

ZEUS PRESS

Financial Economics Research

VOLUME 3 · ISSUE 3 · 2026

E-ISSN 3006-3663 · P-ISSN 3006-3655

© 2026 The Author(s). Authors retain copyright in their articles.



ZEUS PRESS

FER

Financial Economics Research

OPEN ACCESS · DOUBLE-BLIND PEER-REVIEWED ACADEMIC JOURNAL

VOLUME 3 · ISSUE 3 · 2026

E-ISSN 3006-3663 · P-ISSN 3006-3655

<https://journals.zeuspress.org/index.php/fer/index>

FINANCIAL ECONOMICS RESEARCH · JOURNAL · VOLUME 3 · ISSUE 3 · 2026

ZEUS PRESS

Financial Economics Research

FER

ISSUE

Volume 3 · Issue 3 · 2026

PUBLISHED BY

Zeus Press

OPEN ACCESS · DOUBLE-BLIND PEER-REVIEWED ACADEMIC JOURNAL

VOLUME 3 · ISSUE 3 · 2026

E-ISSN 3006-3663 · P-ISSN 3006-3655 · DOI Prefix 10.70267

<https://journals.zeuspress.org/index.php/fer/index>

Recommended citation: Financial Economics Research, Volume 3, Issue 3 (2026).

Financial Economics Research

ISSN	3006-3663 (Online), 3006-3655 (Print)
DOI PREFIX	10.70267
WEBSITE	https://journals.zeuspress.org/index.php/fer/index
CONTACT	service@zeus-press.org ; +852 56089963

ABOUT THE JOURNAL

Financial Economics Research (FER) is a double-blind peer-reviewed, open-access journal that publishes high-quality research in the field of financial economics. The journal aims to provide a platform for scholars, researchers, and practitioners to share cutting-edge research and insights that contribute to the understanding and enhancement of financial markets, institutions, and practices.

TYPES OF SUBMISSION

The journal publishes: (1) full-length articles, (2) review articles, (3) book reviews, (4) discussion notes and (5) articles in translation.

EDITORIAL AND PEER-REVIEW POLICY

All research articles are subject to editorial assessment and double-blind peer review. The journal follows recognized standards of publication ethics, research integrity, transparency and correction.

PUBLICATION ETHICS AND INTEGRITY

The journal applies principles of research integrity, transparent authorship, disclosure of competing interests, data accuracy and prompt correction of the scholarly record. Suspected misconduct is assessed through an impartial editorial process.

AUTHOR RESPONSIBILITIES

Authors retain responsibility for the accuracy, originality and ethical compliance of their work, including acknowledgements, funding statements, data availability and conflict-of-interest disclosures.

PERMISSIONS

The author is responsible for obtaining all permissions required before submission. Permission and owner details must be provided for third-party content, methods, software, questionnaires and scales. Authors must check applicable licences, obtain permission where required, and include confirmation in the Materials and Methods section.

OPEN ACCESS LICENCE

This publication is licensed under the Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0), which permits noncommercial use, sharing, adaptation, distribution and reproduction with appropriate credit, a link to the licence, and an indication of changes.

DIGITAL PRESERVATION AND RECORD

The publisher supports long-term accessibility of the scholarly record through persistent identifiers, structured metadata and established digital preservation practices. Version and correction information should remain linked to the article of record.

© 2026 The Author(s). Authors retain copyright in their articles.

Published by: Zeus Press

Address: Flat/Rm 91_3 9/F Chinachem Golden Plaza No.77 Mody Road Tsim Sha Tsui KL, Hong Kong

Individual paper reprints: service@zeus-press.org

CONTENTS

Financial Economics Research · Volume 3 · Issue 3 · 2026

A Study on Innovative Approaches to Teaching Cross-Border Marketing Courses in Higher Education Institutions in the Context of Digital Transformation	1
<i>Zhe Hu, Yanqin Wang</i>	
How Physical Climate Risks Impact the Risk Linkage of the Electricity Industrial Chain	7
<i>Yanlan Liu, Jiusheng Chen</i>	
Systemic Risk Transmission and Stratified Resilience in China's Banking Sector under Trade Frictions: Evidence from Executive Interviews across Different Types of Banks	24
<i>Chenhao He, Jinrui Zhang, Yuxuan Liu, Kangkai Peng</i>	
The Impact of Structural Monetary Policy on Commercial Banks' Credit Risk: A Quasi-Natural Experiment Based on the Central Bank's Carbon Emission Reduction Facility	35
<i>Chenlin Cai</i>	
A Brief Analysis of PROYA's Marketing Strategy Based on 4P Theory	47
<i>Jiayan Song</i>	
The Impact of Green Finance on Corporate Green Innovation: Operating Cash Flow as a Mediating Channel	53
<i>Leyan Liu</i>	
The Impact of the Proportion of Independent Directors on Corporate Profitability—A Comparative Analysis Based on Wuliangye and ST Yanshi	68
<i>Xinyu Zhang</i>	
ESG Performance, Financing Constraints, and Corporate Financial Performance	74
<i>Tingting Luo</i>	
Analysis of Urban-Rural Differences and Countermeasures in Inclusive Elderly Care in Guangxi	84
<i>Rui Pang</i>	
Risk Control: A Multi-Dimensional Review of Risk-Taking, Liquidity Creation, and Green Credit with ESG	99
<i>Mingxuan Shuai</i>	
Baseline Price Rigidity and Promotional Adjustment in Digital Distribution Platforms: Empirical Evidence from the Steam-Epic Rivalry	106
<i>Junyi Liu</i>	
Analysis of the Success and Challenges of Chinese Entrepreneurs in Semporna, Malaysia	117
<i>Shuyang Fan, Fumitaka Furuoka, Suteng Lee</i>	
An Analysis of the Effects of Trade Policy Uncertainty on Corporate Green Investment: The Viewpoints of Market Competition and Green Innovation	129
<i>Yixin Chen</i>	

CONTENTS

Financial Economics Research · Volume 3 · Issue 3 · 2026

Recognition of Data Assets in Financial Statements: A Systematic Literature Review on Concept Discrimination, Accounting Treatment and Management Systems	143
<i>Ruzhen Zhang</i>	

A Study on Innovative Approaches to Teaching Cross-Border Marketing Courses in Higher Education Institutions in the Context of Digital Transformation

Zhe Hu and Yanqin Wang*

Anhui Audit Vocational College, Hefei 230601, China

**Corresponding author: Yanqin Wang.*

Abstract

The digital transformation of cross-border marketing courses has evolved from a technological upgrade in teaching methods to a structural shift in educational paradigms. The digital restructuring of cross-border marketing channels and the rise of data-driven decision-making models are reshaping industry demands for marketing talent competencies, requiring curriculum instruction to adapt in terms of objectives, content frameworks, and practical platforms. However, current courses lag in aligning with job competency requirements, updating platform tools, and deepening industry-academia collaboration, which hinders the efficiency of matching talent development with industry needs. This study establishes an implementation framework for teaching innovation by referencing industry competency standards, focusing on four dimensions: objective reconstruction, content integration, platform development, and collaborative education, providing theoretical references and practical pathways for the digital transformation of business courses.

Keywords

digital transformation, cross-border marketing, course instruction, educational innovation, integration of industry and education

1. Introduction

The global cross-border marketing ecosystem is undergoing profound digital transformation. Emerging business models—social commerce, independent store operations, and AI-assisted content generation—are gradually replacing the traditional paradigm of platform-based sales tracking and advertising with a refined framework that integrates data insights, content creativity, and cross-cultural communication. This evolution demands that university marketing curricula not only impart established knowledge but also cultivate students' data literacy, tool adaptability, and cross-cultural decision-making. However, most higher education institutions still primarily focus on classic theoretical instruction and simulated software operations in cross-border marketing education, resulting in a clear gap between curriculum objectives and the competency standards required for real-world industry roles. Addressing how to respect the logical progression of disciplinary knowledge while responding to the rapidly evolving competency demands of the industry has become the central challenge in current curriculum reform.

2. New Requirements for Cross-Border Marketing Curriculum Teaching in the Context of Digital Transformation

2.1 Digital Reconstruction of Cross-border Marketing Channels and Outreach Methods

Traditional cross-border marketing is highly concentrated on third-party platforms such as Amazon and AliExpress, with operations centered around internal search ranking and advertising placement. After the rise of emerging channels such as TikTok Shop, Temu, and SHEIN, traffic has been simultaneously diverted to independent websites and social media e-commerce, and the channel pattern has shifted from a single-platform dominance to a decentralized multi-touchpoint layout. Consumer information acquisition has shifted, with decentralized paths—short video seeding, live streaming interaction, and acquaintance recommendations—gradually replacing search behavior as the primary touchpoint. “People looking for goods” has given way to “goods looking for people” driven by algorithms. The key nodes to reach consumers are no longer concentrated within the platform site, but scattered among the content field, social field, and private field. Marketers must handle multiple tasks—content planning, community management, and paid traffic acquisition—simultaneously. If the course still focuses on traditional platform operation skills, students will find it difficult to grasp the diversity of traffic sources and the complexity of reach paths, and there is an urgent need to establish a systematic understanding of the channel ecosystem [1].

2.2 The Multidimensional Reshaping of Marketing Capabilities by Data-driven Decision-making Models

The reference frame for enterprise operational decision-making is shifting from empirical judgment to data evidence. In the past, product selection, pricing, and advertising placement mainly relied on the personal experience and market intuition of business leaders. Nowadays, the data dimensions provided by platforms are becoming increasingly refined, and indicators such as conversion funnels, customer profiling, and repeat purchase cycles have become the basic language of daily operations. Marketers no longer receive vague sales figures, but rather behavior trajectories that can be targeted at specific groups, time periods, and touchpoints. This information forces decision-makers to develop a mindset of using data to verify hypotheses. Correspondingly, the job competency structure has undergone substantial changes, and simple skills in copywriting or advertising placement are no longer sufficient. Practitioners need to have the ability to extract effective information from raw data, identify abnormal fluctuations, and judge the correlation between variables. Course teaching cannot ignore this shift in required competencies, if only the marketing theory framework is taught and the systematic embedding of data literacy is ignored, students will find it difficult to understand the logical support behind business instructions after entering the job.

2.3 Upgrading the Demand for Composite Talents in the Cross-border e-Commerce Ecosystem

The complexity of industry ecology has far exceeded the scope of traditional international trade. Enterprises not only require marketers to master platform operations and foreign language communication skills, but also expect them to produce creative content, gain user insights in cross-cultural contexts, and integrate multi-channel resources. A single dimension of professional training is difficult to meet the comprehensive requirements of actual job positions. A qualified cross-border marketing practitioner often needs to simultaneously handle advertising flow, social account operation, localized content production, and even simple supply chain coordination tasks. The blurring of job responsibility boundaries has gradually led to the shift of the “specialist” model to the “generalist” training orientation. If the course teaching still follows fragmented knowledge modules and operates independently, students will find it difficult to adapt to the work rhythm of one person in multiple positions after entering the workplace, and they will also be unable to respond quickly in the complex and ever-changing overseas market.

3. The Main Shortcomings Faced by Cross-border Marketing Course Teaching in Universities

3.1 Insufficient Matching Between Course Objectives and Digital Job Requirements

The goal setting of most cross-border marketing courses in universities still revolves around traditional marketing theory frameworks. The training program usually requires students to master classic theories, be familiar with platform operation processes, and have basic foreign language application abilities, but it rarely includes data interpretation, content planning, and multi platform collaborative operation as clear graduation ability indicators. The recruitment requirements for junior marketing positions in enterprises have already covered specific job contents such as advertising flow, social account maintenance, and competitor monitoring, but the course objectives remain at a relatively broad level of ability description. The difference in discourse system between the two directly leads to a structural deviation between the training direction and the actual employment demand. If the teaching objectives cannot truly reflect the work logic of the industry and the operational norms of the position, the subsequent teaching content arrangement and practical design of the course will lack effective guidance basis [2].

3.2 The Teaching Content System Lags Behind in Following Up on Platform Iteration and Tool Updates

The platform rules and operational tools in the cross-border e-commerce industry are updated frequently. The traffic distribution mechanism of TikTok Shop is adjusted almost every quarter, and the intelligence level of the advertising delivery system continues to deepen. AI-assisted content generation tools are now entering daily workflows. The compilation of textbooks and the revision of course outlines follow their own revision cycles. A new set of textbooks often takes one to two years from project approval to publication, and by the time they are officially put into teaching, some of the operational guidelines may have become outdated. The teacher community also faces pressure, with daily teaching tasks and research assessments taking up a lot of energy. The time to truly follow up on platform changes and convert them into teaching resources is very limited. Schools lack a rapid-response mechanism for industry trends, and course content adjustments must pass through multiple layers of approval. Once the new teaching plan is approved for implementation, the industry's gameplay may have evolved further.

3.3 The Connection Between Practical Teaching Platforms and Real Cross-border Marketing Scenarios is Weak

Most universities rely on cross-border e-commerce simulation software for their practical activities. This type of software breaks down the operational process into standardized steps, allowing students to complete tasks such as product listing and order processing in a virtual environment. Platform data is generated based on fixed parameters, lacking the random fluctuations and competitive variables in the real market. In real scenarios, traffic costs shift in real-time with peer bids, buyer review sentiment is difficult to quantify, and sudden policy changes may alter market entry thresholds overnight. Simulation training cannot replicate such uncertainty. After completing the exercises, students have mastered the process specifications, but have not experienced the pressure of making judgments in the face of real data. The feedback from the company to the interns also confirms this deviation, as newly hired employees are familiar with the backend operation path but lack guidance on how to handle abnormal situations.

