024, Study on Mechanical Properties and Energy Absorption Mechanism of Soft Matrix Mixed Cellular Materials, dissertation, Jinan University.
- [5] Yang J, 2024, Application of a New Soft Matrix Mixed Cellular Material (ACF Material) in Fragile Product Packaging, dissertation, Jinan University.
- [6] Xi H, Pan H, Chen S, et al., 2024, A Theoretical Model for Impact Protection of Flexible Polymer Material, *Theoretical and Applied Mechanics Letters*, 14(03): 217–226.
- [7] Kazemi ME, Logesh S, Lu D, et al., 2019, Mechanical properties and Failure Modes of Hybrid Fiber Reinforced Polymer Composites with a Novel Liquid Thermoplastic Resin, *Elium. Composites Part A: Applied Science and Manufacturing*, 125: 105523.
- [8] Xi H, Guo C, Yang J, et al., 2024, Cushioning Performance of a Novel Polyurethane Foam Material Applied in Fragile Packaging. *Acta Mechanical Solida Sinica*, 37(3): 487–497.
- [9] Jia R, 2024, Biomechanical Study of Knee Joint Protection in Overweight/Obese Population, dissertation, Southern Medical University.
- [10] Jia R, Wang F, Jiang J, et al., 2023, The Biomechanical Effects of Insoles with Different Cushioning on the Knee Joints of People with Different Body Mass Index Grades. *Frontiers in Bioengineering and Biotechnology*, 11: 1241171.
- [11] Huang Z, Huang Q, 2024, Different tilt Angle Wedge Insoles Affect Knee Joints in Patients with Knee Arthritis Finite Element Analysis. *International Competitive Sports Biomechanics Forum and the 23rd National Sports Biomechanics Academic Exchange Conference*, April 20, 2024.
- [12] Tong C, Xie Z, Huang Z, 2023, Effect of Arch Support and Proprioceptive Stimulation Function Insole on Flat Foot Pressure. *13th National Sports Science Conference*, November 4, 2023.
- [13] Fan T, 2023, Virtual Simulation Study on the Protective Effect of Cushioned Insole with Different Materials on Torn

Meniscus, dissertation, Southern Medical University.

- [14] Wang F, 2024, Motion Balance Analysis of Knee Osteoarthritis based on In-body Motion, dissertation, Southern Medical University.
- [15] Huang Z, Chu S, 2024, Effect of Personalized Insole on the Biomechanics of Lower Limb Joints During Three Kinds of Basketball Turns. *Journal of Medical Biomechanics*, 39.
- [16] He C, 2024, Effect of Functional Insole on Lower Limb Biomechanical Characteristics of Badminton Overhead Ball Landing, dissertation, Guangzhou Institute of Sport.
- [17] Huang Z, Huang Q, 2024, Influence of Newly Designed Insole on the Stress of Lower Limb Joints During Badminton Pedaling, International Competitive Sports Biomechanics Forum and the 23rd National Sports Biomechanics Academic Exchange Conference, April 20, 2024.
- [18] He C, Liu Y, Chen X, et al., 2022, Influence of Design Insole on the Lower Limb Biomechanics of Basketball Deflecting Action, 22nd National Conference on Sports Biomechanics, 2022.
- [19] He C, Huang Z, Huang Q, Biomechanical Evaluation of the Impact of Insole Design on Lower Limb Joints during Badminton Overhead Ball Landing, 13th National Sports Science Conference, November 4, 2023.
- [20] Zhang Y, Shi Y, Guo H, et al., 2021, Preparation and Properties of Metal-organic Frame-based Anti-icing Film. *Applied Chemistry*, 38(07): 800–806.
- [21] Liu Y, 2022, Experimental and Numerical Simulation Study on Impact Resistance of Flexible Protective Clothing with Arrow Body, dissertation, Nanjing University of Science & Technology.
- [22] Liu J, 2024, Study on Crashworthiness of Biomimetic Cartilage Foam Buffer and the Impact Protection to RC Piers, dissertation, Foshan University.
- [23] Zhao Y, Xiao Y, Meng Q, 2022, Realization of Intellectual Property Value in Combinatorial Innovation: Based on the Case Study of Linzhi Technology. *Innovation and Entrepreneurship Management*, (1): 34–44.
- [24] Zhao Y, Gui H, Yan R, 2021, “Three-type Innovation” System and its Patent Protection and Operation: A Case Study based on Linzhi Technology. *Innovation Technology*, 21(7): 83–92.
- [25] Zhao Y, Pu X, Xiao Y, 2021, Research on the System of Innovation Ecological Chain — Taking Linzhi Technology as an Example. *Innovation Science and Technology*, 21(10): 10–17.
- [26] Dong J, 2009, Editor, Theory, Method and Practice of Technological Innovation Diffusion, Science Press, China.
- [27] Tang K, 2004, Editor, Theory and Model of Technological Innovation Diffusion, Tianjin University Press, China.

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# Research on Strategies of Energy Internet to Help Smart City Sustainable Development

Cui Wang\*, Rong Zheng, Xin Zhou, Letian Rong

Qingdao City University, Qingdao 266106, Shandong, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** Driven by the wave of informatization and intelligence, the smart city has become a new trend of global urban development. The intelligent transformation of energy systems is of great importance to a smart city. The Internet helps the sustainable development of smart cities by optimizing resource allocation, improving utilization efficiency, and promoting market competition. This study analyzes the current situation and problems of energy Internet supporting smart cities and finds that policy environment, technology maturity, market demand, and industrial chain integration have a significant positive impact on its development. Based on this, relevant strategies are proposed to provide theoretical and practical guidance for the integrated development of smart cities and the energy Internet.

**Keywords:** Energy internet; Smart city; Sustainable development

**Online publication:** April 28, 2025

## 1. Introduction

With the acceleration of urbanization and the continuous progress of science and technology, the construction of smart cities has become an important way to improve the comprehensive competitiveness of cities and the quality of life of residents <sup>[1]</sup>. China has made remarkable achievements in the construction of smart cities, but it also faces many challenges. As an emerging energy system, the energy Internet provides new ideas and methods for the sustainable development of smart cities by optimizing resource allocation and improving utilization efficiency. This paper takes Qingdao as an example to deeply study how the energy Internet can help the development of smart cities <sup>[2]</sup>.

## 2. Current situation of smart city development

### 2.1. Foundation of smart city construction

In recent years, China has made remarkable achievements in the construction of smart cities. Taking Qingdao as an example, from 2020 to 2024, huge investments will be made in the fields of smart power grid, smart charging pile, data center, and optical fiber network. Landmark projects such as Haier New Energy Comprehensive Park

and Blue Valley Smart Energy Management Platform will be completed and put into operation, promoting the intelligent and green transformation of the energy system<sup>[3]</sup>. At the same time, the cross-border integration of intelligent transportation, smart community, industrial manufacturing, and energy Internet has injected new vitality into the construction of smart cities. However, there are also some challenges in the construction of smart cities, such as insufficient talent reserves, cross-departmental collaboration, and information integration problems<sup>[4,5]</sup>.

## 2.2. Research hypothesis and analysis

This study aims to optimize resource allocation, improve energy utilization efficiency, promote market competition, and promote the sustainable development of smart cities through the energy Internet. Four hypotheses are proposed to explore the impact of policy environment, technology maturity, market demand, and industrial chain integration on the development of smart cities. Hypothesis H1: The policy environment has a significant positive impact on the development of smart cities; Hypothesis H2: Technology maturity has a significant positive impact on smart city development; Hypothesis H3: Market demand has a significant positive impact on the development of smart cities; Hypothesis H4: industrial chain integration has a significant positive impact on the development of smart cities.

The correlation analysis results in **Table 1** show that policy environment, technology maturity, market demand, industrial chain integration and smart city development level are all significant, and the correlation values are 0.420, 0.453, 0.492 and 0.504, respectively, and all are greater than 0, indicating that these four factors are positively correlated with smart city development level.

**Table 1.** Analysis of correlation results

	Mean value	Standard deviation	Policy environment	Technology readiness	Market demand	Industrial chain integration	Smart city development level
Policy environment	3.818	0.804	1				
Technology readiness	3.847	0.737	0.420**	1			
Market demand	3.806	0.794	0.453**	0.412**	1		
Industrial chain integration	3.798	0.841	0.492**	0.459**	0.519**	1	
Smart city development level	3.782	0.934	0.504**	0.446**	0.498**	0.634**	1

\* $P < 0.05$ , \*\* $P < 0.01$

The results of regression analysis in **Table 2** show that the standardization coefficients of policy environment and technology maturity are 0.183 and 0.118, respectively, and both are significant at the 0.05 level, indicating that policy guidance and technical support are key elements to promote the development of smart cities. The standardization coefficient of market demand is 0.153, which is also significant at 0.05 level, revealing the promoting effect of market demand on the development of smart cities. The standardization coefficient of industrial chain integration is as high as 0.410 and is significant at the 0.01 level, emphasizing the core position of upstream and downstream cooperation in the industrial chain in promoting the overall development of smart cities.

**Table 2.** Results of regression analysis ( $n = 133$ )

	Nonnormalized coefficient		Coefficient of standardization	t	P	Collinearity diagnosis	
	B	Standard error	Beta			VIF	Tolerance
Constant	-0.023	0.382	-	-0.061	0.951	-	-
Policy environment	0.213	0.090	0.183	2.366	0.019*	1.479	0.676
Technology maturity	0.150	0.095	0.118	1.571	0.021*	1.394	0.717
Market demand	0.180	0.092	0.153	1.956	0.032*	1.518	0.659
Industrial chain integration	0.455	0.091	0.410	5.027	0.000**	1.639	0.610
$R^2$			0.481				
Adjust $R^2$			0.465				
F			$F(4,128) = 29.656, P = 0.000$				
D-W value			1.930				

Note: Dependent variable = smart city development level, \* $P < 0.05$ , \*\* $P < 0.01$

### 3. Simulation analysis of energy Internet to support smart city development

#### 3.1. Simulation model construction

To further study the supporting role of the energy Internet on the development of smart cities, aiming at the specific impact of “Jiaozhou Bay Second Tunnel Green Energy Supporting Project,” the simulation model is built around four key factors: policy environment, technology maturity, market demand, and industrial chain integration. Respectively through the policy effect coefficient (PEC), technology maturity index (TMI), market demand index (MDI), and industry chain integration index (CII) to quantify.

#### 3.2. Simulation results

The simulation results (**Table 3**) showed that with the improvement of technology maturity and market demand, the degree of industrial chain integration has increased year by year, formed a synergy effect, and promoted the improvement of the overall smart city development level (SDL). In the fifth year, the policy effect coefficient (PEC) increased to 0.85, indicating that a policy optimization measure implemented at this time promoted the further improvement of technology maturity, market demand, industrial chain integration, and smart city development level.

**Table 3.** Simulation results

Time step (year-end)	Policy effect coefficient (PEC)	Technology readiness Index (TMI)	Market demand Index (MDI)	Industrial chain integration index (CII)	Smart city development level (SDL)
Initial (0 years)	0.8	6.5	7.0	6.0	55
1 year	0.8	6.8	7.2	6.2	57
2 years	0.8	7.0	7.4	6.4	59
3 years	0.8	7.2	7.6	6.6	61
4 years	0.8	7.5	7.8	6.8	63
5 years	0.85 (policy optimization)	7.8	8.0	7.0	65



## **4. Energy Internet to support smart city development strategy**

### **4.1. Created the top-level design of the energy Internet of “interaction + interconnection + interoperability + mutual trust”**

First, at the level of environmental policy, we should pay attention to the “interaction and mutual trust mechanism,” use big data and AI technology to adjust supply and demand, encourage distributed energy to participate in market trading, introduce carbon trading policies, and promote the application of low-carbon technologies. Secondly, at the technical level, it is necessary to pay attention to the integration of the energy Internet, build an open access system, ensure flexible access and scheduling of energy, promote data interaction between energy Internet and other systems in smart cities, and establish a unified energy big data platform <sup>[6]</sup>. Moreover, at the market-driven level, it is necessary to create an economic incentive mechanism for interaction, interconnection, interworking, and mutual trust. With interaction as the core, demand-side response should be introduced; Build a two-way interactive platform with interconnection as the link; Leveraging connectivity as a bridge to integrate markets and technologies; and, based on mutual trust, we should coordinate market and regulation <sup>[7]</sup>.

### **4.2. Formulate industrial policies conducive to technology diffusion**

It is recommended that smart cities formulate special energy Internet development policies, including accelerating the construction of information infrastructure such as 5G, big data and the Internet of Things, promoting cross-sector and cross-industry data sharing and innovative applications through data open platforms and standardization, and achieving green and low-carbon development through intelligent transportation and energy management technologies, with a focus on supporting the development of new energy and smart grid technologies. Provide tax breaks, financial subsidies, and other incentives and improve the relevant legal construction, give play to the linkage effect of smart energy demonstration projects, and set up demonstration projects in key areas to drive development in other fields <sup>[8,9]</sup>.

### **4.3. Increased investment in scientific research and building an energy Internet research platform**

Establishing an interdisciplinary mechanism to promote renewable energy, encourage the installation of solar energy equipment, and establish a green electricity trading mechanism. Accelerate smart transportation, promote electric vehicles, formulate green building standards, and build urban management platforms using big data and the Internet of Things. Participation in the construction of smart cities and green energy will be encouraged through policy incentives. We will strengthen industry-university-research cooperation, establish joint research and development institutions, focus on key technologies, and promote technological innovation and application <sup>[10]</sup>. We will enhance the transformation of scientific research results, support enterprises in validating technologies, promote the implementation of innovative projects, and help smart cities develop rapidly in the field of energy technology.

### **4.4. Stimulating market demand and promoting technology commercialization**

Using big data and artificial intelligence to improve the efficiency of urban management, and enhance the public’s understanding of smart management through open data and citizen interaction to stimulate the demand for related technologies; To promote the application of energy saving and renewable energy technologies through cooperation with enterprises to achieve optimal allocation of power resources; Build a series of demonstration projects to promote the application of energy-saving technologies in construction, transportation and other fields, and enhance market awareness of smart energy management through data sharing; Demonstrate the application of energy-efficient technologies, and promote the market demand for energy-efficient technologies by raising public awareness of green buildings and smart energy through publicity and education activities <sup>[11]</sup>.

#### **4.5. Promoting the integration technology of regional energy Internet and wide area Internet at the technical level**

Promoting the seamless connection of renewable energy such as wind energy and solar energy with the power grid, and use smart grid technology to achieve dynamic management and distribution of new energy to ensure stable access and supply of energy; The integration of regional Internet and energy saving services to improve energy efficiency services, can be integrated through the intelligent dispatch platform, regional Internet and energy saving services to promote energy efficiency management of buildings and parks; Specific practices through data collection and intelligent analysis, real-time monitoring of energy consumption, and combined with artificial intelligence technology to optimize energy conservation strategies, so as to reduce energy consumption, help achieve the “double carbon” goal; Focus on the development of unified technical standards and protocols, through standardization to improve the interoperability between different energy systems, to ensure the stability and compatibility of technology applications <sup>[12,13]</sup>.

#### **4.6. Ensuring information security and data security, it is recommended to reserve professionals with new quality productivity at the management level**

Establishing a comprehensive information security management system and formulate data privacy protection policies; Encourage enterprises to cooperate with colleges and universities to carry out internship and practical projects, so that students can practice their practical ability in real projects and cultivate their innovative thinking and problem-solving ability; Regularly collect and update talent information, and formulate talent introduction policies to attract talents with cutting-edge technological backgrounds and new quality and productivity-oriented talents, to ensure competitiveness in a rapidly developing technological environment <sup>[14]</sup>.

#### **4.7. Promoting industrial integration and cross-border cooperation**

First, deepen the integration of energy and the industrial Internet. Research shows that industrial chain integration is crucial to the development of smart cities. It is necessary to strengthen industrial chain coordination, ensure system compatibility and mutual operation, establish a standardized technical environment, and promote the rapid application of technical standards. For example, a green manufacturing evaluation system should be formulated to encourage enterprises to save energy and reduce emissions, and energy consumption emissions should be monitored through industrial Internet platforms to provide data support for government regulation <sup>[15]</sup>. Secondly, expand the cross-border application of the energy Internet. We will establish a cross-industry technical standard system, focusing on smart transportation, construction, and medical care. In transportation, an energy management system will be built to monitor and dispatch energy. In the building sector, an energy efficiency management platform will be built to promote energy-saving renovation and green buildings. In the medical sector, developing customized energy solutions to achieve efficient utilization and cost savings.

### **5. Conclusion**

In the era of information technology and intelligence, the integrated development of energy Internet and smart city is of great significance. This paper reveals the key role of policy environment, technology maturity, market demand, and industrial chain integration in the development of smart cities through the analysis of the current situation of smart cities, hypothesis verification, and simulation. From creating top-level design to formulating industrial policies, from strengthening scientific research input to stimulating market demand, from technology integration to management guarantee, and then to promoting industrial integration. These strategies aim to guide the coordinated development of smart cities and the energy Internet. In the future, with the gradual implementation and improvement of various

strategies, it is expected to accelerate the application of the energy Internet in smart cities, build a more intelligent, green, and efficient urban ecosystem, and enhance the sustainable development capacity of cities.

## Funding

Research and Innovation Team Building Project of Qingdao City University (QCU23TDKJ01)

## Disclosure statement

The authors declare no conflict of interest.

## References

- [1] Ding Y, Wang H, Liu M, 2021, Overview of IoT based Smart City Energy Management Technologies. *Proceedings of the CSEE*, 41(10): 2625–2637.
- [2] Zhao Y, Liu Y, Zhang X, et al., 2023, Intelligent energy Management System for Renewable Energy based on Internet of Things. *IEEE Transactions on Industrial Information*, 19(2): 1234–1245.
- [3] Zhang L, Xu W, Jiang C, 2021, Research on Supply-demand Side Collaborative Optimization Control Method of Smart City Power System based on Big Data. *Transactions of China Electrotechnical Society*, 36(3): 1053–1062.
- [4] Wang H, Li M, Zhang Q, et al., 2023, Integrating Renewable Energy into the Grid Using Smart Grid Technologies: A Case Study of Aliso Canyon. *Renewable Energy*, 150: 789–798.
- [5] Liu X, Zhang Y, Wang L, et al., 2023, Smart Grid Integration of Renewable Energy Sources: A Comprehensive Review and Future Trends. *Renewable and Sustainable Energy Review*, 78: 123–134.
- [6] Gao B, Li Z, Wang B, et al., 2022, Research on Smart City Construction based on Ubiquitous Electric Power Internet of Things Technology. *Science and Technology Innovation and Application*, 12(34): 20–23.
- [7] Wang J, 2021, Stimulating New Kinetic Energy of Data Elements to Drive the Transformation and Development of Energy and Electric Power. *Software and Integrated Circuits*, (05): 30–31.
- [8] Dong A, Ni S, Cao M, 2019, Building Energy Internet to Help Smart City Development. *People's Mind*, (07): 64.
- [9] Qu R, Wan Z, Wen J, et al., 2019, Research on the Impact of Energy Construction on Smart City Development. *Straits Technology and Industry*, 33(12): 87–89.
- [10] Zhang S, Miao A, 2016, Energy Internet Supports Smart City Development. *Power of China*, 49(03): 12–17 + 23.
- [11] Zou X, Wang C, 2022, Construction Idea of Smart City Energy System. *Electrotechnical Engineering*, (14): 52–55 + 166.
- [12] Tang Y, Xia Q, Zhang P, et al., 2022, Value Creation, Format Innovation and Development Strategy of Energy Internet. *Global Energy Internet*, 5(02): 105–115.
- [13] Xiong W, 2022, Ten Years of Energy Internet. *Legal Person*, (01): 47–50.
- [14] Yu X, Luo X, 2021, China's "Internet Plus" Smart Energy: Multiple Connotations and Development Promotion. *Fujian Forum (Humanities and Social Sciences Edition)*, (11): 91–101.
- [15] Wang D, 2021, Research on Countermeasures of Ubiquitous Electric Power Internet of Things to Promote Smart City Construction, dissertation, Qingdao University.

### Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# A Comparative Analysis of the International Competitiveness of China's Digital Service Trade

Fuhai Zhang\*

School of Economics, Fujian Normal University, Fuzhou 350117, Fujian, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** In the context of accelerated globalization and the rapid development of the digital economy, the scale of China's import and export trade continues to expand. Enhancing the international competitiveness of China's digital service trade is of significant importance. This article will analyze the current state of China's digital service trade development based on relevant theoretical concepts and provide a discussion on proposals for improving the international competitiveness of China's digital service trade, to offer a reference for the development of digital service trade in China.

**Keywords:** Digital service trade; Digital economy; International competitiveness

**Online publication:** April 28, 2025

## 1. Introduction

Currently, global economic development is progressively shifting toward a service-oriented economy. As one of the world's largest trading nations, digital service trade has become a key driving force of China's service trade. "We will promote the optimization and upgrading of trade in goods, innovate the development mechanism of trade in services, develop digital trade, and accelerate the building of a strong trade country," stated the report to the Party's 20th National Congress. In light of this, studying the international competitiveness of China's digital service trade holds significant practical importance to offer new insights for the development of service trade theory through discussions on industrial classification, infrastructure, and the level of openness.

## 2. Digital service trade-related overview

### 2.1. Digital service trade

Digital trade in services refers to cross-border transactions based on information and communication technology. It is a subset of digital trade and has close ties with trade in services. According to the Statistical Manual of International Trade in Services, digital trade in services is defined as trade completed through online ordering, including the trade of intangible goods <sup>[1]</sup>. In recent years, the OECD has conducted extensive research on digital service trade, further enriching this concept. The OECD views digital service trade as a form of cross-border



transaction facilitated by electronic information networks. Despite continuous development and refinement of the relevant definitions, certain limitations remain. The scope and depth of digital service trade often exceed the boundaries of existing definitions. At the same time, the form of digital service trade will also evolve with the development of digital technology <sup>[2]</sup>. Additionally, as digital technologies continue to evolve, the form of digital service trade will also transform. Moreover, with the growth of digital service trade, new challenges have emerged, including but not limited to the standardization of service quality, legal and regulatory issues related to cross-border data flows, and the rapid advancement of digital technologies. The international community must collaborate to establish effective management mechanisms and standards that will foster the healthy and sustainable development of digital service trade.

## **2.2. The relationship between the digital economy and digital trade**

The relationship between the digital economy and digital trade is both close and complex, characterized by mutual reinforcement and interdependence. The digital economy refers to economic activities that are based on digitalization, such as the development, dissemination, and application of information resources. Digital trade, in contrast, refers to cross-border transactions of services and goods conducted through digital means <sup>[3]</sup>. On the one hand, the rapid advancement of information technology has enabled the digital economy to become a new engine driving global economic growth. In this process, a large volume of digital products and services are created and exchanged, directly contributing to the expansion and diversification of the digital trade market. On the other hand, digital trade involves more than just the exchange of goods and services; it also encompasses various aspects such as technology transfer and the flow of talent, offering a broad range of opportunities for innovation and development within the digital economy <sup>[4]</sup>. Particularly in fields such as software services, online education, and e-commerce, digital trade has become a crucial force in promoting the growth of the related digital economies.

## **2.3. The theory of national competitive advantage**

The theory of National Competitive Advantage, developed by Michael Porter, asserts that a country's competitive advantage in the global economy depends on its resources, technology, and institutions. These advantages enable a country to achieve higher economic benefits and market share in international trade activities <sup>[5]</sup>. Therefore, according to this theory, a country should actively support its most competitive industries to maximize its gains in international economic and trade activities. For digital service trade, if a country aims to fully leverage its competitive advantage, it must focus on investing in essential production factors such as network infrastructure, human capital, and capital to enhance the competitiveness of its digital service trade sector. Demand conditions refer to the level of need for a product or service within the domestic market. When domestic demand exceeds that of foreign markets, it accelerates the generation of economies of scale, giving the country's industry a stronger competitive edge. This is because increasing demand for high-end goods drives businesses to innovate, improve product quality, and strengthen their global competitiveness <sup>[6]</sup>. If a country experiences a growing demand for digital service trade or anticipates a high demand ahead of foreign markets, it can stimulate the development of its digital service trade. This, in turn, leads to economies of scale, encourages technological reform, and ultimately enhances the global competitiveness of its digital service trade sector.

# **3. Analysis of the development status of China's digital service trade**

## **3.1. The scale of digital services trade is becoming increasingly large**

The World Trade Organization (WTO) and the United Nations Conference on Trade and Development (UNCTAD) update data on global trade in digital services annually. According to the relevant data, in 2023, the global export



volume of digital delivery services is projected to reach 4.25 trillion US dollars, representing a 9% year-on-year increase and accounting for 54.2% of global service exports, setting a new record. From 2019 to 2023, the average annual growth rate of global digital delivery service exports reached 10.8%, 4.9 percentage points higher than the growth rate of service exports during the same period <sup>[7]</sup>. The deep integration and widespread application of digital technologies across all aspects of international trade continue to drive the transformation of global trade patterns. The number of global online shopping users is growing rapidly, and e-commerce activities are more vibrant than ever, indicating considerable development potential. With China's robust economic growth and the ongoing deepening of its opening-up policies, the scale of China's digital services trade is expected to continue expanding in the future. The connection between China and the international market will be further strengthened, fostering innovation and development in digital service trade and injecting new sources of momentum into the nation's economy.

### **3.2. The structure of trade in digital services has been continuously optimized**

Currently, China's digital service trade is experiencing strong growth. According to data released by the Ministry of Commerce, China's total import and export of digital services in 2023 is expected to reach 366.6 billion US dollars, marking a 3.5% year-on-year increase. Among this, the import and export volume of cross-border e-commerce reached 2.38 trillion yuan, representing a 15.6% year-on-year growth and accounting for 5.7% of the total value of China's trade in goods. These figures indicate that China's digital service trade has become a vital engine driving the high-quality development of its service trade <sup>[8]</sup>. Furthermore, with the rapid advancement of China's digital technologies, the structure of digital service trade is continuously optimizing. The scope of digital service trade has gradually shifted from traditional sectors, such as tourism and transportation, to emerging fields like cloud computing, big data, and artificial intelligence. These emerging areas not only enhance the efficiency and convenience of China's digital service trade but also broaden the scope and methods of service trade, expanding both the range of trade partners and how services are exchanged.

### **3.3. Digital service trade policies have been gradually improved**

In recent years, China has continuously enhanced its policy system for digital trade in services. Both top-level design and detailed implementation rules have been scientifically planned and structured, resulting in a relatively comprehensive policy support framework. For instance, the release of the Opinions of the General Office of the CPC Central Committee and the General Office of the State Council on the Reform, Innovation, and Development of Digital Trade has provided clear direction and goals for the reform, innovation, and development of digital trade. This guideline defines the guiding ideology, working principles, and key objectives for digital trade development while also proposing specific measures to support the growth of digital trade segments and business entities, promote institution-based opening of digital trade, and improve the governance system for digital trade <sup>[9]</sup>. Moreover, China has actively supported the development of various digital trade segments, including, but not limited to, digital product trade, digital services trade, and digital technology trade. The international expansion of China's digital product trade has been further advanced through strengthening innovation in digital application scenarios and models, improving the quality and level of digital content production, and cultivating and expanding cross-border digital delivery channels.

## **4. Suggestions on the development of international competitiveness of China's digital service trade**

### **4.1. Improving the industrial classification of digital service trade**

With the rapid advancement of information technology and the ongoing expansion of application fields, digital

service trade has become an integral part of international trade. In promoting the development of digital service trade, China should establish an industrial classification system tailored to its national conditions while also drawing on the best practices of other countries <sup>[10]</sup>. When classifying the digital service trade industry, it can be done based on the direction of service content, service form, service object, and industry adaptability. Digital service trade encompasses a broad range of services. Depending on the specific content of the service, it can be subdivided into categories such as data processing services, cloud computing services, online software services, digital education services, and more. Each service category has its unique technical requirements and market demand, which are closely linked to government policies and effective market mechanisms. Clear classification helps both enterprises and governments to conduct business and formulate policies in a targeted manner. The classification based on the form of service distinguishes digital service trade by the mode of provision, such as cloud-based services, downloadable services, and real-time online services. A clear classification facilitates the optimization of resource allocation and enhances the user experience. Additionally, classification based on service object and industry adaptability is essential. The customer base for digital service trade is diverse, encompassing not only individual consumers but also enterprises and government agencies <sup>[11]</sup>. Different customer groups and industries have distinct demands for digital services. Therefore, when classifying industries, it is crucial to consider the characteristics of the service objects and the needs of various industries to better meet the development needs of different sectors.

## **4.2. Strengthening infrastructure construction for trade in services**

The construction of infrastructure for digital trade in services involves not only physical infrastructure but also the establishment of technical standards and service specifications. In this regard, China should strengthen top-level design by incorporating the digital transformation of service trade into the national economic development strategy, clarifying development goals, and creating long-term plans. For example, local governments should adopt a series of policies and measures based on local conditions and actual needs, encouraging enterprises to actively pursue the digital transformation of service trade through financial subsidies, tax relief, and other support. At the physical level, there should be increased investment in digital infrastructure <sup>[12]</sup>. This includes accelerating the construction of new infrastructure, such as 5G networks, data centers, digital twins, cloud computing platforms, and big data models to provide robust support for the digitalization of trade in services. Additionally, it is essential to deepen the integration of digital technologies with the real economy. Enterprises should be encouraged to adopt advanced technologies like big data, cloud computing, artificial intelligence, and the Internet of Things to enhance the quality and efficiency of digital service trade. Furthermore, it is crucial to establish and improve mechanisms for protecting digital intellectual property rights (IPR) and privacy. First, at the national level, a legal and regulatory system for IPR protection related to digital service trade should be established and refined, clarifying the ownership of data property rights and safeguarding innovation. Second, security norms should be defined for the collection, use, storage, and transmission of personal data to ensure the protection of personal privacy. For instance, investment in the research and development of data encryption, identity verification, access control, and other technical measures should be increased to ensure the proper protection of personal privacy and trade data.

## **4.3. Promoting the coordinated development of regional digital trade**

First, it is essential to upgrade the level of network infrastructure in regions with relatively slower digital development. This can be achieved by accelerating the construction of new infrastructure, such as 5G networks and gigabit optical networks, in these areas to ensure that all regions have access to high-speed and stable network connections. This would provide a solid foundation for digital trade. At the same time, the promotion

of digital facilities, such as the Internet of Things (IoT) and big data centers, should be prioritized to improve data processing and storage capabilities, offering strong technical support for digital trade. Second, advanced information technologies, such as IoT, big data, and artificial intelligence, should be fully leveraged to drive the digital transformation and upgrading of production and manufacturing processes in the real economy. This would enhance production efficiency and quality levels. In practice, the digital intelligence of industrial supply chain management should be strengthened, with a focus on enabling traceability of manufacturing sources, real-time updates of warehousing and distribution, and achieving a high degree of intelligence and visualization of the supply chain. Such advancements can help reduce costs and increase efficiency <sup>[13]</sup>. Moreover, the scope of digital services should be continuously expanded. Enterprises should be encouraged to strengthen their capacity for digital service trade, incorporating digital technologies such as intelligent systems, cross-border e-commerce, and mobile payment to transform offline trade activities into online operations and services. This will enhance the market competitiveness of enterprises. Finally, leading enterprises in the field of digital service trade in different regions should foster cooperation and exchanges. By leveraging brand effects, the “catfish effect,” and scale advantages, they can promote the coordinated development of regional digital trade, ensuring that digital trade becomes a driving force for growth and collaboration across different regions.

#### **4.4. Enhancing the level of openness of digital service trade**

In the context of the rapid development of the global digital economy, optimizing the business environment for digital service trade is crucial for enhancing the openness of digital service trade. First, China should actively improve relevant laws and regulations, strengthen intellectual property rights protection, and promote the facilitation of electronic payments. By providing a favorable operating environment for digital service trade enterprises, China can attract more foreign investors and enterprises to enter the Chinese market, thus fostering the development of two-way trade. Improving the transparency of the market environment is a top priority in this optimization process <sup>[14]</sup>. This requires the development of unified industry standards and trading norms, simplifying approval processes, and lowering market access thresholds. These steps will help reduce uncertainties for foreign companies entering and operating in China, thereby increasing their confidence in the Chinese market. Additionally, information such as policies, regulations, industry guidelines, and market analysis should be promptly shared with enterprises through information disclosure platforms. Providing comprehensive market intelligence and policy interpretation will help enterprises make more informed strategic decisions. Second, China should continuously establish and improve a rapid adjudication mechanism for intellectual property rights, raising the cost of infringement and strengthening the protection of copyrights, patents, trademarks, and other intellectual property rights. This will not only encourage enterprises to invest more in innovation but also attract high-quality digital service trade projects to settle in China. Finally, accelerating the development of emerging payment methods, such as mobile payments and cross-border e-commerce, will simplify cross-border transaction processes and reduce transaction costs. This will also enhance the convenience and flexibility of China’s digital service trade, making it more competitive on the global stage.

#### **4.5. Deepening international cooperation on digital service trade**

Deepening cooperation on trade in digital services and investment can help broaden the international market for enterprises and is an effective way to enhance China’s international competitiveness in digital service trade. On the one hand, China should leverage its large domestic market and its strengths in internet technology to establish cooperative relations with foreign enterprises and develop and operate cross-border e-commerce platforms. In doing so, while promoting trade between the two sides, China can also enhance the international image and

brand value of its digital service trade <sup>[15]</sup>. On the other hand, China should actively promote the creation of an international platform for digital service trade exchange and cooperation. This can be achieved by hosting and participating in digital service trade fairs, academic seminars, and other related activities. These platforms for exchange and cooperation will not only strengthen collaboration between China and other countries in the digital services sector but also help China stay informed about the latest international development trends. This will ultimately contribute to the creation of a new pattern for China's "going out" and "bringing in" digital service trade, promoting a more robust global presence for China's digital services.

## 5. Conclusion

In a nutshell, enhancing China's competitiveness in global digital service trade is a long-term endeavor. This goal requires not only the focused attention and proactive actions of government departments but also the collective efforts of enterprises, research institutions, and all sectors of society. By forming a united front, these stakeholders can work together to promote the prosperity and development of China's digital service trade, ensuring its growth and competitiveness on the global stage.

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Li G, 2024, Research on the Path to Enhance China's Service Trade Competitiveness from the Perspective of Digital Economy. *National Circulation Economy*, (23): 41–44.
- [2] Shi Y, 2024, Study on the Impact of Digital Economy Development on the Optimization of China's Service Trade Export Structure. *International Business Finance and Accounting*, (21): 16–21 + 27.
- [3] Qiao L, 2024, Study on the Path of Digital Economy Enabling High-quality Development of China's Service Trade. *Journal of Liaoning Normal University (Social Science Edition)*, (05): 10–12 + 59.
- [4] Yao J, Chen L, 2024, Research on the Mechanism of Digital Economy Promoting the High-quality Development of China's Service Trade Exports. *Heilongjiang Finance*, (09): 36–40.
- [5] Yu T, Zhang Y, 2024, Research on the International Competitiveness of China's Digital Service Trade and Its Influencing Factors. *Business Economics*, (08): 80–85.
- [6] Hu K, 2024, Analysis on the Influence Mechanism of the Opening of Digital Service Trade on the Innovation Quality of Enterprises, dissertation, Southwestern University of Finance and Economics.
- [7] Liu J, Zhang C, 2024, Research on International Competitiveness of China's Digital Service Trade. *China Business Review*, (12): 9–13.
- [8] Zeng J, 2024, Study on the Impact of Digital Input on the Export Scale of Digital Service Trade, dissertation, Shanghai International Studies University.
- [9] Feng S, 2024, Study on the Impact of Digital Infrastructure Construction in Countries Along the "Belt and Road" on China's Service Trade Exports, dissertation, Harbin University of Commerce.
- [10] Hu Z, 2024, Research on the Mechanism of Digital Economy Promoting High-quality Development of China's Service Trade. *National Circulation Economy*, (04): 37–40.
- [11] Wang Q, Miao P, 2024, Collaborative Development of Digital Service Trade and Digital Infrastructure. *Contemporary Finance and Economics*, (02): 125–138.

- [12] Tan J, 2023, Research on International Competitiveness of Chinese Service Trade Enterprises under the Background of Digital Economy. *Modern Corporate Culture*, (31): 61–64.
- [13] Wang Y, 2024, Research on the Impact and Mechanism of Digital Service Trade Development on Enterprise Innovation Quality, dissertation, Beijing Foreign Studies University.
- [14] Xia J, 2023, Promoting High-quality Development of Service Trade with Digital Technology. *Red Flag Manuscript*, (19): 38–40.
- [15] Chen S, 2023, Research on Improving China's Service Trade Competitiveness Relying on the Development of Digital Economy. *Guide of Economic Research*, (15): 72–74.

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



# Research on Alleviating the Financing Constraints of Small and Micro Enterprises in Hainan under the Background of Digital Inclusive Finance

Yanling Liu\*, Yun Li

Hainan Vocational University of Science and Technology, Haikou 570100, Hainan, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** With the establishment of Hainan Free Trade Port, the small and medium-sized enterprises in Hainan Free Trade Port have developed and grown in the continuously optimized enterprise environment. The continuous establishment of a large number of small and micro enterprises makes its social and economic development play a non-negligible role. However, due to the small size and insufficient economic strength of small and micro enterprises, their status in the financial system is often very humble. Therefore, under normal circumstances, small and micro enterprises are faced with financing difficulties and high costs, which has a great side effect on their development. The proposal and continuous development of digital inclusive finance, so that small and micro enterprises in access to a wide range of financing opportunities at the same time, their financing methods are more convenient than in the past, the cost is getting lower and lower. This paper deeply discusses the role of digital inclusive finance in easing the financing constraints of small and micro enterprises and puts forward corresponding suggestions <sup>[1]</sup>.

**Keywords:** Digital inclusive finance; Small and micro enterprises in Hainan; Financing constraints

**Online publication:** April 28, 2025

## 1. Introduction

With the formulation and release of the overall plan for the construction of Hainan Free Trade Port, the state has increased its support for Hainan's economic policies in all aspects, and the economic development of Hainan has attracted more and more attention. However, as one of the pillars of Hainan's economic development, small and micro enterprises are facing a series of challenges. For example, financing is difficult, expensive, and credit evaluation is insufficient. The core of digital inclusive finance is to improve the coverage of financial services through digital technology, reduce the financing threshold, and improve efficiency, which will provide more convenient and low-cost financial support for small and micro enterprises <sup>[2]</sup>.

## **2. Current situation of digital inclusive finance development in Hainan Province**

With the launch of the development plan for promoting inclusive finance (2016–2020), inclusive finance has come into public view. In today's constantly updated and iterated digital technology, the emergence of digital inclusive finance has played a significant role in promoting the development of inclusive finance. In Hainan Province, the government also attaches great importance to the development of inclusive digital finance and has formulated many policies and measures to promote its development.

### **2.1. Digital financial inclusion coverage**

By the end of 2023, Hainan Province had achieved a significant increase in financial service coverage, especially in rural and remote areas. The penetration rate of mobile payment has reached 30 million mobile payment users in Hainan Province, and the payment transaction volume has exceeded 1 trillion yuan. Residents and tourists in Hainan mostly rely on platforms such as Alipay and Wechat Pay for payment, especially in the tourism and retail industry, where payment scenarios are becoming increasingly popular.

### **2.2. Digital financial inclusion platforms**

In the digitalization of inclusive finance, Hainan has not only promoted the development of local financial platforms but also promoted financial innovation through external cooperation. In terms of the financing scale of Internet financial platforms, the cumulative amount of loans provided by Internet platforms in Hainan Province will reach 30 billion yuan in 2023. especially in agriculture, tourism, catering, and other industries, the demand for loans will increase. Most of the loans are directed to small and micro enterprises and farmers. The number of fintech companies has increased, with more than 150 in Hainan Province, covering areas such as blockchain, artificial intelligence, and big data analysis. These enterprises offer customized financial products, such as micro-loans, insurance, and payment tools, to individuals and small and micro enterprises.

### **2.3. Digital financial innovation and cross-border business**

As a free trade port, Hainan has attracted a large amount of foreign capital to enter the digital finance sector.

With the promotion of the Hainan Free Trade Port policy, the cross-border payment business in Hainan increased by 35 percent in 2023, with more than 50 billion yuan of cross-border payment transactions completed in Hainan. The green finance market in Hainan is also expanding, with the total transaction volume of green financial products exceeding 20 billion yuan in 2023, covering fields such as green bonds and green insurance <sup>[3]</sup>.

### **2.4. Inclusive financial loans**

Inclusive financial loans in Hainan Province have covered a wide range of low-income groups, small and micro enterprises, and agricultural producers.

The balance of inclusive financial loans in Hainan will reach 150 billion yuan in 2023, up 20 percent year on year. About 70 percent of the loans went to small and micro enterprises and individual consumers. For inclusive financial products in the agricultural sector, Hainan's loans to farmers and agricultural enterprises totaled about 50 billion yuan in 2023, accounting for one-third of inclusive financial loans.

### **2.5. Financial digitalization and fintech talent**

While promoting the integration of fintech and inclusive finance, Hainan also pays attention to the training of financial talents. Many traditional financial institutions such as banks, insurance companies, and securities firms have strengthened cooperation with Internet enterprises and launched brand new online financial services. Online services not only improve the efficiency of services but also effectively control the cost so that financial services

can bring convenience to more people. Under continuous development, Hainan has also made important progress in the innovation of inclusive financial products and services <sup>[4]</sup>.

### **3. The development of small and micro enterprises in Hainan and the financing difficulties they face**

Compared with large and medium-sized enterprises, small and micro enterprises have unique advantages such as small scale and flexible operation mode. However, these advantages also hide disadvantages: Lack of capital, chaotic management, low market competitiveness, and high financing costs <sup>[5]</sup>.

#### **3.1. The problem of credit rating**

When small and micro enterprises in Hainan Province need financing, due to the small scale of small and micro enterprises, the management level is not high, the financial data is not perfect, and financial institutions have very little information about them, resulting in the credit rating results being difficult to obtain. At the same time, small and micro enterprises lack perfect credit records due to their short history or poor management, which makes it difficult for financial institutions to evaluate their credit status, which further increases the difficulty of credit rating. As a result, small and micro enterprises are faced with high credit rating difficulties in financing <sup>[6]</sup>.

#### **3.2. Guarantee problems**

Small and micro enterprises in Hainan Province also face a guarantee problem when seeking external financing. For example, the value of the collateral is not high, the risk of the guarantee institution is high, the guarantee fee is high, the information asymmetry and the lack of trust are etc. At the same time, the operation conditions of small and micro enterprises are relatively unstable, and guarantee institutions are often unwilling to risk high risks to guarantee them, so it becomes more difficult to obtain guarantee support. At the same time, to make up for potential risk losses, guarantee institutions often charge higher guarantee fees, which makes small and micro enterprises face higher financing pressure <sup>[7]</sup>.

#### **3.3. Financing channels**

Small and micro enterprises are faced with the challenge of having too few financing channels when financing. This problem is mainly reflected as follows: First, the financing channels of small and micro enterprises mainly rely on traditional bank loans, while there are few other financing channels. The single financing channel not only restricts the financing of enterprises but also increases the risk of financing. Secondly, due to the small scale and short operating history of enterprises, it is difficult to meet the financing requirements of traditional financial institutions, resulting in a high financing threshold, and many enterprises are unable to raise financing.

#### **3.4. High interest rates and red tape**

Small and micro businesses in Hainan Province usually face problems such as high interest rates and red tape when seeking financing. Small and micro enterprises are small in scale and have relatively weak credit status, so financial institutions usually set their loan interest rates higher to cover potential risks. As a result, small and micro enterprises need to bear higher credit costs when financing <sup>[8]</sup>.

## **4. Analysis of related causes of financing problems faced by small and micro enterprises in Hainan Province**

### **4.1. Imperfect credit system**

Small and medium-sized enterprises in Hainan, especially start-ups, generally lack perfect credit records. Traditional financial institutions are more cautious about the financing needs of these enterprises, especially financial institutions such as banks, which often rely on traditional ways of judging loan risks such as credit records, financial statements, and collateral of enterprises. However, many small and medium-sized enterprises in Hainan did not establish a complete credit history in the early days of their establishment, or because of their small scale and opaque finance, they have high credit risks and find it difficult to obtain support from traditional financial institutions.

### **4.2. Insufficient guarantees and collateral**

SMEs often lack sufficient fixed assets and high-value collateral, which makes it difficult to obtain traditional bank loans. Bank loans rely heavily on collateral, and many Hainan SMEs, especially those in the service, Internet, and cultural and creative sectors, often do not have enough collateral assets.

### **4.3. Single financing channels**

Although Hainan has vigorously promoted the development of fintech and digital financial inclusion in recent years, many SMEs still rely on loans from traditional banks, which have strict lending standards and long approval cycles, resulting in relatively undiversified financing channels. The main financing channel for SMEs in Hainan is still bank loans, but banks generally require high asset collateral and guarantees during the approval process, which makes it difficult for funds to flow into SMEs quickly. Hainan's capital market is not yet fully mature, and it is difficult for SMEs to obtain funds through equity financing, especially some innovative and technology-based SMEs, which lack the resources and experience to attract investors.

### **4.4. Financial products and services lack pertinence**

Despite Hainan's active promotion of fintech, many financial products and services are still not fully tailored to the specific needs of SMEs. For example, many traditional financial institutions have high loan products and interest rates, while small and micro enterprises have limited profit margins and can hardly afford high loan interest rates. The interest rate of traditional bank loans is high, especially for small and medium-sized enterprises with bad credit and lack of guarantee, and the financing cost is heavy. The existing financial products are more biased towards large enterprises, and it is difficult to customize services for the actual needs of SMEs, resulting in many SMEs being unable to obtain financial products suitable for their development.

There are many reasons why SMEs in Hainan face financing difficulties, including challenges in the market environment, as well as deficiencies in the financial system and policy implementation. To solve these problems, the government, financial institutions, and enterprises need to cooperate to alleviate the financing difficulties of SMEs by improving the credit system, expanding financing channels, and providing customized financial products.

## **5. The role of digital financial inclusion**

Digital inclusive finance, as a major innovation in the modern financial field, has unique advantages and functions. The rise of digital inclusive finance has greatly expanded the coverage and accessibility of financial services <sup>[9]</sup>. Through the use of digital technology, financial services can break through the limitations of traditional models

and achieve a more convenient and efficient service experience. This provides great convenience for small and micro enterprises that are located in remote areas and difficult to reach by traditional financial services so that they can equally enjoy the dividends of financial services. In addition, digital financial inclusion has enhanced small and micro enterprises' sense of trust and security in the financing process by enhancing the transparency and traceability of financial services<sup>[10]</sup>.

Digital financial inclusion is a brand new financial service that can better improve the financing environment of small and micro enterprises. After summarizing, this paper finds that it is mainly reflected in the following aspects:

### **5.1. Improving the availability of financing**

Through the digital inclusive financial platform, it is easier for small and micro enterprises to obtain financing information and submit applications. This new financial service uses advanced information technology and big data analysis to collect business information and credit records more comprehensively and quickly, and then makes a more accurate assessment of the credit and repayment ability of enterprises, making it more convenient for small and micro enterprises to obtain financing<sup>[11]</sup>.

### **5.2. Reducing financing costs**

Traditional financing methods often require a variety of procedures and a long waiting time, which invisibly increases the financing cost of enterprises. Digital financial inclusion, on the other hand, simplifies the financing application and approval process through an online and automated process, making operation and time costs lower, thus making financing costs lower for small and micro enterprises<sup>[12]</sup>.

### **5.3. Broadening financing channels**

Traditional financing channels mainly rely on traditional financial institutions such as banks, but in the context of digital inclusive finance, the development of the Internet has effectively connected traditional financial institutions and other financing channels. Small and micro enterprises have more choices in financing, and financing has become flexible and convenient<sup>[13]</sup>.

With the launch of the Hainan Smart Financial Integrated Service Platform on June 6, 2022, the purpose of this service platform is to further solve the financing pain points of SMEs by relying on digital government and financial technology, which plays a significant role in expanding the financing channels of small and micro enterprises. By April 2024, the number of enterprises served by this platform had reached 505,302. The cumulative application amount is as high as 41164.82 million yuan, and its popular products such as: Recruitment enterprise loan, technology e-loan, "Sea Micro Loan" — Huinongdai, etc., effectively expand the financing channels of small and micro enterprises in Hainan Province, and further alleviate the financing difficulties of small and micro enterprises in Hainan Province<sup>[14]</sup>.

### **5.4. Improving the risk management ability**

Digital financial inclusion uses big data analysis and advanced risk assessment models to more accurately identify and assess the risks of small and micro enterprises so that small and micro enterprises can greatly improve their risk management. It enables small and micro enterprises to have a clearer understanding of their risk management, thus reducing financing risks and improving their ability to continue operation<sup>[15]</sup>.



## Disclosure statement

The authors declare no conflict of interest.

## References

- [1] Xing Y, Wang Q, 2023, A Study on the Impact of Digital Inclusive Finance on Corporate Financing Constraints — A Case Study of Small and Medium-sized Board Listed Companies. *Journal of Shandong University of Finance and Economics*, 35(04): 24–36.
- [2] Wang X, 2022, Financing Constraints and Employment Term Structure of Small and Micro Enterprises under the Background of Digital Inclusive Finance, dissertation, Nanjing Agricultural University.
- [3] Zhang X, Peng G, 2021, Digital Financial Inclusion Development and Regional Innovation Ability: A Nonlinear Impact Study based on Data from 282 Cities. *Technical Economics and Management Research*, (10): 32–36.
- [4] Kong X, 2020, Digital Financial Inclusion, Spatial Spillover Effect and Income Growth: Based on Urban-rural Dual Aggregate Empirical Analysis. *Journal of Dongbei University of Finance and Economics*, (3): 61–68.
- [5] Yao D, Xie H, Liao Y, 2023, Can Digital Finance Ease Financing Constraints for SMEs? — Empirical Evidence from Listed SMEs. *Journal of Yibin University*, (02): 31–38.
- [6] Wei X, 2019, Risk and Supervision of Digital Inclusive Finance. *Finance Theory and Practice*, (06): 49–54.
- [7] Han Y, Yue X, 2023, Research on the Policy of Digital Inclusive Finance to Support the Development of Small and Micro Enterprises in Henan Province. *Journal of Henan Institute of Animal Husbandry Economics*, 36(03): 52–55.
- [8] Zhang Y, Zhou Y, 2021, Digital Inclusive Finance, Traditional Financial Competition and Rural Industry Integration. *Journal of Agrotechnical Economics*, (9): 68–82.
- [9] Yan J, 2021, Problems and Countermeasures of Digital Inclusive Finance in Supporting SMEs' Financing. *Shanghai Commerce*, (8): 32–33.
- [10] Chen J, 2022, Research on Financing Countermeasures of Small and Micro Enterprises under the Background of Digital Inclusive Finance. *Science and Technology Entrepreneurship Monthly*, 35(05): 38–40.
- [11] Wu J, 2019, Research on Credit Enhancement Mechanism of Small and Micro Enterprises from the Perspective of Digital Inclusive Finance. *Jilin Finance Research*, (03): 26–34 + 40.
- [12] Li J, Pratt, Whitney, 2023, Financial and Micro, Small and Medium Enterprises Financing Constraints, dissertation, Shandong Normal University.
- [13] Gao F, 2019, Research on Mutual Promotion Mechanism of Digital Inclusive Finance and Micro, Small and Medium-sized Enterprises' Financing. *Business News*, (19): 44–45.
- [14] Cai W, Xu M, Duan J, 2019, The Development Path, Problems and Suggestions of Digital Inclusive Finance in China. *Financial Technology Times*, 29(7): 83–89.
- [15] Zhou L, Yin K, Ying H, et al., 2024, Research on Financing of Small and Micro Enterprises with Digital Inclusive Financial Services — A Case Study of the First Digital Credit Investigation Experimental Area for Small and Micro Enterprises in China. *Southwest Finance*, (01): 54–68.

### Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# Discussion on Important Problems of Corporate Income Tax Accounting Treatment

Dan Luo\*

Hubei Optical Valley World Commercial Investment and Operation Co., Ltd., Wuhan 430070, Hubei, China

\*Corresponding author: Dan Luo, 275736822@qq.com

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** With the rapid development of the Chinese market economy system, income tax as an economic lever has become more and more prominent in regulating the economy. Since the beginning of the accounting reform, the Ministry of Finance has promulgated the accounting standards for income tax and put forward the corresponding procedures and methods, which is a leap forward in the development process of domestic income tax accounting. The relationship between income tax and accounting, the nature of income tax, and the basic characteristics and the apportionment of income tax accounting are expounded in this paper. Payable tax with impact accounting regulations, deferred with debt regulations, and balance sheet debt with income statement debt regulations are compared given the existing problems in the accounting treatment of domestic income tax, and the choice of applicable treatment methods are discussed. Finally, the accounting treatment of important income tax such as consolidated accounting statements, construction enterprises, tax losses, and discount of income tax liabilities are analyzed, and the treatment methods and corresponding countermeasures are put forward to improve the domestic income tax accounting problems.

**Keywords:** Corporate income tax; Income tax accounting; Treatments

**Online publication:** April 28, 2025

## 1. Introduction

The accounting treatment of corporate income tax is an important accounting activity that recognizes, calculates, and reports corporate income tax following corresponding accounting standards and systems under the tax law, and provides an important basis for enterprise operation, management, and the development and improvement of enterprise accounting system<sup>[1]</sup>. With the reform and continuous improvement of the social market economic system in our country, the corresponding accounting standards are set up for corporate income tax accounting treatment, which is used to guide and regulate corporate tax behavior. However, in practical application, the accounting treatment of corporate income tax may be affected by many factors. Therefore, it is of great practical significance to conduct in-depth research on the current income tax treatment methods and explore the application value of various treatment methods to practical accounting treatment problems.

## **2. Corporate income tax and accounting problems**

### **2.1. Relationship between income tax and accounting**

Corporate income tax is a tax levied on enterprises and other income-earning organizations in China in respect of their production and business income and other income. As soon as the income tax appeared, it had a natural connection with accounting. Because the determination of taxable income is mainly derived from the results of accounting records and calculations, the rules and methods of collecting income tax are now gradually improved with the continuous development and innovation of accounting. In addition, the collection of income tax also plays a powerful role in promoting the development of accounting, prompting it to continuously improve the accounting system.

Since the income tax and accounting perform different functions, they follow different principles and serve different purposes in the economic field. Hence, these two different branches are formed. The payment of income tax should be determined by the tax law, while accounting follows the accounting standards, the calculated tax amount will be different due to the differences.

Taxpayers, in the calculation of income tax, cannot be separated from the total profit calculated according to the accounting method and the accounting information. It needs to make full use of the accounting information based on the adjustment following the provisions of the tax law. Because accounting information has provided the basis for tax calculation. Modern income tax can be mature and perfect with the support of modern accounting theory.

Therefore, there is no reasonable connotation of modern income tax without the support of accounting theory. In addition, the tax adheres to the historical cost principle, which does not allow for the adjustment of accounting data to the actual situation during the calculation process, whereas accounting theory tends to be more responsive to the accounting environment. As income tax and accounting have a close relationship, and the income tax law is mandatory, the processing of income tax is always relatively lagging behind the accounting processing, so the income tax on the development of accounting has a certain negative effect <sup>[2]</sup>.

### **2.2. Basic features of income tax accounting**

The basic characteristics of income tax accounting are mainly reflected in three aspects, namely, independence, legality, and unity <sup>[3]</sup>. Independence mainly refers to the difference between the processing method of tax accounting and financial accounting, and the boundary between accounting profit and taxable income is distinguished. The legal nature of the tax accounting work is mainly refers to the development of tax accounting based on the current national tax laws and regulations as its fundamental basis, the main body of the business need to fulfil their tax obligations following the law, with the accounting regulations and tax laws and regulations to carry out the tax payment and supervision of the formation of taxes and other work. Uniformity means that tax accounting is the same among different taxpayers.

## **3. Comparative analysis of accounting treatment for income tax**

The enterprise income tax accounting treatment method should start through four steps: Firstly, the calculation of enterprise assets and enterprise liabilities should be identified; Secondly, the accounting book value and income tax calculation should be accurately determined; subsequently, the division and continuity of enterprise liabilities and enterprise income tax assets should be clarified; finally, the corresponding amount of tax payable should be calculated <sup>[4]</sup>. However, a clear explanation of the policy rules does not exist for the calculation of tax liabilities and determination of assets, so enterprises need to employ external professionals to accurately check the accounting income tax processing work and choose different forms of income tax processing.

### **3.1. Comparison of the tax payable method and tax effect accounting**

#### **3.1.1. The tax payable method**

The tax payable method, which is calculated by the provisions of the Tax Act, generally establishes a liability account for income tax payable as well as an income tax expense account and uses the income tax payable as the current income tax expense. Under the tax payable method, the accounting treatment is relatively simple. For example, the timing difference between taxable income and pre-tax accounting profit does not need to be apportioned across periods so that the current income tax expense is equal to the current income tax payable.

#### **3.1.2. The tax effect accounting method**

The core of the tax effect accounting method is the inter-period apportionment of income tax expense, which implements the matching principle. This method involves the creation of a deferred tax account, together with an income tax payable and its income tax account. The tax impact method tries to make up for the shortfall that tax payable possesses in the description above by recognizing income tax expense mainly using matching with pre-tax accounting profit, which adjusts for permanent differences using the current period's pre-tax accounting profit.

#### **3.1.3. Differences and connections**

The tax payable method and the tax effect accounting method have both commonalities and differences. Accounting profit before tax should be calculated by the accounting system, income tax expense is recognized in the period in which it arises or is used to offset the cost of income tax, and this point is the same as the permanent difference between the taxable income in the calculation of the cost of the same by the provisions of the tax law. The difference between the two methods are mainly follows: Firstly, when the tax rate is unchanged, the treatment of timing differences between the two methods of accounting basis differences; secondly, the recognition of income tax expense, offsetting income tax expense, while the impact of timing differences on income tax using the tax effect accounting method to confirm, and then credited to the debit or credit of deferred tax, using the amount of income tax impact of the timing differences confirmed <sup>[5]</sup>.

### **3.2. Comparison of the deferred and debt methods**

#### **3.2.1. Comparison of commonalities**

The commonality between the deferral method and the debt method is reflected in the following: Firstly, the accounting treatment of permanent differences is the same. Both of them will be the income tax effect of permanent differences in the amount of income tax expense, recognized as current income tax expense or offset current income tax expense, no longer deferred allocation to future periods, reflecting the accounting principles of cash basis. Secondly, the accounting treatment of timing differences is consistent. They defer the amount of income tax effect when the timing difference arises and allocate it to the future accounting periods, which reflects the accounting principle of accrual basis. At the same time, the tax rates used in recognizing the income tax effect of timing differences are the same. The total amount of income tax expense measured by either the deferred method or the debt method is the same for the entire accounting period from the creation to the full reversal of the timing differences, with the difference being in the measurement of the income tax expense for each period by the two methods <sup>[6]</sup>.

#### **3.2.2. Comparison of differences**

Firstly, the tax rates applied to the calculation of the amount of the income tax effect when timing differences are reversed are different. The difference between the deferral method and the debt method is rooted in "adjustments," i.e., the debt method is applied when a change in tax rates or a change in tax levies affects the adjustment of



previously fixed deferred tax liability balances, whereas the deferral method does not give rise to adjustments. As a result, the debt approach is more adjustable and more flexible, and controllable than the deferral approach. The deferral method is simpler when dealing with timing differences, but the results may be inaccurate when tax rates change; the debt method is better able to adapt to changes in tax rates.

Secondly, the focus of the impact on the accounting statements is different. The objective of the deferral method of accounting is to match the income tax expense with the income recognized in the computation of accounting profit before tax, and therefore the amount of the income tax effect of timing differences in the current period is deferred and is treated as a reversal of the income tax expense or benefit in the period in which the timing differences arise. The objective of the liability method of accounting is to treat the amount of the income tax effect of timing differences as either an asset or a liability in the balance sheet, thereby satisfying the definitions of an asset and a liability in the conceptual framework of accounting, and accordingly, the amount of the expected income tax effect of timing differences is defined and reported as the amount of income tax that will be payable or receivable in the future.

Thirdly, the treatment of special situations is different. Using the debt method of accounting, the amount of the income tax effect of timing differences is calculated at the current tax rate, but if the enterprise knows the income tax rate at which timing differences occurring in the current period will be reversed in the future, the timing differences can be calculated at the amount of their income tax effect based on the expected future income tax rate. However, when the deferred method is used, even if the enterprise knows the income tax rate of the differences occurring in the current period at the time of reversal in the future, the enterprise does not calculate the amount of its impact on income tax according to the tax rate at the time of reversal in the future, and still recognizes the amount of deferred tax according to the calculation of the current tax rate<sup>[7]</sup>.

### **3.3. Comparison of balance sheet debt regulations and income statement debt regulations**

#### **3.3.1. Comparison of commonalities**

Firstly, it has the same theoretical basis. The theory of owners' equity is the basis of everything, and both the income statement debt approach and the balance sheet debt approach are based on it. The theory states that the increase in the owner's equity is the income of the enterprise, and the decrease in the owner's equity is the expense, and the net income is formed when the expense is less than the income, which can be obtained by the owners of the enterprise. Secondly, the principle of going concern is matched with the principle of accruals. A business is a going concern if its production and operation activities continue for an indefinitely extended period in the future. Based on the definition of going concern, the business period is considered to be infinitely long based on the assumption, so that it can be deferred and adjusted to the period after the use of balance sheet debt method and income statement debt method to find out the impact of timing differences on income tax.

#### **3.3.2. Comparison of differences**

Firstly, differences in accounting results and their objects. The accounting method that uses inter-period accounting for timing differences is the income statement liability method. In contrast, the balance sheet liability method is a method of accounting that uses temporary differences to account for intervals. The content of the difference between the two methods is not the same. In addition to timing differences, the tax consequences of temporary differences can be reversed in future periods, as long as the balance sheet debt method as deferred income tax liabilities or tax assets as soon as the differences arise. Secondly, the focus is different. Income statement debt approach to the existence of different effects on the future as an adjustment to the income tax expense at the time, focusing on the income statement of the expense and income two items, and it needs to be identified one by one the timing of the difference between the expense and income items in accounting and tax law. The balance



sheet debt approach focuses on the balance sheet liabilities and assets and regards the future tax effects of these differences as an asset and liability. It needs to identify the temporary differences between the tax base and the carrying amounts of assets and liabilities one by one.

#### **4. Analysis of typical income tax accounting treatment problems**

The new standard requires the balance sheet debt method to be applied in listed companies, and some commercial insurance companies, commercial banks, and large central enterprises have started to apply it, but overall, the adoption rate of the balance sheet debt method is still not high. Except for the tax impact accounting method, which is more frequently adopted by commercial banks, the tax payable method is the accounting treatment used by most enterprises before the implementation of the balance sheet debt method. As the application of accounting standards may be affected by various factors in actual operation, different issues need to be analyzed specifically in light of the reality. The accounting treatment of enterprise income tax under current Chinese accounting standards mainly involves the following factors: Revenue recognition, expense, asset measurement, and tax rate changes<sup>[8]</sup>. The following will analyze several types of important income tax accounting issues.

##### **4.1. Consolidating accounting statement problems**

Under the old accounting standards system, the scope of consolidation of an enterprise's accounting statements usually included the parent company and its subsidiaries. However, under the new accounting standards, the scope of consolidation of consolidated accounting statements has changed, expanding the scope of consolidation, the consolidation of accounting statements now includes the parent company and subsidiaries in addition to the traditional parent company, but also includes the parent company which plays a role in the actual control of the subsidiary, that is, as long as the enterprise can be able to carry out substantial control of subsidiaries including in the scope of the consolidated accounting statement preparation, this provision is in line with the international accounting standards, but there are a lot of difficult to solve the problem in the implementation of the process itself, especially the complex shareholding merger between enterprises, there is no precise definition and format terms, so the difficulties in the consolidated accounting statements of the problem is mainly in the recognition of income, expenses, assets measurement of the three major aspects.

In this case, the main countermeasure is to take into account the income tax differences between parent and subsidiary companies and to ensure that the consolidated statements truly reflect the financial position of the enterprise group by adjusting items such as internal transactions and deferred income tax assets and liabilities<sup>[9]</sup>. From the practical application point of view, the main measures that can be taken are: Firstly, the scope of consolidation of the consolidated financial statements is determined, the doubts and difficulties encountered in practice with the provisions of the standard are to be discussed, and the conditions and criteria for inclusion in or exclusion from the scope of consolidation are refined; secondly, some penetrating accounting models is established, and the internal transaction reconciliation is set up, which is responsible for reconciling the revenues, costs, and cash flows of the internal transactions of the enterprise at all levels. And actual equity share, etc., special attention to unequal capital contributions and partial sale of assets to the outside world; thirdly, the fair value assessment is clarified in the process of business combinations, and the market method is mainly carried out during the context of a high degree of marketization development in the assessment of the fair value of net assets.

##### **4.2. Construction corporate tax planning problems**

As a basic industry of the national economy, the construction industry plays an indispensable role in promoting social development. However, the complex operating environment and special business model make

construction enterprises face greater tax pressure. Because of the long project cycle and large capital investment, construction enterprises have experienced great changes in the ideas and methods of income tax accounting for tax payments<sup>[10]</sup>. Therefore, it is necessary to coordinate the differences between the enterprise income tax law and accounting standards to ensure the truthfulness, accuracy, completeness, and reliability of accounting information. In this case, the choice of accounting policy is orientated towards income tax, the internal management process of construction enterprises is optimized, and then the reliability of professional judgement of financial managers is needed to be improved.

### **4.3. Tax loss problem**

The relevant documents of the State Taxation Letter of the State Administration of Taxation of China stipulate that the year in which an enterprise commences production and operation is the year in which the calculation of profit and loss begins, and the expenditure on preparatory activities incurred by an enterprise in carrying out preparatory activities before engaging in production and operation shall not be counted as a loss for the current period, and shall be carried out by the provisions of the documents. It is stipulated that except as otherwise provided in the ASBE No.18-Income Taxes and standards, an enterprise shall recognize deferred income tax assets arising from deductible temporary differences to the extent, taxable income will probably be available against which the deductible temporary differences can be utilized<sup>[11]</sup>.

According to the above norms, for the issue of tax losses during the period of preparation of the enterprise, it is necessary to consider separately the year in which the start-up expenses are incurred and the year in which the production operation is started. Firstly, for the purely preparatory year, since there is generally no income in the purely preparatory year, a loss must be incurred for accounting purposes as a result of the expenditure on the start-up costs, but the tax provisions stipulate that the expenditure on the start-up costs shall not be counted as a loss for the current period.

Secondly, the start-up cost is amortized during the establishment period in the pure production and operation year, and the tax return should be reduced by the amortized start-up costs until the deductible start-up costs are fully amortized for tax purposes. Thirdly, in the year in which start-up expenses are incurred and production activities are commenced at a later stage, an upward or downward adjustment should be determined based on the difference between the start-up expenses incurred in the current year and the amortization of the start-up expenses payable in the current year, in the same way as in the accounting treatment described above.

### **4.4. The problem of discounting income tax liabilities**

Compared with asset items, the relationship between the book value of liabilities and the items that can be deducted before tax in calculating taxable income is more obscure, which leads to difficulties in understanding the tax basis of liabilities. In the author's opinion, it can be started from the intrinsic relationship between the main factors affecting the taxable income, pre-tax deductible items, and the profit and loss items in accounting. The amount of the taxable base of a liability is determined by the impact of the liability on the accounting profit and loss, combining of taking into account the provisions of the tax law on whether the profit or loss and the periods of the taxable amount or deductible loss. The following steps can be used to analyze and judge the amount of the tax basis of a liability:

The first step is whether the carrying value of the liability relates to an item of profit or loss (whether past, present, or future), i.e., whether a change in the carrying value would directly result in a change in income or expense for accounting purposes. The second step is determining whether the carrying value of the liability has already affected the accounting profit and loss item. The third step is to determine whether the amount of the profit

and loss item related to the book value of the liability is allowed to be deducted under the tax law. The fourth step is whether the cumulative amount of gains and losses related to and affected by the book value of the liability has been fully deducted at the statement date. If the full amount has been deducted, the carrying amount of the liability also no longer includes future deductible amounts, and the tax basis is the same as the carrying amount<sup>[12]</sup>.

## 5. Countermeasures and suggestions

### (1) Improvements on the harmonization of tax law and accounting standards

Firstly, enterprises need to establish a regular accounting and tax communication mechanism. Regular meetings should be set up to bring together accounting and tax professionals to discuss current issues in accounting treatment as well as the latest regulations and policy changes in the tax department. Secondly, accounting and tax personnel should work together to develop accounting treatment plans. Accounting and tax departments should work together to develop an accounting treatment plan, which can ensure that it complies with accounting standards and meets tax requirements at the same time. When it comes to revenue recognition, expenses, etc., both parties can discuss the best way to avoid the contradiction between accounting treatment and tax law. Thirdly, enterprises need to focus on optimizing the accounting process. Accounting and tax departments can discuss the accounting process together and identify potential problems and risks. Through joint analysis, more effective processing methods can be found to reduce the occurrence of inconsistencies and errors between the two, thus improving the accuracy and compliance of accounting processing.

### (2) Enhancement of the internal control and compliance management

Firstly, enterprises should establish a sound internal control system. It needs to include the establishment of clear accounting policies and procedures to ensure that all accounting processing activities can be carried out within the framework of standards and regulations. The internal control system should cover revenue recognition, expenses, asset measurement, etc., while the division of responsibilities and the approval process need to be clearly defined to prevent errors and non-compliance. Secondly, enterprises should focus on strengthening internal audit and supervision. Through regular internal audits, enterprises can identify problems in accounting processing and take corrective measures promptly. Internal audits also help to assess the effectiveness of internal controls, provide timely recommendations for improvement, and ensure that compliance with standards and regulations is maintained.

### (3) Reasonable construction of tax planning and risk management system

Legal compliance is the basic principle of tax planning. Enterprises must comply with local tax laws and regulations when carrying out tax planning and must avoid taxes through improper means. Firstly, it is necessary to clarify the planning objectives and choose tax planning strategies carefully. Enterprises in tax planning should be clear planning objectives, such as reducing costs and improving competitiveness. Appropriate planning strategies should be selected and chosen carefully to avoid overly aggressive or risky practices according to the objectives. Secondly, enterprises should focus on risk management. Tax planning is not only about current interests but also involves the long-term development of the enterprise. Enterprises should consider the impact of the planning strategy on the future and avoid the long-term risks brought by short-term behavior. In the planning process, risk assessment and management should be emphasized, and unnecessary risks should be avoided. Thirdly, the relevant work should be carried out transparently and ethically. Enterprises should maintain transparency in tax planning and ensure that accounting treatment and disclosure comply with standards and regulations.

## 6. Conclusion

Corporate tax planning is facing new opportunities and challenges with the development of society and the adjustment of accounting standards. The treatment of various income tax accounting methods under the current accounting standards is expounded in this paper, and the important income tax accounting treatment issues from the aspects of revenue recognition, expense, asset measurement and tax rate changes in the accounting treatment of corporate income tax are analyzed to provide references for enterprise income tax planning. The accounting standard of current society proposes new requirements for the accounting treatment of enterprise income tax, and there do exist some special cases in which the corporate income recognition, asset measurement, and other unspecific aspects. Corporates need to continuously improve the coordination of tax law and accounting standards, combine with their own experience, carry out scientific analyses, build a feasible tax planning system, and promote the sustainable development of corporates.

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Ministry of Finance, 2006, Accounting Standards for Business Enterprises No.18 — Income Taxes, Beijing Economic Science Press.
- [2] Feng H, 2009, Research on China's Enterprise Income Tax Accounting, dissertation, Capital University of Economics and Business, 2009.
- [3] Li W, 2018, A Brief Discussion on the Basic Characteristics of Tax Accounting. *Accounting Learning*, (14): 181.
- [4] Zhang Y, 2017, Research on Several Issues of Accounting Treatment Methods for Corporate Income Tax. *Knowledge Economy*, (09): 95–96.
- [5] Li Y, 2008, Discussion on Accounting Treatment Methods for Income Tax. *Times Trade (Second Half)*, (10): 135.
- [6] Zhong L, 2005, The Connection and Difference Between the Deferred Method and the Liability Method. *China Agricultural Accounting*, (12): 21.
- [7] Zhou Y, Mi Z, Huang Q, et al., 2018, Changes in Income Tax Accounting under New Accounting Standards and Their Impact on Enterprises. *Value Engineering*, 37(03): 21–23.
- [8] Wang Z, 2023, Research on Corporate Income Tax Accounting under China's Current Accounting Standards. *Accounting Learning*, (34): 143–145.
- [9] Zhao S, 2024, Discussion on Related Issues of Consolidated Financial Statements for Business Combinations under New Accounting Standards. *Business Culture*, (15): 146–148.
- [10] Huang J, 2024, Tax Planning and Tax Risk Prevention Strategies for Construction Enterprises. *Investment and Entrepreneurship*, 35(15): 91–93.
- [11] Yu L, Jiang B, 2022, Discussion on Suggestions for Improving the Reform of Corporate Income Tax. *Accounting Communications*, (02): 145–149.
- [12] Tang Z, Feng S, Zhang Y, 2020, Analysis of Difficult Issues and Handling Techniques in Corporate Income Tax Accounting under the Balance Sheet Liability Method. *Commercial Accounting*, (21): 64–68.

### Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



# Investigation into Custom-Built Operational Models for Small and Medium-Sized Commercial Banks

Jie Zhang\*, Ming Chen, Xingzhi Song

Nueva Ecija University of Science and Technology, Cabanatuan 5100, Nueva Ecija, Philippines

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** This research centers on commercial banks' human resource allocation. It constructs a staffing model grounded in human capital value creation theory and analyzes relevant factors through longitudinal panel data regression. Taking City Commercial Bank A as an instance, the model identifies 12.3% redundant positions and matches jobs with business scale. Additionally, the study proposes a "staffing effectiveness salary" system, providing a framework for optimizing commercial bank human capital in the digital age.

**Keywords:** Commercial banks; Staffing optimization; Human capital contribution rate; Cost elasticity; Performance linkage

**Online publication:** May 7, 2025

## 1. Introduction

The global financial landscape is evolving. Financial market reforms are deepening, and Internet finance, with its cost advantage, is emerging and challenging traditional banks by meeting diverse financial needs. As key regional players in the traditional banking system, small and medium-sized banks must innovate HR strategies to enhance competitiveness. However, their existing structures and job position setups struggle to keep up with business growth and innovation. Allocating resources to match strategies and improve efficiency is crucial, and staffing is a key part of this.

Currently, small and medium-sized banks need to boost their organizational and management efficiency. Their growing business and changing market environment demand more from human resource management, and traditional methods are no longer sufficient.

Staffing, a specialized and critical HR management task, is guided by business goals and considers factors like costs, asset scale, and industry benchmarks in this study's macro-scheduling model. It overcomes single-method limitations, ensuring data-driven resource allocation and better internal management.

This study uses City Commercial Bank A as a case to explore enhancing internal management through scientific staffing optimization. Small and medium-sized banks often face issues like irrational job position allocation and low efficiency, so systematic analysis is needed. Bank staffing impacts operation, cost control,



and competitiveness, and research in this area has drawn much attention. This paper reviews bank customization research, including theories, methods, and more.

## 2. Literature review

Commercial bank customized systems rest on a multi-disciplinary framework. Core theories involve Strategic Human Capital Allocation Theory <sup>[1]</sup>, derived from the dynamic capabilities theory. It employs a strategic HR planning model to dynamically adapt business scale, organizational structure, and human resources, maximizing human capital input benefits. Post Value Evaluation Theory <sup>[2]</sup>: Derived from the work analysis paradigm of the scientific management school, after the modern post evaluation system is upgraded, the post value matrix is constructed with responsibility-ability-output, and the relevant indicators are quantified. Organizational efficiency-driven theory <sup>[3]</sup>: Focuses on the coupling of organizational structure and human configuration and puts forward the concept of organizational energy efficiency ratio. Research shows that flat architecture can improve the efficiency of manpower allocation, but it needs the support of process reengineering and digital tools.

The foundation stage of classical theory (1870s–1950s): Adam Smith’s division of labor theory promotes the design of job specialization; Taylor’s scientific management theory establishes the principle of “work simplification;” Max Weber’s hierarchical theory lays the foundation of post system standardization. During the behavioral science phase (1960s–1990s), Herzberg’s Two-Factor Theory differentiated motivators and hygiene factors to enhance job design. At the same time, Hackman and Oldham’s Job Characteristics Model linked core work dimensions to psychological outcomes. Smith *et al.* proposed that the pressure-post characteristic model reveals the regulating effect of post autonomy and feedback mechanism on job burnout. Modern integration development stage (21st century): In the strategic adaptation theory, Hyatt *et al.* demonstrated a positive link between role clarity, decision autonomy, and organizational performance; under the contingency design theory, Poppleton builds the post design decision tree model based on environmental uncertainty; in the digital empowerment theory, Grant proposed a dynamic post configuration framework driven by algorithm <sup>[4]</sup>.

The study of staffing optimization began in the 1870s and 1880s. Taylors scientific management principle takes work simplification as the core and is an important method of early job systematic design. In 1959, the two-factor theory of incentive health care prompted enterprises to pay attention to the design of work content. The work characteristic model of Oldham *et al.* can be used for new job design and old job optimization <sup>[5]</sup>. Michael *et al.* generalized the related theories and constructed the physical model <sup>[6]</sup>. Some scholars use a variety of factors to improve employee performance based on the work characteristic model. Hyatt found that job settings considered multiple factors, and strategies should be selected based on production uncertainty <sup>[7]</sup>. Poppleton summarized new work-organization design methods, Adam studied incentive staffing optimization, Paul proposed the Zero-base staffing method, and Western scholars focused on work efficiency and other aspects of staffing research <sup>[8,9]</sup>.

## 3. Current situation analysis

Staffing head office functional departments in small and medium-sized commercial banks is challenging, with three main issues. Decision-making lacks a scientific basis; HR decisions are often based on subjective experience rather than data-driven analysis, leading to misalignment with operational demands.

Improper selection of fixed methods: There are significant differences in the functions and businesses of different departments. However, many human resource managers often ignore these differences when choosing fixed methods and do not understand the fixed methods applicable to different departments, resulting in a large deviation between the results and the actual situation.

Lack of standardized benchmarks impedes alignment with industry best practices, and there is a lack of unified standards for the proportion of functional departments of the head office in the industry, which makes banks lack of reliable reference basis in the process of staffing, which increases the difficulty of staffing.

Small and medium-sized commercial banks face numerous challenges in staffing. Although there are many methodologies, for the head office of the head office functional departments cannot be generalized, mechanically copied, and need to be analyzed according to the specific situation. Compared with large state-owned commercial banks and national joint-stock commercial banks, urban commercial banks have the characteristics of regional operation and relatively limited resources, which makes cost management, especially human cost management, become the focus of their operation and management. Therefore, scientific compilation is of great significance for City Commercial Banks to reasonably control costs and improve operational efficiency.

#### **4. Challenges faced**

Staffing is a difficult problem in bank HR management. It requires determining the appropriate number of employees, understanding department needs, and avoiding experience-based design.

This study takes the allocation of functional departments of the head office of Bank A as the entry point, based on the theory of strategic human resource management, explores the method of functional departments of the head office of small and medium-sized commercial banks, reveals the establishment management difficulties of urban commercial banks and proposes solutions:

Shifting from empirical to scientific decision-making: Banks often rely on experience. The City Commercial Bank's HR department simply adjusts historical staffing or takes extreme measures when performance declines, lacking objective analysis. When handling other departments' applications, it judges by common sense, leading to budget-allocation information asymmetry and frequent bargaining between the HR department and business departments.

If the specific adjustment is delegated to the department (or branch), although the department understands the reality, but lacks the analysis method and basis, which can easily cause contradictions.

Differentiation analysis and judgment: The post management and development goals of different departments of City Commercial Banks are different, which are closely related to the nature and system of the departments. The determination of the different nature of the department post establishment needs in-depth analysis, but the current judgment is hasty, lacks detailed analysis, resulting in the results and actual inconsistency, and the establishment of a rigid setting. This may lead to the inability to introduce suitable talents due to staffing restrictions, which will affect efficiency, or unreasonable staffing allocation of some departments, resulting in unreasonable workload and staffing.

Balancing cost control and labor efficiency remains a critical challenge. Banks must weigh the trade-offs between lean staffing (which risks overburdening employees) and excessive staffing (which escalates costs), requiring a holistic approach to optimize resource allocation.

Considering the cultural characteristics and management concept of urban commercial banks, at present, there is a lack of unified norms in the staffing process, which is influenced by the management concept, mode, and personnel of the bank. Different banks have different requirements for work fullness, and different branches of the same bank may also have differences in staffing ideas and methods due to historical and regional factors.

#### **5. Design and strategies**

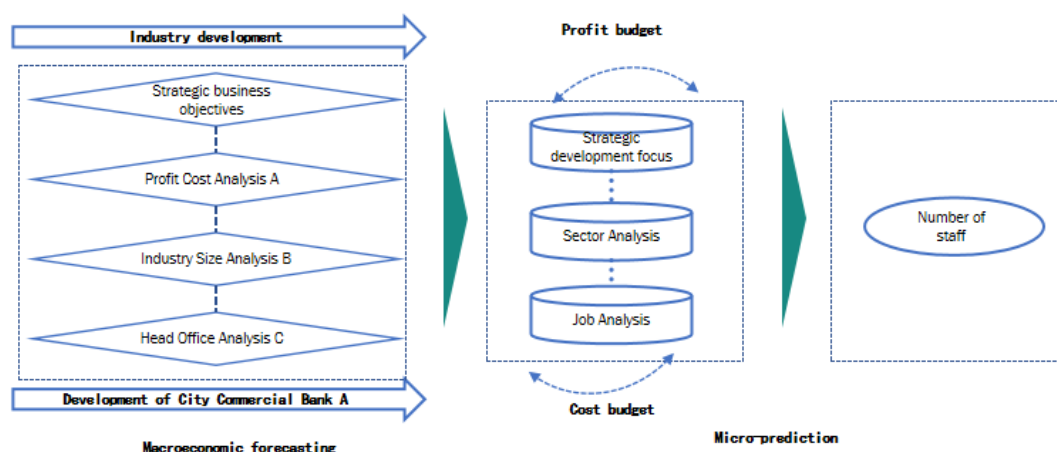
City Commercial Bank staffing consists of two steps: Macro and micro. Before staffing, post determination,

and work structure/workload analysis are necessary, followed by macro and micro staffing. Macro-level staffing aligns strategic goals with industry benchmarks (e.g., allocating 70% to operations and 30% to management) to optimize human capital allocation (e.g., management vs. operational staff), thereby aligning human capital with organizational goals, human cost control, and other macro levels. Micro-arrangement is to determine the specific number of personnel for each department in the post, to provide a basis for each department to clarify the post personnel allocation. In the aspect of post-establishment management, macro monitoring should be combined with independent adjustment. The human resources department is responsible for macro-control and monitoring, while the business department will face changes in personnel demand due to business changes, so it needs to have certain authority to adjust it independently. Next, the macro allocation process of A City firm is introduced in detail.

### 5.1. Determine the customized model

In the process of the allocation, first of all, through the analysis of the banking industry, the company from micro analysis to macro analysis, refine and summarize the main influencing factors of the overall city firms, determine the key drivers of the allocation, and then combined with the actual situation and dynamic development of A City firms, establish A model.

Through the overall analysis, based on the strategic management objectives of A City firms, we determine three main driving factors: cost and profit analysis, business scale analysis and scale effect analysis of the main branches, to obtain the overall establishment of A City firms; then through department analysis and post analysis, based on the different development orientation of the department, as illustrated in **Figure 1**.



**Figure 1.** Staffing model of Bank A

Among them, the three main driving factors are as follows: The profit cost analysis is the basis of the bank; the reasonable profit scope is the premise of effective regulation of human cost; the human factor is the main cost and the key to profit consumption; the business scale analysis depends on the distribution and control strategy of the branch and the branch is the business unit replication, and the number and scale have a significant influence on the allocation.

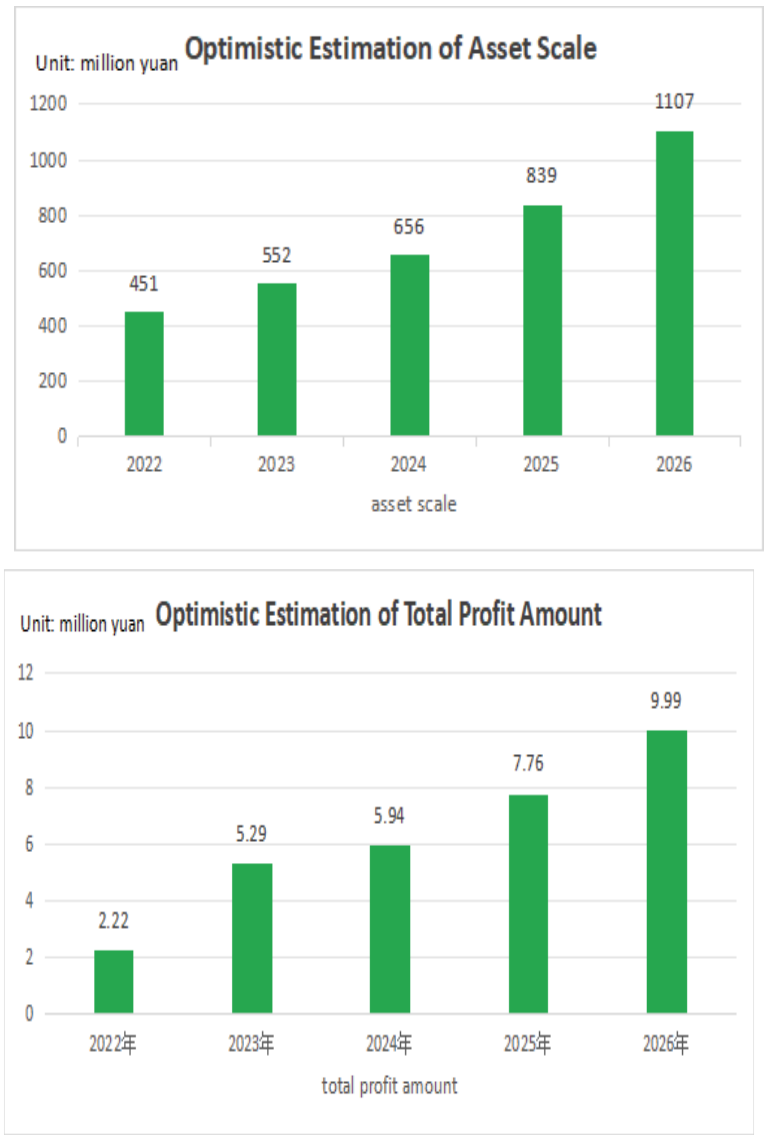
### 5.2. Prediction steps

Through the analysis of the key driving factors and the comprehensive consideration of all related factors, the macro classification forecast is mainly divided into the following four steps: the first step is the profit cost analysis; The second step involves industry scale analysis; the third step is the head and branch office analysis.

6. Results

6.1. Profit cost analysis

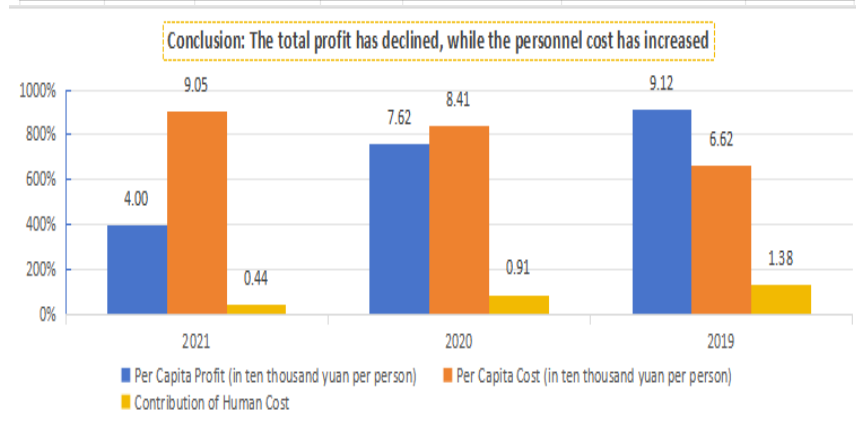
(1) Forecast profit: Make an in-depth analysis of the strategic objectives of A City Commercial Bank, combine its current business development status, market capacity, and prospects, and use relatively optimistic asset scale and profit growth data to forecast. The next five years, the asset scale and total profits of Bank A are shown in **Figure 2** below. Through the analysis of the asset scale and total profit growth in 2022–2024, it can be predicted that the asset scale and total profits in 2025 will be 83.9 billion yuan and 776 million yuan, respectively.



**Figure 2.** Profit forecast table of Bank A (forecast under the condition that the asset scale growth rate is 22.9%)

(2) Evaluation of the contribution rate of labor cost: Compared with the historical data of the development of Bank A in 2019–2021, it is found that with the gradual decline of profits, labor cost increased significantly, resulting in a significant decline in the contribution rate of labor cost, with an average of 0.91 as shown in **Figure 3**. Among them, per capita profit = profit income/number; per capita cost = total human cost/number; human cost contribution = profit income/total human resource cost. This data indicates the profit output of one yuan per input.