3.4 The Lack of Support for the Collaborative Mechanism Between Industry and Education and the Construction of Dual Qualified Teachers

Industry-education collaboration has long remained a one-way output—enterprises merely provide internship positions. The real operational data and typical work cases of industry associations and leading enterprises are difficult to enter classroom teaching, and the main channel for schools to obtain cutting-edge industry trends is still teachers' personal social networks, lacking institutionalized information transmission channels. Most of the teachers in the group enter teaching positions directly after graduating from universities, lacking systematic experience in cross-border marketing practice. Faced with the rapid iteration of industry operation logic, teachers' knowledge update speed lags significantly behind that of frontline practitioners. The

willingness of enterprises to participate in cooperative education has been declining year by year, due to the unequal input-output ratio - sending backbone personnel into the classroom and opening up backend data for teaching use require additional manpower and time, while short-term benefits remain unclear [3].

4. The Implementation Path of Teaching Innovation in Cross-Border Marketing Courses Under Digital Transformation

4.1 Reconstruction of Course Objective System Guided by Job Skills

The adjustment of the course objective system needs to start with job demand research. Colleges and universities should organize professional teachers to systematically sort out the work content of typical positions such as cross-border e-commerce operation specialists, advertising pitchers, and content planners, extract recurring tasks and decision-making situations from daily work, using them as the basis for curriculum goal design. Traditional syllabi use vague expressions like “mastering knowledge” and “understanding theory” to describe learning outcomes—terms that are difficult to measure and lack clear job relevance. The new target system should translate capability requirements into observable and evaluative behavioral performance, such as “being able to adjust bidding strategies based on advertising data” or “being able to write localized product copy for specific target markets”, replacing the previous vague capability descriptions. The division of target levels also needs to be adjusted synchronously, with the requirements for memorization and understanding compressed, while the weight of application, analysis, and evaluation increased, so that the course objectives truly reflect the cognitive requirements of job positions.

The deep logic of goal reconstruction lies in transforming the employment standards of enterprises into specific indicators of course learning outcomes. The expectation of enterprises for entry-level positions is not the mastery of theoretical knowledge, but whether the new employee can quickly take over daily operational affairs after joining. This means that the course objectives need to respond to this reality by incorporating specific work content such as advertising ROI analysis, competitor monitoring report writing, and cross-cultural communication design into the teaching objectives, so that students' learning process corresponds to the work process of the position. There are significant differences in the requirements for ability structure among different positions. Content based positions focus on creative output and copywriting expression abilities, while data based positions emphasize more on indicator interpretation and logical deduction abilities. Course objectives should set differentiated ability modules for students' different development directions, allowing students to choose corresponding ability training paths based on their own interests and career planning [4].

4.2 Updating Modular Teaching Content Guided by Digital Tools

Updating modular teaching content must start with tool iteration. The advertising delivery systems, data dashboards, and AI tools used in daily operations receive version updates and new features every few months. If the pace of updating teaching content is disconnected from the iteration of the tools, it will be impossible for students to apply what they have learned. The course team should establish a tracking mechanism for changes in industry tools, regularly review the rule changes and functional adjustments of mainstream platforms, and adjust the teaching focus and operational training content of each module based on this, and the structure of teaching modules should also be adjusted, as traditional chapter division is accustomed to organizing content according to marketing functions, such as “Fundamentals of Advertising”, “Consumer Behavior”, etc. This division method has no corresponding relationship in job work, and it is difficult for students to connect scattered knowledge into a complete workflow after learning. The new module design should be organized around the application scenarios of digital tools, linking knowledge points according to the logical clues of work tasks, and embedding dispersed marketing theories into specific tool operations and decision-making contexts. For example, in the advertising placement module, students need to simultaneously handle interrelated decision variables such as budget allocation, audience targeting, and creative material selection, rather than learning advertising principles and data analysis methods separately and then piecing them together on their own. The modules should also maintain a progressive relationship, with basic modules ensuring that students have the ability to independently operate mainstream tools, while the advanced modules introduce complex tasks such as cross platform combination delivery and multi-dimensional data cross analysis, so that the teaching content presents a ladder from tool proficiency to strategic thinking.

4.3 Construction of a Practical Training Platform and Case Library Characterized by the Combination of Virtual and Real Elements

The construction of training platforms needs to balance the operability of virtual simulation environments with the complexity of real business scenarios. The simulation software currently used by most universities provides a standardized operating interface, but cannot reproduce uncontrollable variables such as advertising bidding fluctuations, exchange rate changes, and buyer dispute resolution in the real market. The direction of platform upgrade should be to embed real business data and dynamic market signals in the virtual environment, so that students can face uncertainty consistent with real positions in simulated operations. The setting of practical training tasks should also avoid repetitive process operations, and should design phased projects that require comprehensive judgment, such as requiring students to complete the entire process from product selection decision-making to advertising placement to order fulfillment within a simulation cycle, and to cope with unexpected situations such as intensified competition and negative feedback crises that may occur randomly during the process.

The quality of case library construction directly affects the effectiveness of practical training teaching. The selection of teaching cases requires the establishment of clear screening criteria, and relying solely on publicly available enterprise reports and experience sharing posts on the internet cannot meet the depth requirements of teaching for cases. Colleges should establish a regular case collection channel with partner enterprises to obtain real operational data and decision documents that have been desensitized, ensuring that the case content contains complete background information, decision nodes, and result data. The presentation of cases also needs to take into account the applicability of different course modules. Cases for basic teaching should focus on the analysis and training of a single variable, while cases for comprehensive training should include complex situations interwoven with multiple variables, so that case resources can cover the complete teaching chain from specialized skill training to comprehensive decision-making exercises. The accumulation of typical cases will provide support for the continuous improvement of subsequent courses, and the common problems exposed by students in practical training can contribute to the optimization of teaching content and case design [5].

4.4 Teacher Co-construction and Curriculum Co-research Supported by School Enterprise Collaboration

The deepening of school enterprise collaboration requires breaking through the existing one-way transmission mode from the level of cooperation mechanism. Enterprises have long faced the dilemma of imbalanced input-output ratio, with additional manpower and time costs required for key personnel to teach on campus and for backend data to be opened up. However, the benefits of cooperation are difficult to manifest in the short term. If the school wants to maintain a long-term stable cooperative relationship, it should create practical value for enterprises—through curriculum development, talent delivery, and on-the-job training—shifting cooperation from one-way output to mutual benefit. At the level of teacher development, sending teachers to enterprises for on-the-job training is an effective way to fill the gap in practical experience. Schools should provide corresponding policy support in workload assessment and performance evaluation, and lower the institutional threshold for teachers to participate in enterprise practice. The depth of participation of enterprise mentors in teaching also needs to be further improved, moving beyond a lecture at the end of the semester or joint guidance for graduation projects, and instead letting enterprise backbone participate in the module design, case development, and classroom teaching throughout the entire process. The joint research of courses requires the school to open up the course development process to enterprises, regularly organize teaching seminars with the participation of teachers and enterprise backbone, adjust course content and practical training plans around the latest changes in the industry, and keep the courses in a dynamic and updated state.

5. Conclusion

Digital transformation brings not only knowledge supplementation and tool replacement, but also a fundamental questioning of course goal positioning, content logic, and training methods. Teaching design that ignores real industry needs leaves students trapped between theory and practice, while one-way technological catch-up—disconnected from educational principles—may reduce training to mere tool proficiency. The

effectiveness of the implementation of innovative teaching paths depends on whether universities can establish a sustainable dynamic calibration mechanism between industry competency standards and disciplinary education logic, so that courses can truly become effective intermediaries connecting academic literacy and professional competence.

References

- [1] Schlegelmilch B B, Mills J A. Artificial Intelligence and the Future of Marketing Education[J].Journal of Marketing Education, 2025, 47(2):91-93.
- [2] Beninger S, Reppel A, Stanton J, et al. Facilitating Generative AI Literacy in the Face of Evolving Technology: Interventions in Marketing Classrooms[J]. Journal of Marketing Education, 2025, 47(2):112-125.
- [3] Crittenden V, Peterson A R. Digital Disruption: The Transdisciplinary Future of Marketing Education[J]. Journal of Marketing Education, 2019, 41(1):3-4.
- [4] Richter S, Giroux M, Piven I, et al. A Constructivist Approach to Integrating AI in Marketing Education: Bridging Theory and Practice[J]. Journal of Marketing Education, 2025, 47(2):94-111.
- [5] Peña P, Riley J, Davis N. Marketing Meets the Machine: Practical Applications and Innovative Pedagogical Insights from the Frontlines of AI Adoption[J]. Marketing Education Review, 2025, 35(4):269-270.

Author Biography

Hu Zhe (October 1993-), Female, Han ethnicity, From Fuyang, Anhui, Graduate student, Research direction: Marketing.

Wang Yanqin (November 1989), female, Han ethnicity, born in Fuyang, Anhui, with an intermediate professional title and a postgraduate degree, Research Focus: Finance.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

How Physical Climate Risks Impact the Risk Linkage of the Electricity Industrial Chain

Yanlan Liu and Jiusheng Chen*

School of Economics & Management, Chongqing Normal University, Chongqing, China

**Corresponding author: Jiusheng Chen.*

Abstract

The physical risks of climate change are transmitting shocks along the entire electricity industrial chain, disrupting the cross-sectoral interdependencies between them. This study measures dynamic risk linkage across the upstream, midstream, and downstream segments of China's electricity industry chain using the DCC-GARCH model. Then, the MF-VAR model is used to investigate the impact of physical climate risk on the electricity power industry chain. The results reveal that the risk linkage network of China's electricity power industry chain exhibits significant heterogeneity. Upstream-midstream and upstream-downstream linkages are primarily characterized by negative risk hedging, whereas midstream-downstream connectedness displays positive risk synergy. Furthermore, different types of physical climate risks affect risk linkage within the power industry chain through distinct short-term impact pathways. Specifically, extreme temperatures and droughts influence upstream-midstream linkages by altering the power generation mix, whereas extreme rainfall directly disrupts midstream-downstream linkages through physical grid failures. In contrast, when these individual physical risks are aggregated into a comprehensive index, a rise in that index enhances overall risk co-movement. Moreover, the impacts of climate risk on segment returns are asymmetrical, with the midstream generation segment as the core value-loss zone and main vulnerability. These findings provide policy guidance to enhance climate adaptability and prevent cross-segment risk transmission.

Keywords

climate change, physical climate risk, electric power industry chain, DCC-GARCH model, MF-VAR model

1. Introduction

Promoting a green energy transition and optimizing the energy structure are not only the core pathways to achieving carbon neutrality but also vital cornerstones for ensuring national energy security and maintaining stable economic and social operations. As a pillar industry of the national economy, the stable and healthy development of the electricity power industry chain is key to fulfilling this foundational role. However, as global climate change intensifies, climate risk is becoming a major challenge threatening the stable operation of the power system. In February 2021, Texas experienced a once-in-a-century extreme cold storm, leaving approximately 4 million households without power for several days. In the summer of 2022, the Yangtze River basin in China endured the most severe meteorological drought since 1961, causing a sharp decline in hydropower generation. These extreme events clearly demonstrate that physical climate risks are exerting dual pressure on the power system from both supply and demand sides, posing a severe and complex security challenge.

Existing literature has primarily focused on the impact of climate risks on energy price volatility and power market operation. For example, Li et al. (2024) [1] employ an ARDL/NARDL model to examine the effect of climate risks on the dirty-clean energy stock price dynamic conditional correlations. However, few studies have systematically examined, from a holistic perspective of the electricity industry chain, how climate risks, particularly physical climate risks, influence risk interdependencies across its various segments. In fact, the upstream and downstream segments of the electricity industry chain are highly interdependent. Once a particular segment is impacted by extreme weather, the resulting supply shortages, price fluctuations, or facility shutdowns can easily propagate upstream and downstream along the industry chain, creating a multiplier effect that ultimately leads to systemic risk.

The impact of physical climate risks on the electricity sector is multifaceted and multi-path. Heavy rainfall can directly damage power plants and transmission and distribution facilities, triggering power outages and equipment scrappage. High temperatures and drought reduce river runoff, lowering hydropower output. Shortages of cooling water also restrict the operation of thermal and nuclear power units, resulting in tight power supply during summer peak demand periods. In addition, extreme cold, on the other hand, can cause ice accumulation on transmission lines, leading to failures such as broken wires and toppled towers. Moreover, these physical impacts can disrupt fuel transportation routes, interrupting the supply of coal and natural gas, thereby further jeopardizing power generation capacity and the normal functioning of society as a whole. It is evident that physical climate risks do not strike a single point in isolation but simultaneously affect multiple links in the chain, including power generation, fuel supply, and transmission and distribution.

For this reason, it is necessary to view the electricity industry chain as a complete risk transmission system. Climate risks often trigger a chain reaction through technical interdependencies and cost pass-through between upstream and downstream segments. Abdullah et al. (2023) [2] point out that during times of crisis, significant tail risk contagion exists within the electricity market, providing direct evidence for cross-segment risk diffusion under extreme climate events. A study by Apergis et al. (2015) [3] on the Australian market also shows that climate policy uncertainty can lead to structural breaks in electricity prices and generates risks across various segments of the entire industrial chain. The operational disruptions in the real economy caused by physical or policy shocks can rapidly spread to capital markets through channels such as corporate earnings expectations and investor sentiment, resulting in sharp fluctuations in stock prices within the power sector. For example, during the surge in coal prices in 2021, the total market capitalization of China's thermal power sector contracted sharply, while the coal mining index rose against the trend during the same period. Such cross-segment and cross-market risk linkages are sufficient to drag the entire electricity industry chain into crisis, directly threatening the stability of the entire industry chain. This gap highlights the urgency of treating the industry chain as a unified entity for risk transmission and of thoroughly exploring how physical climate risks influence internal risk correlations within it.