Indicators such as human resources and profits from 2019 to 2021						
Year	Profit (in ten thousand yuan)	Total Human Cost (in ten thousand yuan)	population	Per Capita Profit (in ten thousand yuan per person)	Per Capita Cost (in ten thousand yuan per person)	Contribution of Human Cost
2021	5749	13000	1437	4.00	9.05	0.44
2020	10432	11507	1369	7.62	8.41	0.91
2019	12102	8787	1327	9.12	6.62	1.38
average	--			6.91	8.02	0.91



**Figure 3.** The contribution rate of labor cost of A City Bank

At the same time, refer to the same type of city firms in 2021 annual report, can conclude that human cost contribution rate, such as bank of Beijing 3.82, 3.27, Nanjing bank, Hangzhou bank 3.84, in short, the average city bank human cost contribution rate in 3.84, so A City firms is much higher than the same City Commercial Banks. A City firms is compared with other city firms 10 times, and on the human cost contribution difference by 4 times:  $3.84/0.91$ , the labor cost relative to profit, belongs to the relatively high.

(3) Forecast the total labor cost of A City firms: According to the forecast annual profit situation and labor cost contribution rate of A City firms, forecast the total labor cost to obtain the estimated range of the total labor cost. To this, according to the previous analysis, we can see that A City firms of human cost contribution rate is relatively high, so, considering the cost of human resource management, we of human cost contribution rate in three ways (select the three typical human cost contribution rate data: a. 2021 A City firm human cost contribution rate, b. A City firm in the past three years lowest human cost contribution rate, c. The average human cost contribution rate is shown in **Table 1**.

**Table 1.** Estimated annual total human cost from 2022 to 2026 in three categories

Year	Profit (RMB M)	Cost rate 1 (2021)	Cost rate 2 (best in 3 years)	Cost rate 3 (average)	Total cost 1 (RMB M)	Total cost 2 (RMB M)	Total cost 3 (RMB M)
2022	21,158	0.44	1.38	2.38	48,086	15,332	8,890
2023	51,925	0.44	1.38	2.38	118,011	37,627	21,817
2024	58,393	0.44	1.38	2.38	132,711	42,314	24,535
2025	76,634	0.44	1.38	2.38	174,168	55,532	32,199
2026	99,884	0.44	1.38	2.38	227,009	72,380	41,968



According to the profit-based cost analysis, Thus, we draw the conclusion of pre-compiled labor cost: Considering the management development and future regulation of commercial banks in A City, We interval the data for the total human cost forecast, That is, the three prediction methods are used to finally obtain the regional number range, To ensure that the data has some flexibility and practical significance, According to the formula of “Total human cost = annual profit target/labor cost contribution,” Calculate the estimated range of labor cost of A City Commercial Banks from 2022 to 2026: 153.32–88.9 million yuan in 2022; In 2023, RMB 376.27 million to RMB 218.17 million yuan; In 2024, 42,314–245.35 million yuan; 555,5532–32.199 million yuan in 2025; In 2026, it will be 72,380 to 419.68 million yuan.

(4) Accounting per capita labor cost: based on the forecast total labor cost range, combined with the per capita cost of the previous year and the current growth of labor cost, the per capita labor cost is predicted to be obtained for the estimated staffing. Among them, the estimated labor cost = last year’s labor cost (1 + N%). (According to the comprehensive factors such as industry growth forecast, industry wage level, and life changes, it is preliminarily determined that the per capita increase in 2022 is 15% compared with 2021, so that the annual per capita labor cost increase N is 15%.)

At the same time, three kinds of forecasts are made for preparation, among which, estimated staffing = estimated total labor cost/estimated per capita labor cost, which are also predicted in three ways, as shown in **Table 2**.

**Table 2.** Forecasted per-capita labor cost of A City Bank

Total labor cost of previous year (in ten thousand yuan)	Population of previous year	Per-capita cost of previous year (in ten thousand yuan)	Expected per-capita labor cost (in ten thousand yuan)	Estimated staffing level 1	Estimated staffing level 2	Estimated staffing level 3
13,000	1,437	9.05	10.40	4,622	1,474	855
15,332	1,450	10.57	12.16	9,705	3,094	1,794
21,817	1,794	12.16	13.99	9,489	3,026	1,754
24,535	1,800	13.63	15.68	11,111	3,543	2,054
32,199	2,054	15.68	18.03	12,592	4,015	2,328

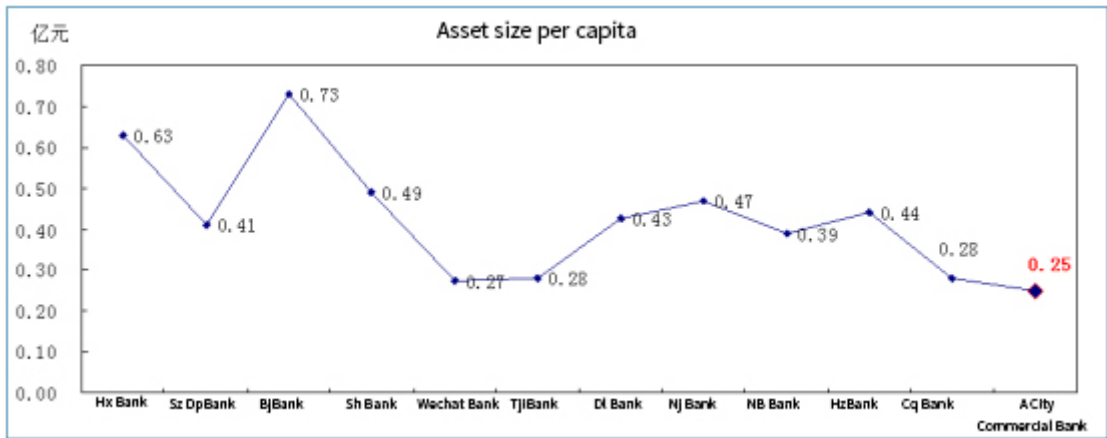
(5) Estimated staffing: Based on the above annual profit and human cost contribution, And derive the projected total labor cost in three ways, at the same time, Considering the adjustment and contractility of future management, Using the interval of the total human costs, As a result: in 2022, The staffing range is expected to be 855–1,474 people; In 2023, It is estimated that the manpower staffing range is 1,794–3,094 people; In 2024, It is estimated that the manpower staffing range is 1,754–3,026 people; In 2025, It is estimated that the manpower staffing range is 2,054–3,543 people; In 2026, It is estimated that the manpower establishment range is from 2,328 to 4,015 people.

In short, profit cost analysis is a common prediction method that combines profit development with personnel cost. It is widely used in various industries and has certain advantages for personnel development and cost control. However, this method is more suitable for the production of enterprises closely related to profits and personnel. In enterprises that do not correspond one-to-one, such as investment banks, staffing cannot be determined based on profit, it is only one of the factors to consider.

## 6.2. Industry scale analysis

(1) Analysis of asset ratio per capita: Select typical national joint-stock commercial banks and urban firms

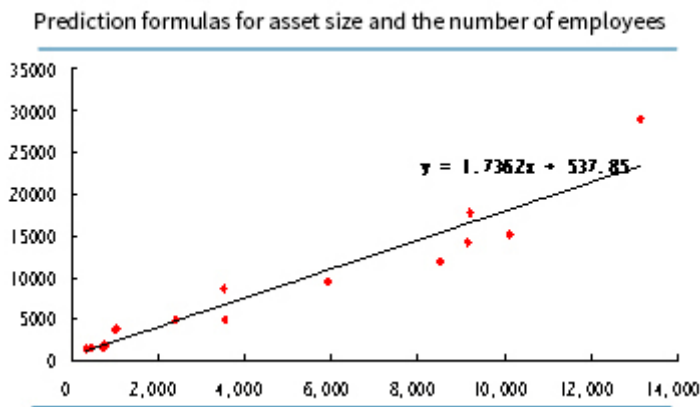
to chart the per capita asset size. It can be seen that national commercial banks with assets below 100 billion are relatively low, with A total average of 0.42 and 0.25, as shown in **Figure 4**.



**Figure 4.** Per capita asset size of banks

(2) Considering the data of national commercial joint-stock commercial banks and urban commercial banks, with assets of 5,000–10,000 billion yuan, they have an average number of about 18,000, and an average ratio of about 0.52. Thus, compared with the larger joint-stock commercial banks, the number of urban commercial banks is smaller, and the per capita assets are smaller.

(3) The fitting assets and staff compiled data formula, and according to the A City firm actual forecast: according to the size and number of assets, we predict the size and establishment of the dynamic relationship, among them, to avoid the data method using the superposition of bias, we use the data fitting, draw the scale of the simulation prediction formula  $y = 1.7362x + 537.85$  as shown in **Figure 5**.



**Figure 5.** Fitting figure of the number of bank assets size

Combined with the historical data of A City firm in the past three years, its staffing is predicted according to the industry scale. From 2022 to 2026, when the asset scale is 441–100.7 billion yuan, the corresponding staffing is 1,304–2,286 people, respectively. The asset scale prediction method can be controlled according to the business scale based on the macro scale development, but it is only applicable to enterprises closely related to personnel. If the number of people and profits are not one-to-one, it needs to be further considered and is one of the factors considered in the compilation.

### 6.3. Head office and branch office analysis

Analyzing the composition and development trend of the number of banks, there is a scale effect on the expansion of the number of banks. The number of people in the head office is stable, the annual change is small; when branches, branches and branches increase, the number of people will increase exponentially, with each new branch. The number will increase substantially, so the increase in branches is the scale effect of expanding staffing.

(1) Analysis of the proportion of branches and branches have a certain number of people, while the proportion of the head office is 21.35%, the lowest bank of Shanghai is 16.73%, and the highest is the Bank of Nanjing, 27.32%, as shown in **Table 3**. A City firm belongs to 17.48% in 2019, 8.70% in 2020, and 21.09% in 2021. Although it is increasing year by year, it belongs to the middle level and is an acceptable range.

**Table 3.** Proportion and average number of employees in branches of A City Bank

NO.	Bank name	Total number of employees	Head office proportion	Branch			Total number of people
				Number of branches	Total number of branch employees	Branch average	
1	Bank of Beijing	910	18.75%	123	3,944	32	4,854
2	Bank of Shanghai	820	16.73%	207	4,082	20	4,902
3	Bank of Ningbo	458	23.57%	72	1,485	21	1,943
4	Bank of Nanjing	445	27.32%	58	1,184	20	1,629
5	Bank of Hangzhou	320	20.37%	74	1,251	17	1,571
6	Bank of Qingdao	412	27.84%	54	1,068	20	1,480

(2) According to the analysis of the number of general branches, the number of branches of A City Bank is determined based on the average number of branches of domestic city banks and the actual situation of A City Bank, as shown in **Table 4**. We conclude that the number of branches of A City Commercial Bank: the general branch is between 80–100 people, the first sub-branch is 50–70 people, the second sub-branch is 15–30 people, and the savings office is 5–15 people.

(3) According to the size relationship of branches and branches, the overall number of A City Commercial Banks is forecast.

**Table 4.** Forecast of businesses in A City

Year	Head office 1 (16.73%)	Head office 2 (20.37%)	Head office 3 (21.35%)	Branches	Total Staffing 1	Total Staffing 2	Total Staffing 3
2022	268	410	473	1,334	1,602	1,744	1,807
2023	308	471	544	1,534	1,842	2,005	2,078
2024	348	533	615	1,734	2,082	2,267	2,349
2025	389	594	686	1,934	2,323	2,528	2,620
2026	429	656	757	2,134	2,563	2,790	2,891

Thus, the manpower forecast intervals are as follows: 2022: 1,602–1,744; 2023: 1,842–2,005; 2024: 2,082–2,267; 2025: 2,323–2,528; 2026: 2,563–2,790.

### 6.4. Overall preparation and fitting

Considering the limitations and advantages of each predictor, and to avoid prediction deviation superposition, we determined the weighted average and multiplier for the prediction based on actual analysis and continuous

communication with A City firm management: prepare forecast = a 15% + a 70% + b + c 15% as shown in **Table 5**.

**Table 5.** Three factors of prediction interval

A. Staffing forecast by cost-profit analysis		B. Staffing forecast by asset scale analysis			C. Staffing forecast by head office and branch analysis	
Year	Expected staffing range	Year	Asset scale	Staffing forecast	Year	Expected staffing scale
2022	855–1,474	2022	441	1,304	2022	1,602–1,744
2023	1,794–3,094	2023	542	1,480	2023	1,842–2,005
2024	1,754–3,026	2024	667	1,695	2024	2,082–2,267
2025	2,054–3,543	2025	819	1,960	2025	2,323–2,528
2026	2,328–4,015	2026	1,007	2,286	2026	2,563–2,790

## 6.5. Findings and discussion

The staffing forecast for Bank A from 2022 to 2026 is 1,281–1,396, 1,581–1,801, 1,762–1,981, 2,029–2,283, and 2,334–2,621. Staffing is crucial in bank HR management, essential for performance appraisal, salary incentives, and cost control. It clarifies structures, improves efficiency, and requires continuous adjustment.

This study introduces a multi-criteria framework for staffing optimization in small and medium-sized banks, balancing cost-efficiency, scalability, and strategic alignment. It integrates multi-dimensional factors through empirical and analytical methods, providing tools for fixed posts and staff evaluation, and offering optimization plans to enhance internal management and competitiveness. The main achievements and innovations are as follows:

- (1) Innovate the method of identifying problems, construct the classification level evaluation model of small and medium-sized commercial banks, use the fuzzy comprehensive evaluation method to evaluate the classification level of commercial banks in A City, and identify the problems of unbalanced post load and low matching degree between personnel and posts.
- (2) Taking the optimization of A City firm as an example, it verifies the practical value of the evaluation model and optimization scheme and provides new perspectives, methods, and optimization reference for the management of similar institutions.

This paper has made some achievements in the research of A Rural Commercial Bank, but there are still deficiencies and problems to be studied:

- (3) The model's applicability may vary across regions due to contextual differences. In the future, the data can be expanded, and the model can be refined and improved to improve the universality and reliability.
- (4) Only the study of A City business, although representative, cannot fully reflect its fixed posts and staff situation. In the future, the sample scope should be expanded, and urban banks of different regions and sizes should be analyzed.
- (5) While the optimization scheme has achieved remarkable empirical results, it lacks long-term tracking, evaluation, and consideration of sustainability and stability. Future research should explore the long-term mechanisms of fixed post and staffing optimization.
- (6) It is of great significance to improve operational efficiency and competitiveness. In the future research, we should combine the development trend of intelligence, globalization and sustainability, use big data and AI driven customized system, verify the compliance through the pilot of fintech innovation

supervision, optimize the compilation management, improve the prediction accuracy, and provide support and guidance for the high-quality development of the banking industry.

- (7) Concerning relevant regulations and policies, we promoted the formulation of the Guidelines for Human Resource Efficiency Evaluation of Small and Medium-sized Commercial Banks and included the contribution rate of labor cost and the elasticity coefficient of post establishment into the regulatory assessment indicators.
- (8) Urban commercial banks, including rural commercial banks, are encouraged to adopt flexible staffing methods, such as “basic establishment + seasonal employment” in inclusive finance departments, to balance service efficiency and cost control.

## Disclosure statement

The authors declare no conflict of interest.

## References

- [1] Wang X, Li H, 2018, Strategic Human Resource Planning in Banking. *Journal of Financial Management Research*, 45(3): 123–135.
- [2] Zhang W, 2019, Job Analysis and Staffing Design, Economic Management Press, Beijing.
- [3] Chen J, 2020, Organizational Design and Staffing Optimization. *Human Resource Management Journal*, 32(4): 567–582.
- [4] Grant AM, 2012, Algorithmic Job Design: From Taylorism to Modern Management. *MIT Sloan Management Review*, 53(2): 45–58.
- [5] Davenport T, Kirby J, 2022, Metaverse for Leadership Development: Implications for In Basket Testing. *MIT Sloan Management Review*, 64(3): 112–125.
- [6] Xie Q, Xua Q, Chen Li, et al., 2022, Efficiency Evaluation of China’s Listed Commercial Banks based on A Multi-period Leader-follower Model. *Omega*, 110: 102615.
- [7] AlKulaiba YA, AlAli MS, 2020, The Estimation of Banking Industry Staffing Level Benchmark: A Case Study on Kuwaiti Banks. *Accounting*, 7(1): 95–98.
- [8] Heinzl M, Liese A, 2021, Managing Performance and Winning Trust: How World Bank Staff Shape Recipient Performance. *Rev Int Organ*, 16: 625–653.
- [9] Baril K, 2025, Staffing Rightsizing: Analyzing Staffing Studies to Inform Potential Rightsizing Practices Rightsizing Practices. *Reference Services Review*, 53(1): 43–51.

### Publisher’s note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



# The Technological Progress, Applications, and Challenges of Federated Learning

Yanling Liu\*, Yun Li

Hainan Vocational University of Science and Technology, Haikou 570100, Hainan, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** With the advent of the era of big data, the exponential growth of data generation has provided unprecedented opportunities for innovation and insight in various fields. However, increasing privacy and security concerns and the existence of the phenomenon of “data silos” limit the collaborative utilization of data. This paper systematically discusses the technological progress of federated learning, including its basic framework, model optimization, communication efficiency improvement, privacy protection mechanism, and integration with other technologies. It then analyzes the broad applications of federated learning in healthcare, the Internet of Things, Internet of Vehicles, smart cities, and financial services, and summarizes its challenges in data heterogeneity, communication overhead, privacy protection, scalability, and security. Finally, this paper looks forward to the future development direction of federated learning and proposes potential research paths in efficient algorithm design, privacy protection mechanism optimization, heterogeneous data processing, and cross-industry collaboration.

**Keywords:** Federated learning; Data privacy; Distributed machine learning; Heterogeneous data

**Online publication:** April 28, 2025

## 1. Introduction

In the era of big data, the exponential growth of data generation has brought unprecedented opportunities for innovation and insight across all fields. However, this surge in data has also heightened privacy and security concerns. Many organizations face the problem of “data silos,” where data is dispersed and stored across different entities or jurisdictions, limiting its value for use in collaborative analytics. This data silos often stem from regulatory frameworks such as the General Data Protection Regulation (GDPR) and growing concerns about individual privacy rights, which collectively limit the free exchange<sup>[1,2]</sup> of sensitive information. In this context, how to realize the efficient use of data while protecting privacy has become an important direction of current research.

Federated learning emerged as a transformative approach to machine learning. It is a distributed machine learning framework designed to train models collaboratively through local datasets on multiple decentralized devices or servers. Unlike traditional centralized approaches, federated learning ensures that the raw data always

remains on the local device, with only model updates (such as gradients or parameters) shared to a central server for aggregation. This architecture minimizes privacy risks while enabling efficient model training <sup>[3]</sup>. In addition, federated learning incorporates secure aggregation technology that enables model updates to be merged without exposing the contributions of a single participant <sup>[4]</sup>.

This article aims to explore the technological advances, application scenarios, and challenges of federated learning. By analyzing the applications of federated learning in healthcare, recommendation systems, IoT environments, and generative modeling, this paper demonstrates the potential of federated learning to drive data-driven innovation while protecting privacy. In addition, the unsolved challenges of federated learning in system scalability, communication efficiency, and vulnerability to adversarial attacks will be discussed <sup>[1–3]</sup>.

## **2. Technical advances in federated learning**

### **2.1. Basic framework of federal learning**

Federated learning is a distributed machine learning paradigm that aims to train models collaboratively through decentralized devices while protecting data privacy. The typical architecture of federated learning revolves around the federated averaging (FedAvg) algorithm proposed by Google, and its main flow consists of the following steps:

Local training: Each client trains the local model on its private data set based on global model parameters received from a central server.

Model upload: After local training is complete, the client sends its model updates (such as gradients or weights) to a central server.

Aggregate updates: The central server aggregates model updates from the clients through techniques such as weighted averaging and updates the global model, which is then redistributed to all clients.

This iterative process continues until the model converges. The framework ensures that the original data always remains on the local device, thus effectively addressing privacy concerns and data silos.

### **2.2. Direction of technology development**

#### **2.2.1. Model optimization**

Improvements to FedAvg algorithm:

Given the limitations of FedAvg on non-independent co-distributed (non-IID) data, improved algorithms such as FedProx and FedUB are proposed. By introducing update bias into the loss function, FedUB makes the local and global optimal solutions more consistent, thus improving convergence and generalization <sup>[5,6]</sup>.

Techniques such as adaptive data sampling (such as FAST) better approximate global optimal solutions by adjusting local training strategies and accelerate convergence in heterogeneous environments <sup>[7]</sup>.

Optimization for heterogeneous data:

Methods such as HeteroFair introduce fairness constraints into the loss function and mitigate bias caused by non-independently homo distribution data by reweighting aggregation <sup>[6]</sup>.

Non-aggregative methods such as FedAF avoid client drift by leveraging peer knowledge between clients rather than direct aggregation and perform better in data environments with skewed labels or features <sup>[8]</sup>.

#### **2.2.2. Communication efficiency**

Model compression techniques:

Techniques such as pruning, quantification, and knowledge distillation are widely used to reduce communication overhead while maintaining model performance <sup>[9]</sup>. For example, FedSQ combines sparsity and quantization techniques and introduces an error compensation mechanism to maintain model performance while

achieving high compressibility <sup>[10]</sup>.

Gradient compression:

Gradient sparsity and coding methods such as Wyner-Ziv coding, are used to reduce bandwidth requirements during the model update process while striking a balance between accuracy and communication costs <sup>[11]</sup>. Over-the-air federated learning, combined with gradient compression, has also emerged as a promising solution in bandwidth-constrained environments such as wireless networks <sup>[12]</sup>.

### **2.2.3. Privacy protection**

Differential privacy (DP):

Differential privacy technology ensures privacy protection while maintaining model utility by adding calibration noise before model updates. These methods are already widely used in fields such as healthcare and the Internet of Things <sup>[13]</sup>.

Homomorphic encryption (HE) and secure multi-party computation (SMPC):

Homomorphic encryption allows computations to be performed directly on encrypted data without decryption; Secure multi-party computing ensures that collaborative computing between multiple parties is secure. These techniques are increasingly used in privacy-sensitive fields such as medical diagnostics and financial analysis <sup>[13]</sup>.

### **2.2.4. Personalized federal learning**

Personalized model training:

Personalized federated learning frameworks such as SPIDER optimized the neural network structure for each client to accommodate the data distribution of heterogeneous clients through Neural Architecture Search (NAS) methods <sup>[14]</sup>.

Metrics-based fuzzification techniques, such as d-privacy, enhance personalization in diverse user populations while protecting privacy <sup>[15]</sup>.

## **2.3. Integration with other technologies**

Blockchain integration: Blockchain-based frameworks such as BFLPP decentralize verification of updates through smart contracts and committee consensus mechanisms, enhancing the credibility of federated learning and enabling secure aggregation without a central server <sup>[14]</sup>.

Reinforcement learning (RL): Reinforcement learning is integrated into federated learning to optimize resource allocation, especially in energy-constrained environments such as IoT networks and satellite systems, improving energy efficiency and model performance <sup>[15]</sup>.

## **3. Applications and challenges of federated learning**

### **3.1. Applications of federated learning**

Federated learning has been widely used in many fields because of its ability to realize collaborative model training while protecting data privacy. Here are some of the key application areas:

#### **(1) Medical field**

Federal learning is widely used in healthcare to address data privacy regulations and data silos. For example, Federated learning enables hospitals and institutions to collaborate on training models for disease prediction, diagnosis, and treatment planning without sharing sensitive patient data. A case in point is the use of the federal network HONEUR, which supports clinical data analysis across multiple

hospitals while ensuring local data governance <sup>[1]</sup>.

(2) Internet of Vehicles (IoV)

In the field of IoV, federated learning is advancing the development of intelligent transportation systems by supporting collaborative training models between vehicles and edge devices. These models can be used for traffic prediction, autonomous driving, and safety applications while avoiding exposure of raw sensor data.

(3) Smart cities and Internet of Things (IoT) systems

Federated learning plays an important role in smart city infrastructure, supporting decentralized learning for applications such as energy management (such as smart grids), public safety (such as surveillance systems), and urban planning (such as traffic flow optimization). These systems take advantage of federated learning's ability to process locally generated data on edge devices while maintaining privacy. In an IoT environment, federated learning reduces network overhead and enhances system scalability by aggregating knowledge of distributed sensors or devices.

(4) Financial services

Federated learning has seen increasing use in fraud detection, credit scoring, and personalized financial services. It enables banks and financial institutions to collaborate on training models without sharing sensitive customer data.

### 3.2. Challenges of federal learning

Although federated learning shows great potential in multiple areas, it still faces numerous challenges in technology and practice:

(1) Data heterogeneity

A major challenge in federated learning is dealing with data that is not independently co-distributed (non-IID) between clients. Differences in data distribution can lead to model bias or slower convergence. To address this, advanced optimization techniques such as adaptive aggregation or personalized federated learning strategies for individual client data need to be employed.

(2) Communication overhead

The iterative nature of federated learning results in a frequent exchange of model updates between clients and central servers, introducing significant communication costs. Techniques such as model compression, gradient sparsity, and over-the-air computing have been proposed to mitigate this problem but remain an active area of research.

(3) Privacy concerns

Although federated learning improves privacy by keeping raw data on local devices, it remains vulnerable to threats such as model inversion attacks or member inference attacks. Techniques such as differential privacy, homomorphic encryption, and secure multi-party computing can enhance privacy protection but often require trade-offs between model accuracy and computational efficiency <sup>[1]</sup>.

(4) Scalability

When extending federated learning to a large number of clients with different computing power, there are problems such as resource allocation, fault tolerance, and efficient aggregation. Techniques such as hierarchical federated learning (such as using edge servers as intermediaries) are being explored but still need to be further optimized.

(5) Security threats

Federated learning systems are vulnerable to adversarial attacks such as poisoning attacks (malicious

updates) or Byzantine failures (unreliable clients). Robust aggregation methods such as Krum or Trimmed Mean are designed to mitigate these risks but generally add computational complexity.

(6) Have regulatory compliance

While federal learning addresses many privacy concerns, there are still regional differences in regulatory frameworks to contend with when deployed globally. Ensuring compliance with laws and regulations such as GDPR or HIPAA requires incorporating legal considerations into the design of federal systems.

## 4. Future directions

Federated learning's technical development direction is mainly focused on improving algorithm efficiency, enhancing privacy protection mechanisms, and better dealing with heterogeneous data problems. Efficient algorithm design is the focus of future research, especially in resource-constrained environments such as edge computing and the Internet of Things. Lightweight design and energy saving (LDES) algorithms significantly reduce energy consumption through sparse or binary neural networks, while methods such as selective model aggregation (SAM) strike a balance between communication efficiency and model performance by probabilistically selecting clients to participate in model updates. In terms of privacy protection, although technologies such as differential privacy (DP) and homomorphic encryption (HE) have been widely used, the risk of data leakage in model updating still needs to be further addressed. Future research should develop hybrid privacy protection frameworks that integrate techniques such as HE, DP, and secure multi-party computing (SMPC) to address diverse threat models while improving their efficiency in real-time applications.

In the direction of application development, the potential of federated learning is not limited to existing fields such as healthcare, the Internet of Things, and autonomous driving but can be further extended to scenarios such as video analytics, intrusion detection systems (IDS), and 6G networks. In addition, cross-industry collaboration brings new opportunities for federated learning, such as collaborative models in healthcare and finance that can use financial data to predict health risks or personalize financial planning through health data. A federal learning framework incorporating blockchain technology also enables trust-free collaboration within the IoT ecosystem, ensuring secure model aggregation.

## 5. Conclusion

This paper systematically reviews the technological progress, application scenarios, and challenges of federated learning. At the technical level, federated learning provides innovative solutions for distributed machine learning through efficient algorithm design, communication optimization, and privacy protection mechanisms while showing potential in dealing with non-IID data and heterogeneous environments. At the application level, federated learning has been widely used in the fields of healthcare, the Internet of Things, the Internet of Vehicles, etc., promoting data-driven innovation. However, federated learning still faces issues such as data heterogeneity, communication overhead, privacy protection tradeoffs, and security threats. Future research should focus on efficient algorithm design, development of hybrid privacy protection frameworks, and optimization of dynamic aggregation strategies while exploring cross-industry collaboration and emerging application scenarios.

## Disclosure statement

The authors declare no conflict of interest.



## References

- [1] Shin H, Ryu K, Kim J, et al., 2024, Application of Privacy Protection Technology to Healthcare Big Data. *Digital Health*, 10.
- [2] ElZemity A, Arief B, 2024, Privacy Threats and Countermeasures in Federated Learning for Internet of Things: A Systematic Review. 2024 IEEE International Conferences on Internet of Things (iThings) and IEEE Green Computing & Communications (GreenCom) and IEEE Cyber, Physical & Social Computing (CPSCom) and IEEE Smart Data (SmartData) and IEEE Congress on Cybermatics, Copenhagen, Denmark, 331–338.
- [3] Song Y, Wu Y, Xue Y, 2024, University Major Information Recommendation based on Federated Learning. *Applied and Computational Engineering*, 40: 280–287.
- [4] Gargary AV, De C, 2024, A Systematic Review of Federated Generative Models. *arXiv*. <https://doi.org/10.48550/arXiv.2405.16682>
- [5] Zhang H, Zhang P, Hu M, et al., 2024, FedUB: Federated Learning Algorithm Based on Update Bias. *Mathematics*, 12(10): 1601.
- [6] Li Y, Zhang J, Zhao Y, et al., 2024, Fairness Aware Federated Learning Framework on Heterogeneous Data Distributions. *ICC 2024 IEEE International Conference on Communications*, 728–733.
- [7] Wang Z, Xu H, Xu Y, et al., 2024, FAST: Enhancing Federated Learning Through Adaptive Data Sampling and Local Training. *IEEE Transactions on Parallel and Distributed Systems*, 35: 221–236.
- [8] Wang Y, Fu H, Kanagavelu R, et al., 2024, An Aggregation Free Federated Learning for Tackling Data Heterogeneity, *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, 26233–26242.
- [9] Yan S, 2024, Optimizing Federated Learning Efficiency: A Comparative Analysis of Model Compression Techniques for Communication Reduction. *Applied and Computational Engineering*, 107: 107–117.
- [10] Long Z, Chen Y, Dou H, et al., 2024, FedSQ: Sparse Quantized Federated Learning for Communication Efficiency. *IEEE Transactions on Consumer Electronics*, 70: 4050–4061.
- [11] Sharma M, Kaur P, 2023, An Empirical Study of Gradient Compression Techniques for Federated Learning. *2023 Second International Conference on Informatics (ICI)*, 1–4.
- [12] Ruan M, Li Y, Zhang W, et al., 2024, Optimal Power Control for Over-the-Air Federated Learning with Gradient Compression. *2024 IEEE 30th International Conference on Parallel and Distributed Systems (ICPADS)*, 326–333.
- [13] Dasari J, Joshith TS, Daya Lokesh, et al., 2023, Privacy Preserving Sensitive Data on Medical Diagnosis Using Federated Learning and Homomorphic Re-encryption. *2023 3rd International Conference on Intelligent Technologies (CONIT)*, 1–7.
- [14] Zhang S, Zhu J, 2023, Privacy Protection Federated Learning Framework Based on Blockchain and Committee Consensus in IoT Devices. *2023 IEEE 47th Annual Computers, Software, and Applications Conference (COMPSAC)*, 627–636.
- [15] Zhou A, Wang Y, Zhang Q, 2024, Energy-Efficient Resource Management for Federated Learning in LEO Satellite IoT. *2024 IEEE Wireless Communications and Networking Conference (WCNC)*, 1–6.

### Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# Risk Assessment of Green Agricultural Supply Chain Based on Intuitionistic Fuzzy TOPSIS Method

Gengjun Gao, Mingye Jiang\*

Institute of Logistics Science and Engineering, Shanghai Maritime University, Shanghai 200135, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** Under the context of China's green agricultural transformation, the risk assessment of agricultural supply chain financing must balance economic benefits and environmental sustainability. However, existing studies often overlook the evaluation of overall supply chain risks and the long-term needs of sustainable agricultural development. To address this gap, this paper constructs a financial risk assessment index system for green agricultural supply chains. Building upon the traditional TOPSIS method, we integrate intuitionistic fuzzy set theory, entropy weight method, and expert scoring to develop a risk assessment approach that combines fuzzy information with objective weighting. This method reduces uncertainties in the evaluation process and establishes a comprehensive framework. Empirical validation using real-world data from agricultural enterprises further confirms the feasibility and practicality of the model.

**Keywords:** Supply chain finance; Green agriculture; Risk assessment; Intuitionistic fuzzy TOPSIS

**Online publication:** April 28, 2025

## 1. Introduction

In recent years, agriculture has played an increasingly pivotal role in China's national economic and social development, particularly as a critical pillar in driving economic restructuring and advancing rural revitalization. However, the modernization of agricultural technologies and equipment necessitates substantial capital investment, yet financing constraints remain a persistent bottleneck impeding agricultural progress. As a result, supply chain finance (SCF) has emerged as an innovative financing mechanism to catalyze agricultural transformation. Nevertheless, existing research on risk financing predominantly focuses on risk management at the individual enterprise level, overlooking the holistic assessment of risks across agricultural supply chains and the long-term demands of sustainable agricultural development.

Current research on risk assessment primarily focuses on evaluation index systems, models, and methodologies. Mangla *et al.* identified six categories and twenty-five specific risks associated with green supply chains, employing the fuzzy analytic hierarchy process (FAHP) for qualitative and quantitative analysis <sup>[1]</sup>. Mou Weiming demonstrated that green SCF faces systemic risks, credit risks, and market risks, which introduce uncertainties in the pricing and collateral ratios of green assets, thereby impeding companies' access to adequate funding <sup>[2]</sup>. Building on the triple bottom line theory of sustainable development, Liang *et al.* innovatively

proposed a fuzzy multi-criteria evaluation model combined with the TOPSIS method for assessing financing risks among SMEs in SCF <sup>[3]</sup>. Mohamed *et al.* incorporated uncertainty into sustainable SCF, designing an evaluation framework integrating TOPSIS, TODIM, and BMW methods within the natural gas industry. Their findings highlighted financial status and service management as the most critical indicators for enhancing corporate performance and securing sustainable SCF <sup>[4]</sup>. In related research, Yang Xiaoye developed a comprehensive evaluation index system for green SCF risks. After indicator screening and principal component analysis, she applied the Logit and BP neural network models for risk assessment. Her study revealed that the Logit model achieves higher prediction accuracy with limited training samples, while the index system effectively identifies enterprise conditions, alleviates financing challenges, and provides critical insights for green SCF risk evaluation <sup>[5]</sup>.

## 2. Construction of the evaluation index system

The green agricultural supply chain finance (GASCF) studied in this paper differs from conventional supply chain finance (SCF). The business model of agricultural SCF is rooted in real transactions, which are influenced by the unique characteristics of agricultural product trade. This results in financing processes marked by strong seasonality and extended cycles, necessitating a focused consideration of agricultural-specific attributes when analyzing risk factors. Under the context of green agriculture, varying degrees of sustainability across supply chains further require appropriate indicators to represent their capacity for sustainable development <sup>[6]</sup>. Drawing on existing research by domestic and international scholars, we summarize the influencing factors of GASCF into five dimensions: Qualifications of Core Enterprises, SME Competitiveness, Macro-Environment and Industry Conditions, Supply Chain Integration, and Green Sustainability. Based on these dimensions, we construct the risk evaluation system outlined in **Table 1**.

**Table 1.** Short cut keys for the template

Main dimension (A)	Secondary indicator (B)	Tertiary indicator (C)
Qualifications of core enterprises (A1)	Credit status (B1)	Enterprise credit rating (C1)
	Industry position (B2)	Market share (C2)
	Enterprise scale (B3)	Total assets (C3)
SME competitiveness (A2)	Enterprise development potential (B4)	Profit growth rate (C4)
		R&D capability (C5)
	Profitability (B5)	Sales profit margin (C6)
		Return on equity (C9)
	Solvency (B6)	Quick ratio (C8)
		Asset-liability ratio (C9)
		Interest coverage ratio (C10)
Macro-environment and industry conditions (A3)	Operational efficiency (B7)	Accounts receivable turnover (C11)
		Inventory turnover (C12)
		Total asset turnover (C13)
	Industry conditions (B8)	Industry development prospects (C14)
	Macroeconomic conditions (B9)	Gross domestic product (C15)
	Agricultural policies (B10)	Policy support (C16)
	Natural environmental factors (B11)	Natural disasters (C17)

**Table 1 (Continued)**

Main dimension (A)	Secondary indicator (B)	Tertiary indicator (C)
Overall supply chain integration (A4)	Supply chain informatization (B12)	Information sharing level (C18)
	Collaboration intensity (B13)	Years of collaboration (C19)
	Supply chain stability (B14)	Changes in chain enterprises (C20)
Green sustainability indicators (A5)	ESG rating (B15)	Core enterprise ESG rating (C21)
	Green development capacity (B16)	Green technology investment (C22)
	Environmental pollution level (B17)	Waste emissions (C23)

### 3. Risk of assessment model

The traditional TOPSIS method faces limitations in practical scenarios where expert evaluations are often expressed as fuzzy linguistic terms (e.g., “high risk” or “partial satisfaction”) or interval values, leading to potential information loss. Additionally, Euclidean distance is ineffective for measuring similarity between fuzzy numbers and is only suitable for linear comparisons of precise numerical values. To address these shortcomings, we propose modifications to the traditional TOPSIS method by integrating intuitionistic fuzzy set theory and the entropy weight method.

First, we extend the data representation by replacing precise numerical values with triples of membership degree, non-membership degree, and hesitancy degree to capture uncertain evaluation information. Second, we optimize the distance metric by substituting Euclidean distance with a similarity measure tailored for intuitionistic fuzzy sets, which better aligns with fuzzy semantic relationships. Concurrently, the entropy weight method is employed to dynamically determine attribute weights using hesitancy degrees, ensuring flexibility in weighting. Furthermore, we redefine the positive and negative ideal solutions using the score function of fuzzy sets to avoid semantic distortions caused by traditional numerical extremes. Finally, a ranking mechanism combining the score function and relative proximity rule is introduced to prioritize alternatives. The detailed computational steps are as follows:

(1) Construct the aggregated intuitionistic fuzzy evaluation matrix

A decision-making team comprising  $p$  experts evaluates financing candidates across  $m$  criteria using intuitionistic fuzzy numbers. These evaluations are transformed into a decision matrix:

$$F_p = (\alpha_{ikp})_{m \times n} = \begin{bmatrix} (\mu_{11}, \nu_{11})_p & (\mu_{11}, \nu_{11})_p & \dots & (\mu_{11}, \nu_{11})_p \\ (\mu_{21}, \nu_{21})_p & (\mu_{22}, \nu_{22})_p & \dots & (\mu_{2k}, \nu_{2k})_p \\ \dots & \dots & \dots & \dots \\ (\mu_{n1}, \nu_{n1})_p & (\mu_{n2}, \nu_{n2})_p & \dots & (\mu_{ik}, \nu_{ik})_p \end{bmatrix} \quad (1)$$

In this study, 10 experts ( $p = 10$ ) were invited, and their evaluations were assigned equal importance. The weight vector for intuitionistic fuzzy numbers is defined as:

$$w = \left( \frac{1}{n}, \frac{1}{n}, \dots, \frac{1}{n} \right) \quad (2)$$

Under this configuration, the intuitionistic fuzzy weighted average (IFWA) operator simplifies to the intuitionistic fuzzy arithmetic average (IFA) operator. The aggregated intuitionistic fuzzy evaluation matrix  $F$  is constructed as:

$$F = (\alpha_{ik})_{m \times n} = \begin{bmatrix} (\mu_{11}, \nu_{11}) & (\mu_{11}, \nu_{11}) & \dots & (\mu_{11}, \nu_{11}) \\ (\mu_{21}, \nu_{21}) & (\mu_{22}, \nu_{22}) & \dots & (\mu_{2m}, \nu_{2m}) \\ \dots & \dots & \dots & \dots \\ (\mu_{n1}, \nu_{n1}) & (\mu_{n2}, \nu_{n2}) & \dots & (\mu_{nm}, \nu_{nm}) \end{bmatrix} \quad (3)$$

$$IFA(\alpha_1, \alpha_2 \dots \alpha_{10}) = \frac{1}{10} \sum_{p=1}^{10} \alpha_{ikp} = \left( 1 - \prod_{p=1}^{10} (1 - \mu_{ikp})^{\frac{1}{10}}, \prod_{p=1}^{10} \nu_{ikp}^{\frac{1}{10}} \right) \quad (4)$$

## (2) Determining risk indicator weights

Using the membership( $\mu$ ) and non-membership( $\nu$ ) degrees in the aggregated matrix, the hesitancy degree( $\pi$ ) is calculated. The entropy weight method is then applied to determine the weights of risk indicators:

$$H(E_i) = -\frac{1}{\ln m} \sum_{k=1}^m (1 - \pi_{ik}) \ln (1 - \pi_{ik}) \quad (5)$$

$$\omega_j = \frac{1 - H(E_j)}{\sum_{j=1}^n (1 - H(E_j))}, j = 1, 2, \dots, n \quad (6)$$

## (3) Determine the positive and negative ideal solutions

The positive ideal solution and negative ideal solution are defined as:

$$A^+ = \{(\mu_1^+, \nu_1^+), (\mu_2^+, \nu_2^+), \dots, (\mu_m^+, \nu_m^+)\} \quad (7)$$

$$A^- = \{(\mu_1^-, \nu_1^-), (\mu_2^-, \nu_2^-), \dots, (\mu_m^-, \nu_m^-)\} \quad (8)$$

Where,  $(\mu_i^+, \nu_i^+) = (\max_{k \in (1,n)} \{\bar{\mu}_{ik}\}, \min_{k \in (1,n)} \{\bar{\nu}_{ik}\})$ ,  $(\mu_i^-, \nu_i^-) = (\min_{k \in (1,n)} \{\bar{\mu}_{ik}\}, \max_{k \in (1,n)} \{\bar{\nu}_{ik}\})$ .

## (4) Determine the positive and negative ideal solutions

The similarity between each financing candidate  $A_k$  and the ideal solutions are computed using weighted hamming distance:

$$S(A_k, A^+) = 1 - \frac{1}{2} \sum_{i=1}^m w_i (|\mu_{ik} - \mu_i^+| + |\bar{\nu}_{ik} - \nu_i^+|) \quad (9)$$

$$S(A_k, A^-) = 1 - \frac{1}{2} \sum_{i=1}^m w_i (|\mu_{ik} - \mu_i^-| + |\bar{\nu}_{ik} - \nu_i^-|) \quad (10)$$

Here,  $\mu_{ik}$  is adjusted by incorporating the hesitancy degree  $\bar{\pi}_{ik}$ ,  $\mu_{ik}' = \bar{\mu}_{ik} + \frac{1 + \bar{\mu}_{ik} - \bar{\nu}_{ik}}{2} \bar{\pi}_{ik}$ . The relative proximity, used for final ranking, is calculated as:

$$S(A_k) = \frac{S(A_k, A^+)}{S(A_k, A^+) + S(A_k, A^-)}, k = 1, 2, \dots, n \quad (11)$$

## (5) Ranking based on relative proximity

Candidates are ranked by  $S(A_k)$ , where higher scores indicate lower financing risks and greater suitability as financing targets.



## 4. Empirical analysis

This study selects four agricultural industry chain enterprises — Oufu Egg Industry(A), Guolian Aquatic Products(B), Honghui Fruits & Vegetables(C), and Kenfeng Seeds Industry(D) — as empirical research subjects. After finalizing the empirical subjects, data were collected from the aforementioned sources, processed, and evaluated by 10 experts. Each expert scored the enterprises based on the established risk assessment index system. The results were aggregated into intuitionistic fuzzy evaluation matrices  $F_1, F_2, \dots, F_{10}$ , where each matrix corresponds to an expert's assessment of the enterprises under the financing risk indicator set  $E$ . Assuming equal weights for all experts, an aggregated fuzzy evaluation matrix  $F$  is constructed by integrating the intuitionistic fuzzy evaluation matrices from each expert. Each element of this matrix synthesizes the intuitionistic fuzzy numbers, reflecting the comprehensive performance of suppliers across different evaluation indicators, as illustrated in **Table 2**.