In light of this, this study focuses on China's electricity industry chain, dividing it into upstream, midstream, and downstream segments. First, the DCC-GARCH model is employed to measure the dynamic risk correlations among these segments. Subsequently, the Mixed-Frequency Vector Autoregression (MF-VAR) model is introduced to identify the differentiated impacts of physical climate risks on risk correlations within the industry chain and their transmission characteristics.

The contributions of this study are as follows: First, it expands the scope of research on the relationship between climate risks and energy markets from a holistic industry chain perspective; second, it quantifies the asymmetric effects of physical climate risks in risk transmission across different segments; and third, it provides decision-making guidance for enhancing the climate resilience of the electricity industry chain and preventing cross-segment risk transmission.

2. Literature Review

2.1 Climate Risk

Early research focused primarily on physical climate risks, including the direct economic and social impacts of extreme weather events. Mideksa et al. (2010) [4] pointed out that rising temperatures would alter cooling demand and affect power generation efficiency. Golombek et al. (2011) [5] narrowed their analysis to Western European markets and confirmed the multi-dimensional impacts of climate change on power systems. Emanuel

(2005) [6] showed that the destructive power of tropical cyclones had increased markedly over the previous three decades. Anna et al. (2014) [7] examined the immediate effects of heatwaves on power markets and found that extreme heat significantly increased electricity price volatility. As research progressed, scholars began to quantitatively assess climate impacts. Diaz et al. (2017) [8] quantified the economic risks associated with climate change, and Stern et al. (2016) [9] called for a more scientific decision-making framework that encompasses climate and energy issues. Recently, the literature has further classified climate risks into physical risks and transition risks.

Regarding physical risks, Pokhrel et al. (2021) [10] reveal the growing drought risks from a global water resource perspective. Vliet et al. (2016) [11] analyze the vulnerability of power generation infrastructure and point out that water shortages severely limit the cooling capacity of thermal and nuclear power plants. Concerning transition risks, Dupont et al. (2023) [12] systematically review thirty years of climate policy evolution in the European Union and illustrate the far-reaching impacts of policy uncertainty on energy markets. Oberthür et al. (2016) [13] analyze the EU's positioning under the Paris Agreement and offer approaches for understanding climate policy coordination. Ma et al. (2023) [14] construct a news-based climate policy uncertainty index for China, which serves as a vital tool for the quantitative measurement of transition risks. Several studies examine the interaction between the two types of risks simultaneously. For instance, Rao et al. (2023) [15] find that climate risks and carbon emissions exert heterogeneous shocks on energy markets through asymmetric spillover effects. Collectively, these studies demonstrate that climate risks extend beyond environmental issues and have become core economic variables driving financial market volatility and industrial chain restructuring.

2.2 The Impact of Climate Risk on Power Markets

Existing literature has confirmed the significant impacts of climate risks on power markets from multiple dimensions. Regarding prices and volatility, Ciarreta & Zarraga (2015) [16, 17] analyzed the price transmission mechanism of spot power markets in the Iberian Peninsula and Central Europe and established volatility models for the Spanish power market. Ioannidis et al. (2021) [18] used a periodic GARCH model with conditional skewness and kurtosis components to capture the complex volatility characteristics of electricity prices. Using data from the power market of England and Wales, Tashpulatov (2013) [19] provided empirical evidence on volatility. Employing the event study method, Mosquera-Lopez et al. (2018) [20] identified the causal effect of a specific supply shock, namely suspended hydropower generation, on electricity price dynamics.

In terms of market connectedness and risk spillovers, methodological advancements have been substantial. Diebold & Yilmaz (2009) [21, 22] proposed a spillover index framework based on variance decomposition and subsequently developed it into a predictive directional measurement approach, which has become a standard tool for risk spillover research. This method has been widely applied to power market studies. Pen Y L et al. (2010) [23] conducted an early analysis of volatility transmission mechanisms across European power forward markets. Diebold et al. (2019) [24] adopted a network topology approach based on variance decomposition to measure the connectedness structure of European power markets. Furthermore, research has expanded to cross-market linkages. Ding Qian et al. (2022) [25] investigated spillover effects among carbon, fossil energy, and clean energy markets from both time and frequency domains. Their results show that attention to climate change acts as a key factor driving cross-market risk spillovers. Focusing on China's carbon market, Yan et al. (2023) [26] tested the dynamic spillover effects of climate policy uncertainty and coal prices on carbon prices. From the perspective of information efficiency, Ren et al. (2024) [27] uncovered asymmetric spillover patterns between fossil energy and green markets.

2.3 Risk Linkages Within the Electricity Industry Chain

Most existing literature focuses on price spillovers and volatility transmission within a single market or across different markets, and can be categorized into three main lines of research. The first line of research centers on horizontal risk linkages among electricity markets. Sæther & Neumann (2024) [28] analyzed the impacts of the 2022 energy crisis on the North Sea power market and found that crisis shocks spread rapidly to neighboring markets through electricity prices. Ly et al. (2022) [29] adopted Copula-GARCH and dynamic state-space models to explore multi-dimensional dependence structures among European power markets. Hellwig et al. (2020) [30] provided a measurement framework for market integration. Uribe et al. (2020) [31]

quantified the integration features of the North Sea power market. These findings have greatly enhanced our understanding of horizontal risk spillovers between markets; however, their analytical units inherently sever the vertical linkages between electricity generation, transmission, and consumption, making it difficult to directly apply them to vertical risk analysis within the industrial chain.

The second line of research begins to address the internal structure of the power system. Do et al. (2020) [32] analyzed dynamic volatility linkages between the Irish and Great Britain markets, and their research implicitly addressed cross-border co-movement within the power industry chain. Erdogdu (2016) [33] identified asymmetric volatility features in European power markets, while Rao et al. (2023) [34] further verified the asymmetric transmission of climate shocks across energy markets. However, these studies still treat the electricity market as a “black box” and do not delve deeply into the heterogeneous responses and amplification mechanisms of shocks across various stages within the industrial chain.

The third research strand extends to the broad impacts of climate risks on energy firms. Fuss et al. (2008) [35] were among the earliest scholars to examine how climate policy uncertainty shapes energy investment decisions. Ma Rufe et al. (2022) [36] investigated how economic policy uncertainty drives volatility spillovers in power markets. From the firm performance perspective, Pham et al. (2024) [37] revealed the correlation between energy consumption and external shocks. Cepni et al. (2022) [38] discussed the feasibility of hedging climate risks through green assets. Although these studies are becoming increasingly numerous, most treat the industrial chain as a homogeneous whole, overlooking the possibility that climate risks may generate heterogeneous shocks through the interdependent structures between upstream and downstream segments of the chain, thereby altering the risk landscape of the entire chain.

In summary, the existing literature has established a comprehensive framework covering risk identification, quantitative measurement, and analysis of transmission mechanisms. However, significant shortcomings remain in the following areas: First, few studies treat the upstream, midstream, and downstream segments of the power industry chain as an integrated risk system and directly measure the vertical risk correlations within it. Second, there is a lack of empirical testing from a time-varying perspective on how physical climate risks, by altering the degree of these vertical linkages, lead to the amplification or buffering of risks across different segments of the industry chain. Third, the microfoundations of how climate risks exert heterogeneous shocks on the revenues of various segments through industry chain linkages have not been sufficiently elucidated.

3. Research Design

3.1 DCC-GARCH Model

To scientifically measure the level of dynamic risk linkage within the power industrial chain, this paper adopts the DCC-GARCH model proposed by Engle (2002).

First, to depict the volatility clustering inherent in the return rate series of the upstream, midstream, and downstream segments of the power industrial chain, univariate GARCH models are constructed for each series, respectively. Since the GARCH(1,1) model has been widely verified to effectively capture the volatility characteristics of most financial time series, this paper adopts this baseline model, and its conditional variance equation is specified as follows:

$$\sigma_{i,t}^2 = \omega + \alpha \varepsilon_{i,t-1}^2 + \beta \sigma_{i,t-1}^2 \quad (1)$$

The coefficients ω , α and β are estimated via the maximum likelihood method. ω refers to the constant term; α is the coefficient of the lagged squared residual; β is the coefficient of the lagged conditional variance itself. The sum $\alpha + \beta$ reflects the persistence of residual volatility. A larger value of this sum implies that current volatility is strongly affected by historical shocks, and the magnitude of future volatility decays slowly; the opposite holds true for a smaller value.

After obtaining the conditional variances and standardized residuals of the return rate series for each segment, a dynamic conditional correlation structure is constructed. As a multivariate extension of the GARCH model, this model first establishes a GARCH model for each variable to generate standard deviations and obtain standardized residuals. These standardized residuals are then used to estimate the correlation coefficient matrix in the form of a GARCH-type specification.

3.2 MF-VAR Model

Traditional VAR models cannot directly estimate parameters when they contain variables with different data frequencies; all variables must be converted to a uniform frequency, which may result in the loss of sample information. As a type of model capable of direct estimation using mixed-frequency data, the MF-VAR effectively addresses this limitation of standard VAR models. For the estimation of missing values, the Kalman filter approach or Bayesian mixed-frequency data method is predominantly adopted. Data iteratively generated from these two approaches can efficiently supplement the sample information embedded in low-frequency data without sacrificing information contained in high-frequency series. This paper employs the second method to estimate the MF-VAR model.

According to relevant literature, the general form of the MF-VAR(p) model can be derived by modifying the standard VAR model. This paper assumes that the high-frequency data are monthly series:

$$x_t = \phi_c + \phi_1 x_{t-1} + \phi_2 x_{t-2} + \cdots + \phi_p x_{t-p} + \mu_t, \quad \mu_t \sim \text{iidN}(0, \Sigma) \quad (2)$$

Equation (1) is converted into matrix form as follows. Let $X_t = [x'_t, \dots, x'_{t-p+1}]$ and $\Phi = [\phi_1, \dots, \phi_p, \phi_c]'$. The matrix representation of the MF-VAR model is presented below, which also serves as the state transition equation of the MF-VAR model.

$$X_t = F_1(\Phi)X_{t-1} + F_c(\Phi) + v_t, v_t \sim \text{iidN}(0, \Omega(\Sigma)) \quad (3)$$

where $F_1(\Phi)$ denotes the coefficient matrix of the MF-VAR model in matrix form, and $F_c(\Phi)$ stands for its constant term. v_t represents the stochastic error term of the MF-VAR model, which follows an independently and identically distributed normal distribution with a mean of zero and variance $\Omega(\Sigma)$. $\Omega(\Sigma)$ is an $n \times n$ matrix whose upper-right block equals Σ , while all other elements are zero.

4. Data and Descriptive Statistics

4.1 Data

To examine the impacts of climate risks on risk linkages within the power industry chain, this paper constructs stock return series covering the upstream, midstream, and downstream segments based on the actual structure of the industry chain. The detailed classification is as follows: the upstream segment includes coal mining, thermal power equipment, photovoltaic equipment, and wind power equipment; the midstream segment covers thermal power generation, hydropower generation, wind power generation, and photovoltaic power generation; the downstream segment consists of power supply equipment and power grid equipment. Considering industrial representativeness, market capitalization, and data availability, this paper selects listed companies with typical industry characteristics from each segment, totaling 26 firms. The sample period runs from January 2011 to December 2023, and all data are recorded at a monthly frequency. The original stock price data are obtained from the CSMAR database, and returns are calculated based on prices adjusted for stock splits and dividends.

For each listed company, this paper calculates its monthly logarithmic return. To further capture the systematic volatility characteristics of each segment in the industry chain, principal component analysis (PCA) is applied to the stock return series of firms within the upstream, midstream, and downstream segments separately. The first principal component is extracted as the representative return series for each segment. This method retains most of the original information while effectively reducing data dimensions and highlighting common trends.

To investigate the impacts of physical climate risks, this paper selects the following annual climate indices: extreme heat index, extreme cold index, extreme precipitation index, extreme drought index, and a composite index measuring the overall level of physical climate risks. These climate indices are sourced from the ISETS Energy-Finance Network.

4.2 Descriptive Statistics

Table 1 illustrates the descriptive statistics of return series for the electricity industry chain. As demonstrated in Table 1, the mean values of all series are close to zero, which is consistent with the typical characteristics of financial return series. In terms of variance, the midstream return series exhibits the highest volatility, followed by the upstream series, while the downstream series has the lowest volatility, indicating that the power generation

segment in the midstream faces the greatest market uncertainty. Furthermore, the Jarque-Bera test rejects the null hypothesis of normality at the 1% level for all samples, confirming that the return series follow a typical leptokurtic and fat-tailed distribution. Unit root tests confirm that all series are stationary.

Table 1: Descriptive Statistics

	Mean	Variance	Skewness	Kurtosis	JB	ADF	Q(10)	Q ² (10)
upstream	0	3.497	0.473**	1.403***	20.050***	-4.897**	4.766	11.249***
midstream	0	6.434	0.182	3.490***	86.167***	-4.487**	7.169	43.013***
downstream	0	2.587	0.540***	3.445***	91.210***	-5.409**	14.165	41.337***

Notes: ***, ** and * are statistically significant at 1%, 5% and 10%, respectively.