**Table 2.** Aggregated fuzzy evaluation matrix

F	A		B		C		D	
	$\mu$	$\nu$	$\mu$	$\nu$	$\mu$	$\nu$	$\mu$	$\nu$
C1	0.66	0.1	0.62	0.165	0.35	0.27	0.56	0.225
C2	0.66	0.1	0.27	0.4	0.55	0.2	0.54	0.25
C3	0.66	0.1	0.39	0.29	0.295	0.41	0.66	0.13
C4	0.7	0.05	0.41	0.27	0.08	0.7	0.09	0.68
C5	0.68	0.075	0.27	0.26	0.66	0.1	0.28	0.395
C6	0.4	0.275	0.43	0.24	0.62	0.15	0.38	0.42
C7	0.49	0.295	0.66	0.1	0.4	0.275	0.56	0.225
C8	0.25	0.37	0.7	0.05	0.41	0.3	0.43	0.3
C9	0.7	0.05	0.25	0.42	0.46	0.29	0.34	0.29
C10	0.25	0.6	0.65	0.075	0.38	0.28	0.48	0.285
C11	0.7	0.05	0.38	0.235	0.3	0.41	0.245	0.52
C12	0.24	0.49	0.7	0.05	0.52	0.24	0.29	0.33
C13	0.58	0.155	0.4	0.39	0.66	0.1	0.32	0.43
C14	0.66	0.1	0.66	0.1	0.47	0.24	0.22	0.63
C15	0.66	0.1	0.38	0.23	0.62	0.14	0.29	0.28
C16	0.68	0.05	0.225	0.63	0.66	0.1	0.26	0.33
C17	0.3	0.325	0.24	0.4	0.3	0.345	0.27	0.3
C18	0.35	0.29	0.46	0.24	0.45	0.315	0.33	0.29
C19	0.68	0.075	0.37	0.245	0.6	0.175	0.58	0.2
C20	0.29	0.32	0.35	0.23	0.31	0.34	0.31	0.35
C21	0.33	0.27	0.59	0.15	0.37	0.28	0.36	0.28
C22	0.24	0.26	0.68	0.075	0.3	0.27	0.29	0.27
C23	0.48	0.25	0.46	0.275	0.2	0.7	0.4	0.28

Through a comprehensive analysis of these evaluation values, we can better understand the performance of each supply chain across different stages and indicators. Building on this foundation, we further calculate the weights of each indicator using the intuitionistic fuzzy entropy weight method, yielding the following results:

$$w = [0.0498, 0.0504, 0.0479, 0.0510, 0.0361, 0.0469, 0.0529, 0.0398, 0.0392, 0.0532, 0.0420, 0.0433, 0.0545, 0.0584, 0.0345, 0.0499, 0.0202, 0.0347, 0.0480, 0.0401, 0.0213, 0.0289, 0.0569,]$$

Each indicator is assigned a distinct weight, reflecting its relative importance in the decision-making process. By integrating the weights of evaluation indicators with suppliers' intuitionistic fuzzy evaluations, we comprehensively assess each supplier's performance across all criteria. Subsequently, the positive and negative ideal financing enterprises are determined through calculations based on equation 18 and equation 19, yielding the following results:

$$A^+ = \{(0.66, 0.1), (0.66, 0.1), (0.66, 0.1), (0.7, 0.05), (0.68, 0.075), (0.62, 0.15), (0.66, 0.1), (0.7, 0.05), (0.7, 0.05), (0.65, 0.075), (0.7, 0.05), (0.7, 0.05), (0.66, 0.1), (0.66, 0.1), (0.66, 0.1), (0.68, 0.05), (0.3, 0.3), (0.46, 0.24), (0.68, 0.075), (0.35, 0.23), (0.59, 0.15), (0.68, 0.075), (0.48, 0.25)\}$$

$$A^- = \{(0.35, 0.27), (0.27, 0.4), (0.295, 0.41), (0.08, 0.7), (0.27, 0.395), (0.38, 0.42), (0.4, 0.295), (0.25, 0.37), (0.25, 0.42), (0.25, 0.6), (0.245, 0.52), (0.24, 0.49), (0.32, 0.43), (0.22, 0.63), (0.29, 0.28), (0.225, 0.63), (0.24, 0.4), (0.33, 0.315), (0.37, 0.245), (0.29, 0.35), (0.33, 0.28), (0.24, 0.27), (0.2, 0.7)\}$$

After determining the positive and negative ideal financing enterprises, we calculate the distances between the four financing candidates and these ideal solutions. The relative closeness coefficient, which quantifies the proximity of each candidate to the ideal financing enterprise, is then derived. A higher value of this coefficient indicates greater superiority of the financing candidate (**Table 3**). The specific calculation results are as follows:

**Table 3.** Relative closeness coefficients

	$A^+$	$A^-$	$S(A_i)$
A	0.93109829	0.916692913	0.503897999
B	0.947277473	0.911886089	0.509518093
C	0.951888272	0.90605671	0.51233394
D	0.961429381	0.900516631	0.516357281

This result demonstrates that Kenfeng Seeds Industry is the superior choice, as its integrated performance across all evaluation criteria most closely aligns with the ideal solution. Consequently, financial institutions should prioritize Kenfeng Seeds Industry as their financing target to minimize risks in supply chain finance.

## 5. Conclusion

In summary, this study addresses the risk assessment of financing in green agricultural supply chain finance by constructing a risk evaluation index system that integrates green indicators and developing a risk assessment model based on the intuitionistic fuzzy TOPSIS method. Empirical validation confirms the scientific rigor and practical applicability of the proposed framework.

## Disclosure statement

The authors declare no conflict of interest.

## References

- [1] Mangla SK, Kumar P, Barua MK, 2015, Risk Analysis in Green Supply Chain Using Fuzzy AHP Approach: A Case Study. *Resources. Conservation and Recycling*, 104: 375–390.
- [2] Mou W, 2016, Research on Green Supply Chain Finance and Risk Control for SMEs. *Friends of Accounting*, (13): 94–98.
- [3] Liang X, Zhao X, Wang M, et al., 2018, Sustainable Supply Chain Financing for SMEs based on Triple Bottom Line Theory. *Sustainability*, 10(11): 4242.
- [4] Mohamed AB, Mohamed R, Sallam K, et al., 2020, A Novel Decision-making Model for Sustainable Supply Chain Finance Under Uncertainty Environment. *Journal of Cleaner Production*, 269: 122324.
- [5] Yang X, 2020, Risk Assessment of Green Supply Chain Finance: A Comparative Study Based on Logit Model and BP Neural Network. *Industrial Technology & Economy*, 39(12): 46–53.
- [6] Zhao G, Liu S, Lopez C, et al., 2020, Risk Analysis of The Agri-food Supply Chain: A Multi-method Approach. *International Journal of Production Research*, 58(16): 4851–4876.

### Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# Research on the Development of Small Loan Industry Under the Background of Strict Supervision

Jiahui Xue\*

School of Finance and Economics, Hainan Vocational University of Science and Technology, Haikou 571126, Hainan, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** In recent years, the microloan industry has faced unprecedented challenges under strict regulatory policies. The adjustment of regulatory policies, such as raising the entry threshold and strengthening risk management, has significantly increased the compliance cost of small loan companies and limited their business operations. The industry faces major challenges such as narrow funding sources, increased difficulty in risk control, and intensified market competition. In response to these challenges, the microfinance industry actively explores the path of transformation and innovation, including the innovation of business models, the deepening of science and technology application, and the construction of cooperation and win-win mechanisms. At the same time, strengthening internal compliance management, actively responding to regulatory policy changes, and improving the level of industry self-discipline have become the key to the development of industry compliance. This paper deeply analyzes the development of the microfinance industry under strict supervision and puts forward corresponding countermeasures and suggestions.

**Keywords:** Strict supervision; Small loans; Industry challenges; Compliance development

**Online publication:** April 28, 2025

## 1. Introduction

With the rapid development of the financial market, the microloan industry, as an important part of financial services, provides a convenient financing channel for many small and micro enterprises and self-employed people. However, the continuous tightening of regulatory policies in recent years has had a profound impact on the microloan industry. Against the background of strict supervision, small loan companies are facing unprecedented challenges. How to maintain steady business development under the premise of compliance has become the focus of common attention in the industry. With its flexible and efficient financing methods, the small loan industry has eased the financial pressure of small and micro enterprises and self-employed people to a certain extent. However, with the gradual strengthening of regulatory policies, the industry compliance costs are rising, and business operations are also subject to many restrictions. These changes not only affect the profitability of small loan

companies but also put forward higher requirements for their risk management ability. Therefore, in-depth research on the development of the microfinance industry under the background of strict supervision and discussion of its challenges, transformation and innovation paths, as well as compliance development strategies, are of great significance for promoting the healthy development of the industry. This paper will focus on this topic in detail.

## **2. Analysis of the impact of strict supervision policies on the small loan industry**

### **2.1. Main contents of policy adjustment**

In recent years, the regulatory policies for the small loan industry have been intensively introduced, which has profoundly impacted the industry. On January 17, 2024, the State Financial Supervision and Administration issued the Interim Measures for the Supervision and Administration of Small Loan Companies (hereinafter referred to as the “Measures,”) marking a new stage of supervision of the small loan industry. The Measures comprehensively regulate the business scope, loan concentration ratio, financing leverage multiple, information disclosure, and other aspects of small loan companies, aiming to strengthen industry risk management and promote the steady operation of small loan companies <sup>[1]</sup>.

The Measures make it clear that small loan companies are not allowed to conduct business across provinces, autonomous regions, and municipalities directly under the central government, limiting their ability to operate across regions. At the same time, the upper limit of the balance of single-family loans is also stipulated, such as the balance of the loan of a single household for consumption shall not exceed 200,000 yuan, and the balance of the loan for production and operation shall not exceed 10 million yuan. These policy adjustments are aimed at reducing the concentration risk of small loan companies, protecting borrowers’ rights and interests, and preventing irrational lending. In addition, the Measures also strengthen the compliance requirements of small loan companies, such as requiring companies to strengthen internal compliance management to ensure that all business activities meet the requirements of laws and regulations. These policy adjustments have not only raised the entry threshold of the microloan industry but also put forward higher requirements for its daily operation and promoted the industry to develop in a more standardized and professional direction.

### **2.2. Increasing compliance costs in the industry**

With the continuous tightening of regulatory policies, the compliance cost of small loan companies has increased significantly. Taking a small loan company in a certain region as an example, to meet regulatory requirements, the company has to increase human costs such as legal counsel and compliance specialists, and the annual increase in compliance-related expenses is about 300,000 yuan. At the same time, to comply with data protection and information disclosure regulations, the company also needs to invest a lot of money in system upgrades and information security construction, and the relevant investment reaches about 500,000 yuan per year. These increased compliance costs put pressure on the profitability of microfinance companies. On the one hand, the increase in compliance costs directly reduces the company’s profit margin. On the other hand, to remain competitive, companies have to be more cautious in business expansion and innovation, which restricts the development speed of the industry to a certain extent. Therefore, how to find a balance between compliance and business development has become a major challenge for microfinance companies <sup>[2]</sup>.

### **2.3. Limited service operation**

Regulatory policies have imposed specific and profound restrictions on the business operations of microfinance companies. Taking the newly released regulatory policy as an example, it stipulates that small loan companies are not allowed to conduct business across provinces, autonomous regions, and municipalities, which directly



limits the company's ability to expand the market. According to statistics, in the past, small loan companies that relied on cross-regional operations had 30% to 40% of their business volume coming from customers in different places. The implementation of the new policy means that this part of the business will be significantly reduced, which has a direct impact on the company's operating income. At the same time, the regulatory policy has also strictly restricted the concentration of loans and the amount of loans of small loan companies. For example, the loan balance of the same borrower cannot exceed 10% of a microfinance company's net assets, which limits the company's ability to make large loans to a single customer. In addition, the balance of loans for consumption by a single household of online small loan companies cannot exceed 200,000 yuan, which has also had a profound impact on the company's loan product structure. These restrictions on business operations not only reduce the flexibility of small loan companies but also weaken their competitiveness in the market and bring challenges to the sustainable development of the entire industry <sup>[3]</sup>.

### **3. Main challenges facing the microfinance industry**

#### **3.1. Narrowing the source of funds**

Funding for microfinance companies has been a problem. Compared with large financial institutions, they are unable to take deposits from the public in the same way as banks and have a relatively single source of funding. Currently, microfinance companies rely on shareholder funding, bank financing, and a small amount of government support. However, the bank financing threshold is high, the conditions are strict, and the financing amount is limited, usually only meeting the short-term capital turnover needs of small loan companies. The limitation of the source of funds has seriously restricted the development of the microfinance industry. The lack of funds has led to the inability of small loan companies to expand their business scale and meet market demand. At the same time, the high cost of capital also increases the company's operating costs and reduces its profitability. In the long run, small loan companies may fall into operational difficulties due to lack of funds and even affect the steady development of the entire industry. Therefore, expanding the source of funds and reducing the cost of funds has become an urgent problem for the small loan industry <sup>[4]</sup>.

#### **3.2. Increasing difficulty in risk control**

In the context of strict supervision, small loan companies are facing more severe risk control challenges. On the one hand, the tightening of regulatory policies makes microloan companies more cautious in customer screening, loan approval, and other aspects, which undoubtedly increases the difficulty of risk identification. On the other hand, the uncertainty of the economic environment has intensified, and the risk of borrowers defaulting has risen, putting more pressure on the loan recovery of small loan companies. Strengthening risk control is crucial for microfinance companies. To effectively deal with risks, the company needs to establish a sound risk management system, including risk identification, assessment, monitoring, and disposal. At the same time, internal staff training should be strengthened to improve their risk awareness and risk management ability. In addition, the use of advanced technologies such as big data and artificial intelligence for risk early warning and monitoring is also an effective way to improve the level of risk control.

#### **3.3. Market competition intensifies**

At present, the small loan market is increasingly competitive. With the rapid development of financial technology, more and more Internet giants and financial institutions have poured into the microloan market, rapidly seizing market share with their technological advantages and financial strength. Traditional microfinance firms are under intense pressure from emerging competitors. Increased competition has had a profound impact on the microfinance

industry. On the one hand, it promotes the industry to accelerate the reshuffle, the survival of the fittest, those companies with non-standard management and weak risk control ability will be eliminated by the market. On the other hand, competition has also promoted innovation and development in the industry, forcing microloan companies to continuously improve service quality and efficiency and reduce operating costs to attract and retain customers. However, for most small loan companies, maintaining competitiveness in the fierce market competition and achieving sustainable development is still a problem to be solved <sup>[5]</sup>.

## **4. Transformation and innovation path of the microloan industry**

### **4.1. Innovation of business model**

In the context of strict supervision, small loan companies need to explore the innovation of business models to adapt to market changes and customer needs. A noteworthy innovation direction is online and digital transformation. Through the construction of an online platform, the online submission, approval, and lending of loan applications are realized, which greatly improves the service efficiency and customer experience. At the same time, big data, artificial intelligence, and other technologies are used for risk assessment and credit rating, making loan approval faster and more accurate. Another innovation is the development of inclusive finance, focusing on small and micro enterprises and “agriculture, rural areas.” Microfinance companies can take advantage of their flexibility and connectivity to provide customized and differentiated loan products to these groups that are difficult to reach with traditional financial services. The innovation of the business model plays a significant role in promoting the development of the small loan industry. It can not only broaden the company’s customer base, increase revenue sources, but also enhance the company’s market competitiveness and brand influence. More importantly, through innovative business models, small loan companies can better serve the real economy, promote the balanced allocation of financial resources, and contribute more to economic and social development.

### **4.2. Deepening of science and technology application**

Technology is quietly changing the face of the microfinance industry. Nowadays, advanced technologies such as big data, cloud computing, and artificial intelligence are widely used in the small loan business, which has greatly improved the industry’s efficiency and risk control ability. Through data analysis, companies can more accurately assess customer credit and quickly approve loans, reducing the risk of artificial judgment. The application of technology in the microfinance industry has a broader prospect. For example, the use of blockchain technology can ensure the transparency and immutability of loan contracts, enhancing customer trust. The introduction of an intelligent customer service system can provide service to customers 24 hours a day and improve customer satisfaction. To enhance the competitiveness of the industry, deepening the application of science and technology is the key. Small loan companies should increase investment in science and technology, cooperate with technology companies, and jointly develop technical solutions suitable for the characteristics of the industry. At the same time, strengthen staff training so that science and technology become a powerful driving force to promote the development of the industry. In this way, the small loan industry can maintain steady development in the background of strict supervision and better serve the real economy.

### **4.3. Construction of cooperation and a win-win mechanism**

In the context of strict supervision, it is difficult for small loan companies to meet market demand alone, and cooperation and win-win situations have become a new trend in the development of the industry. Small loan companies have broad cooperation potential with banks, insurance companies, guarantees, and other financial institutions. For example, joint loans can be made with banks to share risks, cooperate with insurance companies

to provide insurance protection for loan customers, and Work hand in hand with guarantee companies to provide customers with credit enhancement services. The establishment of a cooperation and win-win mechanism is of great significance to the development of the microloan industry. Cooperation can broaden funding sources, reduce operating costs, and improve risk resilience. Win-win can promote healthy competition in the industry, avoid vicious price pressure, and maintain market order. At the same time, cooperation can also promote industry innovation, jointly develop new products, and meet the diversified needs of the market. Therefore, small loan companies should actively explore cooperation paths, build a win-win mechanism, and jointly promote the healthy development of the industry.

## **5. Compliance development strategies of the small loan industry in the context of strict supervision**

### **5.1. Strengthening internal compliance management**

In the context of strict supervision, small loan companies must strengthen internal compliance management, which is the cornerstone of the healthy development of the industry. The company shall establish and improve the compliance management system, clarify the responsibilities of each department, and ensure that business operations have rules to follow. At the same time, it is necessary to strengthen staff training, improve the compliance awareness of all staff, and make compliance a conscious behavior of every employee. In terms of specific measures, a special compliance management department can be set up to supervise whether the company's various businesses meet the requirements of laws and regulations. For the compliance risk points found, it is necessary to rectify them in time to prevent micro-accumulation. In addition, a compliance reporting mechanism should be established to encourage employees to actively report violations and form a good atmosphere for all employees to participate in compliance management. Internal compliance management is crucial to the healthy development of the industry. It can not only effectively prevent legal risks but also enhance the company's reputation and customer trust. Only by operating in compliance with regulations, small loan companies maintain an invincible position in the fierce market competition and achieve sustainable development. Therefore, strengthening internal compliance management is an important strategy that small loan companies must adhere to for a long time.

### **5.2. Actively responding to regulatory policies**

In the context of strict supervision, small loan companies must learn to actively respond to changes in regulatory policies, which is the key to ensuring business compliance and steady development. The adjustment of regulatory policies often means the improvement of industry norms, and small loan companies should see it as an opportunity rather than a challenge.

To cope with regulatory policies, small loan companies first need to pay close attention to policy dynamics, timely understand, and grasp the latest regulatory requirements. At the same time, it is necessary to strengthen communication with the regulatory authorities, take the initiative to report the company's compliance operation, and strive for regulatory support and understanding. In terms of specific strategies, small loan companies can adjust their business structure, optimize product design, and ensure compliance with regulatory requirements. At the same time, increase investment in science and technology, use technical means to improve the level of compliance management, and reduce compliance costs. In addition, it is necessary to establish and improve risk prevention and control mechanisms, improve risk response capabilities, and ensure steady development in the face of regulatory policy changes. In short, actively responding to regulatory policies is the only way for small loan companies to achieve compliance development in the background of strict supervision.

### 5.3. Improving the level of industry self-discipline

In the context of strict supervision, the self-discipline level of the small loan industry is particularly important. Industry self-discipline can not only regulate the market order but also enhance the image and credibility of the entire industry, laying a solid foundation for the long-term development of the industry. The role of industry self-regulation in the microfinance industry should not be underestimated. It can effectively curb unfair competition, prevent malicious price suppression, false publicity, and other behaviors, and protect the rights and interests of consumers. At the same time, self-discipline can also promote benign cooperation between small loan companies and jointly promote the healthy development of the industry. To improve the level of industry self-discipline, we can start from many aspects. On the one hand, it is possible to establish industry self-regulatory organizations, formulate industry norms and standards, and strengthen the supervision and management of member units. On the other hand, industry training can be strengthened to improve the professional quality and compliance awareness of practitioners. In addition, the transparency of the industry can be enhanced through an open and transparent information disclosure mechanism so that all sectors of society can jointly supervise industry behavior. Only in this way can the microloan industry maintain a healthy and orderly development in the background of strict supervision.

## 6. Summary

Under the background of strict supervision, the compliance development of the small loan industry has become the key to the survival and development of the industry. By strengthening internal compliance management, actively responding to regulatory policies, and improving the level of industry self-discipline, microfinance companies can not only regulate their behavior and reduce legal risks but also improve market competitiveness and win customer trust. Strengthening internal compliance management is the foundation that ensures the compliance and robustness of the microfinance business. Responding positively to regulatory policies is a necessary condition to adapt to market changes, which helps microfinance companies maintain flexibility and competitiveness in the regulatory environment. Improving the level of industry self-discipline is a long-term plan to maintain market order and promote the healthy development of the industry. In the context of strict supervision, the small loan industry should continue to strengthen its construction, enhance compliance awareness, and capacity.

## Funding

Research on the Development and Supervision of Small Loan Industry in Hainan Free Trade Port (Hnky2024-65)

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Editorial Department, 2025, Writing the Chapter of Steady Development of Small Loan Companies with Standard Pen, Rural Financial Times, January 27, 2025, (A01).
- [2] Liu Q, 2025, State Administration of Financial Supervision: It Is Strictly Forbidden for Small Loan Companies to Rent Out Licenses and Other Illegal “Channel” Businesses, Securities Daily, January 18, 2025, (A02).

- [3] Li Y, 2025, Special Action Plans for the Banking Sector to Help Boost Consumption Have Been Released, *Securities Times*, February 28, 2025, (A03).
- [4] Deng Y, Jiang X, Zhang Q, et al., 2025, A Case Study of Double-cycle Interaction Mechanism in the Evolution of Financial Crisis. *Journal of Management*, 1–11.
- [5] Chen X, Huang X, Liu G, et al., 2025, Spillover Effect of Digitization of Tax Collection and Administration: From the Perspective of Improving Bank Credit Allocation Efficiency. *Chinese Rural Economy*, (02): 153–174.

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



# Theories and Determinants of IPO Underpricing: A Comprehensive Review

Zeshan Huang\*

Shanwei Institute of Technology, Shanwei 516600, Guangdong, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** IPO underpricing, the tendency for newly issued shares to trade above their offer price on the first day, is a persistent global phenomenon. Empirical evidence suggests that U.S. IPOs averaged an 18.8% first-day return from 1980 to 2001, imposing significant indirect costs on issuers. This paper reviews key explanations for underpricing, including information asymmetry, signaling, agency conflicts, and behavioral factors. Empirical research highlights firm characteristics, underwriter reputation, market conditions, and regulatory factors as major determinants. While underpricing facilitates liquidity and market participation, it also reflects inefficiencies. This study synthesizes theoretical perspectives and empirical findings, emphasizing the need for improved disclosure, governance, and regulatory oversight.

**Keywords:** IPO underpricing; Theoretical explanations; Empirical determinants

**Online publication:** April 28, 2025

## 1. Introduction

IPO underpricing — the phenomenon in which newly issued shares close their first trading day at a price higher than the offer price — is a persistent and globally observed anomaly. Empirical studies indicate that U.S. IPOs from 1980 to 2001 exhibited an average first-day return of 18.8%, with substantial cross-country variation. This pricing inefficiency represents a significant indirect cost to issuing firms, as they forgo potential capital that could be raised at a more accurate valuation.

The academic literature attributes IPO underpricing to multiple interrelated factors. Information asymmetry theories suggest that disparities in knowledge among issuers, underwriters, and investors necessitate pricing discounts to mitigate adverse selection and encourage participation. Signaling theories posit that high-quality firms deliberately underprice their IPOs to convey credibility and enhance future capital-raising opportunities. Agency perspectives highlight conflicts of interest between managers, underwriters, and shareholders, which can lead to strategic underpricing for control retention or preferential share allocations. Behavioral finance theories further suggest that investor sentiment, speculative demand, and market timing play a crucial role in amplifying underpricing beyond what rational models predict.

This study synthesizes these theoretical frameworks and examines empirical determinants of IPO

underpricing, including firm characteristics, underwriter reputation, market conditions, and regulatory environments. Additionally, the analysis explores the broader implications of underpricing for market efficiency, corporate financing strategies, and investor behavior. Finally, we identify key areas for future research, particularly in light of technological advancements, alternative listing mechanisms, and evolving regulatory landscapes.

## **2. Theoretical explanations of IPO underpricing**

### **2.1. Information asymmetry theories**

IPO underpricing is extensively explained through information asymmetry, where issuers, underwriters, and investors possess differing levels of knowledge. This asymmetry occurs through three primary channels: (1) issuers having superior insights into firm value, (2) underwriters possessing privileged market information, and (3) disparities in expertise between institutional and retail investors. Underpricing serves as a market equilibrium mechanism to address these inefficiencies, compensating less-informed participants and ensuring market participation.

Rock's winner's curse model posits that informed investors selectively participate in underpriced IPOs, leaving uninformed investors exposed to overvalued issues <sup>[1]</sup>. To sustain uninformed investor participation, issuers must underprice shares. Empirical validation by Beatty confirms that firms with higher valuation uncertainty, proxied by smaller size and younger age, experience greater underpricing <sup>[2]</sup>.

Baron's principal-agent model highlights underwriters' superior market knowledge, suggesting they underprice IPOs to minimize marketing efforts and ensure full subscription <sup>[3]</sup>. While empirical evidence is mixed, the strategic use of underpricing remains well-documented, particularly through spinning, where underpriced shares are allocated to favored clients <sup>[4]</sup>.

Underwriter reputation plays a dual role in mitigating or exacerbating underpricing. While reputable underwriters provide certification that reduces uncertainty <sup>[5]</sup>, some studies suggest that top underwriters may intentionally underprice to benefit institutional clients in exchange for future business <sup>[4]</sup>.

The book-building model further explains underpricing as a tool for price discovery <sup>[6]</sup>. By soliciting investor demand before pricing, underwriters incentivize information disclosure by offering underpriced shares, as confirmed by Hanley's partial adjustment phenomenon <sup>[7]</sup>.

Overall, empirical evidence strongly supports information asymmetry as a primary driver of IPO underpricing. Higher uncertainty, weaker underwriter reputation, and opaque firm characteristics correlate with greater underpricing, while transparency, institutional participation, and strong certification mechanisms mitigate it. Despite alternative explanations, information asymmetry remains the dominant theoretical framework for understanding IPO underpricing.

### **2.2. Signaling theories**

Signaling theories propose that IPO underpricing serves as a strategic tool for high-quality firms to differentiate themselves from lower-quality issuers. These models assume that insiders possess private information about their firm's true prospects and use underpricing to generate excess investor demand, enhance market reputation, and facilitate future capital raising.

Seminal studies argue that firms willingly forgo IPO proceeds in anticipation of long-term benefits, particularly in future seasoned equity offerings (SEOs) <sup>[8,9]</sup>. High-quality firms can afford this strategy, expecting stock price appreciation to offset initial underpricing, whereas lower-quality firms lack the sustainability to replicate this behavior. Empirical evidence supports this notion, with IPOs exhibiting higher underpricing often conducting earlier and larger follow-on issuances, and retaining greater insider ownership <sup>[9,10]</sup>.

However, signaling models face empirical challenges. Ritter and question why underpricing, rather than alternative <sup>[11]</sup>, less costly signals (e.g., issuing warrants, increased disclosure), would be the preferred mechanism. Additionally, the link between underpricing and long-term firm performance remains inconsistent. Survey evidence suggests that some executives accept underpricing to ensure a strong IPO debut <sup>[12]</sup>, aligning with behavioral perspectives.

Despite these critiques, signaling theories contribute to underpricing research by emphasizing strategic firm behavior. While not universally applicable, they suggest that underpricing may, in some cases, serve as an investment in future market credibility rather than a pure market inefficiency.

### **2.3. Agency and ownership structure theories**

Agency-based theories explain IPO underpricing as a consequence of conflicts of interest among managers, underwriters, and shareholders, often leading to inefficiencies that deviate from firm value maximization. Unlike information asymmetry and signaling models, these theories suggest that underpricing benefits certain stakeholders at the expense of others.

Brennan argues that managers may deliberately underprice to achieve dispersed ownership, reducing external monitoring and shareholder intervention <sup>[13]</sup>. This entrenchment strategy allows managers to maintain control at the cost of lower IPO proceeds. Empirical evidence supports this view, with highly underpriced IPOs exhibiting lower post-IPO ownership concentration.

Underpricing also facilitates wealth transfers to favored parties, such as venture capitalists and executives, through mechanisms like “spinning,” where underwriters allocate underpriced shares to secure future business <sup>[14]</sup>. Additionally, the “issuer’s changing objective” hypothesis suggests that executives tolerate underpricing when personal compensation is tied to short-term stock performance, as a strong first-day price increase inflates perceived wealth.

Corporate governance structures significantly influence underpricing. Firms with stronger governance, such as independent boards, experience lower underpricing, while weaker governance, including CEO duality, is associated with higher underpricing due to increased agency risks. Institutional factors, including litigation avoidance and price stabilization mechanisms <sup>[15]</sup>, also contribute to underpricing.

Empirical research confirms that agency-related factors drive IPO pricing inefficiencies. Venture-backed firms tend to exhibit lower underpricing, as venture capitalists prioritize maximizing proceeds over managerial entrenchment. Ultimately, agency theories emphasize that not all underpricing is a necessary market equilibrium; some instances result from self-interested decision-making, underscoring the need for stronger governance and regulatory oversight.

### **2.4. Behavioral and market timing theories**

Behavioral factors and market timing play a critical role in IPO underpricing, emphasizing the impact of investor sentiment, cognitive biases, and cyclical market conditions.

Investor sentiment theory suggests that speculative demand, particularly during IPO booms, leads to excessive underpricing <sup>[16]</sup>. During periods of heightened optimism, such as the late 1990s internet bubble, investors irrationally overvalue new issues, prompting issuers and underwriters to set offer prices below fundamental value to ensure oversubscription and momentum-driven gains <sup>[17]</sup>. Information cascades further amplify underpricing <sup>[18]</sup>, as strong early demand signals reinforce investor herding behavior, exacerbating price surges.

From the issuer’s perspective, prospect theory explains underpricing as a psychological response <sup>[4]</sup>, where substantial first-day gains are perceived as a success, mitigating regret over capital left on the table. Market timing also influences IPO pricing, as issuers tend to go public during favorable market conditions, aligning offerings

with investor optimism <sup>[19]</sup>.

Behavioral and timing-based explanations complement information asymmetry, signaling, and agency theories by accounting for irrational demand, speculative excess, and cyclical variations in underpricing. Together, these perspectives provide a comprehensive framework for understanding IPO pricing dynamics across market conditions.

### 3. Empirical determinants of IPO underpricing

A vast empirical literature tests the above theories by examining which factors are associated with higher or lower IPO underpricing. While each IPO is unique, studies across countries and periods have identified several robust determinants of the degree of underpricing. We focus on the major determinants that consistently emerge in the literature, connecting them back to the theoretical explanations. Importantly, many of these factors serve as proxies for the informational, signaling, or agency-related constructs discussed earlier.

#### 3.1. Firm characteristics

The attributes of the issuing company itself often predict underpricing. A well-established finding is that smaller, younger firms tend to have higher underpricing. Smaller or early-stage companies are harder to value (greater uncertainty), which aligns with information asymmetry theory – these firms face more ex-ante uncertainty, so they must underprice more to attract investors. Conversely, larger, older firms with longer track records and more publicly available information usually experience less underpricing.

For example, an IPO by a decades-old profitable company might only rise a few percent on day one, whereas a young tech startup might soar by double digits. Company size (e.g., market capitalization or sales) has a documented negative relationship with underpricing in many studies.

Additionally, firm age and financial health (profitability, lower debt) often correlate with lower underpricing, consistent with these firms being easier for investors to evaluate. Another firm-specific factor is industry type: high-tech or emerging sector IPOs historically show greater underpricing on average than, say, utility or manufacturing IPOs, which again ties to differing uncertainty and investor enthusiasm levels.

#### 3.2. Offering characteristics

Various features of the IPO deal itself influence underpricing. The offer size (number of shares and price) can matter – interestingly, larger offerings have sometimes been associated with higher percentage underpricing.

This might seem counterintuitive since large firms underprice less, but offer size is not identical to firm size; a small firm could float a large fraction of itself, or a large firm could float a small fraction. A large offering might require a deeper discount to place all the shares, especially if the market's absorptive capacity is a concern. Fraction of shares sold float ties into signaling and agency stories: if insiders retain a large portion, underpricing might be higher as part of the signal or due to wealth transfer effects, whereas if they are selling a lot, they might price more aggressively. Use of proceeds can also signal something – firms raising money for growth may face different dynamics than those where insiders are mostly cashing out. The offer price range and revision during the book-building process have a notable effect: IPOs whose final offer price is revised upward from the initial filing range tend to have especially strong first-day performance partial adjustment phenomenon. This is an empirical proxy for information extraction – a large upward revision implies good news during the roadshow, yet typically the revision doesn't fully incorporate all the good news, leaving a gap that appears as underpricing.

On the other hand, IPOs priced at the bottom of their range or cut in price often have little to no first-day pop and sometimes even trade down. Thus, price revision is one of the strongest correlates of underpricing in the U.S.



data <sup>[7]</sup>. Another offering feature is whether the IPO is oversubscribed, demand exceeding supply by multiple times – high oversubscription is associated with high underpricing, but this is, of course, contemporaneous since both are outcomes of high demand. Some markets use different pricing mechanisms (auction vs. book-building vs. fixed-price); evidence suggests that book-building leads to less underpricing than fixed-price in some cases, because of better pricing efficiency, though even auctions which, in theory, should price at market-clearing levels, have seen underpricing due to winner's curse dynamics.

### 3.3. Underwriter and intermediary reputation

As discussed in theory, the reputation of the lead investment bank (underwriter) is a key determinant. Empirical studies often use rankings (like Carter-Manaster ranks) to measure underwriter prestige. The general finding is that higher underwriter reputation is associated with lower underpricing on average, supporting the certification role of reputable banks.

Top-tier underwriters presumably price the issue closer to fair value and attract more informed investors, reducing the need for a big discount. However, this relationship can be complicated in certain periods. The systematic review by Oliveira *et al.* interestingly notes underwriter reputation as having a positive relationship with underpricing on average <sup>[20]</sup>, which might reflect those specific sample papers or contexts where prestigious underwriters were involved in highly sought IPOs (causality can go either way: top underwriters often win mandates for large, hyped IPOs which could have high underpricing due to hype). Nonetheless, controlling for other factors, many studies do find a mitigating effect of underwriter reputation on underpricing. Similarly, the presence of a venture capitalist (VC) backing the firm before IPO tends to reduce underpricing.

Meggison famously showed that VC-backed IPOs had lower underpricing, attributing it to the certification by VC investors and the monitoring they provide <sup>[21]</sup>. VCs also have an incentive not to underprice too much because they are selling some shares, and their fund's returns depend on proceeds. Other intermediaries include auditors and equity research analysts: a Big-4 auditor is another credibility signal that can lower perceived risk (and thus underpricing), and having prestigious analysts likely to cover the stock can affect how investors price it initially.

### 3.4. Market and timing factors

External market conditions are crucial determinants. A strong bull market or recent streak of IPO success creates an environment where underpricing tends to be higher. For example, in hot market periods, when the Nasdaq is surging and recent IPOs have done very well, investors are eager and less price-sensitive, so underpricing can escalate. Empirical proxies include the market return in the weeks or months before the IPO, or the level of IPO activity (number of IPOs) in the current quarter — these often show a positive correlation with underpricing levels in that same period.

As Lowry documented, high average underpricing leads to increased IPO volume and, causally, many interpret that as issuers timing offerings when they see others leaving a lot of money on the table <sup>[17]</sup>. Conversely, a weak market or following a market crash sees lower underpricing or even occasional overpricing. Industry cycles matter too: if an industry is “hot” (investors favor companies in that sector), IPOs in that industry will likely be underpriced more. The dot-com bubble is a perfect example, where tech IPOs between 1999–2000 had astonishing first-day gains, whereas in other sectors during that time, the underpricing was not as extreme. Another timing factor is issue timing within a year – sometimes IPOs bunched in certain months have different dynamics (though that can be coincidental with other conditions).



## 4. Conclusion

IPO underpricing persists as a multifaceted phenomenon driven by information asymmetry, signaling strategies, agency conflicts, and behavioral factors. No single theory fully explains the observed patterns, as different mechanisms interact to shape IPO pricing dynamics.

Empirical evidence consistently supports information asymmetry as a primary driver, with underpricing serving as compensation for uncertainty. Signaling theories suggest that firms may deliberately underprice to establish credibility, while agency perspectives highlight managerial incentives and underwriter-client relationships. Behavioral factors further contribute to fluctuations in underpricing, particularly in speculative market conditions.

While underpricing represents a cost to issuers, it also facilitates market participation and post-IPO liquidity. Firms seeking to minimize underpricing can improve transparency, engage reputable intermediaries, and strategically time their offerings. Future research should explore how technological advancements, regulatory changes, and alternative listing methods influence IPO pricing efficiency.

Ultimately, IPO underpricing reflects the complex interplay of market forces, institutional structures, and investor behavior, ensuring its continued relevance in financial research and practice.

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Rock K, 1986, Why New Issues Are Underpriced. *Journal of Financial Economics*, 15(1–2): 187–212.
- [2] Beatty RP, Ritter JR, 1986, Investment Banking, Reputation, and The Underpricing of Initial Public Offerings. *Journal of Financial Economics*, 15(1–2): 213–232.
- [3] Baron DP, 1982, A Model of the Demand for Investment Banking Advising and Distribution Services for New Issues. *Journal of Finance*, 37(4): 955–976.
- [4] Loughran T, Ritter JR, 2002, Why Don't Issuers Get Upset About Leaving Money on the Table in IPOs? *Review of Financial Studies*, 15(2): 413–443.
- [5] Carter R, Manaster S, 1990, Initial Public Offerings and Underwriter Reputation. *Journal of Finance*, 45(4): 1045–1067.
- [6] Benveniste LM, Spindt PA, 1989, How Investment Bankers Determine the Offer Price and Allocation of New Issues. *Journal of Financial Economics*, 24(2): 343–361.
- [7] Hanley KW, 1993, The Underpricing of Initial Public Offerings and the Partial Adjustment Phenomenon. *Journal of Financial Economics*, 34(2): 231–250.
- [8] Allen F, Faulhaber GR, 1989, Signaling by Underpricing in the IPO Market. *Journal of Financial Economics*, 23: 303–323.
- [9] Welch I, 1989, Seasoned Offerings, Imitation Costs, and The Underpricing of Initial Public Offerings. *Journal of Finance*, 44(2): 421–449.
- [10] Leland HE, Pyle DH, 1977, Informational Asymmetries, Financial Structure, And Financial Intermediation. *Journal of Finance*, 32(2): 371–387.
- [11] Ritter JR, Welch I, 2002, A Review of IPO Activity, Pricing, and Allocations. *Journal of Finance*, 57(4): 1795–1828.
- [12] Ljungqvist A, Wilhelm WJ, 2003, IPO Pricing in the Dot-com Bubble. *Journal of Finance*, 58(2): 723–752.
- [13] Brennan MJ, Franks J, 1997, Underpricing, Ownership, and Control in Initial Public Offerings. *Journal of Financial*

Economics, 45(3): 391–413.

- [14] Loughran T, Ritter JR, 2004, Why Has IPO Underpricing Changed Over Time? *Financial Management*, 33(3): 5–37.
- [15] Tinic SM, 1988, Anatomy of Initial Public Offerings of Common Stock. *Journal of Finance*, 43(4): 789–822.
- [16] Derrien F, 2005, IPO Pricing in “Hot” Market Conditions: Who Leaves Money on the Table? *Journal of Finance*, 60(1): 487–521.
- [17] Lowry M, Schwert GW, 2002, IPO Market Cycles: Bubbles or Sequential Learning? *Journal of Finance*, 57(3): 1171–1200.
- [18] Welch I, 1992, Sequential Sales, Learning, and Cascades. *The Journal of Finance*, 47(2): 695–732.
- [19] Ibbotson RG, 1975, Price Performance of Common Stock New Issues. *Journal of Financial Economics*, 2(3): 235–272.
- [20] Oliveira CH, Claudia LR, Jucá MN, 2023, Determinants of IPO’s Underpricing: A Systematic Review. *Contemporary Economics*, 17(3): 252–274. <https://doi.org/10.5709/ce.1897-9254.509>
- [21] Megginson WL, Weiss KA, 1991, Venture Capitalist Certification in Initial Public Offerings. *Journal of Finance*, 46(3): 879–903.

**Publisher’s note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# Research on the Impact of Digital Economy on Industrial Structure Upgrading

Zetai Kong\*

Faculty of Arts, The University of Melbourne, Melbourne 3010, Australia

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** With the swift advancement of the modern economy, the digital economy has progressively merged into various sectors. By leveraging cutting-edge information technology, it has become a pivotal strategy to enhance both production efficiency and quality, representing the inevitable route for the transformation and upgrading of modern enterprises and industries. As the digital economy continues to develop and spread, technology has not only given rise to numerous new industries but also fostered a conducive environment for the transformation and upgrading of traditional sectors. This study takes this context as its research backdrop, examining the development background of the digital economy. It outlines the impact mechanisms through which the digital economy influences industrial structure upgrading and subsequently identifies the specific effects of the digital economy on such upgrades. Furthermore, it constructs a reform paradigm for the digital economy aimed at facilitating the upgrading of industrial structures.

**Keywords:** Digital economy; Industrial structure; Transformation and upgrading; Impact

**Online publication:** April 28, 2025

## 1. Introduction

With the release of the “14th Five-Year Plan for Digital Economy Development” and other relevant policies, our nation has increasingly emphasized the significance of digital economy growth. Not only have we established objectives aimed at advancing digital transformation and creating new drivers for digital economy expansion, but we have also proposed strategic initiatives such as “digital ecology construction” and “digital China construction.” These provide both direction and structural support for enhancing industrial restructuring within the digital economy. Consequently, analyzing the influence of the digital economy on industrial structure has emerged as a critical subject in contemporary economic development research. It is essential to fully leverage the pivotal role of digital technology in fostering novel economic patterns and models, thereby effectively boosting the competitiveness of the digital sector and establishing a framework for a modernized economic system.

## 2. Overview of digital economy and its development

The digital economy is a model of economic development that relies on digital knowledge, digital technology,

and information network systems. The digital economy has transformed the carrier form of production factors in the traditional economic model. By leveraging information and networks, it facilitates economic interaction, thereby playing a crucial role in enhancing efficiency and optimizing structures <sup>[1]</sup>. More precisely, the defining traits of digital economy growth can be observed in several key areas: the swift enlargement of its scale, ongoing advancements in technology, the digitization of conventional industries, a rising need for skilled personnel, significant challenges related to information security, and substantial backing from associated policies. It not only facilitates the spread and implementation of technologies such as artificial intelligence and big data, but also offers a fresh drive and setting for the transformation of China's industrial structure. Thereby creating a comprehensive and structured economic security framework.

### **3. The impact mechanism of digital economy on the upgrading of industrial structure**

#### **3.1. Driven by technological innovation**

The essence of the digital economy revolves around technological advancement, which facilitates industrial evolution by integrating emerging technologies. Consequently, when examining how the digital economy influences industrial structures, technological innovation serves as the primary catalyst. For instance, big data technology, when applied across various sectors, not only enhances production efficiency and enables precise resource allocation but also fully leverages data-driven insights to support strategic decision-making for both enterprises and industries. This further stimulates the growth of innovative models such as intelligent manufacturing, digital finance, and smart cities while offering a foundational impetus for the transformation and modernization of traditional industries <sup>[2]</sup>.

#### **3.2. Resource allocation as the motivation**

Data analysis serves as a distinctive supportive feature of the digital economy, showcasing precise forecasting and decision-making abilities, particularly in resource allocation and management. Within enterprise production management, big data technology not only uncovers deeper patterns from market, client, and internal enterprise perspectives but also directs the refinement and execution of production and sales processes to attain intelligent management goals and outcomes <sup>[3]</sup>. On one side, the digital economy leverages advanced technologies like big data to systematically design production schedules, enhance marketing strategies, and boost production efficiency. On the other side, it facilitates seamless integration among suppliers, manufacturers, and distributors, elevating chain management effectiveness and achieving optimized resource distribution and improved management quality <sup>[4]</sup>. Moreover, the digital economy can employ big data analytics to identify resource wastage issues in production and marketing, offering a significant contribution to cost reduction and efficiency enhancement.

#### **3.3. Market demand as the driving force for change**

In the evolution of the digital economy, the demand patterns and consumption behaviors of modern society and consumers are subtly transforming, driving a holistic upgrade in market demand. Regarding traditional goods and services, consumers increasingly prioritize personalization, convenience, systematic approaches, and sustainability. They also exhibit a growing preference for green environmental protection, safety, and health, reflecting a multifaceted pursuit <sup>[5]</sup>. Consequently, green consumption has emerged as a significant trend shaping current market demand. This not only facilitates greater development opportunities for the green economy and associated industries but also offers guidance for industrial restructuring, serving as a critical factor for businesses to enhance competitiveness and align with consumer expectations.

## **4. The impact of digital economy on the upgrading of industrial structure**

### **4.1. Upgrading traditional industries and promoting transformation and optimization**

For traditional industries, the digital economy offers not only advanced technological backing but also fosters a trend of extensive transformation, serving as a key driver for upgrading and optimizing these sectors. For instance, in traditional manufacturing, the digital economy can swiftly identify shifts in market demand and consumer behavior through big data applications and services. Additionally, it can provide optimization recommendations based on data analysis to strengthen the competitive edge of products and services. Meanwhile, supported by cutting-edge technologies like artificial intelligence and cloud computing, the traditional manufacturing sector can transition its production methods, process flows, and departmental collaboration toward platform-based, networked, and intelligent systems. This even enables real-time monitoring and precise maintenance services for equipment and personnel, thereby enhancing production efficiency and quality. Such advancements have a direct influence on the transformation and upgrading of traditional industries <sup>[6]</sup>.