5. Results and Discussion

5.1 Estimation of Univariate Volatility Models

To estimate the GARCH model, 10 GARCH family models, including the GARCH, IGARCH, and GJR-GARCH models with Student's t distribution, the skewed Student's t distribution, and normal distribution, were utilized to fit the stock market return series. The selected models were chosen based on the Akaike information criterion (AIC), the Bayesian information criterion (BIC), the Schwarz information criterion (SIC), and the Hannan-Quinn information criterion (HQIC). Table 2 shows the GARCH model fitting results for each segment of the electricity industry chain. For the Upstream return series (Panel A), the optimal model is IGARCH (1,1) with Student's t distribution. The sum of the ARCH coefficient and the GARCH coefficient equals one, which is consistent with the IGARCH model. The Ljung-Box test and ARCH-LM test on the standardized residuals after model estimation are both insignificant, confirming that the model fully captures the volatility clustering effect of the series. As for the Midstream return series (Panel B), the optimal model is GJR-GARCH(1,1) with Student's t distribution. This model introduces an asymmetric coefficient γ as its core parameter. The estimation results show that γ is -0.34904, which implies a strong leverage effect exists in the midstream power generation segment. For the Downstream return series (Panel C), the best model is GARCH (1,1) with a skewed Student's t distribution. The skewness parameter estimated from the model is greater than 1, indicating that the return distribution is right-skewed. In other words, the probability of extreme positive returns is slightly higher than that of extreme negative returns.

Table 2: GARCH Model fitting results for the Upstream Return Series

Model	AIC	BIC	SIC	HQIC
Panel A: Upstream Return Series				
IGARCH(1,1)-t	4.103877	4.178257	4.102778	4.134064
GARCH(1,1)-t	4.115038	4.208013	4.113333	4.152771
GARCH(1,1)-sstd	4.119916	4.231486	4.11748	4.165196
GJR-GARCH(1,1)-t	4.122769	4.234339	4.120333	4.16805
GARCH(1,2)-t	4.127042	4.238612	4.124606	4.172322
GARCH(1,1)-norm	4.129988	4.204368	4.128889	4.160175
GARCH(1,2)-sstd	4.131839	4.262004	4.128548	4.184666
GARCH(1,2)-norm	4.141851	4.234826	4.140147	4.179585
GARCH(2,1)-norm	4.142094	4.235069	4.14039	4.179828
GARCH(2,2)-norm	4.153779	4.265349	4.151343	4.199059
Panel B: Midstream Return Series				
GJR-GARCH(1,1)-t	4.392406	4.503976	4.38997	4.437686
IGARCH(1,1)-t	4.44206	4.51644	4.440961	4.472247
GARCH(1,1)-t	4.442367	4.535342	4.440662	4.4801
GARCH(1,1)-sstd	4.444599	4.556169	4.442163	4.48988
GARCH(1,2)-sstd	4.448865	4.57903	4.445574	4.501692
GARCH(1,2)-t	4.457838	4.569408	4.455403	4.503119
GARCH(1,1)-norm	4.522751	4.597131	4.521652	4.552938
GARCH(2,1)-norm	4.535026	4.628001	4.533322	4.57276
GARCH(1,2)-norm	4.535405	4.62838	4.533701	4.573139
GARCH(2,2)-norm	4.547579	4.659149	4.545143	4.592859
Panel C: Downstream Return Series				
GARCH(1,1)-sstd	3.679437	3.753817	3.678338	3.709624

Model	AIC	BIC	SIC	HQIC
IGARCH(1,1)-t	3.682076	3.793647	3.679641	3.727357
GARCH(1,1)-t	3.685464	3.778439	3.683759	3.723197
GJR-GARCH(1,1)-t	3.701526	3.813096	3.699091	3.746807
GARCH(1,2)-t	3.741848	3.853419	3.739413	3.787129
GARCH(1,2)-sstd	3.755642	3.885808	3.752352	3.80847
GARCH(2,2)-norm	3.756095	3.867665	3.753659	3.801375
GARCH(1,1)-norm	3.768673	3.843053	3.767574	3.79886
GARCH(2,1)-norm	3.784435	3.87741	3.782731	3.822169
GARCH(1,2)-norm	3.831791	3.924766	3.830086	3.869524

5.2 Estimation of DCC-GARCH Model

After obtaining robust univariate volatility models, this paper adopts the DCC-GARCH model to estimate the time-varying correlation coefficients for each pair of segments among the upstream, midstream, and downstream. The estimation results of the DCC parameters are presented in Table 3.

As described in Table 3, both parameters θ_1 and θ_2 are significantly positive at the 1% level, and their sum is less than one, satisfying the model's stability condition. To test the overall goodness-of-fit of the DCC-GARCH model, joint diagnostic tests are performed on the multivariate standardized residual series obtained from the model estimation. The Ljung-Box Q test shows no significant autocorrelation in any of the standardized residual series or their squared counterparts, suggesting that the model has fully captured both linear and nonlinear dependence within the return series.

Table 3: Estimation Results of DCC-GARCH Parameters

	μ	ω	α	β	shape	γ	skew
upstream	0.0000	0.0003	0.0001	0.9999	9.4092*		
midstream	0.0000	0.4697**	0.3290***	0.7593***	5.8003***	-0.3490***	
downstream	0.0000	0.4056**	0.1468*	0.6985***	6.2081		1.0210***
	θ_1	θ_2	AKaike	Bayes	shibata	Hannan-Quinn	
DCC estimates	0.0383	0.8239***	11.485	11.894	11.455	11.651	

Based on the above optimal DCC-GARCH model for each segment of the electricity industry chain, this paper extracts three sets of dynamic conditional correlation coefficient series: upstream-midstream, upstream-downstream, and midstream-downstream. The descriptive statistics are presented in Table 4, which clearly reveal the structural characteristics of internal risk connectedness within the electric power industry chain.

As described in Table 4, the average correlation coefficient between upstream and midstream is -0.629 and remains negative throughout the full sample period. This reveals a persistent, strong risk-hedging effect within the traditional energy value chain centered on coal and thermal power. Rising upstream raw material and equipment costs directly squeeze the profits of midstream power generators, resulting in a stable negative correlation between their returns. As for the upstream and downstream pair, the average correlation coefficient is -0.345, indicating an overall negative relationship and significant risk hedging between the upstream and downstream segments of the power industry chain. Turning to the Midstream and downstream pair, the average correlation coefficient is 0.397 and remains predominantly positive over the entire sample period, demonstrating a prominent risk synergy between midstream power generation and downstream equipment sectors.

Table 4: Descriptive Statistics of Dynamic Correlation Coefficients

	Mean	standard	minimum	maximum	median
upstream-midstream	-0.629298186	0.049659114	-0.736310115	-0.510187466	-0.632071917
upstream-downstream	-0.344806006	0.059473032	-0.470133111	-0.163083685	-0.34867761
midstream-downstream	0.39690847	0.067369572	0.17390101	0.509480533	0.412156872

Next, we will analyze the dynamic correlation among various segment pairs in the electricity industry chain. Figure 1 shows that the correlation between the upstream and midstream segments remains strongly negative in the long run, with fluctuations primarily driven by cost shocks to the coal-power value chain. From 2011 to 2013, the correlation coefficient hovered around -0.75. During 2014-2015, hydropower output rebounded, and coal prices entered a downward cycle. In 2020-2021, the combined impacts of extreme weather and the global

energy crisis triggered a coal price surge. It was not until 2022-2023 that policies to secure coal supply and stabilize coal prices took effect, alongside advances in electricity pricing marketization reform, gradually reverting the correlation coefficient back to its long-term average.

Figure 1: Dynamic Correlation Coefficient between Upstream and Midstream

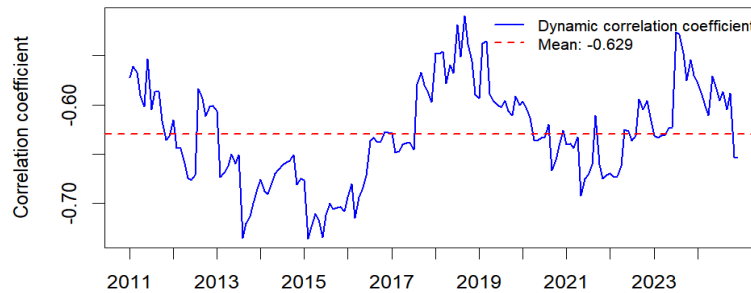
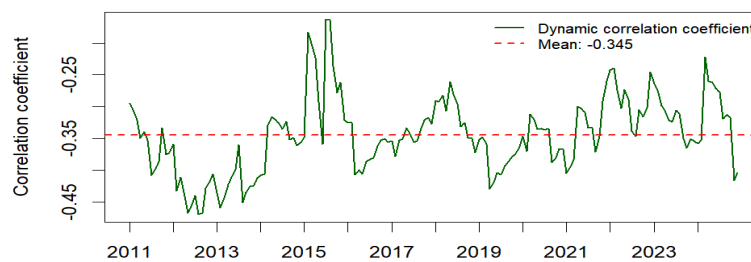


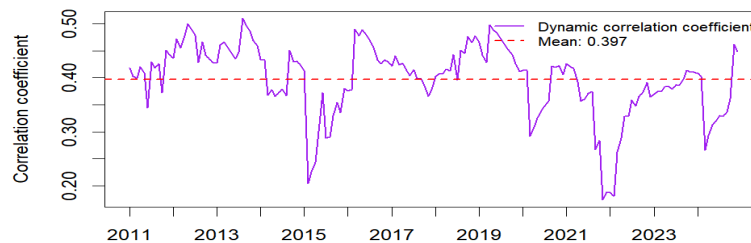
Figure 2 illustrates a moderate negative correlation between upstream and downstream segments of the electricity industry chain, whose dynamic evolution is primarily driven by the interplay of equipment investment cycles and power grid construction policies. Between 2012 and 2013, the correlation coefficient reached -0.45. During 2014-2015, increased investment in distribution grid upgrades and the implementation of policies to stabilize economic growth jointly boosted demand for power grid equipment. From 2016 to 2019, the correlation coefficient fluctuated around its mean. The extreme surge in coal prices in 2021 brought thermal power investment willingness to a record low, dragging the correlation coefficient down again.

Figure 2: Dynamic Correlation Coefficient between Upstream and Downstream



The correlation between the midstream and downstream segments exhibits stable positive co-movement in Figure 3, reflecting the inherent alignment between the expansion of power generation installed capacity and the associated demand for supporting equipment. During the 12th Five-Year Plan period (2011-2015), driven by clear capacity expansion targets, the correlation coefficient steadily climbed from 0.2 to 0.5. A sharp drop occurred in 2014-2015, mainly because abundant hydropower output curtailed thermal power investment. In 2021, widespread losses in the thermal power sector and the phase-out of new energy subsidies weighed on short-term equipment demand, triggering a pullback of the coefficient.

Figure 3: Dynamic Correlation Coefficient between Midstream and Downstream



In conclusion, using the DCC-GARCH model, this paper systematically uncovers the complex and time-varying risk linkage network within China's power industry chain, laying an empirical foundation for accurately identifying risk spillover channels and evaluating the transmission effects of external shocks.

5.3 Impact of Physical Climate Risks on Risk Linkages in the Electricity Industry Chain

The previous section accurately measured the degree of internal risk linkages. To further elucidate how exogenous climate risks affect the internal correlation structure of the electricity industry chain, we employ the Mixed-Frequency Vector Autoregression (MF-VAR) model to systematically trace the transmission channels. Impulse response functions are employed to empirically test the time-varying effects of five climate risk factors—low temperature disaster (LTD), high temperature disaster (HTD), extreme rainfall disaster (ERD), extreme drought disaster (EED), and the General Physical Climate Risk Index (GCPRI) on the three dynamic correlation coefficient series.

The impulse response results (Figure 4-8) clearly reveal the differentiated impacts of various physical climate risks on the correlation among distinct segments of the electricity industry chain, with these effects characterized by a short-lived and highly heterogeneous nature. However, owing to their distinct physical properties, different climate risks exert notably divergent influences on specific links of the power industry chain, leading to notable differences in the direction and magnitude of their shocks.

5.3.1 Effects of Low Temperature Disasters (LTD) on Risk Linkages in the Electricity Industry Chain

Figure 4 shows that extreme low temperatures exert a significant positive shock on the midstream-downstream correlation. Extreme cold greatly increases heating power demand, driving a sharp surge in load on midstream power generators. Meanwhile, peak regulation and power supply guarantee pressures mount on the downstream grid sector, which markedly strengthens their short-term coordination in coping with demand spikes.

By contrast, extreme cold triggers a notable negative shock to the upstream-downstream correlation, stemming from misaligned demand transmission. The core priority of downstream firms is real-time power supply security, focusing on stable power transmission and distribution as well as load assurance. Their demand is directly linked to midstream power generation rather than upstream equipment or raw materials, which weakens and delays demand transmission to the upstream and reduces the direct correlation. Under extremely low temperatures, the upstream fails to respond swiftly to indirect downstream demand, dampening their interactive linkage.

For the upstream-midstream correlation, the shock turns positive in the initial phase before turning negative thereafter. The short-run positive effect arises from the surge in coal consumption by thermal power units during cold weather, urgent maintenance needs for anti-freezing of wind and solar power facilities, and anti-icing inspections for hydropower equipment. These factors trigger a sharp increase in the midstream's short-term demand for coal procurement and spare parts supply from the upstream. As upstream output capacity becomes tightly tied to midstream power supply assurance, their correlation rises rapidly. Later, due to saturated upstream supply, receding midstream demand, and stabilized power supply mechanisms, the midstream's incremental reliance on the upstream fades, pulling the correlation downward.

Figure 4: Extreme Low Temperature

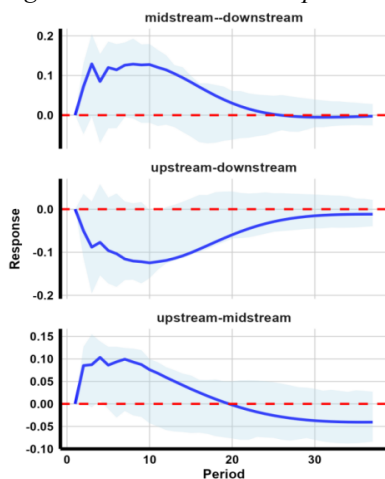
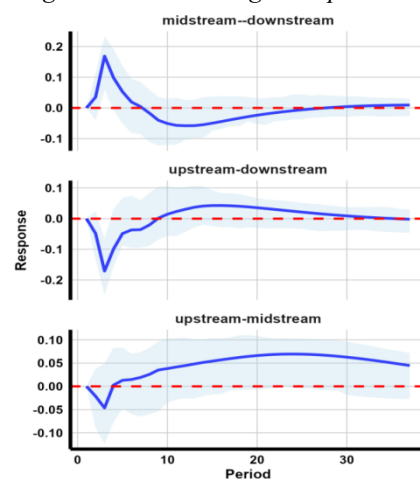


Figure 5: Extreme High Temperature



5.3.2 Effects of High Temperature Disasters (HTD) on Risk Linkages in the Electricity Industry Chain

Figure 5 indicates that extreme high temperatures generate a shock on the midstream-downstream correlation that follows an initial increase followed by a decrease. In the early stage, rising cooling loads strengthen the positive co-movement between midstream power generation returns and downstream grid returns. However, prolonged high temperatures reduce photovoltaic power generation efficiency, decrease hydropower inflows, and increase overload risks for grid equipment, placing simultaneous pressure on both power generation and transmission segments. This disrupts their coordination and drives the correlation downward.

Extreme heat delivers a strong negative shock to the upstream-downstream correlation, for reasons similar to those for extreme low temperatures: demand transmission from downstream core operations to upstream raw materials and equipment is blocked by the midstream. Meanwhile, upstream producers maintain normal output without emergency capacity adjustments, creating a supply-demand disconnect with downstream needs and pushing the correlation sharply lower.

The upstream-midstream correlation fluctuates from negative to positive. To meet surging power loads, midstream thermal power plants must procure coal immediately to run units at full capacity. At the same time, high temperatures cause power curtailment for midstream wind and solar facilities, temporarily suppressing upstream demand for new energy equipment. This mismatch between upstream supply structure and midstream generation demand pulls the correlation rapidly into negative territory.

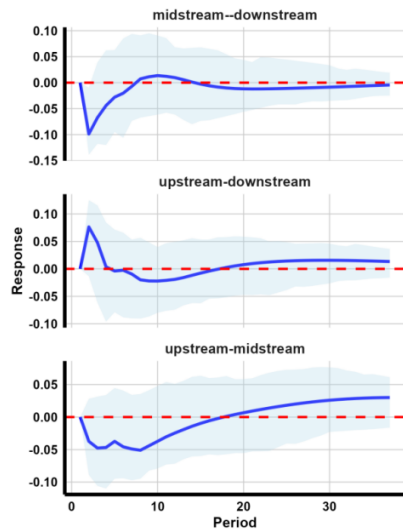
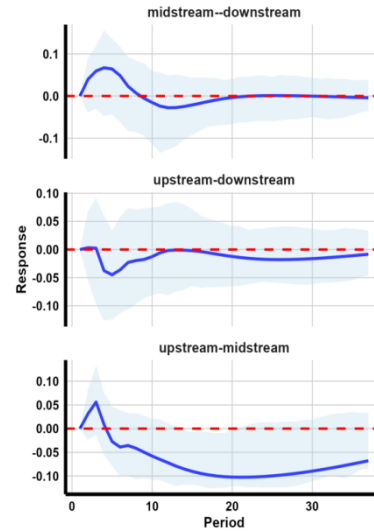
As the heatwave persists, market forces and policy interventions gradually correct this imbalance. On the one hand, upstream coal producers ramp up supply by activating temporary production capacity and clearing transportation routes, gradually matching the fuel demand of thermal power generators. On the other hand, regulatory measures such as coal price controls and subsidies for new energy equipment purchases normalize the midstream's demand for fuels and hardware. Production coordination between upstream and midstream sectors steadily recovers, eventually lifting the correlation to a relatively high level of 0.75. Ciarreta et al. (2017) [39] study continuous electricity prices in Germany and Austria and find that extreme temperature shocks induce pronounced volatility clustering at intraday high-frequency intervals. This finding offers theoretical support for the negative-to-positive fluctuation pattern of the upstream-midstream correlation triggered by heatwaves documented in this paper.

5.3.3 Effects of Extreme Rainfall Disasters (ERD) and Extreme Drought Disasters (EED) on Risk Linkages in the Electricity Industry Chain

As two opposing extreme hydrological and climatic events, extreme rainfall and extreme drought exert opposite effects on risk linkages in Figure 6 and Figure 7.

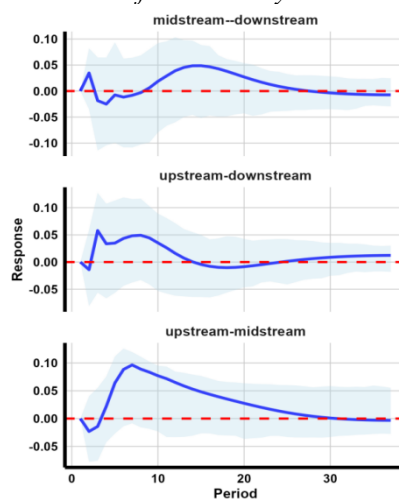
Extreme rainfall imposes a more pronounced shock on the midstream-downstream correlation in Figure 6. Heavy rainfall leads to excess hydropower generation and water spillage, waterlogging-induced shutdowns of thermal power plants, and malfunctions of wind and photovoltaic facilities. Output from midstream power plants becomes highly unpredictable, making stable coordination with downstream transmission and distribution impossible and thereby undermining their linkage. Meanwhile, extreme rainfall may increase upstream demand for hydropower equipment maintenance and downstream demand for grid restoration, triggering a positive response in the upstream-downstream correlation.

By contrast, extreme drought significantly strengthens the upstream-midstream correlation in Figure 7. Drought immediately suppresses hydropower output, forcing thermal power units to cover baseload power and sharply increasing the short-term correlation between coal demand and power generation. In the later stage of drought, the midstream gradually optimizes its energy mix by maximizing wind and solar output to offset hydropower shortages and reduce reliance on thermal power, thereby cutting demand for upstream coal and driving the correlation down rapidly. The short-run positive shock of drought on the midstream-downstream correlation reflects the shared pressures of supply security and coordination needs faced by power generators and grid operators amid anticipated power shortages.

Figure 6: Shocks of Extreme Rainfall*Figure 7: Shocks of Extreme Drought*

5.3.4 Effects of General Physical Climate Risk Index (Gcpri) on Risk Linkages in the Electricity Industry Chain

As a comprehensive indicator, an increase in the GCPRI generates positive short-term shocks to all three correlation pairs in Figure 8. This suggests that when the overall level of climate risk rises, all segments of the power industry chain collectively face systemic pressures related to power supply security and operational safety. The upstream energy and equipment supply, midstream power generation, and downstream grid transmission sectors all need to strengthen coordination under uncertainty to cope with potential extreme weather events. Consequently, overall risk linkages across the industry chain intensify in the short run. This reflects the inherent requirement for coordinated response between power generation sources and the power grid in the face of climate risks.

Figure 8: Shocks of General Physical Climate Risk

Empirical evidence from the mixed-frequency model in this section demonstrates that physical climate risks constitute a key exogenous driver of short-term volatility and structural shifts in internal risk interdependencies within the power industry chain. This provides new micro-level evidence for understanding how climate risks propagate through financial markets and undermine the stability of energy systems.

5.4 Impacts of Physical Climate Risks on Electricity Industry Chain

To further examine the micro-level transmission channels of climate risks, this section employs MF-VAR model to investigate the direct effects of different climate Risk on the representative return series of the upstream, midstream, and downstream.

5.4.1 Effects of Extreme Low Temperatures on Electricity Industry Chain

Extreme low temperatures cause fluctuating positive shocks to upstream returns in Figure 9. Cold weather boosts coal demand, benefiting upstream coal firms in the short term. It also raises demand for equipment inspection and replacement, bringing temporary gains to upstream manufacturers. However, extreme cold exerts sustained negative shocks on midstream returns. Ice accumulation reduces wind output, photovoltaic efficiency drops, and thermal and hydropower units face higher operating costs. Extreme cold may also damage generation facilities, adding downward pressure on returns. Downstream returns also suffer. Grid companies face rising maintenance and capital costs. Equipment demand becomes unstable as thermal investment slows and new energy projects are delayed. Overall, extreme cold negatively impacts all downstream segments.

Figure 9: Extreme Low Temperature

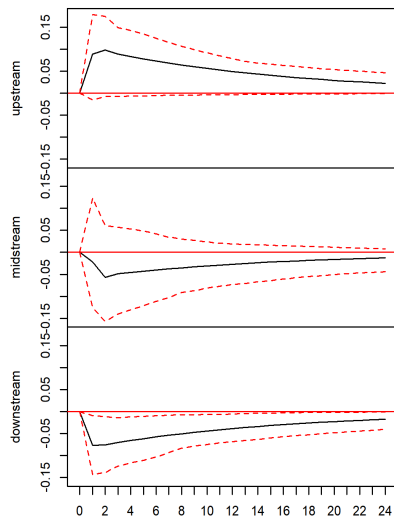
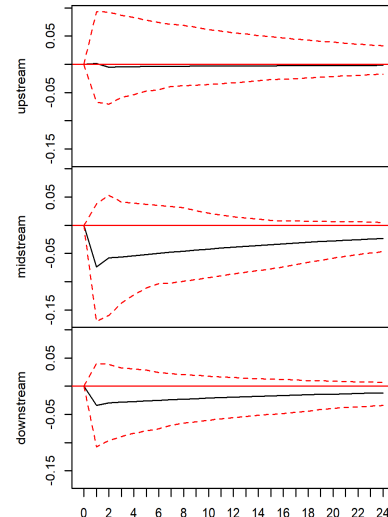


Figure 10: Extreme High Temperature



5.4.2 Effects of Extreme High Temperatures on Electricity Industry Chain

Upstream returns exhibit short-term fluctuations in response to extreme high temperatures, with little long-term impact in Figure 10. High temperatures reduce photovoltaic efficiency and thermal equipment cooling performance, temporarily hurting equipment makers. But surging air-conditioning demand boosts coal consumption, offsetting the negative effects. Thus, the overall upstream impact is limited. In contrast, extreme heat causes sustained and significant negative shocks to midstream returns. Hydropower inflows decline, photovoltaic efficiency falls, and thermal plants face cooling and emission constraints. Although total generation may rise, higher marginal costs, efficiency losses, and rationing risks erode profits, leading to persistent return declines. Downstream returns also suffer negative shocks. Heat increases line losses and reduces transmission efficiency. Grids must use costly peak-regulation resources, raising operating expenses. Hot weather also raises equipment failure risks, requiring more investment in reliability. As a result, downstream segment returns are suppressed.

5.4.3 Effects of Extreme Rainfall and Extreme Drought on Electricity Industry Chain

When hit by extreme rainfall, upstream returns experience short-term negative fluctuations in Figure 11, as post-disaster equipment demand offsets initial damage to wind and solar stations. But midstream sectors suffer sustained shocks: floods threaten hydropower dams, submerge thermal plants, and damage renewable bases, causing output losses and asset damage. Downstream grids also face heavy repair costs and revenue losses from outages. In contrast, extreme drought boosts upstream returns. Hydropower cuts raise coal demand, benefiting coal firms, while sunny weather aids solar generation, lifting equipment expectations. Midstream

impacts are mixed: hydropower loses, but thermal and solar gain from tight supply and price expectations. However, power shortage risks and high operating costs pressure overall midstream returns. Downstream grids face complex, costly dispatching and public pressure from rationing.