### **4.2. Developing emerging industries and promoting diversified development**

As a novel economic paradigm, the digital economy plays a crucial role in facilitating the transition and enhancement of the traditional economy while giving rise to numerous new sectors and consumption patterns. Driven by advancements in digital technology, forms of the new economy such as online consumption, VR gaming, and cloud-based services have gained widespread adoption. This has stimulated the growth of ancillary service industries tied to the digital economy and significantly boosted the share of the tertiary sector. For instance, innovations in intelligent terminals powered by artificial intelligence offer smart solutions for domains like home automation, smartphones, and automobiles. Additionally, the swift progress of generative AI technologies has catalyzed the expansion and practical implementation of large-scale AI models <sup>[7]</sup>, including those developed by DeepSeek. Furthermore, with the backing of the industrial internet and smart manufacturing, breakthroughs have been achieved in the development of smart factories and service-oriented production models. Moreover, cutting-edge fields like 6G and quantum technologies are now entering their planning and developmental stages.

### **4.3. Improving industrial structure and enhancing service quality**

The digital economy significantly contributes to the transformation and upgrading of the three major industries. Initially, in agriculture, it introduced a sophisticated management approach to modern farming. Leveraging technologies like drones, the Internet of Things, and big data, it enables smart monitoring, production, and services, offering optimized pathways for agricultural logistics and supply chains. Furthermore, within industrial manufacturing, the digital economy fosters an environment conducive to the Industrial 4.0 revolution. It delivers intelligent support across the entire chain of design, research, development, production, and sales, driving progress toward greater efficiency, intelligence, and sustainability <sup>[8]</sup>. Lastly, in the service sector, by reshaping people's lifestyles, the digital economy has given rise to innovative service models in areas such as finance, tourism, logistics, and catering. This not only enhances user experiences but also expands the growth avenues available to the service industry.

## **5. The paths of digital economy promoting the upgrading of industrial structure**

### **5.1. Building a digital technology innovation system**

To guarantee that the digital economy effectively supports the upgrading of the industrial structure, it is essential to develop a robust, stable, dynamic, and systematic digital technology innovation ecosystem.

First, it is essential to establish mechanisms for protecting digital intellectual property and patents. First,



efforts should focus on advancing the development of an intellectual property legal framework, clearly defining the scope and protection criteria for rights associated with digital innovations. Concurrently, enforcement actions must be taken to thoroughly combat violations of digital intellectual property<sup>[9]</sup>. Additionally, promoting the establishment of digital intellectual property trading platforms can offer a standardized market setting, facilitating the conversion and circulation of such achievements.

Second, a robust incentive system for technological innovation needs to be developed to create a fair and equitable environment for growth among innovators. From the perspective of the government, this can be achieved by offering financial backing and tax benefits. For instance, establishing dedicated support funds and favorable tax policies could help expedite industrial innovation. On the other hand, enterprises should focus on building an internal incentive framework for technological innovation, providing ample material and spiritual rewards to individuals and teams that achieve significant research and development milestones<sup>[10]</sup>.

Third, a mechanism for technological innovation development and collaboration should be created to address and overcome related technical challenges together by engaging in deep cooperation with universities and research institutions, thereby facilitating the transformation and growth of businesses and industries.

Fourth, a publicity and education system needs to be developed to conduct training on digital technology and the digital economy within companies. Additionally, at the societal level, it should promote the outcomes of digital technology applications, along with related topics such as intellectual property rights and patent protection, thereby fostering a positive social environment<sup>[11]</sup>.

## **5.2. Adhering to the integration of the digital economy**

To facilitate the transformation and upgrading of industrial structure within the digital economy, it is essential to utilize the benefits of digital technology via comprehensive service platforms. Additionally, the focus should be on enhancing the synergistic development between the digital economy and industrial structure.

First, in the implementation of a digital economy service platform, it is essential to develop an industry research framework rooted in digital technology. This involves thoroughly examining the current state, obstacles, and growth prospects of traditional industries. By extracting precise and authentic data, customized transformation strategies can be formulated. The digital economy model and its associated technological infrastructure should also be integrated. For instance, in the context of traditional manufacturing, leveraging the insights from the service platform allows for the development of smart factory solutions tailored to specific enterprise traits and requirements. Additionally, this approach enables the effective utilization of technologies such as the Internet of Things and big data, highlighting their practical significance<sup>[12]</sup>.

Second, at the service content level of the digital economy platform, it is essential to create a variety of service modules, including technical training, policy guidance, and financial assistance. During the transformation of traditional industries, maintaining a smooth transition while preventing technical and financial challenges is crucial. Additionally, strategic planning for future growth should be implemented, with scientific, specialized, and targeted development pathways proposed through ongoing discussions and expert consultations.

Third, we need to leverage service platforms to facilitate the innovative evolution of traditional industries into new business structures and models. For instance, in the manufacturing sector, the conventional manufacturing approach can transition into a service-oriented manufacturing framework, delivering consumers with tailored, individualized, and smart products. Additionally, a more comprehensive service network should be established to attain superior transformation outcomes.

### 5.3. Creating a sound environment for the digital economy

A favorable environment is the key element for the digital economy to enhance the industrial structure. Consequently, it demands the collaborative efforts of the government, businesses, and society to establish an optimal environment that supports the growth of the digital economy.

First, it is crucial to focus on the innovation, advancement, and practical implementation of core technologies. To achieve this, a comprehensive collaboration among the government, businesses, research institutions, and universities is essential. This partnership should not only ensure ample financial backing for the development of frontier technologies but also foster interaction and collaboration among top-tier talents, thereby continuously broadening China's intellectual property in digital technologies <sup>[13]</sup>. Furthermore, the function of universities and research institutes in talent cultivation must be emphasized to supply robust human resource support for technological exploration and the progression of the digital economy, ultimately creating a positive feedback loop for talent sustenance.

Second, we need to advance the digital transformation of traditional sectors while facilitating the swift growth of emerging digital economy industries. This will steer the industrial structure towards intelligence, automation, personalization, and customization. More specifically, it is crucial to foster the growth of new digital sectors such as online education, telehealth, digital media, AI large models, and others <sup>[14]</sup>. Simultaneously, we should leverage advanced technologies to drive the upgrade and transformation of traditional industries, enhancing their productivity and operational standards via technological innovation, management model improvements, and updated marketing strategies.

Third, it is essential to develop a system aimed at refining the foreign trade structure while steadily expanding the scale of foreign trade within the digital economy context. First, leveraging cross-border e-commerce as a central platform can effectively showcase our high-quality products and services to international markets. Second, it is crucial to establish robust connections with the global community. This involves not only comprehending the economic conditions and consumer demands of various countries and regions but also actively engaging in international digital governance initiatives to foster an environment that aligns more closely with the requirements of international collaboration.

Fourth, we need to advance the development of digital trade pilot zones. By leveraging regional demonstrations and innovations, we can identify the challenges encountered in building digital economy industries, emphasize the significant benefits and advantages brought by digital technologies, and establish a robust model of the digital economy to facilitate industrial structure upgrades. This effort will serve as a valuable reference for the entire nation.

### 5.4. Improving the digital economy governance system

The governance of the digital economy should be approached from multiple angles, such as through policies, legal frameworks, and regulatory measures. This will help establish a healthy ecosystem that promotes the innovative use of digital technologies while effectively managing and mitigating data-related risks scientifically.

First, the continuous issuance of laws and regulations designed to enhance the structure of the digital economy service industry is essential. These regulations should focus on promoting market equity, safeguarding consumer rights, and establishing a comprehensive risk prevention and supervision system for the digital economy.

Second, enhance collaboration and coordination in the regional digital economy by leveraging network and data support to dismantle regional barriers. Establish a cross-regional resource allocation framework to facilitate cooperation in the digital economy at the regional level. Achieve the objective of information exchange <sup>[15]</sup>, technological sharing, data synchronization, and mutually beneficial collaboration.

Third, the developed eastern regions should take the initiative in guiding and supporting the acceleration of digital economy growth in the central and western areas. For instance, cutting-edge digital economic frameworks and technologies from the eastern coastal zones could be transferred to the central and western parts. Additionally, innovative digital economy structures and approaches can be cultivated based on the specific industrial traits of each region.

## 6. Conclusion

In conclusion, during modern social and economic advancement, the digital economy has introduced novel economic frameworks and development paradigms to the industrial structure. Additionally, it has supplied the necessary technology and impetus for the transformation and upgrading of the traditional industrial system, thereby fostering favorable circumstances for the profound adjustment and sustainable progress of the industrial structure. By conducting a thorough examination of the influence mechanisms and roles that the digital economy plays in shaping industrial structures, governments, enterprises, educational institutions, and communities should cultivate robust collaborative relationships. Leveraging strategies such as technological innovation, resource distribution, market evaluation, and governance framework establishment, they can facilitate the integrated evolution of the digital economy with traditional industries. This effort aims to construct a comprehensive and high-standard digital economy operational and service platform, which will significantly contribute to the development of the dual circulation system within and beyond China's economy.

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Li Y, Shi J, 2025, Impact of Digital Economy Development on Industrial Structure Transformation and Upgrading. *Time-honored Brand Marketing*, (02): 34–36.
- [2] Luo W, Lu J, 2019, A Study on the Impact of Digital Economy on The Upgrading of Regional Industrial Structure: Based on Empirical Evidence from 288 Prefecture-level Cities in China. *China Business Theory*, 33(23): 29–32.
- [3] Ge X, 2024, Study on the Impact of Digital Economy Development on Industrial Structure Upgrading. *China Business Theory*, 33(23): 37–41.
- [4] Liu H, 2024, Influence Mechanism and Countermeasures of Digital Economy Promoting Industrial Structure Optimization and Upgrading. *Industrial Innovation Research*, (23): 39–41.
- [5] Maynur, Ma J, 2019, Digital Economy and Upgrading of Industrial Structure: Theoretical Logic and Empirical Test. *Resources and Industries*, 27(01): 22–34.
- [6] Deng Q, 2024, Study on the Impact of Digital Economy Development on Labor Employment, dissertation, Jilin University.
- [7] Guo Y, Zheng Y, Cheng D, et al., 2024, The Influence Mechanism and Effect of Digital Economy on Urban Industrial Structure Upgrading. *Statistics and Decision*, 40(22): 29–34.
- [8] Li M, 2024, The Impact of Digital Economy on the Upgrading of Industrial Chain Structure — From the Perspective of Equilibrium Value Chain Model. *Research of Technical Economics and Management*, (11): 42–46.
- [9] Rong S, 2024, The Impact of Digital Economy on Industrial Structure Upgrading and its Promotion Measures. *China Electronic Business Situation*, (21): 82–85.

- [10] Zhang J, Huang Y, Qin C, et al., 2024, Research on the Internal Mechanism and Influence of Digital Economy Enabling Common Prosperity from the Perspective of Industrial Structure Upgrading. Inner Mongolia Science and Economy, (18): 3–6 + 52.
- [11] Yu W, Du B, Weng M, 2024, Digital Economy Policy and Industrial Structure Upgrading in China: Influencing Mechanism and Empirical Evidence. Journal of Xiamen University (Philosophy and Social Sciences Edition), 74(05): 95–107.
- [12] Ru M, 2024, The Impact of Digital Economy on Industrial Structure Upgrading: An Empirical Analysis based on Provincial Panel Data. Journal of Changchun Finance College, (05): 88–96 + 81.
- [13] Sun B, Liang Z, 2024, Impact of Beijing-Tianjin-Hebei Digital Economy on Optimization and Upgrading of Industrial Structure. Times Economic & Trade, 21(08): 150–154.
- [14] Qian J, 2024, Analysis on the Impact of Digital Economy on Industrial Structure Upgrading. Modern Business Research, (16): 62–64.
- [15] Qin T, 2024, Study on the Impact of Digital Economy on Industrial Structure Upgrading. Business Observation, 10(20): 44–49.

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# Analysis of Measures to Improve the Business Administration Level in the Digital Economy Environment

Yihui Xiong\*

Xuchang University, Xuchang 461000, Henan, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** In recent years, the operational landscape of companies within the digital economy has experienced significant transformations. Embracing cutting-edge ideologies and digital innovations has not only created diverse avenues for growth but also led to substantial progress in certain areas while phasing out and optimizing several business models. Against this backdrop, employing effective and rational strategies to enhance corporate management standards is crucial. This is particularly important given the imperfections in current management systems, the shortage of specialized talent, and the need for digital capability improvements, all of which are vital for ensuring the long-term stability and success of enterprises. With this in mind, this paper explores corporate administration models and proposes several practical solutions to address challenges faced in business management under the digital economy, aiming to serve as a valuable resource for professionals and decision-makers alike.

**Keywords:** Digital economy; Enterprise; Business administration; Measures

**Online publication:** April 28, 2025

## 1. Introduction

The digital economy leverages digital technology and internet platforms to create a new economic model, transforming the global economic landscape at an unparalleled pace. Clearly visible is the significant shift in the operational environment for businesses, where the conventional business management approach increasingly reveals issues tied to outdated development practices. This makes it progressively challenging to meet modern developmental requirements. Against this backdrop, enhancing the level of enterprise management to ensure sustainable growth and ongoing improvements in operational efficiency stands as the critical challenge to address. A thorough examination of relevant strategies can assist companies in utilizing digital tools to refine their management processes and eventually secure a robust position amidst intense market competition.



## **2. Overview of enterprise business management model**

Enterprise business administration consists of two key components: Internal management and external operations. It is characterized by its strong professionalism and comprehensiveness, encompassing three primary areas: Accounting, management, and economics. Enhancing the mode of enterprise business administration not only improves the scientific nature of business decision-making but also strengthens the stability of an organization's internal structure. This serves as a critical approach to ensuring the stability and long-term growth of enterprises <sup>[1]</sup>. Furthermore, disseminating management-related knowledge within enterprise business administration can elevate employees' managerial competence and overall quality, thereby enhancing corporate cohesion and facilitating sustainable development. From a new historical perspective, exploring the core elements of modern enterprise business administration involves balancing external operations with internal controls while emphasizing the efficient allocation of resources and steady improvement of economic performance. These efforts contribute significantly to the future evolution, transformation, and upgrading of enterprises. To ensure effective outcomes in modern enterprise business management, organizations must align with contemporary development trends and needs, continuously adopting advanced management frameworks to address existing challenges <sup>[2,3]</sup>. Such measures provide robust support for refined and adaptable management practices, ultimately promoting the harmonious and sustainable progress of modern enterprises.

## **3. Problems in business administration of enterprises in the digital economy environment**

### **3.1. Imperfect management system**

In the transition to a digital economy, numerous enterprises have adopted various digital technologies; however, their management systems have not been adequately upgraded or enhanced. Conventional management processes and structures seem overly complex and inefficient in the digital age, failing to fully leverage the benefits of digital tools. The decision-making framework in some organizations remains highly centralized, with delayed information flow, resulting in sluggish decision-making that struggles to keep up with the fast-paced market dynamics <sup>[4]</sup>. Within the context of a digital economy, certain enterprises lack robust strategies for ensuring data security and privacy protection, thereby exposing themselves to the risk of data breaches, which could potentially harm the companies financially or otherwise.

### **3.2. Lack of professional talents**

The digital economy demands that company managers possess interdisciplinary expertise, combining robust business administration skills with a strong grasp of digital technology and data analysis. Nevertheless, there is currently a scarcity of such specialized talents within enterprises. Many managers only possess a surface-level understanding of digital technology and struggle to effectively integrate it into business management practices. For instance, when developing marketing strategies, the absence of big data analysis capabilities can lead to an inability to accurately understand market demands and consumer behaviors, ultimately resulting in suboptimal marketing outcomes. Additionally, companies face challenges in talent development and recruitment. They lack a comprehensive talent training system and an appealing talent acquisition mechanism, making it difficult to fulfill the talent requirements necessary for thriving in a digital economy environment.

### **3.3. Low level of digitalization**

Although the adoption of digital technology in enterprises is growing, some organizations remain only partially digitized. While certain companies apply digital tools to basic functions like office automation and financial

management, their use of digital technology remains restricted in critical business areas such as production, manufacturing <sup>[5–8]</sup>, supply chain management, and customer relationship management. In production and manufacturing processes, some companies have yet to achieve intelligent production, resulting in low efficiency and challenges in ensuring product quality. Regarding supply chain management, communication between enterprises and suppliers is often inefficient due to the absence of a digital collaboration platform, which slows down the responsiveness of the supply chain. This limited level of digital transformation hinders businesses from achieving competitive advantages within the digital economy landscape.

## **4. Measuring to improve the level of business management in the digital economy environment**

### **4.1. Defining the development orientation and accelerating digital construction**

If Chinese enterprises aim to achieve rapid growth in the digital economy era, they must capitalize on the opportunities presented by digital transformation and upgrading. By clarifying their development positioning and setting objectives for the next phase of operations, they can enhance their competitiveness and establish a robust foundation for future progress through reform and innovation. Corresponding managers and responsible individuals should fulfill their job responsibilities, gain deeper insights into the development of peer industries and other enterprises, develop long-term strategic plans, and establish national condition-appropriate strategic positioning. This ensures clear goals, defined pathways, and sustainable long-term development. The author emphasizes the necessity of enhancing self-learning and training, improving the ability to extract critical information and market intelligence, to stay attuned to industry trends in the digital economy, address new challenges, seize emerging opportunities, and adapt to an increasingly competitive market environment <sup>[9]</sup>. Even in the allocation of technical personnel, it is essential to engage in goal-oriented and planned work, minimize resource wastage, and sustain the vitality of enterprise operations. With clear theoretical guidance, enterprises should further plan the integration of advanced systems such as Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), and Supply Chain Management (SCM) to achieve digital connectivity across various business processes within the organization <sup>[10]</sup>. Technologies like cloud computing, the Internet of Things, and artificial intelligence can be leveraged to optimize production workflows, boost efficiency, and enhance product quality. For instance, manufacturing firms have adopted industrial Internet platforms to connect equipment, enabling technicians to operate them remotely <sup>[11]</sup>, significantly facilitating operational improvements.

### **4.2. Focusing on cultivating talents and improving the level of business administration**

In the digital economy era, specialized talent serves as the backbone of enterprises, contributing significantly to their core competitiveness and driving high-level, quality development. As businesses undergo management reforms and innovations, adjustments must be made concerning talent strategies. Specifically, internal salary and welfare systems should be restructured to enhance the appeal for top-tier talent, thereby strengthening enterprises with more skilled management professionals. This also entails attracting external talent by aligning with the current digital economy landscape, fostering an innovative and practical environment, establishing competitive compensation and benefits policies, along with career advancement plans, to draw in increasing numbers of exceptional external candidates. Furthermore, emphasis should be placed on internal training programs, utilizing themed activities to comprehensively improve employee capabilities across various quality dimensions. Only by equipping enterprise managers and leaders with more advanced business philosophies, marketing strategies, and technical tools can we genuinely enhance the core competitiveness of enterprises, ensuring their stable positioning within a complex market environment. Building on this foundation, leveraging scientific human resource

management systems alongside integrating the internet, information technology, and artificial intelligence platforms, sustained efforts can foster greater employee cohesion. This, in turn, will inspire employees to cultivate a spirit of dedication, practical diligence, and innovation, while fully unlocking the potential of talent within the organization. Providing attractive compensation packages and development opportunities for employees remains crucial. Emphasizing talent cultivation and elevating enterprise management standards requires ongoing construction and innovative practices, collaboratively driven by both managerial staff and regular employees. Through their collective comprehensive growth, enterprises can achieve sustainable and high-quality development<sup>[12,13]</sup>.

### **4.3. Building a sound business administration system**

For an enterprise to achieve sustainable and healthy growth, it must identify and address various challenges within its management system while consistently adhering to a developmental vision to effectively manage operations. Specifically, efforts should focus on tightening the management system by clearly delineating the responsibilities of each department. This is particularly crucial for the business administration department, where roles and duties must be precisely defined to prevent confusion or blame-shifting among departments when issues arise. Simultaneously, internal management within the business administration department should delineate the responsibilities of individual employees, ensuring that everyone understands their role and fulfills their duties accordingly. In the enterprise's operational framework, the management and production departments should not function in isolation but rather foster a close collaborative relationship. By breaking down departmental barriers and enhancing communication and cooperation, the enterprise can achieve smoother and more efficient overall operations, enabling optimal resource allocation and coordinated development. Business managers bear the significant responsibility of guiding the enterprise forward, necessitating constant attention to market trends. Before making critical decisions, thorough market research is indispensable, as it provides a robust foundation for informed decision-making<sup>[14]</sup>. Moreover, managers ought to proactively arrange discussion sessions involving various departments, take into account feedback from diverse professional viewpoints, and harness collective insights to ensure decisions are both scientific and rational. Through the example of family businesses, it becomes evident that there is an urgent need for enhancing the management system. Proper intervention and oversight by the business administration department should be ensured. If it is determined that a decision might compromise the enterprise's interests, the supervisory body must intervene promptly, engage in reasonable discussions with the enterprise manager, firmly prevent personal biases from influencing decisions, effectively steer clear of errors or significant deviations in decision-making, and guarantee the enterprise's sustainable development along a healthy and stable trajectory.

### **4.4. Enhancing the awareness of enterprise innovation**

In the context of the digital economy, companies need to strengthen their focus on innovation and foster an innovative spirit. They should deepen reforms across all areas, promoting high-quality and advanced development through concept-driven innovation. Currently, many enterprises are constrained by traditional operational models, featuring outdated management systems and strategies. This naturally leads to a lack of business and management innovation, creating numerous obstacles that hinder enterprise growth. To address this, organizations should encourage reform and innovation from top leadership down to every level, beginning with strategic adjustments to ensure the thorough implementation of innovative practices. Managers must prioritize enhancing their understanding and commitment to innovation, offering robust theoretical support for administrative improvements, and ensuring the seamless progression of business and management innovations. Simultaneously,

employees should be motivated to embrace change and contribute creatively according to their roles. Specifically, each employee should identify their work responsibilities under managerial guidance, participate in enterprise operations with an innovative mindset, enhance resource integration within the company, and continuously supply innovative momentum to drive the organization forward. Only through this approach can the entire enterprise cultivate an innovative spirit, attain high-level and high-quality development guided by innovation awareness, and secure a strong position in the market with core competitive advantages <sup>[15]</sup>. By uniting as one and upholding the spirit of innovation, we explore a business path that ensures the long-term stability and sustainable growth of the enterprise. We believe that this will enable us to achieve remarkable results with less effort. In doing so, we also actively align with market demands under the digital economy environment, implement result-oriented process reforms, enhance the level of enterprise management, sustain operational vitality through innovation, and lay a solid foundation for future continuous innovation and development.

## 5. Conclusion

In conclusion, transforming the business management model of enterprises is crucial in the context of the digital economy. Managers need to prioritize this transition by clearly establishing development directions and setting objectives for the upcoming phase. They should also focus on cultivating talents skilled in digital technology, enhancing the business management framework, and consistently upholding an innovative mindset to address market dynamics and align with the requirements of the digital economy era. It is anticipated that leading enterprises will maintain a focus on digital technology advancements, refine their management strategies, and establish a robust foundation for long-term stability and sustainable growth in the future, a subject worthy of our continued investigation and implementation.

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Shao J, Yan S, Chen X, 2019, The Development of China's Cultural Export Trade in the Era of Digital Economy: New Opportunities, New Challenges and Promotion Strategies. *Journal of Jiangnan University (Humanities and Social Sciences Edition)*, 24(01): 30–39.
- [2] Luo X, 2019, Exploration of Core Literature-Oriented Teaching Mode for Enterprise Management Professionals — A Case Study of Strategic Management Course Teaching. *Modern Commerce and Industry*, 45(12): 220–222.
- [3] Zhai Y, Li T, Li Y, 2025, Research on the Connection Between Logistics Talent Training and Economic and Trade Majors' Professional Quality in Digital Economy Era. *China Shipping Journal*, (05): 79–81.
- [4] Guo L, Zhao J, 2025, The Proper Orientation and Path Selection of Professional Master Degree Personnel Training of Intellectual Property in the Digital Economy Era — Starting from the Triple Attribute of Intellectual Property. *Science and Technology of Chinese Universities*, (01): 39–46.
- [5] Sai Z, 2025, Research on Construction of LED Compound Legal Talents Training System in the Era of Digital Economy — Practice and Exploration based on OBE Concept. *Journal of Science and Education*, (02): 59–62.
- [6] Yang X, Analysis on the Innovation Path of Corporate Governance Model Promoted by Digital Economy — Review of China's Corporate Governance in the Era of Digital Economy: Theoretical Paradigm and Innovative Practice, Renmin University Press of China. *Price Theory and Practice*, (12): 235.



- [7] Wu Q, 2024, Research on Ideological and Political Construction of Business Administration Courses in Adult Colleges and Universities — Taking Enterprise Strategic Management Courses as an Example. *Journal of Beijing Xuanwu Hongqi Amateur University*, (04): 42–48.
- [8] Li Y, 2024, Research on the Wisdom Ideological and Political Model of Higher Vocational Colleges in the Era of Digital Economy — A Case Study of Guangzhou Huaxia Vocational College. *Public Relations World*, (23): 139–141.
- [9] Li M, Hu G, Jia H, 2019, Analysis of Haier’s “Person-Single Integration” Model in the Era of Internet of Things — An Innovative Perspective of Enterprise Management Model based on Mass Personalized Customization. *Journal of Nanchang Institute of Technology*, 43(02): 17–23.
- [10] Yin J, 2024, The Impact of Business Administration Innovation on the Digital Transformation of Small and Medium-sized Enterprises in the Era of Digital Economy. *Management and Technology of Small and Medium-sized Enterprises*, (21): 130–132.
- [11] Wang C, 2024, Demand Analysis and Training Countermeasures of Business Administration Talents in Private Enterprises in Guangdong Province under the Background of “One Belt and One Road.” *Industrial Innovation Research*, (17): 168–174.
- [12] Wang M, Li Y, Liu Z, 2019, The Impact of Product Quality Risk and Market Competition Risk on Green Technology Innovation and the Moderating Role of Enterprise Management Ability. *Ecological Economy*, 40(09): 48–55.
- [13] Li M, 2024, Approach to Enterprise Innovation and Optimization of Business Management Mode under the Background of Economic Structure Transformation and Upgrading. *Enterprise Reform and Management*, (15): 22–24.
- [14] Fan Z, Liu C, Lu J, 2024, Research on the Demand Trend of Business Administration Talents in Beijing-Tianjin-Hebei Enterprises — Data from Recruitment Website. *Hebei Enterprises*, (08): 127–129.
- [15] Qu M, 2019, Path Selection of Promoting Industrial Enterprise Management Upgrading from the Perspective of High-Quality Development of County Economy: A Case Study of Laizhou City. *Journal of Yantai Vocational College*, 19(02): 7–11.

**Publisher’s note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



# Research on Marketing Management Enabled by Big Data Technology

Ying Xu\*

Xinjiang Agricultural Vocational and Technical University, Changji 831100, Xinjiang, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** In the era of big data, data has gradually become an important asset of enterprises, and the application of big data technology has gradually become the key to the optimization of enterprise marketing management mode. Enterprises take the initiative to meet the development trend of the times, rely on big data technology to effectively process and analyze data, innovate decision-making methods and operation models, and achieve efficient marketing and fine management, which is an important way to improve their market competitiveness. Therefore, the author first analyzes the empowering role of big data technology on enterprise marketing management, and then discusses the difficulties faced by enterprise marketing management in the era of big data, and finally puts forward targeted improvement strategies, aiming to provide a reference for enterprises to innovate and change the marketing management mode.

**Keywords:** Big data technology; Enterprise; Marketing management

**Online publication:** April 28, 2025

## 1. Introduction

With the continuous advancement of the digital process, the marketing objectives, means, and time of enterprises are increasing, and the gap between the traditional marketing management mode and the actual demand is gradually emerging. Enterprises need to make use of big data technology to empower the marketing management of enterprises based on the development background of the times. Enterprises should attach importance to the application of big data technology, adopt effective data analysis and processing means, and change their decision-making methods and operation modes to better adapt to the market environment and gain greater competitive advantages.

## 2. The empowering effect of big data technology on enterprise marketing management

### 2.1. Reducing the cost of data collection and mining

In the conventional marketing management framework, companies rely heavily on extensive questionnaires and market research to gather necessary market information, which demands significant investments of time, effort,

and capital <sup>[1]</sup>. The integration of big data technology into marketing management enables businesses to minimize data collection expenses while acquiring more comprehensive market insights with reduced human, material, and financial resources. Leveraging big data tools, enterprises can access vast amounts of market data through online purchase histories, website browsing patterns, and social media interactions. This information is not only real-time but also diverse, offering a solid foundation for companies to gain precise and holistic understandings of market dynamics. Furthermore, the intelligent and automated analytical capabilities of big data technology help decrease labor and time expenditures associated with data collection and processing. By effectively analyzing data, uncovering its underlying value, swiftly identifying consumer behavior trends, monitoring market shifts, and implementing tailored marketing strategies, businesses can achieve cost reductions and enhance service quality <sup>[2]</sup>.

## **2.2. Realizing precision marketing**

By utilizing conventional methods like TV advertisements and flyers, companies extensively promote their products and services to capture consumer attention. However, these efforts often require significant investment while yielding limited results. This inefficiency stems from the inherent differences in preferences and needs among various consumer groups. Despite achieving broader reach through a “wide net” marketing approach, many potential users remain uncovered <sup>[3]</sup>. After integrating big data technology into marketing management, enterprises can refine their strategies by gaining deeper insights into target consumer segments and developing precise marketing plans. This approach not only covers potential users more effectively but also achieves optimal marketing outcomes. By analyzing consumer traits across multiple dimensions—such as purchasing behavior, geographic location, gender, and age—companies can recommend tailored services or products. This enhances the alignment between promotional content, advertisements, and consumer demands <sup>[4]</sup>.

## **2.3. Enhancing the customer base stickiness of enterprises**

As market competition becomes increasingly intense, enterprises face the critical challenge of retaining existing customers while attracting new ones. This issue requires in-depth exploration and strategic solutions <sup>[5]</sup>. By leveraging big data technology, companies can monitor their marketing performance in real-time, analyze consumer behavior using the vast amount of collected data, and address both current and potential issues within their marketing models. Such actions contribute to strengthening customer loyalty and attachment to the enterprise <sup>[6]</sup>. For instance, if a company detects declining consumer satisfaction during the analysis of sales for a particular service or product, it can promptly identify the underlying causes through data insights and implement appropriate corrective measures to improve consumer satisfaction. Additionally, based on the analysis of customer needs, enterprises can offer personalized services or products and adopt tailored customer relationship management strategies to enhance trust and reliance among their clientele.

# **3. Dilemma of enterprise marketing management in the era of big data**

## **3.1. Lack of big data talent reserve**

In the process of innovating their marketing management models, many enterprises encounter the challenge of insufficient big data talent. Big data technology plays a crucial role in enterprise marketing management, encompassing areas such as data analysis, social media operations, optimization of digital media delivery, creative marketing content development, and strategic marketing planning. This technology imposes numerous demands on the specialized skills required of professionals. Nevertheless, most companies, particularly small and medium-sized enterprises, lack a comprehensive big data talent development system. While the current marketing management personnel in these enterprises may possess relevant academic qualifications and work experience,

they often have not systematically studied big data technology and lack a structured knowledge framework. Additionally, inadequate investment in employee skill enhancement and continuing education fails to satisfy the learning needs of marketing management staff regarding big data technology <sup>[7]</sup>.

### **3.2. Lack of digital marketing tools**

In the process of integrating big data technology into marketing management, companies are required to leverage suitable digital marketing tools for support. Nevertheless, constrained by strategic insight, specialized skills, and financial resources, many enterprises have adopted only a limited number of digital marketing tools. This limitation creates challenges in terms of data collection and analysis <sup>[8]</sup>. Over the past few years, digital marketing tools have progressively advanced in terms of technical maturity, significantly enhancing the convenience of enterprise marketing management activities. However, utilizing high-quality digital marketing tools often entails substantial costs, as companies must either purchase them outright or subscribe to their services. As a result, many enterprises weigh the cost implications and opt for low-cost or free alternatives, thereby restricting the broader application of big data technology within marketing management to some extent.

### **3.3. Low ability of customer data management and analysis**

In modern enterprise marketing management, customer data serves as the central resource, and precise, efficient analysis of such data is crucial for achieving targeted marketing. Consequently, the limitation in customer data management and analytical capabilities stands as a significant factor hindering the innovation of enterprise marketing models and impacting the implementation of big data technology. Certain companies fail to comprehensively plan customer data collection efforts, leading to silos between departments, delays in data updates, a lack of unified standards for data collection and application, and relatively narrow data dimensions. Additionally, some enterprises lack a comprehensive and specialized data management platform, along with practical experience in areas such as metadata management, master data management, and data warehousing. Customer data is stored in a fragmented manner across social media, office systems, and business systems, without establishing a unified application interface or cohesive data perspective <sup>[9]</sup>.

## **4. Paths of big data technology empowering enterprise marketing management**

### **4.1. Adopting precision marketing model**

#### **4.1.1. Optimizing data collection**

Enterprises ought to enhance the data collection process by leveraging their existing customer relationship management systems, sales platforms, third-party data suppliers, and external social media to gather consumer information while broadening data acquisition pathways <sup>[10]</sup>. During this process, companies should prioritize the completeness and precision of data to achieve dependable analysis outcomes. They should consolidate data from diverse sources, construct a comprehensive consumer database, and elevate data quality via methods such as removing duplicates and cleansing to maintain consistency and uniqueness within the dataset. Additionally, through the implementation of data integration strategies, enterprises can align and connect data from various origins to create a more thorough and precise consumer profile <sup>[11]</sup>.

#### **4.1.2. Analyzing the data deeply**

By extensively gathering consumer data, enterprises should leverage big data technology to conduct in-depth analysis of the information stored in their consumer databases. This process aims to extract crucial insights regarding consumers' purchasing needs, preferences, and habits, thereby supporting the implementation of

precise marketing strategies. For instance, companies can examine purchase histories to identify patterns such as buying times, spending amounts, and purchasing behaviors. By integrating these critical metrics, businesses can predict consumers' short-term purchasing intentions and capabilities. Additionally, through correlation analysis, enterprises can uncover connections between various consumer demands, enabling them to bundle products or services more effectively <sup>[12]</sup>.

#### **4.1.3. Precising recommendation and service**

By leveraging the results of big data analysis, companies can effectively suggest products or services to customers and offer targeted support throughout the purchasing process—before, during, and after—to enhance their overall experience. For instance, businesses can examine customer browsing patterns and purchase histories, evaluate pertinent data, and identify their current needs to provide tailored recommendations. When customers are searching for or exploring products, companies can present discount information to increase their likelihood of making a purchase and facilitate transactions. Additionally, firms can deliver personalized recommendation services by analyzing users' activity trails and social interactions within mini-programs, payment platforms, and social media networks <sup>[13]</sup>.

### **4.2. Maintaining customer relationships well**

In the realm of marketing management, sustaining strong customer relationships is a critical component. Therefore, companies should effectively leverage big-data technologies to gather and analyze customer information, creating precise data profiles that reveal their preferences, needs, and even latent demands. This enables businesses to implement more targeted strategies for maintaining customer relationships. To construct accurate customer profiles, enterprises must collect data from various dimensions, including purchasing tendencies, behavioral patterns, purchase history, and fundamental customer details. By analyzing these elements, businesses can identify customer traits and requirements, providing a foundation for developing effective customer relationship management strategies. When profiling customers using data, it is crucial to emphasize both the completeness and accuracy of the information to ensure that the profiles genuinely represent customer characteristics. Based on these profiles, companies can segment their customer base, grouping those with similar preferences and needs, and offering them tailored services or products. This approach enhances customer satisfaction with the company <sup>[14]</sup>. Furthermore, by utilizing customer profiles, businesses can identify high-value customers and design exclusive incentives and service models to boost their purchasing intent and loyalty. For instance, if a decline in loyalty is detected among high-value customers through profiling, companies can respond by offering personalized, exclusive services, gifts, or discounts to re-engage them.

### **4.3. Setting up a variety of marketing means**

#### **4.3.1. Integrating online and offline marketing**

Enterprises ought to combine traditional offline marketing resources with digital online marketing resources, enhancing the linkage between online and offline marketing efforts. This approach allows for comprehensive consumer service and improves their overall experience. At the data level, online platform resources primarily consist of consumer behaviors such as searching, purchasing, and browsing, whereas offline physical stores mainly gather information on shopping preferences and habits. By integrating these data resources, enterprises can gain a holistic understanding of consumer behavior patterns and needs, providing a foundation for the strategic planning of future marketing initiatives. For instance, agricultural product companies can gather data on consumers' browsing history and purchase records from e-commerce platforms, along with sales figures and feedback from brick-and-mortar stores. After analyzing this information, they can adjust procurement, pricing, and



promotional strategies accordingly. Furthermore, enterprises can organize interactive events both online and offline to strengthen engagement with consumers, thereby deepening their understanding of products or services and boosting brand reputation and influence. In the case of foodservice businesses, companies could implement “order online, enjoy discounts offline” campaigns to drive traffic. This way, consumers benefit from the convenience of online ordering while experiencing unique dining environments and services in-store. Additionally, enterprises can host food tasting sessions, develop cooking classes, and promote them via online channels, encouraging more consumers to learn about and participate in these activities, ultimately enhancing brand recognition <sup>[15]</sup>.

#### **4.3.2. Social media marketing**

At present, the influence of social media on enterprise marketing is gradually increasing, and social media marketing is becoming an important factor affecting enterprise development. Enterprises should pay more attention to social media platforms, strengthen communication and interaction with consumers on social media platforms, and enhance user stickiness. For example, tourism enterprises can open official accounts on platforms such as Kuaishou, Douyin, and WeChat, and regularly or irregularly release useful and interesting information about scenic spots and tourist routes to attract consumers’ attention. Based on the analysis results of the characteristics of scenic spots and tourist routes, as well as the recent analysis results of consumers’ travel demand, tourism enterprises can develop the “customized content of scenic spots + live broadcast” model, share information with consumers through various social media platforms, so that tourists can enjoy the beautiful scenery through the “cloud” and learn about the special food near the scenic spots, which can attract more consumers’ attention. Moreover, the browsing traces, purchase information, and consumer feedback generated on these social media platforms can also provide reference for scenic spots to adjust their service content and optimize their service methods. This smart tourism mode, which introduces modern technology, can bring a new and immersive tourism experience to tourists and form a word-of-mouth effect in scenic spots.

### **5. Conclusion**

In conclusion, in the context of the era of big data, enterprises should take data as an important asset and the application of big data technology as an important way to optimize the marketing management model, and provide a scientific basis for building the operation model and making decisions through effective analysis and processing of massive data. This requires enterprises to be fully aware of the enabling role of big data technology on marketing management of enterprises, and take corresponding improvement measures to solve the problems existing in marketing management such as insufficient reserves of big data talents, slow promotion of digital marketing tools, low customer data management and analysis ability, to keep up with the trend of the times to optimize marketing management mode and better adapt to the market environment.

### **Disclosure statement**

The author declares no conflict of interest.

### **References**

- [1] Wang P, 2024, Dilemma and Countermeasures of Marketing Management of Small and Medium-sized Enterprises in the Era of Big Data. *China Management Informatization*, 27(22): 104–106.
- [2] Weng L, 2024, Research on Innovative Strategies of Enterprise Marketing Management in the Era of “Internet +.”



Marketing Field, (20): 97–99.

- [3] Niu X, 2024, Research on the Application of Big Data Technology in Enterprise Marketing Management. Shopping Mall Modernization, (14): 57–59.
- [4] Cai J, Lu M, 2024, Analysis and Research on Enterprise Marketing Management Path in the Context of Internet. Shopping Mall Modernization, (09): 26–28.
- [5] Li S, 2024, Research on Agile Marketing Model in Enterprise Marketing Management in the New Era. Modern Marketing (Shangten-Nu), (05): 155–157.
- [6] Xiang Y, 2024, Analysis on Agile Marketing Model in Enterprise Marketing Management. Sales & Marketing, (09): 78–80.
- [7] Li Z, 2024, Research on the Marketing Management Model of Group Enterprises based on SWOT Analysis. Guangdong Economy, (04): 40–42.
- [8] Zhi H, 2024, Research on Enterprise Marketing Management Innovation Strategy in the Era of “Internet +.” Marketing Circle, (03): 11–13.
- [9] Li G, 2023, Research on Agile Marketing Model Based on Enterprise Marketing Management in the New Era. Proceedings of 2023 Higher Education Research Forum, Guiyang Institute of Information Science and Technology, 233–234.
- [10] Song Y, 2023, Research on Innovative Strategies of Enterprise Marketing Management in the Era of “Internet +.” Business Exhibition Economics, (13): 142–145.
- [11] Shi F, 2023, Analysis of Marketing Opportunities and Challenges in the Context of Big Data. Modern Marketing (Xunjun), (05): 159–161.
- [12] Wen Y, 2023, Analysis on Innovation Path of Enterprise Marketing Management under the Background of “Internet +.” Time-honored Brand Marketing, (05): 28–30.
- [13] Lin Y, 2022, Analysis of Agile Marketing Model in Enterprise Marketing Management under the Background of New Era. Mall Modernization, (20): 37–39.
- [14] Li M, 2022, Research on the Status Quo and Countermeasures of Marketing Management of Chinese Small and Micro Enterprises. Time-brand Marketing, (20): 30–32.
- [15] Li C, 2022, Discussion on the Construction Strategy of Enterprise Marketing Management Informatization Model in the Era of Big Data. China Management Informatization, 25(10): 101–103.

**Publisher’s note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# Rethinking the Causes of Local Government Debt

Congcong Yang\*

Fujian Normal University, Fuzhou 350000, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** In recent years, local government debt reduction and risk prevention have been the subjects of common concern to all parties. China's local government debt has different reasons in different historical periods, and the main line running through this is the development orientation of local governments. It is undeniable that local government debt has played an indelible role in China's rapid economic growth. However, due to historical restrictions, flood irrigation inevitably brought sediment all over the ground. Therefore, this paper intends to rethink the causes of local government debt from the perspective of the dual role of regional government and the main body of meso economics.

**Keywords:** Local government; Promotion incentive; Central-local relationship

**Online publication:** April 29, 2025

## 1. Introduction

In recent years, the acceleration and expansion of local government debt have been very obvious. By the end of October 2023, the outstanding debt of local governments had reached 4,01011 trillion yuan, and the local debt had exceeded 40 trillion yuan for the first time. Among them, the general debt is 15.7086 billion yuan, the special debt is 24.3925 billion yuan, the government bonds are 39.353 billion yuan, and the outstanding government debt in the form of non-government bonds is 165.8 billion yuan. Further, the remaining average life of local government bonds is 9.2 years, including 6.4 years for general bonds and 11.0 years for special bonds; the average interest rate is 3.28%, including 3.27% for general bonds and 3.28% for special bonds. China's local government debt is not highly transparent and highly hidden, quite difficult to monitor, and the causes are relatively complex, which poses a great challenge to the stable development of China's economy.

Since the reform and opening up, China's economy has developed rapidly and created many Chinese miracles, and local governments have played a very important role in this process. On the one hand, we cannot deny the role of local government debt; on the other hand, the expansion of local government debt, especially the quiet expansion of hidden debt, brings great challenges to economic stability. In China, local government debt funds are mainly derived from bank loans, and there are problems such as a single financing channel and serious maturity mismatch, which are easy to produce the risk of debt default. At the same time, as local governments at all levels rely too much on land transfer income in terms of fiscal revenue, in the case of the net income of land transfer gradually decreasing, all local governments are under huge pressure of debt repayment,

and the sustainability of local government debt is gradually prominent <sup>[1]</sup>.

In October 2023, the first Central Financial Work Conference was held in Beijing. The meeting stressed the need to speed up the building of financial power, comprehensively strengthen financial supervision, improve the financial system, optimize financial services, prevent and defuse risks, unswervingly follow the path of financial development with Chinese characteristics, and promote the high-quality development of China's financial sector. At the level of local government debt, the meeting stressed the need to establish a long-term mechanism to prevent and defuse local government debt risks, establish a government debt management mechanism that is compatible with high-quality development, and optimize the debt structure of the central and local governments. It further shows that the mitigation and prevention of local government hidden debt risks is an important direction of China's steady economic growth in the future. To establish an effective local government debt resolution mechanism, the first task is to solve the mystery of the causes of local government debt.