Figure 11: Shocks of Extreme Rainfall

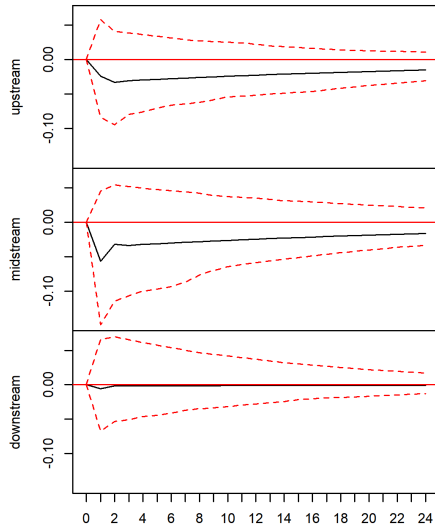
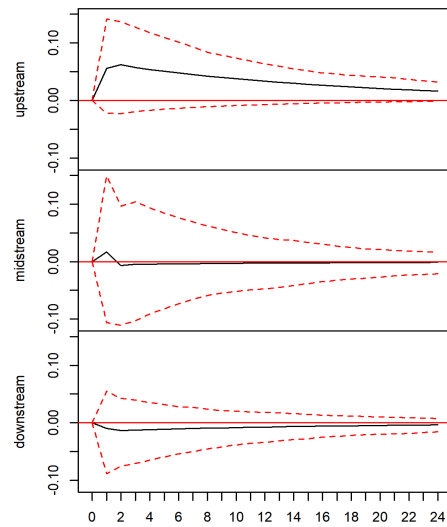


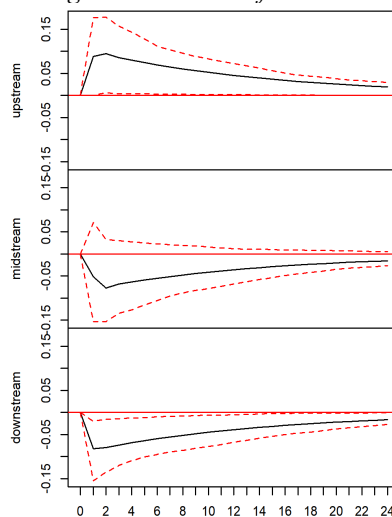
Figure 12: Shocks of Extreme Drought



5.4.4 Effects of General Physical Climate Risk on Electricity Industry Chain

General physical climate risks exert positive shocks on upstream returns while negatively affecting midstream and downstream returns in Figure 13. When climate risks intensify, energy security becomes paramount. Coal, as a reliable baseload source, gains market value, benefiting coal firms. Rising climate awareness also boosts demand for resilient grid equipment, creating opportunities for upstream manufacturers. For midstream generators, climate risks bring operational hazards—unstable output, higher costs, and asset damage—making this segment the main value-loss zone, with returns under persistent pressure. Downstream returns also decline. Grids, as the supply-demand hub, must absorb volatility and damage from climate events, increasing regulation costs and infrastructure spending. Since electricity price adjustments often lag behind these rising costs, downstream returns are suppressed.

Figure 13: Shocks of GCPRI



6. Conclusions

This paper investigates the impacts of physical climate risks on risk interlinkages and segment returns across China's electricity industry chain. Using DCC-GARCH and the MF-VAR models to construct

representative return series for the upstream, midstream, and downstream segments, this study characterizes the time-varying features of risk linkages within the industry chain and identifies the heterogeneous effects of different climate risks on the interlinkage structure and returns at each segment. The main conclusions are as follows.

First, China's electricity industry chain has formed a highly heterogeneous and structurally complex network of risk interlinkages. The DCC-GARCH model reveals that there is negative risk hedging between the upstream and midstream sectors, as well as between the upstream and downstream sectors, stemming from traditional cost conflicts between coal and electricity and imbalances in the supply and demand of power equipment. Conversely, there is positive risk co-movement between the midstream and downstream sectors, reflecting phased resonance between power generation investment and equipment demand.

Second, physical climate risks, as key exogenous shocks, trigger short-term fluctuations in risk linkages within the power industry chain, and their transmission pathways exhibit significant heterogeneity. Impulse response analysis of the MF-VAR model shows that the impact effects of various extreme climate events are concentrated in the early stages and then dissipate rapidly. However, the transmission mechanisms differ markedly. Extreme heat and drought primarily disrupt the upstream–midstream linkage by altering the power generation mix, whereas extreme rainfall directly disrupts interdependencies between the midstream and downstream segments through physical failures in transmission and distribution grids. It is worth noting that when the Comprehensive Physical Climate Risk Index (GCPRI) rises, the market's consensus expectations regarding short-term coordination across all segments strengthen, which in turn amplifies the overall risk co-movement.

Third, the impacts of climate risks on the return rates of different segments of the industry chain are asymmetrically distributed, with the midstream as the core value-loss zone and risk vulnerability. Further analysis reveals that the heterogeneous transmission of these risk interactions is rooted in the differing responses of each segment's profits to climate risks. Under all climate disasters, midstream returns suffer sustained and significant negative shocks, highlighting the dual squeeze between their responsibility to ensure supply and cost pressures. The upstream segment, on the other hand, often experiences periodic positive fluctuations in returns due to the hedging properties of coal resources or the need for equipment upgrades. The downstream power grid segment generally faces downward pressure due to rising system balancing costs. These heterogeneous responses in upstream, midstream, and downstream returns collectively form the micro-foundation for the evolution of the aforementioned risk interlinkage model.

Based on these findings, this study proposes policy recommendations across three dimensions. Financial risk regulators should establish a tiered climate risk early warning system and a cross-segment emergency coordination mechanism. Corresponding industry-wide contingency plans should be activated based on the warning levels of different climate risks. For example, during high-temperature and drought warnings, energy authorities should coordinate upstream coal reserves and transportation capacity in advance, optimize the dispatch sequence of midstream power generation units, and deploy demand response plans to downstream power grids, thereby shifting emergency management from reactive response to proactive prevention.

Policymakers should increase policy support and risk buffers for the midstream power generation segment to strengthen energy supply safety. On the one hand, electricity market reforms should be deepened to provide reasonable economic compensation to power sources, such as thermal power plants, that undertake system reserve and peak-shaving tasks, thereby offsetting the soaring operating costs caused by climate disasters. On the other hand, power generation companies should be guided to use financial instruments such as green bonds, climate insurance, and carbon trading to hedge against physical risks, and they should be provided with fiscal and tax incentives or special re-lending support for upgrading their climate adaptation technologies.

Given the stable negative risk-hedging relationship between upstream and downstream segments of the industrial chain, investors could establish long-short pairing strategies or diversified allocations between upstream and midstream, as well as between upstream and downstream, to effectively hedge against volatility caused by coal-fired power cost conflicts and imbalances in equipment supply and demand. Furthermore, given the heterogeneous transmission pathways of different extreme weather events, implement differentiated sector rotation strategies.

References

- [1] Li D, Wu Z, Tang Y. Do climate risks affect dirty–clean energy stock price dynamic correlations?[J].Energy Economics, 2024, 136.
- [2] Abdullah Mohammad, Abakah Emmanuel Joel Aikins, Wali Ullah G M, et al. Tail risk contagion across electricity markets in crisis periods[J]. Energy Economics, 2023,127, Part B:107100.
- [3] Apergis N, Lau M C K. Structural breaks and electricity prices: Further evidence on the role of climate policy uncertainties in the Australian electricity market[J].Energy Economics, 2015, 52(DEC.PT.A):176-182.
- [4] Mideksa T K, Kallbekken S. The impact of climate change on the electricity market: A review[J].Energy Policy, 2010, 38(7):P.3579-3585.
- [5] Golombek R, Kittelsen S A C, Haddeland I. Climate change: impacts on electricity markets in Western Europe[J].Climatic Change, 2012, 113(2):357-370.
- [6] Emanuel K.Increasing destructiveness of tropical cyclones over the past 30 years[J].Nature, 2005, 436(7051):686.
- [7] Anna, Pechan, Klaus, et al. The impact of heat waves on electricity spot markets[J]. Energy Economics, 2014
- [8] Diaz D, Moore F. Quantifying the economic risks of climate change[J]. Nature Climate Change, 2017, 7(11):774-782.
- [9] Stern P C, Sovacool B K, Dietz T. Towards a science of climate and energy choices[J].Nature Climate Change, 2016.
- [10] Pokhrel Y, Felfelani F, Satoh Y, et al.Global terrestrial water storage and drought severity under climate change[J].Nature Climate Change[2026-06-11].
- [11] Vliet M T H V, Wiberg D, Leduc S, et al.Power-generation system vulnerability and adaptation to changes in climate and waterresources[J].Nature Climate Change, 2016.
- [12] Dupont C, Moore B, Elin Lerum BoassonViviane GraveyAndrew JordanPaula KivimaaKati KulovesiCaroline KuzemkoSebastian OberthürDmytro PanchukJeffrey RosamondDiarmuid TorneyJale TosunIngmar Homeyer.Three decades of EU climate policy: Racing toward climate neutrality?[J].Wiley Interdisciplinary Reviews. Climate Change, 2024, 15(1):n/a-n/a.
- [13] Oberthür, Sebastian, Groen L. The European Union and the Paris Agreement: leader, mediator, or bystander?[J].Wiley Interdisciplinary Reviews: Climate Change, 2016.
- [14] Ma Y R, Liu Z, Ma D, et al.A news-based climate policy uncertainty index for China[J].Scientific Data, 2023, 10(1).
- [15] Rao A, Lucey B, Kumar S. Climate risk and carbon emissions: Examining their impact on key energy markets through asymmetric spillovers[J].Energy economics, 2023(Oct.):126
- [16] Ciarreta A, Zarraga A. Analysis of Mean and Volatility Price Transmissions in the MIBEL and EPEX Electricity Spot Markets[J].Energy Journal, 2016, volume 36(4):41-60.
- [17] Ciarreta Aitor, Zarraga Ainhoa. Modeling realized volatility on the Spanish intra-day electricity market[J]. Energy Economics, 2016,58:152-163.
- [18] Ioannidis F, Kosmidou K, Savva C, et al.Electricity pricing using a periodic GARCH model with conditional skewness and kurtosis components[J].Energy Economics, 2021, 95(6):105110.
- [19] Tashpulatov S N. Estimating the volatility of electricity prices: The case of the England and Wales wholesale electricity market[J].Energy Policy, 2011, 60(sep.):81-90.
- [20] Mosquera-Lopez S, Uribe J M, Manotas-Duque D F. Effect of stopping hydroelectric power generation on the dynamics of electricity prices: An event study approach[J].Renewable and Sustainable Energy Reviews, 2018, 94(OCT.):456-467.

- [21] Diebold F X, Kamil Y. Measuring Financial Asset Return and Volatility Spillovers, With Application to Global Equity Markets[J].Economic Journal, 2009, 119(534):158-171.
- [22] Diebold F X, Yilmaz K. Better to Give than to Receive: Predictive Directional Measurement of Volatility Spillovers[J].International Journal of Forecasting, 2012, 28(1):57-66.
- [23] Pen Y L, Sevi B. Volatility transmission and volatility impulse response functions in European electricity forward markets[J].Energy Economics, 2010, 32(4):758-770.
- [24] Diebold F X, Y Lmaz K. On the network topology of variance decompositions: Measuring the connectedness of financial firms[J].Journal of Econometrics, 2014, 182(1):119-134.
- [25] Ding Qian, Huang Jianbai, Zhang Hongwei. Time-frequency spillovers among carbon, fossil energy and clean energy markets: The effects of attention to climate change[J]. International Review of Financial Analysis, 2022,83:102222.
- [26] Yan W, Cheung A. The Dynamic Spillover Effects of Climate Policy Uncertainty and Coal Price on Carbon Price: Evidence from China[J].Finance Research Letters, 2022.
- [27] Ren X, Xiao Y, Duan K, et al.Spillover effects between fossil energy and green markets: Evidence from informational inefficiency[J].Energy Economics, 2024, 131.
- [28] Sæther Bjarne, Neumann Anne. The effect of the 2022 energy crisis on electricity markets ashore the North Sea[J]. Energy Economics, 2024,.
- [29] Ly Sel, Sriboonchitta Songsak, Tang Jiechen, et al. Exploring dependence structures among European electricity markets: Static and dynamic copula-GARCH and dynamic state-space approaches[J]. Energy Reports, 2022,.
- [30] Hellwig Michael, Schober Dominik, Woll Oliver. Measuring market integration and estimating policy impacts on the Swiss electricity market[J]. Energy Economics, 2020, 86.
- [31] Uribe J M, Stephanía Mosquera-López, Guillen M. Characterizing electricity market integration in Nord Pool[J].Energy, 2020, 208:118368.
- [32] Do H X, Nepal R, Jamasb T. Electricity Market Integration, Decarbonisation and Security of Supply: Dynamic Volatility Connectedness in the Irish and Great Britain Markets[J].SSRN Electronic Journal, 2020.
- [33] Erdogdu E. Asymmetric volatility in European day-ahead power markets: A comparative microeconomic analysis[J].Energy Economics, 2016, 56:398-409.
- [34] Rao A, Lucey B, Kumar S. Climate risk and carbon emissions: Examining their impact on key energy markets through asymmetric spillovers[J].Energy economics, 2023(Oct.):126.
- [35] Fuss S, Szolgayova J, Obersteiner M, et al.Investment under market and climate policy uncertainty[J].Applied Energy, 2008, 85(8):708-721.
- [36] Ma Rufei, Liu Zhenhua, Zhai Pengxiang. Does economic policy uncertainty drive volatility spillovers in electricity markets: Time and frequency evidence[J]. Energy Economics, 2022,.
- [37] Pham Huy, Ha Van, Le Hanh-Hong,et al. The effects of polluting behaviour, dirty energy and electricity consumption on firm performance: Evidence from the recent crises[J]. Energy Economics, 2024.
- [38] Cepni O, Demirer R, Rognone L. Hedging climate risks with green assets[J].Economics Letters, 2022, 212.
- [39] Ciarreta A, Muniain P, Zarraga A. Modeling and forecasting realized volatility in German–Austrian continuous intraday electricity prices[J].Journal of Forecasting, 2017.

Funding

This work was supported by the National Social Science Fund of China [Grant Number: 24BJY078]

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

Systemic Risk Transmission and Stratified Resilience in China's Banking Sector under Trade Frictions: Evidence from Executive Interviews across Different Types of Banks

Chenhao He[†], Jinrui Zhang[†], Yuxuan Liu^{*} and Kangkai Peng

School of Economics and Management, Beijing Jiaotong University, Beijing 264401, China

[†]These authors contributed equally to this work and share first authorship.

^{*}Corresponding author: Yuxuan Liu.

Abstract

Since 2018, the China–U.S. trade war has become a major source of uncertainty in the global economy and has also had significant implications for China's financial system. This paper examines how the spillover effects of the trade war translate into systemic risk within the banking sector, with particular attention to the heterogeneous responses of banks of different sizes and ownership structures. Based on in-depth interviews with senior executives from large state-owned banks, national joint-stock banks, and small local banks, this study applies thematic analysis to identify two main transmission channels through which external economic shocks affect banks, including disruptions in export-related demand and client repayment capacity. The findings suggest that large state-owned banks are relatively less exposed due to their diversified client base and stronger risk-buffering capacity, whereas local banks face more pronounced credit risk pressures, largely driven by their concentrated sector exposure and more limited access to stabilizing financial instruments during periods of stress.

Keywords

trade war, systemic risk, banking, qualitative interviews

1. Introduction

Since 2018, following the Trump administration's launch of the "Section 301 Investigation" targeting Chinese imports, China–U.S. trade relations entered a new phase of sustained friction. This period has been widely regarded as marking a resurgence of protectionist measures at the global level.

The evolution of trade tensions can be broadly divided into three stages. The first stage began in July 2018, when the United States imposed a 25% tariff on approximately \$34 billion of Chinese goods, signaling the formal onset of large-scale trade confrontation. During this period, the impact was primarily concentrated in export-oriented firms directly exposed to U.S. markets.

The second stage emerged in May 2019, when tariffs on roughly \$200 billion of Chinese exports were increased from 10% to 25%. At this point, the effects began to propagate more deeply through global value chains, affecting not only final exporters but also upstream and midstream suppliers.

The third stage started with the signing of the “Phase One” economic and trade agreement in January 2020. Since then, the bilateral relationship has gradually shifted from tariff escalation toward a more persistent form of strategic economic competition, including technology restrictions and regulatory measures.

Table 1: Comparison of Asset Quality of Chinese Commercial Banks in 2024

Category	Indicator	Value	Source
Industry Overall	Average NPL Ratio of Commercial Banks	1.50%	(NFRA, 2024)
Bank Type	NPL Ratio of Large Commercial Banks	≈1.25%	(NFRA, 2024)
Bank Type	NPL Ratio of Rural Commercial Banks	≈3.34%	(NFRA, 2024)
Key Industry	NPL Ratio of Real Estate Sector (affected by both trade and macro cycles)	4.94%	(PBOC/Bank Annual Reports, 2024)
Risk Coverage	Provision Coverage Ratio of Commercial Banks	211.19%	(NFRA, 2024)

Amiti et al. [1] (2019) argue that U.S. tariffs on China generate significant indirect economic effects, with a substantial portion of the costs ultimately borne by the importing country and transmitted to the real economy through higher prices of intermediate and final goods. This transmission compresses corporate profit margins and leads firms to scale back investment in the context of weaker demand and heightened uncertainty. Similarly, Caldara et al. [2] (2020) show that trade policy uncertainty dampens economic activity and increases macroeconomic volatility through expectation channels, while also affecting risk premia in financial markets. Together, these findings suggest that trade shocks operate not only through real economic channels but also through financial market mechanisms that influence systemic risk.

As the literature has expanded, the analytical focus has gradually shifted from individual firms to production networks and supply chain structures. Huang et al. [3] (2019) emphasize that within global value chains, firms are more strongly affected by indirect trade exposure than by direct export shocks, highlighting the importance of industrial linkages in risk transmission. Li Zheng et al. [4] (2024) further show that trade policy uncertainty increases tail risk across Chinese industries, with more pronounced effects in sectors characterized by higher network connectivity. From a theoretical perspective, Acemoglu et al. [5] (2012) in the American Economic Review demonstrate that micro-level shocks can be amplified through production networks and propagate into aggregate fluctuations, providing a key framework for understanding the diffusion of trade shocks along supply chains.

In the financial sector literature, most studies examine the interaction between bank behavior and macro-financial conditions. Angeloni et al. [6] (2015) argue that accommodative monetary policy may increase bank leverage by reducing financing costs, thereby amplifying systemic risk. Roy [7] (2025) further decomposes trade-related shocks into multiple channels, including credit, market, and liquidity risk. Building on this perspective, Caldara et al. [2] (2020) find that trade policy uncertainty affects bank lending behavior by tightening firms’ financing constraints and altering perceived risk exposure, thereby reshaping risk allocation within the financial system.

With regard to bank heterogeneity, Carletti et al. [8] (2024) show from a market power perspective that larger banks tend to adopt more conservative strategies. Li Feifei and Xue Ruile [9] (2025) find that local government debt expansion exerts stronger risk pressure on small and medium-sized banks. Yue Hua et al. [10] (2020) further suggest that managerial capability plays a decisive role in banks’ ability to create liquidity.

Interview evidence further indicates that different types of banks have developed a differentiated risk-buffering structure in response to trade shocks. Large state-owned banks maintain relatively low non-performing loan (NPL) ratios of around 1.25%, which is largely associated with their scale advantages and diversified business portfolios. Joint-stock banks appear more sensitive to market fluctuations, as they are able to capture changes in export orders through supply chain finance instruments and mitigate exchange rate exposure using foreign exchange hedging tools. By contrast, rural commercial banks and city commercial banks, whose operations are more closely embedded in local export-oriented industrial chains and who have more limited access to risk management instruments, exhibit higher NPL ratios of up to 3.34% (NFRA [11], 2024).

Building on this empirical observation, several gaps in the existing literature become more apparent. First, the transmission channels through which trade shocks propagate into the banking system have not been systematically mapped. Most studies treat trade shocks, corporate risk, and bank risk as separate layers, without fully addressing the intermediary role of supply chain networks. Second, micro-level evidence on how banks perceive and process risk remains limited. Existing research largely relies on macro data or econometric inference, while the internal process through which banks interpret signals such as order flows, payment terms, and industrial chain positions is still not well understood, leaving the formation of risk largely as a “black box.” Third, although differences in bank behavior are widely documented, much of the literature focuses on outcome heterogeneity rather than the underlying mechanisms driving differences in risk perception and strategic decision-making.

To address these gaps, this paper draws on frontline interview data and develops an analytical framework of “macro shock–network transmission–risk perception–strategic response.” The framework is used to trace how trade friction shocks are transmitted within the banking system and to explain how heterogeneous banking institutions generate differentiated forms of systemic resilience.

2. Research Design and Interview Methodology

2.1 Sample Selection and Interview Process

The sample was selected with consideration of institutional coverage, regional variation, and relevance to foreign trade exposure. It includes major state-owned commercial banks (Industrial and Commercial Bank of China, Agricultural Bank of China, Bank of China, China Construction Bank, and Bank of Communications), as well as national joint-stock banks, city commercial banks, and rural commercial banks. To capture perspectives at the decision-making level, interviewees were mainly senior executives, including bank presidents and heads of risk management and corporate banking departments, drawn from approximately 9 to 12 banks. The selected institutions cover both economically developed export-oriented regions such as the Yangtze River Delta and Pearl River Delta, as well as central and western provinces. Banks with relatively large asset scales and significant overseas exposure were also included to improve representativeness.

The interviews were conducted primarily in a semi-structured format, using a combination of online and in-person modes. Each interview lasted approximately 40 to 60 minutes. Prior to data collection, participants were contacted through industry associations or direct professional networks, and the purpose of the study was explained. With consent, all interviews were audio-recorded and supplemented with field notes. After each session, recordings were transcribed and merged with notes to form a consolidated dataset for subsequent analysis.

2.2 Interview Outline Design and Ethical Considerations

The interview guide was developed on the basis of existing literature and the specific research questions of this study. It focuses on participants’ perceptions of trade war impacts, mechanisms of risk transmission, bank-level risk management practices, understandings of systemic financial risk, and the heterogeneous effects on different types of financial institutions. A combination of structured and open-ended questions was used to ensure consistency in core information while allowing space for interviewees to elaborate on their experiences and interpretations. Prior to the formal fieldwork, a pilot interview was conducted to refine question clarity and reduce potential ambiguity.

Ethical considerations were integrated throughout the research process. Before each interview, participants were informed of the purpose of the study, the procedure, and their rights as respondents, and informed consent was obtained on a voluntary basis, including the option to withdraw at any time. To protect confidentiality, both institutional and personal identifiers were anonymized in all transcripts and subsequent analysis, with real names replaced by categorical labels. All data were used exclusively for academic purposes, stored in encrypted form, and managed in accordance with standard research data protection requirements.

2.3 Data Coding and Thematic Analysis

The coding process was guided by the analytical framework of “macro shock–network transmission–micro response” developed in the literature review, and further adjusted in line with the specific research questions. To assist the organization and visualization of qualitative data, structure mapping tools were used during the analytical process. To improve reliability, a dual-coding procedure was adopted in which two researchers independently coded the same interview transcripts and subsequently compared their results. Any discrepancies were resolved through discussion until consensus was reached.

Open coding was first conducted on the interview materials. After removing filler expressions, repetitions, and irrelevant content, the transcripts were examined line by line to identify meaningful statements. Key expressions related to shock perception, transmission channels, risk management practices, and institutional characteristics were extracted and assigned preliminary codes, with attention paid to preserving variation in respondents’ wording and avoiding unnecessary aggregation at this stage.

Axial coding was then used to reorganize the initial codes in relation to the analytical dimensions derived from the literature, including real economy transmission, financial condition adjustment, and bank heterogeneity. These were gradually consolidated into four main thematic categories: “Perception of Trade War Shocks,” “Risk Transmission Channels,” “Risk Management Strategies,” and “Differences Among Bank Types.” The resulting categories were reviewed to ensure that no major conceptual dimension of the interviews had been overlooked.

Thematic analysis was ultimately oriented toward addressing the gaps identified in the literature, particularly the mechanisms through which risk perceptions are formed and translated into action across different types of banks. Rather than treating these categories as fixed structures, the analysis focused on their interconnections and variations across institutions, thereby providing an empirical basis for the subsequent discussion.

3. Theoretical Expectations

In the context of global production networks, the effects of trade frictions on the financial system are unlikely to remain confined to firms directly engaged in import and export activities. Instead, they tend to propagate through production and transaction linkages within industrial chains. When tariff shocks reduce external demand, export-oriented firms experience rising operational pressure, which is then transmitted to upstream and downstream partners through reduced order volumes, longer payment cycles, and cost adjustments. Such processes generate a network-based diffusion of risk along the supply chain. The transmission of tariff shocks is not uniform across firms. Differences in bargaining power, technological capabilities, and positions within the value chain lead to asymmetric adjustment patterns. Firms with stronger technological advantages or upstream positioning are generally better able to pass costs downstream, whereas firms in lower value-added or more competitive segments are more likely to absorb shocks through margin compression. As a result, the impact of trade frictions on bank credit risk is more plausibly reflected in the accumulation of indirect pressures transmitted through supply chain networks, rather than being driven by isolated shocks from individual exporting firms.

Against this background, banks differ significantly in how such risks are perceived and managed. Large banks, characterized by diversified client portfolios and more stable funding structures, tend to rely more on macroeconomic conditions and industry-wide indicators in their risk assessment. Market-oriented banks, with deeper involvement in supply chain finance, are more sensitive to micro-level signals such as order flows and settlement patterns, which allows them to capture emerging risks earlier along the industrial chain. By contrast, regional banks are more closely tied to local economic structures and small and medium-sized enterprises, making their risk exposure more directly linked to regional industrial conditions. Taken together, these differences suggest that the banking system does not respond to trade shocks in a uniform manner. Instead, heterogeneous institutions absorb and process risk through distinct channels, resulting in a stratified pattern of risk absorption that contributes to the overall resilience of the financial system under external shocks.

4. Data Analysis

Drawing on the perceptions of frontline banking employees regarding trade frictions and systemic risk across different types of financial institutions (see Tables 2, 3, and 4), and based on a comparison among state-owned banks, joint-stock banks, and city commercial banks, the evidence suggests that the impact of trade frictions on China's banking system is not best understood as a uniform shock. Rather, it operates through a set of structurally embedded and heterogeneous risk formation processes. Across different types of banks, there are noticeable variations in how risks are perceived, how potential vulnerabilities are identified, and how responses are organized. These differences do not eliminate systemic exposure, but they shape distinct pathways through which risks are absorbed and managed within the banking system, contributing to a differentiated pattern of resilience under external shocks.