## 2. Literature review

At present, the domestic scholars on local government debt research mainly focuses on the scale of local government debt calculation, the connotation and characteristics of local government debt risk, the main reason for the expansion of local government debt, the economic effect and social effect of local government debt, local government debt risk warning prevention, etc. In terms of the formation mechanism of local government debt, some scholars believe that it is mainly caused by the following main reasons:

### (1) Budget soft constraints

Yang *et al.* pointed out that under China's political system, local governments have strong optimistic expectations about the central government and believe that the central government will not "die." However, due to resources and capacity restrictions, the central government often acquiesces in local governments to borrow for the reason of developing public services <sup>[2]</sup>. Li *et al.* pointed out that China's fiscal system showed significant vertical fiscal imbalance, aggravating the imbalance through the political stability needs of the central government and the unlimited responsibility governance model under the administrative decentralization system, thus enhancing the confidence of local governments in borrowing <sup>[3]</sup>.

### (2) Fiscal and tax systems

The financial decentralization system is an important factor leading to local government debt financing. Yang *et al.* believed that China's imperfect fiscal system and fiscal decentralization system are important factors leading to the risk of local government debt <sup>[4]</sup>. Tian *et al.* pointed out that since the beginning of economic transformation and development, the imperfect financial system has gradually become prominent, and local governments can only focus on local financing platforms to make up for the huge financial gap <sup>[5]</sup>. Some scholars have confirmed the impact of financial decentralization on local government debt risk based on empirical analysis. According to Chen *et al.*, the existing research indicates that financial decentralization will expand the scale of urban investment bonds of local government financing platforms. The empirical analysis results show that the main driving force for the doubling of the scale of urban investment bonds is the financial decentralization system <sup>[6]</sup>. Pang *et al.* used the two main indicators of the number of financing platforms and the estimated value of prefecture-level city debt to measure the level of local debt, taking this as the explained variable, and constructed a multiple regression model. The results showed that the formation of local government

debt lies in the financial gap caused by the current financial system <sup>[7]</sup>.

### (3) Promotion championship

Promotion incentives will strengthen the motivation of local government debt financing and induce debt risks. Chen *et al.* pointed out that China's fiscal decentralization system and promotion incentive mechanism will increase the impulse of local governments to borrow money and increase the debt burden of local governments <sup>[8,9]</sup>. Some scholars have confirmed the influence of promotion motivation on the scale of local government debt and debt risk based on empirical analysis. Zhang *et al.* added the variable of characteristics of provincial officials to the empirical model, and the results showed that under the strong role of the financial decentralization system, political promotion and economic growth incentives will accelerate this impact and further expand the scale of local debt <sup>[10]</sup>. Zheng, through empirical analysis, found that although local governments still have certain debt space, in recent years, local debt, persistent downward trend and differentiation trend, and the official appraisal system reform is conducive to curb officials borrowing impulse from source and ease the downward trend <sup>[11,12]</sup>.

### (4) Other factors

In addition to the three main factors mentioned above, many scholars have suggested that there are other incentives for local government debt. Miao *et al.* pointed out that the real reason for the risk of local government debt is that the local government is not a real "responsible government," due to China's unique political system, China's local government presents a time and space separation between debt right and debt repayment responsibility. In other words, local governments can borrow by themselves, but they do not have the responsibility to repay the debt when it is due. This separation worsens the risk of local government debt <sup>[13]</sup>. Yang pointed out that the excessive intervention of the government in the economy may increase the distortion degree of the economy, allocating funds flow to more government-led economic activities. If the government-led economic activities have no return or low return, the corresponding debt may form the hidden debt of local governments <sup>[14]</sup>.

## 3. The system logic of the generation of local government debt risk

### 3.1. The relationship between the central government and the local governments

In China, finance is the foundation of national governance and important pillar, so all previous involving fiscal decentralization or fiscal relations between the government system reform is destined to be the process of the central and local government participation and consultation, the typical approach is the central rules or tacit local first exploration, place under the guidance of the central to explore suitable for local specific practices <sup>[15]</sup>. This kind of fiscal decentralization with Chinese characteristics on the one hand is conducive to overall planning, "concentrate resources to do big things," but on the other hand from the reality, the central and local there are various aspects of information asymmetry, blurred legal boundary, in economic growth of this abstract and broad goals prone to vicious competition, fraud conceal, local government debt is also affected by expanding scale, the term structure mismatch, not sustainability, and many other problems..

### 3.2. Competition between governments

As early as in the planned economy period, there was competition and games between local governments in China. After the reform and opening up, the power of local government has been expanded, and "territorial management" and "local competition" constitute the basic mode of intergovernmental competition. Chen *et al.* pointed out that although the regional government competition brought by economic incentive and promotion incentive has a driving role in economic development, it also brings the side effects of "independent

governance,” which restricts the free flow of resources, distorts the allocation of resources, causes market segmentation and hinders the construction of a unified national market<sup>[16]</sup>. Understanding the field of regional government competition is the first step to standardizing the regional government competition behavior and promoting the construction of a unified national market. That is to say, in the process of regional government competition, the “officialdom + market” system around “economic construction as the center” has a far-reaching and complex impact on the scale expansion and risk accumulation of local government debt.

### **3.3. The relationship between the government and the market**

Since China’s economic development has entered the new normal, the good combination of the government and the effective market has become more and more important. In meso economics, some scholars have put forward new resource fields: Quasi-operational resources. Quasi-profit resources is given priority to with the regional urban resources, it is mainly used to ensure the normal national or regional social and economic activities, the public service system, and provide public services for social production, residents life of hardware and software infrastructure, education, science and technology, culture, health, sports city utilities facilities and public life service facilities. The dual attribute that quasi-operational resources can be allocated by both the government and the market determines that the key to the long-term benign interaction between the competent government and the effective market is to clarify the boundary between the two, that is, the mastery of local government in the allocation of operational resources. One of the risk accumulation of local government debt is the local government debt on operational resources allocation appeared a certain degree of distortion, such as part of the elements of a strong correlation with the market is firmly control in the hands of local government, but the local government is not following the principle of market allocation in the market rationing, caused the loss of the efficiency of the market, local debt unsustainable. Therefore, finding out the optimal boundary between the government and the market is also a key step in controlling the local government debt.

## **4. Conclusion**

According to the existing studies, in the study of local government debt risks, there is no lack of suggestions and criticisms on the existing fiscal and tax system and official assessment mechanism that should be reformed. We cannot deny that the current system indeed has many deficiencies due to its historical limitations, and it fails to keep up with the pace of social and economic development in time. But nothing can be achieved overnight. Just as China’s progress is always on the way, the reform and development of the economic system is also a protracted battle. There is still a long way to go from discovering problems and understanding distortion to solving problems and correcting distortion. The use of funds and the structure of debt are the main directions of efforts to control the increment and curb the stock in the future. The key point is that local governments will continue to adapt to their changing roles as the economy develops. Ideally, a promising government can follow economic development and adjust policies and development goals in real time and dynamically based on the usage of operational resources to serve the city.

The effective operation of the field to create a basic framework, two-way incentive development. In other words, the local government to find their positioning, to adapt to their role from “developmental government” to “service government,” improve the allocation of operational resources, combine with the market, realize the sustainable development of local government debt, maintain macroeconomic stability, to achieve the great rejuvenation of the Chinese nation in the struggle.



## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Shen K, Shi Y, 2023, Hidden Debt Risk of Local Governments: Dynamic Evolution, Governance Difficulties and Governance Path. *Economist*, (12): 56–65.
- [2] Yang S, Li S, 2013, Decision on Local Government Debt: An Institutional Interpretation Framework. *Economic System Reform*, (02): 15–19.
- [3] Li Y, Zhang F, 2019, The Formation Mechanism and Incentive Effect of Vertical Financial Imbalance. *Manage the World*, 35(07): 43–59. <https://doi.org/10.19744/j.cnki.11-1235/f.2019.0091>
- [4] Yang X, 2014, Financial System Change, Behavior Anomie and Local Government Debt Governance. *Economic Research Reference*, (53): 17–20.
- [5] Tian X, Xia S, 2017, Study on the Impact of Local Government Debt Risk — based on the Perspective of Land Finance and Real Estate Prices. *Journal of Shanxi University of Finance and Economics*, 39(06): 26–38. <https://doi.org/10.13781/j.cnki.1007-9556.2017.06.003>
- [6] Chen J, Li J, 2015, Financial Decentralization, Promotion Incentive and Local Government Debt Financing Behavior — Provincial Panel Empirical Evidence based on the Perspective of Urban Investment Debt. *Accounting Research*, (01): 61–67 + 97.
- [7] Pang B, Chen S, 2015, Causes, Scale and Risks of Local Government Debt under the Central and Local Financial Pattern. *Comparison of Economic and Social Systems*, (05): 45–57.
- [8] Liu H, Chen Z, 2016, A Study on the Causes of Local Government Debt in the Process of Urbanization in China. *Statistics and Decision-making*, (19): 114–118.
- [9] Chen Z, Chen S, 2014, Institutional Environment, Local Government Investment Impulse and Soft Constraints of Fiscal Budget. *Economic Research*, 49(03): 76–87.
- [10] Zhang Z, Bai Y, 2017, Financial Decentralization, the Characteristics of Provincial Officials and the Scale of Local Government Debt — Empirical Analysis Based on Provincial Government Data from 2010 to 2014. *Scientific Decision-making*, (05): 19–39.
- [11] Zheng J, Li J, 2023, Measurement and Analysis of the Sustainability of Local Government Debt in China. *Fiscal Science*, (05): 112–121. <https://doi.org/10.19477/j.cnki.10-1368/f.2023.05.011>
- [12] Ghosh A, Kim J, Mendoza E, et al., 2013, Fiscal Fatigue, Fiscal Space and Debt Sustainability in Advanced Economies. *The Economic Journal*, 123(566): 4–30.
- [13] Miao X, Fu R, 2013, Connotation and Generation of Local Government Debt Risk: A Literature Review and Thinking on the Spatial and Temporal Separation of Rights and Responsibilities. *Economist*, 2013 (08): 90–101.
- [14] Yang Z, 2023, Local Government Debt Risk: Situation, Causes and Response. *People's Forum*, (09): 68–73.
- [15] Xu L, Hou L, Cheng G, 2022, Financial Decentralization, Promotion Incentives and Local Government Debt Risk. *Statistics and Decision-making*, 38(12): 141–145.
- [16] Chen Y, Li Y, 2023, The Competitive Attribute of “Competent Government” — is based on the Perspective of Meso Economic Resource Generation. *Economist*, (04): 14–22.

### Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# Data Elements Accumulation Enabling the “Three-izations” Upgrading of Manufacturing: Theoretical Mechanism

Hao Xie\*

School of Statistics and Data Science, Lanzhou University of Finance and Economics, Lanzhou 730020, Gansu, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** The data production elements are driving profound transformations in the real economy across production objects, methods, and tools, generating significant economic effects such as industrial structure upgrading. This paper aims to reveal the impact mechanism of the data elements on the “three transformations” (high-end, intelligent, and green) in the manufacturing sector, theoretically elucidating the intrinsic mechanisms by which the data elements influence these transformations. The study finds that the data elements significantly enhance the high-end, intelligent, and green levels of China’s manufacturing industry. In terms of the pathways of impact, the data elements primarily influence the development of high-tech industries and overall green technological innovation, thereby affecting the high-end, intelligent, and green transformation of the industry.

**Keywords:** Data elements; Manufacturing; High-end; Intelligent; Green

**Online publication:** April 28, 2025

## 1. Introduction

With the rapid development of the digital economy and its growing significance in the overall economic framework, data has increasingly been recognized and valued as a production element. In April 2020, the Central Committee of the Communist Party of China and the State Council issued the Opinions on Building a More Perfect Market-Oriented Allocation System for Production Elements, formally designating data as the fifth production element, following land, labor, capital, and technology. As the most advanced and dynamic new production elements, data is driving profound transformations in the objects, methods, and tools of production in the real economy. Data’s role as a production element not only accelerates the development of the digital economy and the formation of digital industry clusters but also generates significant economic effects, such as industrial upgrading and optimized resource allocation. In 2021, the General Secretary emphasized during the 34th collective study session of the Political Bureau of the CPC Central Committee that “data as a new production element has a profound impact on transforming traditional production methods.” On January

4, 2024, the National Data Administration, alongside 16 other departments, issued the Three-Year Action Plan for “data×” (2024–2026), highlighting the multiplier effect of data in empowering economic and social development. Exploring the economic effects of data as a production element, its inherent empowerment, and multiplier effects is crucial for promoting high-quality economic development and advancing Chinese modernization.

As China’s economy shifts toward high-quality development, the upgrading, intelligence, and green transformation of manufacturing have become key priorities. During the Second Session of the 14th National People’s Congress in March 2024, the General Secretary emphasized that regions should “adopt practical, step-by-step, and tailored approaches based on local resource endowments, industrial foundations, and scientific conditions to selectively promote new industries, models, and growth drivers, while using new technologies to upgrade traditional industries and actively advance industrial upgrading, intelligence, and green transformation (referred to as the ‘Three Transformations’).” Indeed, data, as a new production element is not only driving production transformation but also serving as a key force in promoting the “Three Transformations” in manufacturing. Building on this, how to fully leverage data’s role in transforming traditional production methods and how to achieve “data × Industrial Manufacturing” (as proposed in the Three-Year Action Plan to innovate R&D models and support enterprises in integrating design, simulation, and experimental data to foster data-driven product development) are critical focuses for future policy formulation. This paper addresses two key questions: Does data as a production element influence the “Three Transformations” in manufacturing and serve as a driver for industrial upgrading and high-quality economic development? What are the underlying mechanisms? By answering these questions, this study aims to identify the driving forces for industrial upgrading and high-quality economic development based on data in the new era, offering insights for policymaking.

In recent years, scholars have extensively focused on the field of data as a production element. Current literature primarily addresses three key issues:

- (1) Concept and characteristics of data as a production element: Compared to traditional elements such as land, capital, and labor, data is a virtual resource dependent on information technology, leading to unique definitions and characteristics. Jones defined data as “the part of ‘information’ that is neither ‘knowledge’ nor ‘creativity’” and emphasized its virtual nature as a core feature <sup>[1]</sup>. Additionally, researchers such as Veldkamp and Chung, Schaefer and Sapi, Xu *et al.* identified non-rivalry, non-excludability <sup>[2–4]</sup>, increasing returns to scale, positive externalities, ambiguous property rights, and derivativeness as key technical-economic characteristics.
- (2) Operational mechanisms of data as a production element: Research has explored data’s mechanisms from micro, meso, and macro perspectives. Micro-level studies focus on the synergy between data and traditional elements like capital and labor, as well as mechanisms for improving operational efficiency. Meso-level studies emphasize data’s role in promoting industrial integration, linkages, and innovation as a driver of high-quality economic development from Cai *et al.* <sup>[5]</sup>. Macro-level research examines how data amplifies scale effects, innovation, and resource optimization to improve supply-demand matching and refine market and government behaviors.
- (3) Data’s contribution to economic growth: Existing studies analyze data’s growth impact through its unique characteristics. First, data’s virtual nature and reliance on information and communication technology (ICT) products make ICT integration a key growth pathway <sup>[6]</sup>. Second, data’s non-rivalry, non-excludability, and low-cost replication amplify operational efficiency at the macro level, driving economic growth. Third, data’s cross-boundary integration with financial resources alleviates liquidity

constraints for households and firms, stimulating growth through consumption and production. Furthermore, the self-reinforcing synergy between supply and demand sides generates increasing returns to scale and multiplier effects for growth.

Studies on growth pathways primarily explore the relationship between data and traditional elements. Some scholars have constructed theoretical models to analyze the intrinsic mechanisms of data's contribution to growth, often grounded in endogenous growth theory, emphasizing data's role in knowledge production <sup>[7]</sup>.

In addition, some scholars have conducted research on the challenges faced by the value activation of data production elements, including the participation of data production elements in distribution, the establishment of data production elements market mechanisms, and data property rights.

The issue of industrial "three transformations" has also received widespread attention. First, the driving elements of industrial high-endization. Research has found that consumption upgrading, enterprise technological innovation and management, human capital accumulation, tax incentives, and technology finance all promote industrial high-endization. Second, the internal mechanisms and economic effects of industrial intelligent transformation. In terms of internal mechanisms, research has found that industrial intelligence achieves industrial value creation and industrial structure upgrading by influencing production materials, productivity, and production methods. Big data resources, industrial internet of things, and intelligent robots are new elements for the intelligent transformation and upgrading of traditional industries. In terms of economic effects, research has found that industrial intelligent transformation can affect energy efficiency, regional industrial structure advancement, industrial green development efficiency, and industrial structure upgrading. Third, the measurement of industrial greening and the elements influencing green development. In terms of measurement, scholars have used comprehensive weighted decision analysis models, the entropy method to construct indicator systems, R clustering, and the coefficient of variation to measure the level of greening. In terms of elements influencing industrial green development, research has found that digitization, economic agglomeration, technological progress, and openness to the outside world have an impact on industrial greening <sup>[8-11]</sup>.

The enabling role and multiplier effect of data have sparked extensive scholarly discussion, providing strong theoretical support for this study. However, gaps remain, such as limited exploration of the relationship between data and manufacturing industry transformation at the industrial level, with unclear intrinsic mechanisms. This study aims to address these gaps by clarifying the internal mechanisms through which data drives the "three transformations" (high-end, intelligent, and green) of the manufacturing industry. Its potential marginal contribution lies in elucidating these mechanisms, enriching theoretical research on data as a production element, and laying a foundation for future studies.

## 2. Theoretical analysis

High-end, intelligent, and green development is crucial for transforming China's manufacturing industry, which, despite its comprehensive system, faces challenges in high-precision and cutting-edge areas. High-end development is key to overcoming these shortcomings, intelligent development enhances efficiency and profitability, and green development shifts the industry away from extensive growth models. These transformations are vital for industrial upgrading, technological advancement, and high-quality development.

High-tech industries, representing industrial high-end development, are innovation-driven and significantly impact manufacturing transformation. Data, as the "new oil" of the digital economy, plays a pivotal role in empowering high-tech industries and driving high-end manufacturing.

- (1) Data as a high-end production element: Embedded in manufacturing processes, data reduces resource matching and information retrieval costs, lowering marginal costs and increasing marginal benefits.



This drives high-tech industries while upgrading traditional sectors.

- (2) Linking production elements: Data acts as a “bridge,” reconfiguring resource allocation and leveraging agglomeration effects, enhancing resource flexibility and maximizing efficiency, thus supporting high-tech industries.
- (3) Knowledge and technology diffusion: Data facilitates the spread of new knowledge and technologies, accelerating innovation, shortening R&D cycles, and transforming labor-intensive industries into knowledge- and technology-intensive ones.
- (4) Intelligent production and talent development: Data enables intelligent production, replacing repetitive tasks and pushing high-tech enterprises to cultivate top-tier talent, improving productivity. It also enhances communication and collaboration, reducing costs and fostering innovation.

In summary, data drives high-tech industry development by enhancing technological innovation, optimizing resource allocation, and promoting intelligent production, providing a foundation for high-end manufacturing transformation.

In recent years, China has continuously promoted the development of industrial intelligence through top-level design. The “New Generation Artificial Intelligence Development Plan” issued by the State Council in 2017 explicitly proposed the goal of “accelerating the intelligent upgrading of industries.” The “14th Five-Year Plan for Intelligent Manufacturing Development” jointly released by the Ministry of Industry and Information Technology and seven other departments in 2021 pointed out: “In the next 15 years, through a ‘two-step’ approach, we will accelerate the transformation of production methods: First, by 2025, the majority of large-scale manufacturing enterprises will achieve digitalization and networking, with key industry leaders initially applying intelligence; Second, by 2035, large-scale manufacturing enterprises will fully popularize digitalization and networking, with key industry leaders achieving intelligence.” The “Guiding Opinions on Accelerating Scenario Innovation to Promote High-Quality Economic Development through High-Level Application of Artificial Intelligence” issued by the Ministry of Science and Technology and five other departments in 2022 supports universities, research institutes, and new research and development institutions in “exploring application scenarios of artificial intelligence technology for major scientific research and technological development. Encourage active engagement with the technological needs of cities and industries in the transformation of achievements, carry out industry-university-research cooperation in scenario innovation, enhance the market orientation of scientific research, and activate the innovation potential of researchers. Encourage researchers to participate in scenario entrepreneurship, tap into the creative potential of artificial intelligence research achievements, and accelerate the industrial application of artificial intelligence technologies.” To achieve these goals, exploring how data affects the internal mechanisms of industrial intelligence is indispensable. As a new type of production element, data is the foundation of digitalization, networking, and intelligence. Digital technologies such as artificial intelligence, big data, and cloud computing not only enhance the intelligence, informatization, and technological level of traditional industries but also effectively promote the transformation of traditional industrial dynamics and collaborative innovation, nurturing new business models and cultivating new engines for economic growth, thereby driving the transformation and upgrading of traditional industries. The application of data encourages enterprises to increase investment in new technologies and tools, such as artificial intelligence, the Internet of Things, and big data analytics. These technologies can further drive improvements in production efficiency and product quality, promoting the development of industrial intelligence. Research has found that the main drivers of industrial intelligence are technology, human capital, and cost pressures. Further research has found that the main elements driving industrial intelligence are technological innovation, industrial structure upgrading, and openness to the outside



world, with contribution rates of 48.83%, 24.87%, and 19.02%, respectively, cumulatively accounting for 92.72%<sup>[12]</sup>. In summary, the development of data can drive technological innovation, which in turn can promote industrial intelligence.

“Green development is the foundation of high-quality development, and new quality productivity itself is green productivity<sup>[13]</sup>. It is essential to accelerate the green transformation of development methods to support the goals of carbon peak and carbon neutrality.” In the context of the new era, it is crucial to explore how data influences the green upgrading of industries. The high technological content and low environmental cost characteristics of data inherently make their introduction more conducive to harmonizing production and environmental coordination, reducing energy and material consumption, and minimizing environmental impact<sup>[14]</sup>. Compared to other production inputs, digital technologies driven by data not only improve resource allocation efficiency but also contribute to environmental improvement<sup>[15]</sup>. Therefore, the introduction of data inherently supports the green development of the manufacturing industry.

The core driver of green development is green innovation. Green innovation aims at energy conservation, pollution prevention, and waste recycling, encompassing innovations in product design, processes, management support, and implementation. It not only enhances enterprise value but also achieves specific environmental goals and sustainable development. Compared to traditional innovation, green innovation requires simultaneous consideration of economic benefits and environmental quality, making it more challenging, with higher risks and uncertainties. This necessitates stronger financial guarantees and more directional innovation efforts for green innovation. Data contributes to strengthening the financial security for green innovation, reducing the costs associated with green innovation, and improving the quality of green innovation, thereby promoting the development of green innovation.

Financial security and cost efficiency of data in green innovation: Data exhibits increasing returns to scale—larger and more diverse datasets generate greater information and knowledge, exponentially increasing their value and providing robust financial support for green innovation. Data also reduces costs by enabling low-cost collaboration platforms, overcoming barriers of time, geography, and economics, and lowering search and identification costs for knowledge resources. By integrating data into production and sales, entities gain accurate, timely information, reducing costs related to sales, idle capacity, and inventory, while expanding financial flexibility for green innovation. Additionally, data guides the flow of other elements, fostering economies of scale through spatial agglomeration, lowering green innovation costs, and enhancing green technological innovation. Impact of data on green innovation quality: Data enables the use of the internet and big data to analyze user habits and preferences, improving market demand identification. This shifts green innovation from experience-based to data-driven, enhancing R&D relevance and decision accuracy. Integrating data with AI and deep learning boosts experimental prediction accuracy, screening efficiency, and innovation quality. Data also guides the flow of other innovative elements, improving inter-city and inter-industry matching efficiency and reducing resource misallocation. The synergy between data and other elements enhances green economic efficiency, further improving green innovation quality.

### 3. Conclusions and implications

The high-end, intelligent, and green transformation of China’s manufacturing industry is vital for high-quality economic development and modern industrial system construction. Data, as a new production element, drives these transformations by promoting high-tech industries, innovation, and green technology. Key conclusions and policy implications include:

(1) Enhancing data element system: Data is crucial but underdeveloped compared to traditional elements. The establishment of the National Data Bureau and local data bureaus, along with the “East Data West Computing” project, is forming a new data market. Establishing data circulation standards will optimize data property rights, pricing, and usage, unlocking its value as a resource, asset, and capital. However, data flow may initially reduce consumption and economic growth but will ultimately drive technological progress and industrial upgrading, as seen in BYD’s new energy vehicle advancements.

(2) Exploring industrial upgrading effects: Regions should leverage their strengths to boost data capabilities. Central and western China can utilize energy and cost advantages to establish data centers, promoting big data innovation and computing efficiency. Prioritizing investments in data infrastructure and talent development, supported by fiscal and tax policies for green industry data research. This will drive data technology breakthroughs, facilitate green industry transformation, and cultivate competitive data service enterprises and products.

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Jones CI, Tonetti C, 2020, Nonrivalry and the Economics of Data. *American Economic Review*, 110(9): 2819–2858.
- [2] Veldkamp L, Chung C, 2019, Data and the Aggregate Economy. *Journal of Economic Literature*, 62(2): 458–484.
- [3] Schaefer M, Sapi G, 2020, Learning from Data and Network Effects: The Example of Internet Search. SSRN Working Paper, 1894.
- [4] Xu X, Li K, Tian X, 2021, Research Progress on Data as Production Elements. *Economic Perspectives*, (04): 142–158.
- [5] Cai Y, Ma W, 2021, The Impact of Data Elements on High-Quality Development and Constraints on Data Flow. *Quantitative & Technical Economics Research*, 38(03): 64–83.
- [6] Jorgenson DW, Vu KM, 2016, The ICT Revolution, World Economic Growth, and Policy Issues. *Telecommunications Policy*, 40(5): 383–397.
- [7] Farboodi M, Veldkamp L, 2020, A Growth Model of the Data Economy. NBER Working Papers, 28427.
- [8] Xiong X, Zhang T, Duan Y, et al., 2019, Measurement and Differences in Green Development Levels of Urban Agglomerations in the Middle Reaches of the Yangtze River. *Economic Geography*, 39(12): 96–102.
- [9] Zhang X, Wei F, Yuan X, 2020, Evaluation and Evolution of High-Quality Green Development Levels in Chinese Provinces. *Economic Geography*, 40(02): 108–116.
- [10] Gao Y, 2019, Research on Green Development Performance and Influencing Factors in China’s Eight Comprehensive Economic Zones. *Quantitative & Technical Economics Research*, 36(09): 3–23.
- [11] Xu X, Fan H, Su Y, et al., 2021, Research on the Level of Green Economic Development in China and Its Influencing Factors. *Quantitative & Technical Economics Research*, 38(07): 65–82.
- [12] Luo L, Zhang Z, 2024, The Spatial Correlation Network of Industrial Intelligence in Chinese Cities and Its Driving Mechanisms. *Journal of Finance and Economics*, 50(01): 109–123.
- [13] Zhou Q, 2023, Research on the Impact and Mechanism of the Digital Economy on the Green Development of Manufacturing. *Nanjing Social Sciences*, (11): 67–78.
- [14] Bao J, Miao Y, Chen F, 2008, Low-Carbon Economy: A New Transformation in Human Economic Development. *China Industrial Economics*, (04): 153–160.

- [15] Arik L, 2009, Technology, International Trade, and Pollution from U.S. Manufacturing. *American Economic Review*, 99(5): 2177–2192.

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# The Strategy and Influence Analysis of China's Financial Opening to the Outside World to Achieve Balance of Entry and Exit

Yixuan Chen\*

The University of Sydney, Sydney 2050, New South Wales, Australia

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** With the continuous growth of China's economy, financial opening to the outside world has become one of the important means to promote economic development. However, with the continuous acceleration of capital flow, the problem of balance in and out is becoming increasingly prominent. Taking China's financial opening to the outside world as the research object, this paper discusses how China strategically achieves the balance of entry and exit in the field of financial opening to the outside world, and the impact of this balance. Through the quantitative analysis of China's financial opening to the outside world and foreign capital flows, it is found that China needs to strengthen the management of capital items and optimize the structure of capital flows in the process of financial opening to the outside world, to achieve the balance of financial flows in and out. As for the impact of the balance of access and access, the analysis of the impact mechanism shows that the financial opening and access and balance can improve the stability of the financial market, provide sufficient liquidity for the healthy development of the financial market, and alleviate financial risks. Such a strategy is of great practical significance for promoting the sustained and healthy development of China's economy. Therefore, based on the actual situation of China, this paper puts forward some relevant strategy suggestions to guide the practical operation of China's financial opening up.

**Keywords:** Financial opening up; Balance in and out; Capital flows; Financial market stability; Strategy suggestion

**Online publication:** April 28, 2025

## 1. Introduction

Under the influence of globalization, the pace of China's financial opening has been accelerated, and economic exchanges and cooperation have been promoted, resulting in financial risks. Financial opening has helped China modernize its economy, and structural adjustment has become important<sup>[1,2]</sup>. This paper analyzes how financial opening achieves the balance of capital flow in and out, involves specific strategies and impacts, reviews the history of China's financial opening, and studies the relationship between financial opening and capital flow balance. The digital evaluation method is used to evaluate the degree of financial openness and foreign capital flow, identify the places where problems occur, determine the causes of specific defects, and then propose

optimization strategies, including strengthening the management mode of capital items, optimizing the design of capital flow structure, and finally achieving financial flow balance and ensuring stable operation. The research aims to provide policy recommendations for China's financial opening-up and help the economy achieve sustainable and healthy development <sup>[3-5]</sup>.

## **2. China's financial opening to the outside world**

### **2.1. Relationship between China's economic development and financial opening**

China's economic development is closely related to financial opening-up. The promotion of reform and opening-up policies, the improvement of economic strength, and the opening up of the financial sector have provided important support for economic growth. Financial opening up to attract foreign investment, improve resource allocation and enhance market competitiveness, and promote domestic economic structure optimization and industrial upgrading, specific measures. The opening up of the financial sector has led to the flow of funds in the global market and increased the influence of the international financial market <sup>[6]</sup>. The opening of the capital market plays a key role in enhancing the internationalization capability of financial institutions, and the depth and breadth of the financial market have been improved. Financial opening brings about challenges such as stable capital flow and potential financial risks. In the context of rapid economic development, it is important to solve the relationship between economic development and financial opening-up, ensure stable security in the financial sector, and promote sustainable economic growth. This relationship, which tests policymakers' ability to strike a balance between openness and risk control, is the key to China's high-quality development <sup>[7-9]</sup>.

### **2.2. Quantitative analysis of China's financial opening to the outside world**

The degree of China's financial opening to the outside world needs quantitative analysis, which includes several measurement indicators, including the inflow of foreign direct investment, the degree of financial market openness, and the degree of capital account liberalization. Indicators reflect the breadth and depth of financial openness. With the help of a series of policy measures, China has relaxed restrictions on market access, formulated specific implementation rules, and clarified operational procedures to promote the inflow of foreign capital, achieve two-way opening of the capital market, and facilitate the financing needs of enterprises <sup>[10]</sup>. The capital account has been liberalized, financial markets have become more open, and foreign capital inflows have increased. The state strengthens the control of financial risks, ensures market stability during the opening process, and maintains the order of economic operation by improving the financial regulatory framework. Quantitative analysis helps identify the role of financial opening in promoting economic development, and provides a scientific basis for policy making.

### **2.3. Patterns and trends of foreign financial capital flows**

The state and trend of financial capital flow in our country show a diversified development trend in the process of financial opening to the outside world. With the deepening of economic globalization and financial internationalization, the forms of foreign capital flow have expanded from traditional direct investment to securities investment, cross-border financing, financial derivatives transactions, and other forms <sup>[11]</sup>. This diversified capital flow has promoted the maturity of the domestic financial market and increased China's influence in the global financial market. The speed and scale of cross-border capital flow continue to increase, and the dynamic change of capital inflow and outflow has become an important indicator to measure the degree of China's financial opening-up. Against the background of a complex and changeable global financial environment, it is of great significance to study the state and trend of foreign financial capital flow for



formulating a scientific financial opening strategy <sup>[12]</sup>.

### **3. Balance between entry and exit of China's financial opening-up**

#### **3.1. Conceptual and theoretical analysis of access balance**

The balance in and out of financial opening to the outside world means that in the international capital flow, the quantity and structure of incoming and outgoing funds maintain a dynamic balance to prevent a large influx or outflow of capital from adversely affecting the economy. Balance of payments depends on specific measures to strictly control capital flows and achieve an important core of overall economic stability <sup>[13]</sup>. The opening of the capital account is accompanied by significant fluctuations in capital flows, and it is necessary to establish an efficient and perfect adjustment system to prevent strong fluctuations and hidden risks in the financial market. According to the basic principles of an open economy, the degree of openness of the national capital account has been significantly improved, and the temporary flow of capital may cause the economic operation to become unstable. The analysis of the principle of balance of revenue and expenditure highlights that the reasonable structure of capital flow is conducive to guiding the efficient and proper allocation of domestic and foreign capital, ensuring the reasonable allocation of financial resources, and ensuring the smooth operation of the market. Achieving the balance of payments is conducive to maintaining the stability of the financial market, promoting the long-term steady development of the economy, and controlling risks to achieve the dual clear goals. The design of opening-up measures requires a comprehensive assessment of the diversity of international capital flows and market compatibility, and a long-term plan for solid economic growth and sustainable development.

#### **3.2. Current situation and problems of the balance of entry and exit of China's financial opening-up**

The current situation of China's financial opening and entering balance reflects the complicated and diversified characteristics of capital flow. After the intensification of opening-up, the frequency and scale of capital flow increased rapidly. During the opening-up period, the imbalance of funds in and out emerged, and the pressure of capital outflow increased more. The unbalanced situation makes the financial market face a great risk of ups and downs, and directly interferes with the stability of the economy <sup>[14]</sup>. At present, the capital market structure is not fully suitable for the open environment, and the capital flow supervision mechanism still needs to be perfected. The goal of balance in and out needs to be carefully improved through the formulation of capital flow structure policies and other aspects to effectively deal with the challenges and difficulties brought by financial opening.

#### **3.3. Correlation between the balance of imports and exports and the structure of capital flow**

Balance in and out is closely related to the structure of capital flows. In the process of financial opening to the outside world, the structure of capital flow determines whether the balance of financial flow in and out can be achieved. The structure of capital flow is unbalanced, and the amount of capital inflow and outflow is increasing, resulting in exchange rate fluctuations, asset price bubbles, and the weakness of the financial system. We want to ensure the smooth operation of the financial market, improve the structure of capital flow, and arrange the proportion of direct investment, portfolio investment, and other investment. We will properly manage capital matters, make capital flows more open and efficient, promote the smooth operation of the financial sector in opening up to the outside world, and maintain a balanced flow of capital into and out of the financial sector.

## **4. Strategies to achieve balance of financial opening and entering**

### **4.1. Strengthening the management under the capital account**

In the process of realizing the balance of financial opening to the outside world, strengthening the management under the capital account is one of the key strategies <sup>[3]</sup>. Management under the capital account mainly involves the supervision of the capital account and the effective control of capital flows <sup>[4]</sup>. By establishing and improving the foreign exchange management system, improving the information transparency, and forming the early warning mechanism of capital flow, we can effectively avoid the impact of large-scale disorderly capital inflow and outflow on the economy. It is necessary to strengthen the monitoring of short-term capital flows, paying particular attention to abnormal cross-border capital flows, to timely adjust the policy orientation and avoid financial market volatility. Policy formulation should take into account both flexibility and stability, international practice and domestic reality, strengthen the enforcement of laws and regulations, and provide a reliable institutional guarantee for capital flows. Rational allocation of foreign exchange reserves and enhancement of the country's ability to regulate and control the international financial market are also important aspects of management. Through these measures, we can effectively prevent potential financial risks in promoting the facilitation of capital flow, enhance the anti-risk ability of the national economy, and lay a solid foundation for the steady advancement of financial opening-up.

### **4.2. Optimizing the capital flow structure**

Optimizing the structure of capital flow to achieve the balance of financial opening to the outside world is a key means. Adjusting the proportion and direction of various types of capital flows can improve the efficiency of capital investment and make economic performance better. Short-term capital flows must be regulated to prevent market volatility from causing inflows and outflows and affecting the stability of financial markets. Promoting the introduction of long-term capital and investment will help strengthen the support force of the real economy, optimize the domestic industrial structure, and improve the level of industrial optimization and enhancement. Accelerate the cross-border flow of equity capital, attract innovative capital to the local market, promote the enhancement of financial services, and accelerate the process of innovation and development. Effective policy tools and regulatory measures must be implemented simultaneously, and capital flows need to be guided and regulated to ensure that the methods for optimizing the capital structure are put in place to ensure that the national economy remains in a sound state of development.

### **4.3. Establishing an effective entry and exit balance mechanism**

Establishing an effective balance mechanism is an important strategy to realize financial opening to the outside world. The design of the mechanism should include a sound system for monitoring capital inflows and outflows, to grasp the situation of capital flows in real time and adjust relevant policies promptly. Establish a transparent regulatory framework to ensure the safety and legality of capital flows and enhance market confidence. We will strengthen international cooperation and exchanges, learn from successful experiences around the world, and enhance our ability to identify and respond to risks. This mechanism will help maintain the stability of the financial market, promote long-term healthy development, and provide a guarantee for the practice of financial opening to the outside world <sup>[5]</sup>.

## **5. Analysis of the influence of the balance of imports and exports on the financial market and its mechanism**

### **5.1. Influence of balance in and out on financial market stability**

Balance in and out gives financial market stability a role. Financial opening to the outside world pays attention to the balance of entry and exit, especially the balance of capital flow, which has become a key factor affecting the stability of financial markets. A balanced flow of capital in and out of the market can reduce market volatility, improve investor confidence, and keep the market running smoothly. Capital inflows supply all the liquidity needed by the market, and capital outflows prevent the market from overheating and bubble formation. In a state of balanced import and export, the market supply and demand relationship is stable, helping the RMB exchange rate to maintain a reasonable level, and the interest rate can be stable, reducing the impact of sudden adverse market factors on financial stability. Balance in and out can also optimize the efficiency of capital allocation, promote the flow of funds to high-quality projects in the real economy, and improve the efficiency of resource allocation. Maintaining the balance of financial openness and access is crucial to ensuring the stability of the financial market, and is a necessary condition for promoting the healthy and sustainable development of the financial market<sup>[15]</sup>.

### **5.2. Influence of the balance of imports and exports on financial risks**

The balance of financial opening to the outside world has a significant impact on financial risks. Balance in and out helps mitigate the volatility and overall risk of capital flows. When capital flows are too large or unbalanced, markets often experience strong fluctuations, and risks slowly accumulate. Specific adjustment of the amount of capital in and out, so that the market supply and demand of funds are stable, reduces the opportunity for price fluctuations. Reasonable balance in and out can also prevent liquidity risks brought about by cross-border capital flows and ensure that financial institutions can repay the money. The balance mechanism also leaves more room for central banks to implement monetary policies, helping to deal with changes in the international economic environment and fend off external shocks. Achieving balance in and out has become a clear way to maintain market stability, and it is also an important measure to safeguard the domestic financial system in a complex international financial environment.

### **5.3. Promotion of balance in and out to healthy financial development**

The promotion of the balance of entry and exit to the healthy development of finance is mainly reflected in three aspects. Balance in and out has injected sufficient liquidity into the financial market to ensure that the market can still operate normally in the face of fluctuations, and has enhanced the anti-risk ability of the financial system. A reasonable capital flow structure helps to optimize resource allocation and improve the efficiency of the financial market and the utilization rate of capital. In turn, this structural adjustment supports the development of innovative financial products and services, bringing more vitality and competitiveness to financial markets. By maintaining a reasonable balance between entry and exit, the long-term and steady development of the financial market can be achieved, laying the foundation for sustained economic growth.

## **6. Strategic suggestions for balance of financial opening to the outside world**

### **6.1. Strategic suggestions considering the actual situation in China**

Based on considering the actual situation of China, strategic suggestions can be put forward from the following aspects for the balance of entry and exit of financial opening to the outside world. The management framework for capital flows should be optimized, and the review and monitoring of capital accounts should be strengthened

to ensure a balance between capital inflows and outflows. We should pay attention to the internationalization process of RMB and expand the scope of use of RMB through international trade and investment channels, to enhance the international status of RMB. Strengthening the infrastructure construction of the financial market is also key, and improving the level of financial supervision and risk prevention and control capabilities to ensure the stability of the financial market. Promote the gradual opening of the capital account, and gradually relax the access restrictions on foreign financial enterprises, but it must be implemented under the premise of controllable risks. Actively promote the innovation of financial products and services to meet the diversified financial needs of domestic and foreign investors, to further attract foreign investment inflows. Through the implementation of these strategies, risks can be effectively controlled to achieve the balance of financial opening to the outside world and promote the healthy and sustainable development of China's economy.

## **6.2. Practical operation suggestions for financial opening**

In the practice of financial opening, it needs clear strategic goals and feasible steps to achieve the balance of entry and exit. Supervision of the capital account should be strengthened to prevent excessive speculation and prevent disorderly capital flows from posing a threat to market stability. The risk management capacity of financial institutions should be strengthened to ensure their resilience to shocks brought about by international capital flows. Promoting the depth and breadth of the domestic financial market to attract more long-term capital inflows and reduce short-term liquidity pressure. It is necessary to improve the financial infrastructure, enhance the efficiency and transparency of cross-border capital settlement and information transfer, and ensure the safety and controllability of capital flows under open conditions. Strengthen international cooperation, actively participate in global financial governance, and safeguard national financial security and economic interests through bilateral and multilateral mechanisms.

## **6.3. Development direction of China's future financial opening up**

China's future financial opening to the outside world should give priority to the realization of a balance to stabilize the financial market and promote economic growth. It is necessary to pay attention to the specific path of expanding opening areas and maintain appropriate capital flows to prevent excessive market fluctuations. We will improve laws and regulations, set clear standards and thresholds for international capital access, and strengthen market transparency and supervision. It emphasizes the construction of diversified investment channels and guides foreign capital into the real economy to ward off potential financial risks. Promote the process of opening up through technological progress and innovation, deeply integrate with the global financial system, and enhance China's position and influence in the global financial market.

## **7. Conclusion**

In this paper, the balance between entry and exit of China's financial opening to the outside world is discussed from two aspects: Realization strategy and influence. Through quantitative analysis of the degree of financial opening to the outside world and capital flow, we find that in the process of financial opening to the outside world, we need to strengthen the management of capital flow and optimize the structure of capital flow to achieve a balanced management of liquidity. This balance can improve the stability of the financial market, provide sufficient liquidity and reduce financial risks, and has a far-reaching influence on promoting the sustainable and stable development of China's economy. From the research, we also see that although our country has made some achievements in financial opening, it also faces many challenges and difficulties. It is necessary to further develop and improve relevant strategies, strengthen management, and promote sustained



and healthy economic development. This requires continuous trial and error in practical application, and in practice, to repair and improve. For future research, in-depth discussions can be considered at the micro level, focusing on how enterprises maintain the balance of capital liquidity under the open financial environment, and how this will affect the quality and efficiency of enterprises' operations. We can compare and analyze the experience and lessons of China and other countries in the management of capital flow, to help China on the road of financial opening up, steadily advance, do a good job in the management of capital flow, strategically realize the balance of entry and exit, and contribute to the stability of China's financial market and economic development.

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Vuong T, 2025, The Impact of Strategic Management on Organizational Creativity and Its Influence on the Financial Performance of SMEs. *Journal of Entrepreneurship, Management & Innovation*, 21(1): 43–57. <https://doi.org/10.7341/20252113>
- [2] Zhang H, 2024, Secret to Decision: Analysis of the Influencing Factors of the Company's Top Decisions. *SHS Web of Conferences*, 193(1): 1–5. <https://doi.org/10.1051/shsconf/202419301036>
- [3] Chen L, Gao Y, Ma Y, 2025, Does the Chinese Government's System of Rewards and Punishments Encourage Farmers to Use Green Agricultural Technologies? Analysis Based on Three-Party Evolutionary Game. *Polish Journal of Environmental Studies*, 34(2): 1039–1055. <https://doi.org/10.15244/pjoes/187131>
- [4] Kusnanto, Harto AW, Wallitu H, et al, 2024, Analysis of the Influence of Variation in Medical Waste Heating Value on the Electrical Energy Output of Generator in Medical Waste Cogeneration Incinerator System Using Gatecycle Solver, *Journal of Physics: Conference Series*, Volume 2828, 7th International Energy Conference (Astechnova 2023), Yogyakarta, Indonesia.
- [5] Nunes R, Bessa R, Leal C, 2025, The Influence of Operational Management on Financial Performance of Portuguese SMEs. *Springer Proceedings in Business and Economics*. Springer, Cham, 183–198. [https://doi.org/10.1007/978-3-031-73506-6\\_11](https://doi.org/10.1007/978-3-031-73506-6_11)
- [6] Zou W, Li J, Gong X, 2024, A Facile Synthetic Strategy to Simultaneously Achieve Ultra-Wide PL Redshift of Carbon Nanodots and Their High Selectivity and Sensitivity for Mn<sup>2+</sup> Detection. *Materials Today Chemistry*, 37(48): 102001. <https://doi.org/10.1016/j.mtchem.2024.102001>
- [7] Li H, Wu D, Dai Y, et al., 2024, Use of Integrated Multi-Omics Analysis to Determine Antitumor Efficacy of Donafenib in Combination with FADS2 Inhibition in Hepatocellular Carcinoma. *Journal of Clinical Oncology*, 42(16\_suppl): e15083. [https://doi.org/10.1200/JCO.2024.42.16\\_suppl.e15083](https://doi.org/10.1200/JCO.2024.42.16_suppl.e15083)
- [8] Liu C, Song W, Gao C, et al., 2024, Air-to-air Missile Post-Stall Flip Backward Launch Method. *Acta Aeronautica et Astronautica Sinica*, 45(20): 129880. <https://doi.org/10.7527/S1000-6893.2024.29880>
- [9] Rosa G, Sustainable Development of Passenger Transport in Poland in the Context of Young Passengers' Preference Survey. *Public Transport*, 16: 241–268.
- [10] Tapia-O, Solsona JA, Jorge SG, et al., 2025, A Complex-Valued Feedback Linearization-Based Controller for a Voltage Source Inverter Tied to the Grid via a Second-Order Filter. *Cornell University*. arXiv. <https://doi.org/10.48550/arXiv.2502.18245>
- [11] Li Y, 2021, Research on Financial Opening to the Outside World and Supervision. *Public Investment Guide*, (14):



15–16.

- [12] Huang L, 2023, Continue to Expand the Opening of the Financial Sector to the Outside World. *Beijing Observation*, (07): 33.
- [13] Zhao A, 2020, How to Promote the Opening Up of the Whole Field of Finance. *China Foreign Trade*, (09): 12–14.
- [14] Jiang H, 2020, Bond Market Opening Up and Financial Deepening. *China Finance*, (18): 56–57.
- [15] Zhang K, 2020, The Impact of Expanding Financial Opening to the Outside World on China's Financial Industry and Financial Market. *Chinese Science and Technology Journal Database (full-text edition) Economic Management*, (09).

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# The Insurance Industry Promotes High-quality Development

Xuan Shi\*

Beijing Technology and Business University, Beijing 100048, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** With the rapid development of China's insurance market, the high-quality development of the insurance market is faced with many different challenges and various problems. This paper aims to deeply analyze the actual problems in China's insurance market and put forward supporting countermeasures. First, by understanding the background of high-quality insurance development, we can explain the research significance of this paper in combination with the existing national policies. Secondly, by summarizing the current situation of high-quality insurance development, the paper puts forward the shortage of insurance talents in the expansion of insurance scale, the continuous improvement of insurance density and depth, and the growth of insurance compensation in the development of high-quality insurance. Finally, from the perspective of differentiated customized insurance products, training professionals, and providing financial subsidies, we will put forward the corresponding suggestions for the problem and look forward to the future development prospects.

**Keywords:** Insurance; High-quality development; Insurance technology; Risk management

**Online publication:** April 29, 2025

## 1. Introduction

### 1.1. Research background and significance

#### 1.1.1. Research background

In the great rejuvenation of the Chinese nation, insurance plays a vital role. However, as the economy transitions from high-speed growth to high-quality development, the imbalance and mismatch between insurance supply and demand have become increasingly prominent. Promoting the transformation and upgrading of the insurance industry to achieve high-quality development has become an inevitable solution. The growing needs of the people for a better life are placing new demands on the quality of the insurance supply system, and the high-quality economic development is also setting new requirements for the quality development of the insurance industry <sup>[1]</sup>.

From the current development status of the insurance industry, people's demand for insurance has gradually increased with the growth of economic income. The premium scale of China's insurance industry has maintained a steady rise, and both property insurance and life insurance entities have been growing, leading to

a gradual shift in market size. However, at the same time, contradictions between insurance supply and demand, as well as between scale expansion and efficiency improvement, are constraining the high-quality development of the insurance industry. From the perspective of the goals for the development of China's insurance industry, it aims to preliminarily form a framework for high-quality development by 2029, characterized by steadily expanding coverage, increasingly comprehensive protection, continuously improving services, stable and balanced asset allocation, sufficient solvency, and sound governance and internal controls. By 2035, it aims to establish a new pattern of the insurance industry with a complete market system, diverse products and services, scientifically effective regulation, and strong international competitiveness. The insurance industry must provide high-quality services for people's livelihoods and the real economy, which cannot be achieved without its high-quality development <sup>[2]</sup>.

### 1.1.2. Research significance

High-quality development of insurance refers to guiding the insurance industry to establish a correct business philosophy based on strong regulation and risk prevention. It involves shifting from a rapid growth model driven by premium income, which focuses on external expansion, to an internal development model that links assets and liabilities. This shift centers on value and efficiency, truly meeting the diverse and multi-level needs of the general public for the insurance industry. The significance of studying high-quality development in insurance can be seen in four aspects.

- (1) Risk management and social stability: The essence of insurance is risk trading, with the fundamental attribute of serving the real economy <sup>[3]</sup>. The core function of the insurance industry is risk management, which reduces economic losses for individuals and businesses due to unexpected events by dispersing and transferring risks, thereby enhancing society's overall resilience. A high-quality insurance sector can provide more comprehensive and precise risk assessments and protection plans, thus playing a stabilizing role in natural disasters, health crises, and other events, maintaining social order and economic stability. Fully leveraging the insurance industry's functions as an economic shock absorber and a social stabilizer, it can contribute to China's modernization efforts through its high-quality development <sup>[4]</sup>.
- (2) Economic development and capital formation: Insurance funds are an important part of the capital market. By investing in areas such as infrastructure and technological innovation, they can promote capital formation and economic growth. A high-quality insurance industry can allocate funds more effectively, support the real economy, and drive the optimization and upgrading of the economic structure.
- (3) Consumer protection and welfare enhancement: With the innovation of insurance products and services, consumers can enjoy more diverse and personalized insurance solutions. A high-quality insurance industry can better meet consumer needs, providing health, pension, and other protections, improving people's quality of life, and maximizing social welfare. Adhering to the inclusive and equitable development philosophy, implementing the principle of inclusive finance, and upholding the unity of economic and social benefits, we will draw on international experience to vigorously develop more protective businesses such as pensions, health, agriculture, and catastrophe insurance <sup>[5]</sup>.
- (4) Industry innovation and international competitiveness: The high-quality development of the insurance industry continuously drives technological innovation, such as the application of big data and artificial intelligence, which enhances service efficiency and risk management capabilities. This not only boosts the competitiveness of China's domestic insurance sector but also showcases the strength of Chinese insurers in international markets, attracting foreign investment and advancing the internationalization of China's insurance industry.

## 1.2. Literature review

Dai emphasized in the Financial Times that the State Council's release of the 2024 version of the "Ten Measures" marks a new phase of high-quality development for China's insurance industry<sup>[6]</sup>. Compared to the previous two versions from 2006 and 2014, this policy document places greater emphasis on the importance of high-quality development, echoing the requirement at the Central Financial Work Conference that finance should provide high-quality services for economic and social development. Yang explored specific strategies for high-quality development in the insurance market<sup>[7]</sup>, emphasizing that under internal and external pressures, the insurance industry must take the lead in advancing high-quality development to serve and protect economic growth. The article aims to help the insurance industry achieve stable and efficient improvements from a theoretical perspective. Zhao studied the issue of high-quality development in long-term care insurance using Hohhot as a case study<sup>[8]</sup>. The article analyzed the effectiveness and problems of the pilot system and discussed the intrinsic mechanisms of mutual support and coordinated development between the silver economy and long-term care insurance. Wang discussed the importance of establishing a dual prevention and control policy system for agricultural insurance subsidies under the background of promoting high-quality development<sup>[9]</sup>. The article highlighted the significant role of agricultural insurance in advancing the structural reform of agricultural supply and proposed a dual guarantee of subsidy losses and risk dispersion. Zhang and Geng analyzed the current status and issues of the talent training system in the insurance industry and offered suggestions for promoting future high-quality development in the insurance sector<sup>[10]</sup>. The article emphasized the importance of talent cultivation in the high-quality development of the insurance industry and proposed specific measures to strengthen talent development. Gao discussed the path to achieving high-quality development of insurance services in "China Insurance," emphasizing the significant role of the insurance industry in serving national strategies<sup>[11]</sup>. Zeng explored how "insurance, exchange, and chain" can empower high-quality development in the insurance sector in "Financial Digitization," highlighting the potential of blockchain technology in the insurance industry<sup>[12]</sup>. Zheng and Wang constructed an evaluation index system for high-quality development in the insurance industry in "Selected Research Achievements of Zhejiang Insurance," providing a theoretical foundation for objectively assessing the high-quality development of the insurance industry<sup>[13]</sup>.

## 2. Analysis of the current situation of high-quality development of China's insurance industry

### 2.1. The scale of insurance continues to expand

The premium income of China's insurance industry has experienced significant growth since the reform and opening up. In the early 1980s, with the gradual opening of the economy, the insurance industry began to recover and develop rapidly. Entering the 21st century, especially after joining the WTO, the insurance market further opened up, accelerating the growth rate of premium income. In 2013, premium income exceeded 1.7 trillion yuan, and by 2023, this figure surpassed 5 trillion yuan for the first time, growing by 9.14%, far exceeding the GDP growth rate. Premium income growth will face pressure in 2019<sup>[14]</sup>. This growth not only reflects the strong development momentum of the insurance industry but also highlights its important role in the economic system. The growth in premium income is closely related to the rapid development of China's economy and the improvement of people's living standards, as well as innovations in insurance products and services, and increased awareness of insurance.

### 2.2. Insurance density and premium depth are constantly improving

Insurance density and depth are important indicators of the development level of an insurance industry in

a country. Since the reform and opening up, with economic growth and improved living standards, China's insurance density and depth have seen significant increases. Starting from a low base in the 1980s, both insurance density and depth have grown year by year. Especially after entering the 21st century, with further market liberalization and diversification of insurance products, the growth rate of insurance density and depth has accelerated, and by 2023, this figure had increased to 3,635 yuan per person, representing an increase of 187%. Although it has not yet fully met the expected target, it shows improvement compared to previous years. These changes indicate that as the economy develops and residents' incomes rise, public demand for and awareness of insurance products are gradually increasing.

### **2.3. Insurance claims growth**

The increase in insurance claims reflects the enhanced capabilities of the insurance industry in risk management and economic protection. From the low claim levels at the beginning of the insurance industry's recovery in the 1980s, to the rapid growth at the turn of the century, and then to a threefold increase between 2013 and 2023, this change not only demonstrates the rapid development of the insurance industry but also highlights its significant contribution to socioeconomic development. Especially in the face of natural disasters and accidents, the insurance industry has played a crucial role in providing economic compensation, alleviating the financial burden on individuals and businesses.

### **2.4. The scale of insurance assets increased**

The total insurance assets in China have grown significantly over the past few decades. From the initial stage in the 1980s, through steady growth in the 1990s, to rapid expansion in the 21st century, the increase in insurance asset size not only reflects the rapid development of the insurance industry but also demonstrates its influence and investment capabilities in the capital market. In 2014, the total insurance assets exceeded 10 trillion yuan for the first time, and by 2023, this figure had grown to nearly 30 trillion yuan. This growth not only highlights the financial strength of the insurance industry but also reflects its influence and investment capabilities in the capital market. As the scale of insurance assets has expanded, the service capabilities and risk management levels of the insurance industry have significantly improved.

### **2.5. New insurance products are constantly explored**

Currently, the development of science and technology is advancing at an unprecedented pace. Technologies such as the Internet, block-chain, big data, cloud computing, artificial intelligence, the Internet of Things, connected vehicles, and machine learning have emerged and are gradually being applied to industries like finance, with insurance also developing step by step<sup>[15]</sup>. On one hand, insurance continuously enhances the technological attributes of insurance products, promoting high-quality development in the insurance industry. Big data provides a vast amount of sample data for insurance, while connected vehicles facilitate UBI entering the insurance sector, among other applications. UBI can accurately identify risks in new energy vehicle insurance, which helps in setting more precise rates and significantly aids in reasonable pricing. Currently, UBI has seen further application in China's insurance market, and its integration with auto insurance is also strengthening. On the other hand, as the frequency of catastrophic events increases, it is essential to establish efficient and reasonable mechanisms for handling catastrophes and to introduce insurance policies that are compatible with these events, while appropriately considering regional differences and the feasibility of pilots. Strengthening the application of next-generation technologies and accelerating the development of next-generation artificial intelligence have become crucial strategic choices for driving the leapfrog development of the insurance industry, optimizing industrial upgrades, and enhancing overall productivity<sup>[16]</sup>.



### **3. Existing problems of high-quality development of China's insurance industry**

#### **3.1. Supply and demand mismatch**

From the perspective of demand, on one hand, as living standards and incomes rise, people place greater emphasis on spiritual needs. Therefore, their demand for insurance is also changing, favoring personalized and customized insurance products, as well as reasonable premiums tailored to their economic status, risk level, gender, and occupation. On the other hand, people's needs are not only becoming more personalized and customized but also increasingly diverse. For example, pet lovers may need pet insurance, and fans of celebrities might require home collapse insurance. From the supply side, on one hand, the amount of capital in the capital market objectively constrains the amount of insurance capital, further limiting insurance investment. On the other hand, for insurance companies, with the advancement of science and technology and the diversification and customization of consumer demands, as profit-oriented enterprises, they focus more on whether the application of these technologies can generate profits. The process of applying technology inevitably brings losses, and insurance companies are constrained by limited capital while also bearing the risk of potential losses. Therefore, to some extent, the supply from insurance companies lags behind market demand.

#### **3.2. Lack of insurance professionals**

High-quality development in insurance requires insurers to have multifaceted and multidisciplinary talent to address challenges under the market economy. To adapt to social competition and meet consumers' multi-level and diverse needs, it is necessary to develop more new insurance products. Only by providing superior services can one succeed. However, improving insurance quality necessitates talents from different industries. For instance, insurers need not only knowledge of insurance but also medical expertise in long-term care insurance. Such versatile talents are often scarce and require substantial time and resources for cultivation.

#### **3.3. Conflict between public welfare and the rule of law of compulsory insurance**

On the one hand, there is a conflict between public welfare and profitability. The original intention of establishing compulsory traffic insurance was to protect the basic rights of victims in traffic accidents, which has a mandatory and public welfare nature. However, with the advancement of market-oriented reforms, insurance companies have gradually emphasized profitability in the operation of compulsory traffic insurance. This has led some companies to "selectively underwrite," refusing to insure high-risk vehicles or requiring additional commercial insurance. Such behavior violates the public welfare nature of compulsory traffic insurance, affecting its function of serving society. On the other hand, market-oriented reforms bring pressure. In recent years, the implementation of comprehensive auto insurance reforms has increased market pressure on insurance companies in pricing and underwriting. Regulatory authorities hope to reduce consumer burdens and improve the accessibility of insurance services through reform, but this also puts greater profit pressure on insurance companies in underwriting compulsory traffic insurance. Due to the compressed profit margins in commercial auto insurance, insurers have to manage risks more cautiously, which conflicts with the principle of "break-even" for compulsory traffic insurance.

### **4. Measuring for the high-quality development of China's insurance industry**

#### **4.1. Differentiated customized insurance products**

Personalized customization is a new trend in the future development of the insurance industry. Insurance

companies can provide differentiated products to consumers through personalized customization services, allowing consumers to enjoy more personalized and considerate services. Insurance innovation requires innovation in traditional insurance service models, sales methods, and organizational structures, which can be specifically divided into two categories: Underwriting technology innovation and organizational innovation <sup>[17]</sup>. Differentiated customization is a manifestation of underwriting technological innovation. For example, when insuring new energy vehicles, different rates can be customized based on various criteria such as vehicle type, emission standards, and manufacturer. Here, we can leverage cloud computing for differentiated customization. In a cloud computing environment, insurance companies can more easily obtain customer information, including customer ID, purchase preferences, purchase history, and contact details; accurately pinpoint customer needs, driving habits, usage environments, fault histories, and repair cases.

## **4.2. Cultivating professional talents**

The internal organization of insurance companies should be scientifically and reasonably planned, establishing a dedicated department for business training to align with the company's strategic needs for talent development <sup>[18]</sup>. The insurance industry is a service sector, and the core issue in improving service quality is talent. Modern insurance requires not only professionals who understand insurance but also those skilled in digital technology, forming a composite professional talent pool <sup>[19]</sup>. Talent, as an indispensable part of insurance company development, can be cultivated through external cooperation and talent acquisition. In terms of external cooperation, universities, as the main force in talent cultivation, should establish cooperative platforms with schools to apply for high-quality insurance development courses and organize knowledge competitions that attract and nurture more specialized talents. Regarding talent acquisition, experienced professionals should be attracted to form specialized R&D teams responsible for business expansion, management, and innovation, better grasping market dynamics.

## **4.3. Financial subsidies**

Regarding the contradiction between marketization and public welfare of compulsory traffic insurance, we can address it from two aspects: Fiscal subsidies and the establishment of a risk-sharing mechanism. On one hand, increase the intensity of fiscal subsidies. The government can boost fiscal subsidies for compulsory traffic insurance to reduce operating costs for insurance companies, thereby decreasing their tendency to deny coverage for high-risk vehicles. For example, the government could provide additional subsidies for high-risk or special models to encourage insurers to underwrite these vehicles. On the other hand, establish a risk-sharing mechanism. The government can set up a risk-sharing mechanism involving the government, insurance companies, and consumers. By supporting the establishment of catastrophe insurance funds and reinsurance systems through fiscal subsidies, a multi-level risk dispersion mechanism can be formed, alleviating the financial pressure on insurance companies caused by large-scale accidents.

## **5. Conclusion and prospect**

As the economy continues to develop and consumer demands become more diverse, the insurance industry is facing new challenges for high-quality growth. This article analyzes the current state of high-quality development in China's insurance sector and examines the issues that arise during this process, proposing corresponding measures. It emphasizes the role of insurance technology, the customization of differentiated insurance products to meet diverse needs. Additionally, as the main providers of insurance products, insurance companies must continuously learn from best practices, cultivate professional talent, and implement measures

such as customizing differentiated insurance products to address the mismatch between supply and demand in the process of high-quality development. Despite various challenges in the high-quality development of the insurance market, the overall trend remains positive, with unlimited growth potential. China's insurance market is poised for high-quality development.

## Disclosure statement

The authors declare no conflict of interest.

## References

- [1] Fang Y, 2018, Insurance Helps High-quality Economic Development. *China Finance*, (13): 76–78.
- [2] Yuan C, 2024, High-quality Development of the Insurance Industry: To Do a Good Job, One Must First Sharpen His Tools — Interpretation of the 2024 “Ten National Measures.” *Shanghai Insurance*, (10): 9–10.
- [3] Zeng Y, 2020, “Baojia Chain” Empowers the High-quality Development of the Insurance Industry. *Financial Collectivization*, (03): 18–19.
- [4] China Economic Weekly, 2024, Unswerving Follow the Path of Financial Development with Chinese Characteristics and Serve China's Modernization with High-quality Development, PICC. *China Economic Weekly*, (20): 104–105.
- [5] Xing W, 2019, High-quality Development of China's Insurance Industry under the Background of High-level Opening-up. *Contemporary Financial Journal*, (08): 31–34.
- [6] Dai M, 2024, Insurance Industry Can Do Much to Serve the High-quality Development of Economy and Society. *Financial Times*, (012).
- [7] Yang J, 2024, Exploration of the Path to Promote the High-quality and Sustainable Development of Insurance Market. *China Industry and Economy*, (19): 164–166.
- [8] Wang D, 2024, Establishing a Dual Prevention and Control Policy System of Agricultural Insurance Fiscal Subsidy under the Background of Promoting High-quality Development. *Smart China*, (09): 18–21.
- [9] Zhao Y, 2024, Research on the High-quality Development of Long-term Care Insurance under the Background of Silver Economy — Taking Hohhot as an Example. *China Medical Insurance*, (09): 38–43.
- [10] Zhang L, Geng C, 2024, Construction of Talent Training System for High-quality Development of Insurance Industry. *Shanghai Insurance*, (05): 32–34.
- [11] Gao L, 2022, The Realization Path of High-quality Development of Insurance Service “Belt and Road.” *China Insurance*, (03): 12–15.
- [12] Zeng Y, 2020, “Baojia Chain” Empowers the High-quality Development of Insurance Industry. *Financial Electronic*, (03): 18–19.
- [13] Zheng W, Wang X, 2019, Research on the Index System of High-quality Development of Insurance Industry. *Selected Research Achievements of Zhejiang Insurance (2018)*. Zhejiang Banking and Insurance Regulatory Bureau, (9): 191–199.
- [14] Zhu J, 2019, Continuously Promoting the High-quality Development of Insurance Industry. *China Finance*, (02): 50–52.
- [15] Gao L, 2022, The Realization Path of High-quality Development of Insurance Service “Belt and Road.” *China Insurance*, (03): 12–15.
- [16] Liang T, Chen X, 2019, Insurance Industry Needs Radical Change. *Mass Financial Advisor*, (02): 33–35.
- [17] Yang J, 2024, Exploration of the Path to Promote the High-quality and Sustainable Development of Insurance Market. *China Industry and Economy*, (19): 164–166.

- [18] Zhang L, Geng C, 2024, Construction of Talent Training System for High-quality Development of Insurance Industry. Shanghai Insurance, (05): 32–34.
- [19] Wang X, 2024, Discussion on the Path to Promote the High-quality Development of the Insurance Industry. Shanghai Insurance, (06): 33–38.

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# Research on the Influencing Factors of China's Cross-border E-commerce Exports to Countries Along the "Belt and Road"

Xinhao Zhao\*

University of Science and Technology Liaoning, Anshan 114000, Liaoning, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** Cross-border e-commerce, as a new form of international trade, has shown great development potential in the context of the "Belt and Road" initiative. Based on the cross-border e-commerce export data from 2015 to 2024, this paper analyzes the influencing factors of China's cross-border e-commerce exports to countries along the "Belt and Road" by constructing an econometric model. The study found that factors such as the perfection of digital infrastructure, the efficiency of logistics and transportation, the convenience of payment and settlement, and the penetration rate of consumers' online shopping significantly affect the export scale of cross-border e-commerce. Institutional factors such as the development level of e-commerce platforms in countries along the route, market access thresholds, and tariff policies also play an important role. Based on the research results, suggestions are put forward to strengthen the construction of cross-border payment system, optimize the logistics distribution network, promote customs clearance facilitation, and deepen cooperation in the field of e-commerce, to provide references for promoting the development of China's cross-border e-commerce exports to countries along the "Belt and Road."

**Keywords:** The Belt and Road; Cross-border e-commerce; Export trade; Influencing factor

**Online publication:** April 28, 2025

## 1. Introduction

With the booming development of the digital economy, cross-border e-commerce is gradually becoming a new engine to promote the growth of international trade. In the implementation of the "Belt and Road" Initiative, cross-border e-commerce cooperation between China and countries along the route has continued to deepen, and the scale of trade has continued to expand. In-depth research on the key factors affecting China's cross-border e-commerce exports to countries along the "Belt and Road" is of great significance for grasping the development law of cross-border e-commerce and promoting trade facilitation. Based on the development status of cross-border e-commerce, an empirical analysis method is adopted to systematically explore the impact mechanism of digital foundation, logistics system, institutional environment, and other factors on cross-border e-commerce exports, to provide a basis for formulating relevant policies.



## **2. Cross-border e-commerce export development status**

### **2.1. Cross-border e-commerce export scale analysis**

In recent years, China's cross-border e-commerce exports to countries along the "Belt and Road" have shown steady growth. From the perspective of quarterly data changes, the third and fourth quarters of the year are the peak export season, mainly driven by holiday promotions, year-end purchases, and other factors. In terms of regional distribution, Southeast Asia has become the most important export destination with its geographical advantages and huge market potential. Relying on the advantages of land trade routes, Central Asia has witnessed the rapid development of cross-border e-commerce business, while Central and Eastern Europe have achieved sustained growth in cross-border e-commerce exports with the help of increased capacity of China-Europe freight trains. In terms of product categories, mass consumer goods such as electronic products, clothing, shoes and hats, and household items occupy the main share. As a new trade mode, cross-border e-commerce shows strong development resilience, effectively promotes the optimization and upgrading of foreign trade structure, and becomes an important force to promote the high-quality development of foreign trade <sup>[1]</sup>.

### **2.2. Characteristics of cross-border e-commerce export structure**

From the perspective of product structure, consumer goods are the leading category of cross-border e-commerce exports. Electronic products, clothing, and household goods constitute the main export commodity categories, and the market demand continues to be strong and emerging categories such as beauty, personal care, and maternal and child products have strong growth momentum, and the product structure is constantly optimized. From the perspective of market structure, ten ASEAN countries, five Central Asian countries, and Central and Eastern Europe have formed three important market segments. The ASEAN market has a significant youthful consumer group, a high penetration rate of mobile payment, and sufficient market vitality. The Central Asian market has stable demand for daily consumer goods and great potential for market development. The Central and Eastern European markets have strong consumption capacity, high quality requirements, and a relatively large demand for high-end consumer goods. From the perspective of channel structure, third-party cross-border e-commerce platforms are the main transaction channels, independent sites and social e-commerce channels are gradually emerging, and the trend of channel diversification is obvious <sup>[2]</sup>.

## **3. Cross-border e-commerce export factors**

### **3.1. Digital infrastructure factors**

The level of digital infrastructure construction directly determines the basic conditions for the development of cross-border e-commerce exports. There are significant differences in Internet coverage among countries along the Belt and Road. Southeast Asia has a high mobile Internet penetration rate and a wide range of mobile payment applications, laying a good foundation for the development of cross-border e-commerce. The network infrastructure of some Central Asian countries is relatively weak, the bandwidth capacity is insufficient, and the network speed is slow, which restricts the cross-border e-commerce business to a certain extent. In terms of data center construction, Southeast Asia has built several large data centers to ensure the stable operation of e-commerce platforms, while the scale and number of data centers in other regions are still insufficient. The accessibility of cloud computing services also presents regional differences, with mature cloud service applications in developed regions and insufficient technical support in remote areas <sup>[3]</sup>.

### **3.2. Logistics and transportation factors**

The logistics and transportation system are the key supporting factors for cross-border e-commerce exports.

There are regional differences in the connectivity of logistics networks among countries along the routes. The China-Europe routes that have been opened provide stable and reliable freight routes in Central and Eastern Europe, while Southeast Asian ports with dense sea routes have good logistics advantages. The distribution of storage and distribution facilities is uneven; developed areas have modern logistics centers, and remote areas have insufficient storage capacity. The timeliness of international logistics is affected by the customs clearance efficiency of ports, the choice of transportation modes, and other factors, and the terminal distribution cost is high in some areas. The application degree of smart logistics is different, and advanced areas have adopted automatic sorting, intelligent warehousing, and other technologies to improve logistics efficiency. The level of logistics informatization in less developed regions is low, which means difficult to meet the needs of the rapid development of cross-border e-commerce. The coverage of the cargo tracking and positioning system is limited, and some remote areas cannot achieve full tracking, increasing logistics risks. The level of logistics infrastructure construction directly affects the timeliness and cost of cross-border e-commerce distribution, which has become an important factor restricting the expansion of export scale <sup>[4]</sup>.

### **3.3. Payment and settlement factors**

The improvement of the cross-border payment and settlement system significantly affects the development of cross-border e-commerce export business. The penetration rate of digital payment tools varies significantly among countries, and electronic wallets are widely used in Southeast Asia with high payment convenience. In some Central Asian countries, cash transactions are still dominant, and electronic payment acceptance is low. The construction of cross-border payment channels has made mixed progress, and some countries have realized direct local currency settlement, reducing the risk of exchange rate fluctuations. Other regions still need to settle through third-party currencies, increasing transaction costs. There are shortcomings in the payment security mechanism, and some regions have insufficient norms in terms of payment verification and fund supervision, which are prone to transaction disputes <sup>[5]</sup>.

## **4. Cross-border e-commerce export optimization path**

### **4.1. Digital level improvement strategy**

To improve the level of digitalization, we need to start from two aspects: infrastructure construction and technology application. Increase investment in the construction of data centers in countries along the Belt and Road, arrange edge computing nodes, and improve network access speed and server responsiveness. Promoting the commercial process of 5G networks, expanding network coverage, and providing a high-speed and stable network environment for cross-border e-commerce applications <sup>[6]</sup>. Build a big data center for cross-border e-commerce, integrate multidimensional data such as goods, logistics, and payments, and provide support for precision marketing and decision optimization <sup>[7]</sup>. Strengthen the application of artificial intelligence technology in the field of cross-border e-commerce, develop intelligent customer service, intelligent translation, intelligent recommendation, and other functional modules, and improve the service level of the platform. We will improve the application of blockchain technology in cross-border payments and commodity traceability to enhance transaction security and trust. Construction of a cross-border e-commerce digital operation platform, order processing automation, intelligent inventory management, marketing strategy data, and improvement of operational efficiency. Pay attention to the cultivation of digital talents, carry out technical training and experience exchange, and provide talent security for digital transformation <sup>[8]</sup>.

## 4.2. Logistics network improvement strategy

The improvement of logistics network should focus on the optimization of warehousing layout and the improvement of distribution efficiency<sup>[9]</sup>. Build overseas warehouses in key markets to realize nearby storage and rapid distribution of goods, and improve the timeliness of logistics. Improve the construction of cross-border logistics information systems, realize the tracking and positioning of goods throughout the process, and improve the transparency of logistics. We will optimize the operation routes of China-Europe freight trains, increase the density of freight trains, and provide stable and reliable land transport channels for cross-border e-commerce<sup>[10]</sup>. The construction of an intelligent logistics distribution center, the application of automatic sorting equipment, and intelligent robots improve the efficiency of logistics operations. Develop multimodal transport services, integrate air, sea, land, and other modes of transport, and reduce logistics costs. Promote the construction of logistics standardization, unify packaging specifications, waybill format, operation process, and improve the efficiency of logistics operations. Establish a cross-border logistics cooperation platform, integrate logistics resources of all parties, and realize capacity sharing and route optimization. Strengthen the construction of the terminal distribution network, expand the coverage of distribution stations, and improve the express service system<sup>[11]</sup>.

## 5. Conclusion

China's cross-border e-commerce exports to countries along the "Belt and Road" are affected by multiple factors, including hardware elements such as digital infrastructure and logistics systems, as well as soft factors such as institutional environment and market characteristics. Through empirical analysis, it is found that measures such as improving the digitalization level, improving the logistics network, optimizing the payment system, and innovating the market expansion mode can effectively promote the development of cross-border e-commerce exports. In the future, we should continue to promote digital trade facilitation, deepen cross-border e-commerce cooperation, build a more open, inclusive, and win-win trade pattern, and promote the economic and trade relations between China and countries along the "Belt and Road" to a higher level.

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Fan Q, 2021, Analysis on the Influencing Factors of China's Agricultural Exports to Countries along the "Belt and Road" — Based on The Binary Marginal Perspective. *Price Monthly*, (04): 43–50.
- [2] Wang Y, Sheng X, 2024, Research on the Impact of Digital Economy Development of Countries along the "Belt and Road" on China's Cross-Border E-Commerce Exports. *Modern Finance and Economics (Journal of Tianjin University of Finance and Economics)*, (05): 22–44.
- [3] Dong C, 2022, Research on the Influencing Factors of China's Cross-Border E-Commerce Exports to Countries along the "Belt and Road," dissertation, Shenyang University of Technology.
- [4] Li W, 2023, Spatial Characteristics and Influencing Factors of China's Direct Investment in Countries along the "Belt and Road." *Journal of Tianjin Vocational College of Commerce*, 11(05): 3–12.
- [5] Zhou L, Zhou W, 2024, Analysis on the Influencing Factors and Potential of China's Export of Cultural Products to Countries along the "Belt and Road." *China Business Review*, 33(17): 89–93.

- [6] Yang H, Li F, 2021, Research on the Influencing Factors of Export Fluctuations of Cultural Products between China and Countries along the “Belt and Road.” *Cultural Industry Research*, (01): 126–141.
- [7] He J, Wei F, 2023, Research on the Ternary Margin of Grain Export Growth of Countries Along the “Belt and Road” and its Influencing Factors. *World Agriculture*, (05): 19–31.
- [8] Wang W, 2024, The Impact of Cross-Border E-Commerce Development in Trade Partner Countries on China’s Import and Export Trade — based on Empirical Analysis of Countries Along the “Belt and Road.” *Business Economics Research*, (08): 139–142.
- [9] Han D, Li G, Zhong Y, 2020, Comparison of Grain Competitiveness between China and Countries along the “Belt and Road” and Research on Influencing Factors of Grain Trade. *Journal of Jiangxi University of Finance and Economics*, (04): 76–92.
- [10] Zuo L, Zhong B, 2021, Research on China’s Export Trade and Potential of Electromechanical Products to Countries along the “Belt and Road.” *Price Theory and Practice*, (10): 156–159 + 195.
- [11] Zhao P, Wu P, 2021, Research on Factors Influencing Cultural Trade between China and Countries along the “Belt and Road” — Analysis from the Perspective of Export Trade Cost. *Price Theory and Practice*, (12): 143–146 + 201.

**Publisher’s note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# Comparative Analysis of Marketing Research between China and United Kingdom

Qianyu Li\*

University of Birmingham, Birmingham B15 2TT, United Kingdom

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** This paper conducts clustering, potential semantic indexing, comparison, and inductive analysis of research papers on marketing between China and the UK from January 2020 to September 2024. The study found that the Chinese marketing research focuses on digital transformation, policy impact, value co-creation, and emerging e-commerce models. In contrast, the UK marketing research focuses more on sustainability, technology integration, real-time research, and personalized marketing strategies. The study also found that there were few marketing articles published in Chinese and CSSCI journals in China, while the SSCI journals published in English were 62 times more than in Chinese. According to the research, digital marketing and data-driven decision-making, diversified marketing channels, sustainability and circular economy, technological innovation and cutting-edge technology application, meta-universe and blockchain technology, AI + marketing development, brand building, and international market expansion will become the research hotspots in the field of marketing in the future. The research suggests that China should strengthen the construction of an academic marketing platform, and China and the UK should strengthen cooperation in marketing research, learn from each other's strengths, and jointly give full play to their advantages in technology application, market and economy, strategy and innovation, and social media, to contribute to global economic development and marketing research.

**Keywords:** China and Britain; Marketing research; Comparative analysis

**Online publication:** April 28, 2025

## 1. Introduction

### 1.1. Research background

Marketing is a process in which enterprises acquire, maintain, and increase customers by creating, delivering, communicating, and exchanging products and values to meet consumer needs and desires. Marketing usually includes market research, market segmentation, target market selection, market positioning, product strategy, price strategy, promotion strategy, distribution strategy, customer relationship management, market entry strategy, competitive strategy, market analysis, brand management, digital marketing, data analysis, regulatory compliance, social responsibility, etc. Marketing is crucial to the development of enterprises, and it is the key force connecting enterprises with the market, promoting economic development and social progress.

Marketing in China started relatively late, but it has developed rapidly in recent years. In the early



1930s, marketing was introduced into China. The development of China's marketing has also experienced the evolution process from the cognitive period after the initial introduction, to the practical period of blind imitation and blind follow-up, and then to the exploration period of painful review and rational reflection, reflecting the characteristics of low-level "native-born," from the point to the surface, and gradually expanding the application scope and field <sup>[1]</sup>. In recent years, China's marketing industry has developed rapidly, especially in the Internet industry, which has gradually changed from follower to a leading role.

The UK occupies an important position in the field of global marketing, and British scholars and practitioners have made important contributions to the development of marketing theory. In the 21st century, with the rise of the Internet and digital technology, the British marketing industry also began the digital transformation, digital marketing become mainstream, brand and enterprises began to use social media, search engine optimization (SEO), content marketing digital channels to contact and attract consumers, had a profound impact on the global marketing practice.

## 1.2. Literature study

From the literature research, there are many papers studying the development process of marketing in China and the UK, but it is very rare to conduct a direct comparative analysis. Such as Wang *et al.*, with Chinese marketing research literature as the research object, analysis that China marketing management research topic should pay attention to the scientific research direction and social and economic development goals, based on combining marketing management practice do theoretical or applied research, put forward the support, operational solution <sup>[2]</sup>. Wu and Nie, based on the visual analysis of domestic research on brand marketing, found that social media marketing, brand communication, and value co-creation in the era of big data are the current research hotspots <sup>[3]</sup>. Zhang and Guo's research that Xi's economic thought from the global, highly summarizes the high-quality development and market environment, the market main body formed the theory, supply quality, business environment, market size and international market theory five basic argument, has been clear about the marketing innovation and development of favorable conditions and development potential <sup>[4]</sup>.

British market research and research institutions often publish marketing trend report, such as Kantar research, in 2023, 67% of marketers are positive about the possibility of generative artificial intelligence (GenAI), the industry is exploring the opportunity to use GenAI, to improve the efficiency of our development and personalized ideas and large-scale innovation, marketers and agents by creating more visual concepts to discuss GenAI, inject new impetus for the conception stage, and help conceive the story. In our future, there may even be space for synthetic media planning <sup>[5]</sup>. Clark *et al.* deeply discussed the current situation and future of the marketing discipline, studied the influence of Shelby Hunt, made a profound analysis of marketing theory, proposed the path to restore the status of the marketing discipline, and expanded the pioneering R-A theory of Shelby Hunt, namely resource advantage Resource-Advantage theory <sup>[6]</sup>. SIS International's The UK Market Research report, which highlights the importance of UK market research, including sustainable consumption and ethical consumption, artificial intelligence and machine learning integration, agile and real-time research, personalized and microsegmentation, customer Voice (VoC) initiatives, and other <sup>[7]</sup>. Chamboko-Mpotaringa and Tichaawa, a comprehensive overview of published academic materials in the context of tourism marketing, believe that the metaverse is causing a paradigm shift in tourism marketing <sup>[8]</sup>.

## 1.3. Study value

This paper to China network (CNKI), Web of Science journal data as the source data, using cluster analysis, LLR analysis, comparative study, inductive research method, on January 1, 2020 to September 30, 2024,

China, the two most representative countries of the global marketing research hotspot, analysis of the two countries marketing research hotspot, research institutions, research experts, summarizes the two marketing research characteristics, differences, research conclusion, research recommendations. Research to understand the research focus in the field of marketing, research direction change, for the two countries business, research institutions, relevant experts and scholars to strengthen mutual understanding, enhance exchanges and cooperation, joint research to promote the development in the field of global marketing research has very important practical value and academic significance.

## **2. Study methods and data**

### **2.1. Study methods**

#### **2.1.1. Cluster analysis**

Cluster analysis is a statistical method for grouping objects in a dataset to make objects within the same group more similar than objects in different groups. This paper mainly adopts K-means analysis, which is one of the most popular clustering algorithms in data mining and machine learning<sup>[9]</sup>. Its goal is to divide  $n$  points in the dataset into  $k$  clusters, so that each point belongs to the nearest cluster center to minimize the total internal sum of squares of clusters. The core goal of the K-means clustering algorithm is to minimize the sum-of-within-cluster square error (WCSS).

#### **2.1.2. LLR clustering**

LLR clustering, the Log-Likelihood Ratio clustering, is a statistical model-based clustering method that evaluates the similarity between different clusters by calculating log-likelihood ratios. LLR clustering is particularly suitable for clustering analysis of text data because it can deal with the problem of one word's polysemy and one sense multiple words, thus improving the accuracy of clustering.

#### **2.1.3. Comparative study method**

Comparative research is a research method that involves a systematic contrast of two or more objects, groups, phenomena, or concepts to identify similarities and differences between them. This approach is often designed to understand commonalities and personalities in different situations or to assess the impact of different variables on outcomes<sup>[10]</sup>. Comparative studies can be either quantitative or qualitative, specifically depending on the nature of the research questions and data, and these papers are mainly conducted using qualitative comparative research methods.

#### **2.1.4. Inductive research method**

Induction is a method of logical reasoning that extracts general conclusions or principles from particular observations or data. In scientific research, induction is usually used to form hypotheses or theories from experimental results or observational data. Induction is characterized as it relies on empirical data to support conclusions rather than derive results from a theoretical perspective. This paper mainly conducts inductive analysis through empirical data from cluster analysis.

### **2.2. Study data**

#### **2.2.1. Data source**

CNKI database belongs to China National Knowledge Infrastructure (CNKI), and is the largest academic paper database and academic electronic resource integrator in China. The core of Peking University is a periodical

catalogue jointly compiled by Peking University Library and periodical workers and experts from more than a dozen university libraries in Beijing. CSSCI (Chinese Social Sciences Citation Index) is a database developed by the Chinese Social Sciences Research and Evaluation Center of Nanjing University. It mainly searches for the inclusion and citation of papers in the field of Chinese humanities and social sciences.

The Web of Science Database is a global leading citation database covering over 9,200 journals from 1900 to now, covering 178 research disciplines. SSCI, the Social Science Citation Index (Social Sciences Citation Index), is an important international social science literature search tool created by the American Institute of Scientific Information (ISI).

### **2.2.2. Acquisition situation**

In this study, the author conducted a search with “marketing” as the theme in CNKI. The period was set from January 1, 2020, to September 30, 2024. The Chinese and English extension, Peking University core, and CSSCI options were selected, and a total of 479 records were retrieved as sample literature analysis data.

The search included “marketing” as the theme in the Web of Science Core Collection citation index SSCI, with the period set to 1 January 2020 to 30 September 2024, and 29065 data were retrieved when the country was set to the People’s Republic of China. A total of 13999 data points were retrieved when the country was set to England.

## **3. Research process**

### **3.1. Analysis of Chinese marketing research situation**

#### **3.1.1. Analysis of the inclusion status of Peking University Core and CSSCI**

Key keyword (K) LLR cluster analysis of 478 records collected from the CNKI database was performed by CiteSpace software <sup>[11]</sup>, and the output results are shown in **Figure 1**. Analysis of the figure, it can be found that during January 2020 to September 2024, in the CNKI database, published the core of Peking University and CSSCI journals, about marketing research focus on marketing, marketing strategy, feed enterprises, seed market, rural revitalization, brigade fusion, rural tourism, brand marketing and so on eight key direction. There were 138 institutions involved in the study, but the number of stories published was very scattered.

#### **3.1.2. Analysis of SSCI collection and publication status**

Subject word (T) LLR cluster analysis of 29,040 records collected from the Web of Science database was performed by using CiteSpace software, and the output results are shown in **Figure 2**. Analyzing this figure, As it can be found, Between January 2020 and September 2024, In the SSCI database, Related papers marked as China, On the focus of marketing research, More attention should be paid to the seven key directions of stock price crash risk, purchase intention, stock market, urban China, innovation performance, environmental regulation, and supply chain.

### **3.2. Analysis of the UK Marketing research situation**

The subject word (T) LLR clustering of 14946 records collected from the Web of Science database was analyzed using CiteSpace software, and the output results are shown in **Figure 3**. Analyzing this figure, as it can be found, between January 2020 and September 2024, in the SSCI database, related papers in the country marked as the UK, the marketing research focuses on cryptocurrency market, South Korea, social media, entrepreneurial orientation, circular economy, and capital structure.



Figure 1. China (CSSCI)

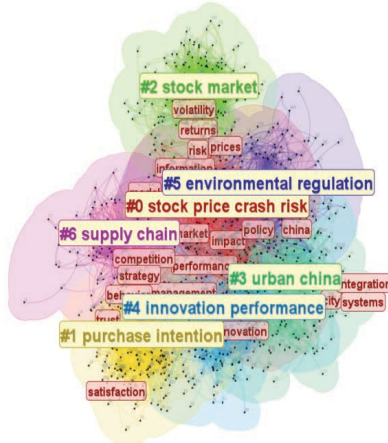


Figure 2. China (SSCI)



Figure 3. UK (SSCI)

### 3.3. Comparative analysis of the marketing research situation between China and the UK

#### 3.3.1. LLR analysis

LSI analysis of the “marketing” research topic articles collected from Peking University Core and CNSCI database using CiteSpace software from January 1, 2020, to September 30, 2024, and **Table 1** was obtained.

**Table 1.** Theme analysis table of China marketing research in September 2020–2024

Data point	Contour coefficient	LLR
27	0.96	Marketing; feed enterprise; marketing strategy; block chain; service contact;
17	0.789	Marketing strategy; “Belt and Road”; Internet; live delivery with goods; current status;
16	0.903	Feed enterprises; feed products; big data; economic benefits; sustainable development;
11	0.911	Seed market; technology innovation; cutting-edge technology; artificial intelligence; innovation strategy;
9	0.932	Rural revitalization; feed industry; family farm, higher vocational college; professional group;
8	0.991	Integration of culture and tourism; mode; cross-cultural communication; cultural and creative products; marketing;
7	0.987	Rural tourism; network; industrial integration; product promotion; tourism function;
5	0.989	Brand marketing; brand value; ebm model; service innovation; marketing strategy;
3	0.989	The Communist Party of China; subject history; Marketing; Marketing; Feed enterprise;
3	0.979	Industrial development; industrial chain; Dongtai watermelon; countermeasures; bitter gourd;

LSI analysis of “marketing” China research topic articles collected from the Web of Science core collection database from 1 January 2020 to 20 September 2024, **Table 2**.

**Table 2.** Subject analysis table (SSCI) in China, September 2020–2024

Data point	Contour coefficient	LLR
258	0.734	Risk of stock price crash; stock return; stock liquidity; stock price synchronization; corporate governance;
202	0.83	Purchase intention; social media; intermediary role, behavior intention; customer participation;
191	0.896	Stock markets; crude oil; spill over risk; economic policy uncertainty; volatility spill;
186	0.777	Urban China; Rural China; Hong Kong; Case Study; Housing Price;
171	0.807	Innovation performance; regulation; entrepreneurship orientation; digital transformation; strategic orientation;
164	0.784	Environmental regulation; carbon emissions; financial development; economic growth; green finance;
120	0.81	Supply chain; closed-loop supply chain; dual-channel supply chain; government subsidies; information sharing;



LSI analysis of the “marketing” UK area research subject articles collected from the Web of Science core collection database SSCI database using CiteSpace software from January 1, 2020, to September 30, 2024, resulting in **Table 3**.

**Table 3.** UK marketing research topic analysis table (SSCI), September 2020–2024

Data point	Contour coefficient	LLR
173	0.796	Cryptocurrency market; stock market; commodity market; financial market; stock return;
158	0.72	South Korea; Labour market; gender gap; Labour market results; Labour market;
138	0.736	Social media; sharing economy; social media encers; Influencer marketing; behavior intention;
126	0.824	Entrepreneurship orientation; export performance; international performance; absorption ability; strategic agility;
119	0.695	Circular economy; energy transition; adoption of circular economy; low-carbon transition; blockchain technology;
117	0.81	Capital structure; corporate value; financial development; foreign direct investment; international trade;

### 3.3.2. Comparative analysis of study topics

LLR clusters in **Tables 1** and **2** were combined into Data 1, and LLR clusters in **Table 3** were combined into Data 2, and the two groups were used for comparative analysis as shown in **Table 4**.

**Table 4.** Comparison analysis of marketing research topics in China and the UK from October 2023 to 2024

Project	China	Britain
Similarities	Technology application	Both sets of data mention the application of technology, and the “blockchain,” “big data,” and “artificial intelligence” in Data 1 and the “blockchain technology” in Data 2 both show the importance of technology in their respective fields.
	Market and economy	Both sets of data involve market and economy-related concepts, such as “marketing” and “stock market” in Data 1 and “financial markets” and “international trade” in Data 2.
	Strategy and innovation	Both data sets emphasize the importance of strategy and innovation, such as the “marketing strategy” and “innovation strategy” in Data 1 and the “strategic agility” and “circular economy adoption” in Data 2.
	Social media	Both data sets mentioned the impact of social media, with “social media” in Data 1 and “social media influencers” in Data 2 showing the important role of social media in different fields.
Differences	Industry focus	More focus on feed enterprises and their related industries, such as “feed enterprises,” “feed products,” “seed market,” and so on.
	Economic policy and the environment	Noted the concepts related to policy and the environment, such as “economic policy uncertainty” and “environmental regulation.”
	Market behavior and psychology	Concepts related to market behavior and psychology, such as “behavioral intention” and “customer participation,” are mentioned.
	Specific areas of technology application	Technology applications are more inclined to be within the industry, such as the application of “artificial intelligence” in the feed industry.
	Development and transformation	Technology applications are more widespread, such as the application of “blockchain technology” in the financial markets.
	Market segments	More focus on the “capital structure,” “corporate value,” and other aspects of corporate financial and market performance.

## 4. Study conclusions and recommendations

### 4.1. Study recommendations

Through the study, the following research is suggested:



First, we should grasp the direction and trend of marketing research. Digital marketing and data-driven decision-making. With the development of big data and artificial intelligence technology, data-driven marketing decisions will become the key. Personalized and customized services consumers' demand for personalized and customized services will be further enhanced. Diversified marketing channels pay more attention to the construction of diversified marketing channels, through the integration of online and offline, to achieve omni-channel sales, improve the brand influence, and market share. Sustainability and circular economy, with an increasing consumer demand for sustainability and circular economy practices. Metasmos and blockchain technology will be the main trends for marketers, especially in energy, resources and industrial and life sciences, and healthcare marketing. Changes in consumer behavior, especially the pursuit of immediate enjoyment and immersive experience, will become a new consumer trend. In marketing investment under economic uncertainty, brands tend to deal with instability and uncertainty through investment, improve organizational ability, and maintain flexibility. With the development of AI + marketing, the application of AI technology in marketing will continue to deepen. Through data mining, NLP, machine learning, and other key technologies, AI will optimize all aspects of traditional marketing and make contributions to the fields of user screening, content creation, creative delivery, effect monitoring, and behavior prediction. Brand building and international market expansion, brand building will become a strong support for promoting high-quality development and creating a high-quality life, at the same time, encouraging enterprises to rely on the international market for new consumption. With the variability of consumer purchasing behavior, consumers have a large choice and changeable demand. We should pay close attention to the market changes and meet the changing needs of consumers by increasing product colors and varieties.

Second, China should strengthen the construction of a marketing academic platform. Chinese domestic journals, Peking University core, and the CSSCI database have insufficient acceptance of marketing research results. A large number of scholars and institutions publish English papers in SSCI journals, which affects the development of the domestic marketing research field in China to a certain extent, and reform and innovation should be vigorously deepened.

Third, China and the UK should strengthen cooperation in marketing research. Britain in market research, started very early, university of London, university of Oxford, London, London school of economics, university college London, university of Cambridge, the economic policy research center, the university of Manchester, the university of Leeds, king's college London, university of Nottingham, university of Birmingham have made various contributions in marketing research, in the financial market, capital structure, company value of marketing leading position, China is currently in the digital transformation, economic policy uncertainty also has certain characteristics. The two sides also have a lot in common in technology application, market and economy, strategy and innovation, and social media, and they can strengthen mutual exchanges and cooperation.

## **4.2. Research outlook**

Looking into the future, the research and development of global marketing will continue to face challenges and opportunities. This paper mainly analyzes cluster analysis, potential semantic index analysis, comparative analysis, and inductive analysis, and through KI database and the Web of Science core collection database. In the next step, the scope of data collection can be further expanded to further improve the universality and representativeness of the research. In terms of research methods, more analytical tools and models can also be used for analysis, especially with the introduction of artificial intelligence analysis technology.

## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Li Y, Zhang Y, 2004, Interpret the Development History of Chinese Marketing. *Journal of Hebei Normal University (Philosophy and Social Sciences Edition)*, (02): 49–52. <https://doi.org/10.13763/j.cnki.jhebnu.psse.2004.02.009>
- [2] Wang Y, Wang S, Hu Y, 2019, 70 Years of China Marketing Research: Review and Outlook. *Economic Management*, 41(09): 191–208. <https://doi.org/10.19616/j.cnki.bmj.2019.09.012>
- [3] Wu G, Nie M, 2022, Visual Analysis of Domestic Research on Brand Marketing based on CiteSpace. *Journal of Hebei University of Engineering (Social Science Edition)*, 39(04): 1–10.
- [4] Zhang Z, Guo G, 2024, Xi Jinping's Economic Thought Leads the Innovative Development of Marketing in the New Era. *Contemporary Economic Management*, 2024: 1–10. <http://kns.cnki.net/kcms/detail/13.1356.F.20241016.1051.002.html>
- [5] Kantar, 2024, Marketing Trends, viewed March 21, 2025, <https://www.kantar.com>
- [6] Clark T, Azab C, Key TM, 2024, Marketing's Next Era: The Scope and Impact of Marketing's Future, The Reach and Legacy of Shelby Hunt. *Journal of Business Research*, 170: 114278.
- [7] SIS International, 2015, Market Research in the United Kingdom, viewed March 21, 2025, <https://www.sisinternational.com/coverage/europe/market-research-united-kingdom>
- [8] Chamboko-Mpotaringa M, Tichaawa TM, 2024, The Impact of Metaverse-Enabled Digital Transformation on Tourism Marketing. *Tourism Review International*, 28(2): 149–162.
- [9] Wu X, 2020, *Data Mining and Analysis: Concepts and Algorithms*, Posts & Telecom Press, Beijing.
- [10] Neuman, WL, 2007, *Social Research Methods: Qualitative and Quantitative Approaches* (5th ed.). China Renmin University Press, Beijing.
- [11] Li J, Chen C, 2022, *CiteSpace: Text Mining and Visualization in Science and Technology* (3rd Edition), Capital University of Economics and Trade Press, Beijing.

### Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

# Construction of College Students' Innovation and Entrepreneurship Education Ecosystem under the Digital Economy

Zhang Li\*

Huangshan University, Huangshan 245000, Anhui, China

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** Under the digital economy, college students' innovation and entrepreneurship education is facing new transformation and reform, such as increasing entrepreneurial opportunities, improving quality, and new development opportunities under the digitalization of education. This paper takes the digital economy as the development background, discusses how to build the digital innovation and entrepreneurship education ecosystem, that is, to form an integration mechanism with digital technology as the important content, digital context as the external environment, and digital organizational form as the guarantee. The specific approaches are as follows: Improve the digital skills and ability of entrepreneurs, carry out the design of digital entrepreneurship courses, strengthen the construction of digital organizations, establish a mechanism for multi-subject participation and value co-creation, and constantly promote the development of innovation and entrepreneurship education under the digital economy.

**Keywords:** Digital economy; Innovation and entrepreneurship; Ecosystem

**Online publication:** April 28, 2025

## 1. Introduction

In the context of the advancement of the Fourth Industrial Revolution and the development of the wave of scientific and technological revolution, the digital economy and digital technology have had a profound impact on the training goals and paths of innovative and entrepreneurial talents. Many scholars at home and abroad have conducted research on innovation and entrepreneurship education in the digital economy environment. Well-known scholars such as Zhu and Liu, Jia and Liu, Liu and Zhao, Guo and Yang <sup>[1-4]</sup>, have researched the elements, core, innovation, team, organization and ecosystem of the digital economy, and their research focuses on the entrepreneurial subject, entrepreneurial content, entrepreneurial organization, business model, ecosystem and other contents under the digital economy. The mode and path of entrepreneurship and innovation education in colleges and universities are reflected in many aspects and multiple subjects, involving organizational structure, external environment, curriculum system, and other aspects under the digital economy. Based on the analysis of the new situation of innovation and entrepreneurship under the digital economy, this paper proposes the construction of

an innovation and entrepreneurship education ecosystem and the specific development path under the digital economy.

## **2. Digital transformation of innovation and entrepreneurship education**

### **2.1. More entrepreneurial opportunities in the digital economy**

With the improvement of digital infrastructure and the popularization of digital technology, the proportion of the digital economy in national GDP continues to increase, and digital models continue to innovate. Digital entrepreneurship has become the main choice for college students to find employment and start businesses. The digital economy has reduced the capital cost and transaction cost required for entrepreneurship, and fields such as live streaming, small program development, private domain operation, and content creation have become important paths to attract young entrepreneurs. Xu and Liu believe that the digital economy can promote the income increase of rural low-income groups by expanding the depth and breadth of employment <sup>[5]</sup>. Yan *et al.* put forward that the digital entrepreneurial economy provides new development opportunities for entrepreneurs <sup>[6]</sup>, who use digital technology and digital platforms to explore entrepreneurial opportunities, such as the development of various software, intelligence, and entrepreneurial opportunities on social media platforms.

### **2.2. High-quality entrepreneurship in the digital economy**

The digital economy provides a path and channel for high-quality entrepreneurship by improving the speed and quality of information transmission, and promoting new business forms and models, such as blockchain, technology, and big data. Wu and Chen proposed that the digital economy can help entrepreneurs to effectively identify entrepreneurial opportunities <sup>[7]</sup>, and make use of the information transparency, low cost, and inclusiveness under the conditions of the digital economy. The higher the quality, technology, and innovation of entrepreneurial opportunities, the higher the income and profits of entrepreneurs. The informatization under the digital economy also reduces the difficulty of financing, eliminates the block of information, enhances the understanding of the project and market control of the angel investors in the investment category, and helps the start-up enterprises to obtain market financing, especially the start-up enterprises with strong science and technology and outstanding strength, the financing difficulty is small, and soon gain the favor and financial support of the investor after entering the market.

### **2.3. Development of digital education**

The first time education digitization was written in the report of the Party Congress was at the 20th Party Congress <sup>[8]</sup>. The form of education has changed the traditional “teachers teach, students learn” situation, with more flipped classrooms and online platform interaction, to guide students to learn enthusiasm, initiative, and creativity. In terms of educational organizations, the digital economy generates virtual subjects and forms education and teaching networks through social interaction. Online community platforms and digital platforms reduce the search costs, information costs, and bargaining costs of information transmission. For college students’ entrepreneurship education, the organizational form of entrepreneurship education presents a network, platform, borderless integration, breaking organizational boundaries, realizing resource sharing in different departments, regions, and laboratories, and serving college students’ entrepreneurship education and entrepreneurial practice by strengthening communication and information transformation mechanisms.

### **3. The construction of innovation and entrepreneurship education ecosystem under the digital economy**

#### **3.1. The characteristics of the digital economy are endogenous factors that shape the new ecology of innovation and entrepreneurship education**

The digital economy has the characteristics of high permeability, platform, data, high additivity, virtuality, and so on. Innovation and entrepreneurship under the digital economy form a process with innovation as the core, based on artificial intelligence, big data, Internet of Things, blockchain, and other technologies, including e-commerce development, unmanned driving, information systems, VR and AI technology, intelligent applications, digital industrialization, and industrial digitalization. The digital economy supports innovative entrepreneurship and achieves high-quality entrepreneurship by improving factor productivity, leveraging digital platforms, and developing high-tech and information technology industries; it creates an innovative platform economy model. Strengthen the benign interaction between online and offline platforms and the organic combination of innovation and entrepreneurship resources, strengthen resource interaction, and improve the efficiency of innovation and entrepreneurship. Liu and Zou proposed that digital technology has changed the traditional entrepreneurial model and formed a good entrepreneurial ecology <sup>[9]</sup>, and the elements of the digital entrepreneurial ecosystem include: Digital multilateral platform, non-platform digital entrepreneurship, digital users, digital infrastructure, formal system, informal system, financing environment, talent environment. Through the network trust mechanism, network sharing mechanism, and multi-party coordination mechanism, the digital ecosystem deepens the interaction between different elements (e.g., capital, technology, talent, etc.), broadens the geographical boundaries of the entrepreneurial ecosystem, and enhances the breadth and depth of entrepreneurial activities.

#### **3.2. Composition of innovation and entrepreneurship education ecosystem under the digital economy**

With the transformation of education modernization, digital ecology and education ecology show symbiotic coexistence and synergistic evolution. The innovation and entrepreneurship ecosystem under the digital economy emphasizes the coordinated development of technology core with the participation of multiple subjects, and emphasizes the coordination and utilization of the digital education model, digital context, digital technology, and digital resources. Highlight the open border and resource sharing, emphasize the dynamic mechanism between the subject and the environment, emphasize the integration of digital technology, data elements, and educational resources, form a development force, build a value co-creation mechanism, and open up the ecosystem value chain. Xu and Wu proposed that the digital transformation of education is a systematic development process <sup>[10]</sup>, the core driving force of which is the new generation of digital technology, and technological innovation drives the evolution of the education system to achieve the link and coordinated development of entrepreneurial education subjects, hardware and software, social resources, and digital technology. It is proposed that the transformation of digital education can be realized through the macro level (policy design), the middle level (data-driven), and the micro level (teaching innovation). Teng and Li put forward that digital technology will eliminate entrepreneurial boundaries and broaden group boundaries <sup>[11]</sup>. Due to the differences in values, social resources, and economic status of different subjects, the effectiveness of digital entrepreneurship education depends on the joint force composition and the effect of digital entrepreneurship education.

Intelligent technology enhances the situational and experiential teaching environment, and students are faced with new development opportunities in virtual and real interaction, multiple interactions, and man-machine collaboration. The development of the digital age is no longer the pursuit of simple knowledge, but



rather creating knowledge for the reality and future. A virtual environment has the learning characteristics of an online scene, data support, personalized customization, immersion experience, and so on. It is interactive, contextualized, and experiential. The “space-time integration” scene constructed by mobile Internet connection breaks through the traditional physical space, especially with the support of AR, VR, MR, and other technologies, forming a multidimensional information system connected by cyberspace, electronic context, and virtual reality.

Organizational boundaries in the digital economy play an important role in reshaping organizational relations and subverting traditional business models. Digital organizational form provides a new organizational system and structure for the innovation and entrepreneurship education concept. Under the digital economy, the organizational structure is flat, flexible, modular, platform-based, dynamic, and other characteristics, emphasizing digitally driven, efficient collaboration and agile cooperation. Guo proposed that new digital technologies and new data elements have promoted the transformation of industrial institutions <sup>[12]</sup>, such as the digital economy driving the platform economy, and the organizational form of digital organizations is flat, flexible, integrated, modular, borderless, dynamic, and other characteristics. Digital organizations complement and symbiosis, and digital platform organizations continue to expand outward, narrowing the boundaries of enterprises and blurring the external form of organizational structure.

Based on the triple helix theory of “government-university-enterprise,” Bao proposed an innovation and entrepreneurship education ecosystem in the digital age, highlighting the sharing and application of digital technology and digital resources <sup>[13]</sup>. Digital technology accelerates the resource complementarity, mutual coordination and collaborative innovation among the three subjects (government-university-enterprises), proposes to give full play to the leading role of the government, universities are in the position of scientific and technological innovation, strengthen the construction of digital infrastructure, introduce intelligent cloud and open learning platform, and promote the coordinated development of the industry. At present, innovation and entrepreneurship education has formed a cooperation mechanism with the participation of multiple subjects, such as the government, social resources and forces, industries, universities, etc., but the relevant cooperation is not in-depth and comprehensive, information communication is not smooth, and the cooperation content is narrow. In the digital economy environment, give full play to the sharing and cooperation advantages of universities and governments under the construction of digital platforms, such as the construction of an information platform for digital enterprises to connect with financing institutions or angel investors, optimize investment projects, play the role of factors, form online evaluation and online investment, and save costs.

## **4. Digital economy entrepreneurship education development path and strategy**

### **4.1. Establishing entrepreneurship education and training objectives under the digital economy**

Digital technology affects the content and form of college students’ entrepreneurship education. The current education infrastructure, education platform construction, group interaction, teaching, and practical training environment of colleges and universities depend on the development status of digital technology. From traditional multimedia to new information technology (digital technology) under the education and teaching, such as data computing and storage technology under the university network space, internal and external communication and interconnection under the Internet of Things technology, personalized teaching and management evaluation system under the intelligent technology, immersive technology to help virtual interactive learning, mobile terminal supported smart classroom under the mobile technology.

For college entrepreneurs, the training objectives of digital entrepreneurship education include attaching

importance to college students' innovative thinking, digital awareness, digital literacy, digital behavior and practical ability, digital organization, digital leadership, and digital learning ability. Among them, digital entrepreneurial skills are mainly reflected in the following four aspects. The first level is digital skills and basic applications, such as social media applications, public accounts, apps, e-commerce, and other fields. The second level is the application and future development of digital technology in the industrial field, clarifying the practical application of digital industrialization and industrial digitalization; The third level is the development mode of digital industry, using digital thinking and digital technology to understand the development mode of digital economy; The fourth level can use digital technology, combined with professional technical innovation or product service innovation, is the highest level.

By carrying out special training on digital technology (data acquisition and analysis, network technology, programming, use of new software) and other knowledge, college students can make up for their defects in data acquisition and analysis, mining data value, keeping up with the development of digital technology, and being familiar with the application scenarios of digital technology. The basic digital quality of college students is general, and their professional and technical ability is not strong, which leads to entrepreneurial projects mainly concentrated in e-commerce and other industries with weak skills, resulting in weak specialization and innovation. Therefore, the comprehensive improvement of digital literacy and digital skills has become an important component of college students' entrepreneurial quality.

## **4.2. Digital entrepreneurship education curriculum and teaching design**

At present, most entrepreneurship education follows the traditional education model, and the digital innovation and entrepreneurship education still needs some improvement. Take Carnegie Mellon University as an example. In terms of organizational structure and teaching content, the university has set up the Swartz Entrepreneurship Center, emphasized the cultivation of students' professional ability in digital technology, and launched the "comprehensive art design and technology project," including business courses, professional courses, entrepreneurship and creation courses, innovation courses, product development courses and practical experience components. A portal course, such as Introduction to computing creation practice or information design, is specially provided for students without a design or computer-related professional learning background to help students understand professional knowledge in the computer field. Students can experience the whole process of product design and entrepreneurship in the course plan. Xiao proposed that entrepreneurship education courses can be divided into four categories<sup>[14]</sup>: General courses, project courses, integration courses and open courses, and built an educational mechanism of multi-subject participation, integration of specialized innovation, integration of theory and practice, integration of both inside and outside the school, and integration of production and innovation.

In the digital economy environment, the model of entrepreneurship education has added new content. The traditional mode of thinking is mainly taught in the classroom, reflecting "innovation," "adventure," "practice," and other contents, while the entrepreneurship education in the digital age takes digital skills, digital applications, digital practices, and digital risks as the main contents. Under the requirements of entrepreneurial quality and ability in the era of digital intelligence, the curriculum system includes: Digital strategy, digital entrepreneurs, digital supply chain, digital enterprise entrepreneurship, digital analysis tools, digital finance, and other content. In the setting of general courses, under the background of the development of the digital economy, the content of digital entrepreneurship education has formed a content system of Internet thinking, e-commerce, and information technology with innovation as the core. With the application of digital economy in production and life, traditional entrepreneurial elements are endowed with digital attributes, and the task

of entrepreneurial education is to train students to have the skills to survive in the rapidly changing market environment to adapt to the uncertain environment. Project courses focus on various entrepreneurship competitions, national innovation plans, incubation practice, industrial cooperation and other contents, promote college students to participate in situational simulation and social practice entrepreneurial activities, and give full play to the advantages of multi-channel main resources; The integration course emphasizes the integration with specialty and practice, industry and course; Open courses emphasize the integration of education and teaching resources through MOOCs and the use of platforms for tracking, big data analysis and open evaluation. Educational models in the digital economy include design thinking, SPOC (Small Private Online Course), TRIZ (Theory of Inventive Problem Solving), etc.

### **4.3. Organizational construction of entrepreneurship education under the digital economy**

Taking American universities as an example, Huang and Zhang explained that to promote the circulation and sharing of organizational resources for entrepreneurship education in the whole university <sup>[15]</sup>, Stanford University established the Entrepreneurship Research Center, and relied on the entrepreneurship network platform of entrepreneurship education to integrate various resources such as colleges, interdisciplinary projects, research centers and laboratories. The implementation of the organizational system requires the construction of a platform, the elimination of geographical barriers and resource dispersion barriers, the establishment of a leading group, the establishment of development goals, the promotion of an open and flexible organization, the use of powerful multi-party resources, to provide resources and suggestions for college students' innovation and entrepreneurship, and the formation of powerful guidance.

The digital economy promotes the organizational changes of entrepreneurship education through the following ways: First, the establishment of a sharing platform for information and resources, the formation of a dedicated digital guidance and management service department for innovation and entrepreneurship, unified planning, management, organization and coordination, to ensure efficient cooperation among various departments on campus, and to realize the flow and sharing of knowledge, information, talents, resources and other elements among multiple subjects. The more entrepreneurial elements within a digital organization, the closer the communication and connection between each other, the more prosperous the digital entrepreneurial activity. Through the screening and configuration of entrepreneurial factors, the digital multi-agents take the needs of digital users as the core, connect the heterogeneous factors of each agent, and realize the coupling of factors. And recruit skilled digital technology and information technology personnel to manage. Taking Stanford University as an example, based on the organization of resource sharing and circulation in Entrepreneurship education, the Stanford Entrepreneurship Network was founded to serve entrepreneurial projects and form a digital innovation and entrepreneurship service platform. Including website, public account, course platform, contest management system, etc., to provide strong network support for digital innovation and entrepreneurship education, comprehensive digital application of innovation and entrepreneurship information content, such as the website by multiple subjects to provide resources and participation, to achieve information resource coordination, set up relevant functional modules. Such as an interactive communication module, a course construction module, an entrepreneurial project display module, alumni resources, and so on. The digital innovation and entrepreneurship competition system provides registration channels for college students, project management and display, investment promotion, entrepreneur support, contest mentor library, and other columns, helping all kinds of entrepreneurship competitions to steadily advance and efficiently use resources. In the course section, an online learning system is set up to provide various digital teaching resources and auxiliary resources, communication platforms, and forums to mobilize students' learning enthusiasm.

#### **4.4. Constructing an innovation and entrepreneurship education evaluation system featuring student-centered and human-machine coordination**

The differences between the evaluation system of innovation and entrepreneurship education under the digital economy and the traditional education evaluation system are mainly reflected in the following aspects: The degree of digital technology, more attention to effectiveness and output, personalized training, and the man-machine collaboration mode. The evaluation system of innovation and entrepreneurship education should fully stimulate the participation of multiple evaluation subjects (universities, governments, enterprises, social groups, etc.), use text recognition, image recognition, speech recognition and other technologies to read traditional media information, and strengthen automatic data collection and analysis; Using big data technology to collect process learning data; Artificial intelligence technology is used to create simulation environment, virtual task scene, collaborative environment, etc., to test students' problem-solving ability in real task situations. Fully demonstrate students' knowledge structure, ability performance, and inner potential, and provide a detailed "digital portrait" for each student; Build a distributed learning profile (coupling decentralized data via the Internet) that certifies students' diverse learning outcomes. Intelligent technology is used to collect and analyze college students' learning time, learning habits, learning styles, learning methods, and other personal information. On this basis, personalized evaluation programs and visual feedback reports are formulated.

#### **4.5. Digital multi-subject value co-creation under continuous improvement**

In the digital economy environment, an innovative development mode with digital technology as the core should be opened, resource sharing and platform-based value co-creation path should be highlighted, online and offline education resources should be gathered, and new education situations in the virtual environment should be set up, and industrial collaboration and cross-border integration should play a role in the output efficiency of innovation and entrepreneurship education. Centering on the industrial chain, integrating the data chain, connecting the innovation chain, activating the capital chain, and cultivating the talent chain, giving full play to the role of sharing education information resources and integrating resources, it is easy to form economies of scale and innovation effects, and form a multiplier effect of resource utilization. We will combine research and development, incubation centers, practice platforms, and social industries to build an ecosystem of collaborative innovation. Du *et al.* proposed that digital entrepreneurs make use of network resources and social capital in the ecosystem to form entrepreneurial opportunities <sup>[16]</sup>; In digital entrepreneurship opportunities, cross-field and cross-level cooperation has increased. The digital economy provides a platform for the coordinated development of multiple entities, establishes a communication mechanism and a sharing mechanism, such as the construction of the basic layer (website, public account, application software and technology development, etc.), the data layer (capital resource data, education resource data, industrial information data, policy data), and the realization of the goal layer (value creation). Build a technology research and development cooperation platform, an education resource sharing platform, an industrial information cooperation platform, a venture capital cooperation platform, a human resources exchange platform, etc., to achieve the participation and sharing of multiple subjects.

### **Funding**

- (1) Analysis of College Students' Innovation and Entrepreneurship Education System Construction under Digital Economy Environment (2021jyxm1404)
- (2) In-depth Development of Experience Tourism in Traditional Villages in Huizhou under the Digital Economy Environment — A Case study of Traditional Villages in Yixian County (2022AH051929)



## Disclosure statement

The author declares no conflict of interest.

## References

- [1] Zhu X, Liu Y, Chen H, 2020, Digital Business: Core Elements and Generating Mechanism Study. *Journal of Foreign Economics and Management*, (04): 19–35.
- [2] Jia J, Liu M, 2021, Digital Entrepreneurial Teams: The Connotation, Characteristics and Theoretical Framework. *Journal of Research and Development Management*, (01): 101–109.
- [3] Liu Z, Zhao C, Li B, 2020, Digital Social Entrepreneurship: Theoretical Framework and Research Prospects. *Foreign Economics and Management*, 42(4): 3–18.
- [4] Guo H, Yang Z, 2021, From Digital Technology to Digital Entrepreneurship: Connotation, Characteristics and Internal Relations. *Foreign Economics and Management*, 43(9): 3–23.
- [5] Xu C, Liu Y, 2023, Digital Economy Contributes to the Common Prosperity of Rural Low-income Groups: Theoretical Mechanism and Micro-evidence. *Jiangnan Forum*, (03): 35–42.
- [6] Yan Z, 2022, Research on Digital Entrepreneurship: Theoretical Framework and Future Prospects from the Perspective of Innovation. *Foreign Social Sciences*, (3): 92–109 + 198–199.
- [7] Wu C, Chen Y, 2024, Digital Economy, Entrepreneurship and The Size of Middle-income Groups. *Reform*, (01): 94–110.
- [8] Li H, 2024, Embracing Digital Technology Wave to Speed Up the Construction of Chinese Social Science Education Power Network, Seeking Truth From Facts, viewed March 22, 2025, [http://www.qstheory.cn/2024-07/01/c\\_1130172126.htm](http://www.qstheory.cn/2024-07/01/c_1130172126.htm)
- [9] Liu Z, Zou W, 2020, Digital Entrepreneurship Ecosystem: Theoretical Framework and Policy Considerations. *Guangdong Social Sciences*, (4): 5–14.
- [10] Xu Q, Wu Y, 2023, Driving Factors and Logical Framework of Education Digital Transformation: From the Perspective of Innovation Ecosystem Theory. *Modern Distance Education Research*, 35(2): 31–39.
- [11] Teng T, Li A, 2024, Opportunities, Challenges and Path Selection of Entrepreneurship Education in Chinese Universities in the Digital Economy Era. *Jiangsu Higher Education*, (4): 82–87.
- [12] Guo Z, 2023, Evolution of Industrial Organization in the Era of Digital Economy: Trends, Characteristics and Effects. *Chinese Rural Economy*, (10): 2–25.
- [13] Bao M, 2022, Innovation and Entrepreneurship Education Ecosystem in the Digital Age: Based on the Triple Helix Theory. *Research in Technical Economics and Management*, (10): 31–35.
- [14] Xiao S, 2022, Design of Curriculum System for Innovative and Entrepreneurial Talents Training in Application-oriented Undergraduate Universities under OBE Education Model. *Theoretical Research and Practice of Innovation and Entrepreneurship*, 5(19): 68–70.
- [15] Huang Y, Zhang Y, 2023, Analysis on the Organizational Construction of Entrepreneurship Education in Research Universities in the Digital Era. *Journal of Wenzhou University (Social Sciences Edition)*, 36.
- [16] Du J, Wang T, Hao X, et al., 2022, Formation and Development of Entrepreneurial Opportunities in Digital Ecosystem: An Exploration based on Social Capital Theory. *Advances in Psychological Science*, 30(6): 1205–1215.

### Publisher's note

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.



# A Comprehensive Review of Factors Influencing Compliance

Renhong Liu<sup>1,2\*</sup>, Mohd Shukri Ab Yajid<sup>2</sup>, Jacqueline Tham<sup>2</sup>

<sup>1</sup>Hongshan College, Nanjing University of Finance and Economics, Nanjing 212413, Jiangsu, China

<sup>2</sup>Management and Science University, Shah Alam 40100, Selangor, Malaysia

*\*Author to whom correspondence should be addressed.*

**Copyright:** © 2025 Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), permitting distribution and reproduction in any medium, provided the original work is cited.

**Abstract:** Compliance, as a very important aspect of corporate governance, has developed earlier in the world, while China's compliance management has developed relatively late and is currently lacking in development. However, many enterprises suffer serious losses without compliance management, especially import and export enterprises, which are forced to exit the market due to poor compliance management. This article is based on the urgent need of Chinese enterprises for compliance management, but the lack of research by scholars. It summarizes the literature on the factors affecting compliance, hoping to be helpful for the study of compliance management.

**Keywords:** Compliance; Influencing factors; Internal control; Executive compensation; Shareholding structure

**Online publication:** May 7, 2025

## 1. Theoretical basis and connotation of compliance

### 1.1. The origin and connotation of compliance management

The term “compliance” first appeared in the regulatory process of the US banking industry. In the long economic activities of mankind, due to the psychology of human pursuit of interests, economic crimes have been committed one after another. Society and the government are urgently demanding stricter systems to ensure the fairness of economic activities. In terms of compliance, the most important regulation is the Sarbanes-Oxley Act. This bill innovatively proposed that the management of the company needs to be responsible for the authenticity of the financial audit report and fill the loopholes in the company's operations legally. In this way, the honesty of the company's operations is forced to be enforced by senior executives through compulsory means.

In 2006, the China Banking Regulatory Commission issued the “Guidelines for Compliance Risk Management of Commercial Banks,” pointing out that compliance means that the business activities of commercial banks are consistent with the laws, administrative regulations, departmental regulations and other normative documents applicable to banking business activities, ensuring that the enterprise has legal business rules and becomes a legal self-regulatory organization, and its code of conduct and professional ethics are consistent. With the development of economic activities in all aspects, financial institutions play an increasingly important

role in economic activities, and financial organizations are increasingly aware of the importance of compliance. At the same time, non-financial institutions, such as enterprises, have also begun to pay attention to the importance of their compliance. In this way, through effective control methods, they can constrain their economic activities from violating basic ethics and reduce possible economic risks in this regard.

At present, to enhance the compliance of enterprises themselves, more and more enterprises are carrying out structural reforms in their structures, adding internal compliance management and internal audit departments. The increase of these departments, to a certain extent, reflects that enterprises are aware of the importance of compliance to their development. At the same time, this measure is also a response of enterprises to the overall emphasis on compliance by the country and society from Wang, and it is also a favorable guarantee for improving enterprise risk management and internal control under the pressure of upstream customers to assess their cooperation risks by Christina. Scholars have made sufficient research on the correlation between internal audit and compliance management by Roy, Sheila PL, and Kelly N.

Regarding internal audit, more studies focus on the relationship between corporate governance and risk management and internal control (Xiong and Zheng). In terms of compliance management, more studies focus on individual compliance characteristics, model research, and system construction in the securities, banking, and insurance industries (Yu and Yang). At the same time, “compliance audit” only emphasizes the audit model that meets established standards (Zheng and Li), with a single connotation.

## **1.2. Measurement of business compliance**

In research, researchers often use whether listed companies have been administratively punished by government departments for illegal and unethical behavior as a substitute variable for business compliance. Similarly, according to research needs, the illegal and irregular data that researchers often need are usually manually collected through channels such as company announcements and official websites of regulatory agencies and processed accordingly by Wang.

## **2. Compliance construction in various industries**

At present, many industries have entered the process of compliance management assessment. In terms of industry, almost all major supporting industries in China are involved, such as aerospace, infrastructure, coal mining, automobile manufacturing, etc.

In the study of Li *et al.*, the concept of “Internet +” was introduced into the coal industry, combining “Internet +” with coal production to achieve transparency and openness of production and improve production safety and production efficiency;

In his study, Chen explored the relationship between compliance and risk control related factors and set up the implementation evaluation steps of specific risk control through compliance management in the aerospace field, laying a certain foundation for the application of compliance in the aerospace field.

For infrastructure projects, Yang *et al.* conducted research and proposed a RFID-based hazard identification system, which can identify the hazards in the on-site compliance management and personnel safety of infrastructure projects. In the automobile manufacturing industry, Yang believes that the use of compliance should be targeted <sup>[1]</sup>. In the field of automobile production, automobile manufacturing companies should consider the company’s situation when considering the production safety of employees, and design targeted compliance management regulations to improve the production safety factor of employees. Chen conducted an in-depth analysis of the risks existing in automobile manufacturing plants <sup>[2]</sup>, conducted an in-depth investigation of the regulations and environment faced by workers, and proposed specific optimization measures based on the

investigation content to rationally use the control measures formulated by corporate compliance and improve the reliability of the company's comprehensive safety development. Formela *et al.* explored the application of compliant ship pollution issues. Based on the safety of ship operation, scholars explored research trends from multiple perspectives, such as material risks, human risks, and accidental risks, and analyzed and predicted future research directions from the perspectives of ship risk assessment and collision avoidance risk quantification.

### **3. The relationship between compliance and other variables**

#### **3.1. Compliance and executive compensation**

Liu constructed a model of executive compensation level and internal control information disclosure compliance through empirical research and believed that executive compensation level is significantly negatively correlated with internal control information disclosure non-compliance. The higher the compensation level, the stronger the executive awareness, the more effective the internal control operation, and the lower the incidence of information disclosure violations. Moderate executive compensation incentives are conducive to reducing internal control information disclosure violations of listed companies.

Wei constructed a regression model for empirical research, using the classic interaction coefficient test and the group regression coefficient variability test. The results show that the vertical compensation gap of the executive team is significantly positively correlated with corporate misconduct. When controlling other influencing factors, the greater the vertical compensation gap of the executive team, the more serious the corporate misconduct.

Lu verified its main research hypothesis through eight multivariate regression analysis models, using the regression coefficient significance test and group regression coefficient difference test. The empirical results show that executive compensation incentive strategies can significantly reduce the incidence and severity of violations, providing evidence for executive compensation incentives.

#### **3.2. Compliance and shareholding structure**

Chen concluded that shareholding concentration is significantly negatively correlated with the possibility of corporate misconduct. The higher the shareholding concentration, the lower the possibility of corporate misconduct. This conclusion still holds after using three methods for robustness testing. Empirical research has found that major shareholders play an active role in corporate governance. The empirical analysis used 6548 Chinese A-share sample observation data collected and processed from the Guotai Junan main board database, and the analysis software used was STATA 12.0.

Wang verified the research hypothesis through regression analysis of nine models. The empirical results show that there is a significant negative correlation between ultimate control and corporate misconduct; that is, the greater the ultimate control, the lower the possibility of corporate misconduct, and the concentration of ultimate control can inhibit corporate misconduct. The conclusion is that there is a significant negative correlation between ultimate control and corporate misconduct; that is, the greater the ultimate control, the lower the possibility of corporate misconduct, and the concentration of ultimate control can inhibit corporate misconduct.

#### **3.3. Compliance and internal control**

Goh BW found that if a company has certain defects in internal control, then the company is more likely to need to carry out financial restatements, which puts the company at a greater operating risk. Bargerion *et al.* believe that when a company's internal control is better, the company's information to the society is more accurate and transparent, which can further reduce the impact of information asymmetry and help achieve the company's compliance goals. Byungjin Kwak and Byung T believe that if a company has effective internal control, it can

achieve positive development of the company to a certain extent by strengthening its information transmission and increasing its financing opportunities. On the contrary, bad internal control is often prone to fraud and loss of public trust.

He used the Dibo Index released by Shenzhen Dibo Company to measure the quality of internal control and found that the quality of internal control was significantly negatively correlated with the possibility of financial restatement. The better the internal control, the lower the possibility of financial restatement. Chen used corporate litigation as a substitute variable for litigation risk to study the relationship between internal control and legal risk and found that the higher the quality of internal control, the lower the legal risk of the company<sup>[3]</sup>. Bai conducted a study on the relationship between internal control quality and earnings management, indicating that high-quality internal control can effectively suppress earnings management behavior<sup>[4]</sup>. Wang conducted an empirical test based on the internal control index of Xiamen University and found that the higher the quality of internal control<sup>[5]</sup>, the lower the probability of financial restatement, indicating that internal control is an effective factor in inhibiting management from financial restatement; Dai and Li found in their research that if the internal control of an enterprise is good, the profitability of the enterprise will increase, that is, the internal control of the enterprise is consistent with the change of the enterprise performance. Fang found that in terms of enterprise risk, high-quality internal control can inhibit the possibility of enterprise risk to a certain extent, and in terms of financing, high-quality internal control can help the stock growth of the enterprise and enable the enterprise to obtain more development space.

Wang used the company reports of China's A-share listed companies in 2014 as samples and studied the specific relationship between internal control and corporate violations through empirical research. The study found that within the scope of accounting information and business compliance research, the better the internal control, the lower the risk of corporate violations. Chen analyzed the data of Chinese main board companies from 2012 to 2016, used the data to conduct a Logit empirical test, and found that companies with internal control defects are more likely to violate regulations. Chu found through empirical research that the quality of internal control is significantly negatively correlated with corporate violations<sup>[6]</sup>. Wang selected non-financial listed companies and paired listed companies that violated regulations in Shanghai and Shenzhen A-shares from 2008 to 2017 as research samples<sup>[7]</sup>. The quality of internal control is negatively correlated with the probability and severity of corporate violations. Xi also found through empirical research that the quality of internal control of listed companies is negatively correlated with their violation rate.

## 4. Conclusion

Facing increasingly fierce market competition, to respond to the needs of the market and the country, compliance control has become a sector that enterprises must face. Facing important aspects such as enterprise risk assessment and corporate financial information, compliance control has become irreplaceable for enterprises. This article summarizes relevant literature to provide a reference for researchers.

## Disclosure statement

The authors declare no conflict of interest.

## References

- [1] Yang G, 2019, Research on Problems and Measures of Safety Production Management of Automobile Manufacturing

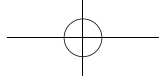
Enterprises in the New Era. *Chinese Management Information Technology*, (14): 117–118.

- [2] Chen L, Wang J, 2020, Risk Analysis and Safety Management of Automobile Manufacturing Plant. *Modern Marketing*, (10): 150–151.
- [3] Chen X, 2020, Research on the Relationship between Corporate Social Responsibility, Internal Control and Corporate Litigation Risk, Master's Thesis, Nanjing University of Science and Technology.
- [4] Bai J, 2024, The Influence of Internal Control on Earnings Quality: Mediating Role based on Social Responsibility. *Technology and Market*, (02): 163–168.
- [5] Wang Y, 2023, Controlling Shareholder Equity Pledge, Internal Control and Financial Restatement, Master's Thesis, Shandong University of Finance and Economics.
- [6] Chu S, 2020, Customer Concentration, Internal Control Quality and Enterprise Violation, Master Dissertation, Shandong University of Finance and Economics.
- [7] Wang L, 2020, Executive Background Characteristics, Internal Control Quality and Corporate Violations, Master Dissertation, Shandong University of Finance and Economics.

**Publisher's note**

Bio-Byword Scientific Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.





## Integrated Services Platform of International Scientific Cooperation

Innoscience Research (Malaysia), which is global market oriented, was founded in 2016. Innoscience Research focuses on services based on scientific research. By cooperating with universities and scientific institutes all over the world, it performs medical researches to benefit human beings and promotes the interdisciplinary and international exchanges among researchers.

Innoscience Research covers biology, chemistry, physics and many other disciplines. It mainly focuses on the improvement of human health. It aims to promote the cooperation, exploration and exchange among researchers from different countries. By establishing platforms, Innoscience integrates the demands from different fields to realize the combination of clinical research and basic research and to accelerate and deepen the international scientific cooperation.

### Cooperation Mode



Clinical Workers



In-service Doctors



Foreign Researchers



Hospital



University



Scientific institutions

# OUR JOURNALS



The *Journal of Architectural Research and Development* is an international peer-reviewed and open access journal which is devoted to establish a bridge between theory and practice in the fields of architectural and design research, urban planning and built environment research.

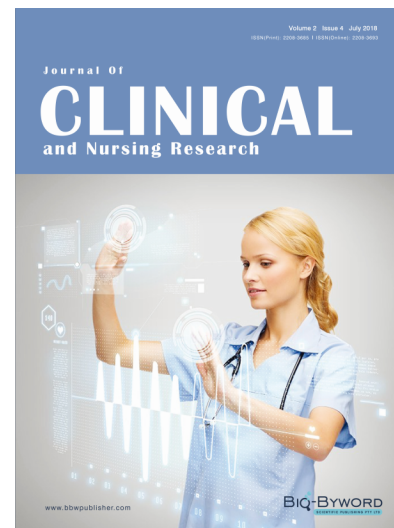
Topics covered but not limited to:

- Architectural design
- Architectural technology, including new technologies and energy saving technologies
- Architectural practice
- Urban planning
- Impacts of architecture on environment

*Journal of Clinical and Nursing Research (JCNr)* is an international, peer reviewed and open access journal that seeks to promote the development and exchange of knowledge which is directly relevant to all clinical and nursing research and practice. Articles which explore the meaning, prevention, treatment, outcome and impact of a high standard clinical and nursing practice and discipline are encouraged to be submitted as original article, review, case report, short communication and letters.

Topics covered by not limited to:

- Development of clinical and nursing research, evaluation, evidence-based practice and scientific enquiry
- Patients and family experiences of health care
- Clinical and nursing research to enhance patient safety and reduce harm to patients
- Ethics
- Clinical and Nursing history
- Medicine



*Journal of Electronic Research and Application* is an international, peer-reviewed and open access journal which publishes original articles, reviews, short communications, case studies and letters in the field of electronic research and application.

Topics covered but not limited to:

- Automation
- Circuit Analysis and Application
- Electric and Electronic Measurement Systems
- Electrical Engineering
- Electronic Materials
- Electronics and Communications Engineering
- Power Systems and Power Electronics
- Signal Processing
- Telecommunications Engineering
- Wireless and Mobile Communication