Table 2:

Interview Module	Research Question	Representative Original Statements (Evidence)	Inductive Concept	Theme	Core Code
Perception of Trade Shocks	Risk Transmission Mechanism	"Risk does not exist in isolation; it spreads through upstream and downstream relationships in the industrial chain."	Trade shocks diffuse level by level through the industrial chain	Networked risk transmission via supply chains	Industrial chain; risk transmission
Perception of Trade Shocks	Supplier Risk Exposure	"Suppliers of export enterprises are more obviously affected, with extended accounts receivable cycles."	Non-direct export enterprises are also affected by trade shocks	Implicit supply chain risk exposure	Network effects; supply chain risk
Perception of Trade Shocks	Tariff Cost Pass-through Capacity	"Many enterprises cannot fully pass on tariffs and can only compress profit margins."	Enterprises' bargaining power determines the degree of cost pass-through	Profit margin compression	Price transmission; profit compression
Bank Risk Management	Risk Identification Mechanism	"Banks not only focus on individual enterprises but also identify risks from an industrial chain perspective."	Banks identify potential risks from an industrial chain perspective	Industrial chain perspective in risk control	Industrial chain identification; risk assessment
Bank Risk Management	Credit Process Control	"The three checks (investigation, review, inspection) form a closed-loop credit risk control."	Standardized processes strengthen risk control	Credit process governance	Three checks on loans; credit closed loop
Bank Risk Management	Risk Customer Management	"For customers showing risk signals, we implement list-based management and one-account-one-policy."	Personalized risk resolution and dynamic monitoring	Refined risk management	List-based management; one-account-one-policy
Macro Policy Influence	Monetary Policy Influence	"Banks adjust resource allocation according to central bank policies, such as developing inclusive finance."	Monetary policy is transmitted to the real economy through banks' strategies	Policy-oriented strategic adjustment	Monetary policy; resource allocation
Macro Policy Influence	Foreign Exchange Risk Management	"Banks can provide enterprises with hedging products such as forward contracts."	Foreign exchange derivatives are used to reduce trade risks	Exchange rate risk management	Forward contracts; exchange rate hedging
Systemic Risk Cognition	Risk Sources	"Trade shocks are mostly transmitted indirectly through supply chains."	Indirect supply chain risks outweigh direct export risks	Indirect risk exposure	Supply chain transmission; asset quality
Bank Operating Pressure	Sources of Profit Pressure	"Deposit growth is sluggish, liability costs are rising, and loan spreads are narrowing."	Dual squeeze on both asset and liability sides	Balance sheet structural pressure	Liability costs; narrowing spreads

Future Risk Judgment	Banking Sector Risks	“Credit risk remains the main risk for the banking system in the future.”	Bank risks exhibit structural characteristics	Credit risk dominance	Credit risk; structural risk
----------------------	----------------------	---	---	-----------------------	------------------------------

Table 3:

Analysis Dimension	City Commercial Banks	Large State-owned Banks	Joint-stock Banks	Cross-case Comprehensive Conclusion
Risk Transmission Mechanism	Risks mainly transmitted through local industrial chain upstream and downstream	Impacts more pronounced in technology-intensive industrial chains	Rising risks for SMEs in upstream supply chains	Trade shocks exhibit networked diffusion through supply chains
Price Pass-through Capacity	Most enterprises struggle to fully pass on tariffs	Enterprises' bargaining power depends on technological barriers	Leading enterprises have stronger pass-through capacity	Industrial chain position determines price pass-through capacity
Credit Risk Management	Emphasis on industrial chain identification and list-based management	Strengthened cash flow analysis and post-loan management	Adjusted credit structure to reduce foreign trade exposure	Banks generally strengthened industrial chain perspective in risk management
Foreign Exchange & Policy Response	Resource allocation adjusted according to central bank policies	Strict implementation of regulatory policies and provision of hedging products	More prudent cross-border fund management	Monetary and foreign exchange policies are important institutional constraints on bank risk management
Systemic Risk Cognition	Systemic risk depends on local industrial structure	Overall stability of the banking system is strong	Industry risks diffuse through supply chains	The banking system as a whole has relatively high resilience
Sources of Operating Pressure	Dual squeeze on asset and liability sides	Stable deposit base	Balancing pressure between regulatory indicators and risk control	Different banks differ in liability structure and scale advantages
Competition & Strategic Positioning	Leverage localization advantages to improve decision-making efficiency	Steady operation relying on scale and institutional advantages	Enhance competitiveness through product innovation	Bank competitive advantages stem from scale, institutions, and localized services
Future Risk Judgment	Credit risk is the main source of risk	Trade shock impact is limited but shows industry differences	Structural risks related to government debt	Bank risks exhibit structural characteristics

Table 4:

Theme No.	Core Theme	Theoretical Keywords
T1	Networked risk transmission via supply chains	supply-chain transmission
T2	Asymmetric bargaining power and profit compression	bargaining power, profit compression
T3	Industrial chain perspective in credit decision-making	supply-chain credit assessment
T4	Institutional policy constraints	institutional governance
T5	Bank asset-liability pressure	balance-sheet pressure
T6	Institutional resilience of the banking system	systemic resilience
T7	Structural evolution of trade shocks	structural risk transformation

Interview evidence suggests that the transmission of trade frictions to bank credit quality is not primarily driven by firms directly engaged in import and export activities. Instead, it unfolds gradually through supply chain networks, operating as a form of network-mediated risk propagation. Among state-owned bank employees, trade frictions are not perceived as triggering abrupt systemic stress through asset price volatility

or liquidity shocks. Rather, risk is understood as being passed along industrial linkages in a stepwise manner. Several interviewees pointed out that upstream firms with stronger bargaining power are often able to transfer tariff costs downstream, while midstream processors face simultaneous pressure from cost transmission and delayed payments. Risk therefore tends to accumulate at structurally vulnerable nodes within value chains rather than spreading evenly across sectors. A key factor shaping this process is the heterogeneity in firms' ability to absorb or pass through tariff shocks. According to interviewees, this capacity is closely linked to firms' position in the industrial chain and the level of technological barriers in their industry. Firms with stronger technological capabilities or market dominance are more likely to shift costs downstream, whereas firms operating in more competitive or low-margin sectors tend to absorb shocks through profit compression.

Despite a shared recognition of these transmission channels, banks differ markedly in how such risks are observed and interpreted. Large state-owned banks tend to assess risk primarily through industry structure and macro-level changes, relying on broad sectoral performance rather than individual export exposure. Interviewees noted that high-tech manufacturing and "specialized, refined, distinctive, and innovative" firms generally exhibit stronger resilience to trade frictions, while asset-light service industries are more sensitive to external demand fluctuations. Joint-stock banks, by contrast, are more directly exposed to supply chain finance activities and therefore place greater emphasis on network-based risk signals. Their risk perception is closely tied to developments at logistics, order, and settlement nodes, allowing earlier identification of delayed or embedded risks within supply chains. City commercial banks exhibit a more regionally embedded risk perception pattern. Their exposure is largely concentrated within provincial industrial chains, and risk transmission is mainly associated with local small and micro enterprises, making the effects more localized rather than nationally diffused.

Differences are also evident in risk identification logic. State-owned banks rely less on single indicators such as export dependence and more on long-term relational banking practices, incorporating cash flow stability, credit history, and overall business structure into their assessment framework. City commercial banks have increasingly incorporated an industrial chain perspective, extending analysis beyond individual firms to upstream and downstream conditions, and adopting list-based credit management to enhance screening precision. Joint-stock banks, in comparison, rely more heavily on high-frequency data and market signals, including order fluctuations, logistics indicators, and exchange rate sensitivity, and adjust their credit exposure accordingly by reducing lending to high-risk export-oriented firms and reallocating resources toward domestic demand and technology-driven sectors.

In terms of risk governance, institutional constraints and organizational flexibility shape distinct response patterns. State-owned banks tend to operate within centrally aligned regulatory frameworks, relying on conservative credit approval processes, strengthened post-loan monitoring, and increased field inspections to manage emerging risks rather than adjusting credit strategies aggressively. Joint-stock banks combine regulatory compliance with market-oriented instruments, including foreign exchange hedging, credit restructuring, and portfolio adjustment. City commercial banks, benefiting from relatively decentralized decision-making structures, are able to respond more quickly in credit approval and risk disposal, relying on differentiated lending practices and higher liquidity buffers to maintain local credit stability.

At the system level, these differentiated behaviors contribute to distinct functional roles within the banking sector. Large banks, supported by scale advantages and sovereign backing, play a stabilizing role during periods of external shock, providing counter-cyclical credit support. Joint-stock banks operate through a balance between market responsiveness and risk control, supported by diversified funding structures. City commercial banks, however, are more tightly bound to local economic conditions, and their risk-bearing capacity is largely shaped by regional industrial structure and the financial health of small and micro enterprises.

Interview evidence suggests that the effects of trade frictions on China's banking system are not primarily reflected in abrupt financial market volatility. Instead, they tend to be absorbed and redistributed within the system through industrial chain linkages, bank–enterprise relationships, and institutional arrangements. Across different types of banks, variations in risk perception, identification practices, and governance approaches jointly shape a differentiated resilience structure under the interaction between state influence and market mechanisms. While this structure contributes to short-term financial stability, it may also be associated with

the gradual accumulation of pressures in weaker segments of industrial chains and more vulnerable regional economic nodes, where risks tend to emerge in delayed and less visible forms.

Based on the systematic organization and thematic coding of semi-structured interview data from practitioners across the three categories of banks, several core themes were identified. The analysis began with interview responses concerning trade war impacts, risk management practices, and the macro policy environment. These materials were progressively condensed into analytical categories, moving from descriptive statements to more abstract thematic patterns. The final coding results highlighted several recurring dimensions, including supply chain-based risk transmission, differences in price pass-through capacity, bank-level risk management strategies, institutional and regulatory constraints, and overall banking system stability.

Taken together, the findings indicate that trade shocks extend beyond firms directly engaged in import and export activities. Their effects are transmitted through industrial networks, ultimately influencing bank credit quality, liquidity conditions, and profitability structures. At the same time, banks have generally strengthened their reliance on industrial chain-based analysis in credit assessment, enhanced both pre-loan screening and post-loan monitoring, and increasingly used foreign exchange hedging instruments to manage exposure. Institutional factors—including central bank monetary policy, macro-prudential regulation, and internal governance mechanisms—also play an important role in moderating risk transmission and providing a stabilizing buffer for the banking system. Rather than serving as a purely descriptive summary, this section reflects how interview material was transformed into analytical categories and, subsequently, into conceptual relationships. It provides the empirical basis for the analytical framework developed in this study, which links trade shocks, risk transmission processes, bank-level behavioral responses, and institutional governance mechanisms.

5. Discussion and Implications

The trade friction between China and the United States is not simply a macroeconomic shock. Interview evidence suggests that its effects operate through industrial chain linkages and are gradually transmitted across different layers of the banking system, where they are absorbed and reallocated rather than immediately reflected in financial aggregates. In this sense, the risks associated with trade frictions extend beyond tariff impacts on exports and are more clearly reflected in slower-moving channels such as payment cycles, profit compression, and the financial conditions of upstream and downstream firms that are indirectly exposed to international trade.

This pattern of transmission helps explain why the resilience of China's banking system appears differentiated rather than uniform. Large state-owned banks, supported by stronger balance sheets and long-standing relationships with large corporates, tend to maintain stability through broad sectoral exposure and continued credit support in strategic areas. Their role is often described in practical terms by interviewees as providing a stabilizing function during periods of external uncertainty. Joint-stock banks, with closer ties to market activity, are more sensitive to high-frequency signals such as order changes and cash flow fluctuations. They adjust credit allocation more actively and make use of financial instruments such as hedging products to manage exposure. City commercial banks, by contrast, are more closely embedded in local economies, where risk control relies heavily on proximity to clients and more granular lending arrangements, including differentiated credit policies at the account level.

Overall, the interviews suggest that external shocks are rarely transmitted directly into the core of the banking system. Instead, they are gradually filtered and redistributed through multiple institutional and organizational layers. This process does not eliminate risk, but it changes its form and timing, shifting from immediate exposure to more delayed and localized manifestations.

These findings also imply a shift in how risk is perceived within banks. Traditional indicators such as export dependence or balance sheet ratios appear insufficient to fully capture emerging vulnerabilities. Interviewees increasingly emphasized the importance of understanding firms within their broader industrial and relational context, including their position in supply chains, their dependence on key counterparties, and the stability of their business networks. From this perspective, risk assessment is gradually moving away from isolated financial indicators toward a more network-oriented understanding of firm behavior and interdependence. This

shift reflects an attempt to better capture the complexity of risk transmission under conditions of heightened external uncertainty.

6. Policy Recommendations

This study contributes to the understanding of how trade frictions affect the banking system by focusing on the micro-level perceptions of frontline practitioners. Rather than treating banks as a homogeneous entity, the analysis highlights differences in how state-owned banks, joint-stock banks, and city commercial banks perceive and respond to external shocks. These differences help to illustrate how risk is transmitted across borders and regions, and how it is gradually absorbed within industrial chains rather than concentrated at a single point in the financial system. From this perspective, the findings offer an empirically grounded account of how risk is distributed in a more layered and uneven manner across China's banking structure, complementing existing macro-level studies with more granular evidence from practice.

In practical terms, the results suggest that risk management strategies may benefit from greater differentiation across bank types. For large state-owned banks, this may involve further refinement of counter-cyclical credit allocation, particularly in strategic sectors. For joint-stock banks, improving the use of market-based risk management tools, including hedging instruments and portfolio adjustment mechanisms, appears increasingly important. For city commercial banks, the emphasis remains on strengthening their capacity to monitor and manage risks within local industrial chains, where exposure is more concentrated and directly tied to regional economic conditions. At the regulatory level, the findings point to the value of more targeted supervision that takes institutional heterogeneity into account, rather than relying on uniform policy frameworks.

Several limitations should be acknowledged. The empirical evidence is based on interviews with frontline branch employees from a limited number of banks and regions, which constrains the generalizability of the findings. In addition, the analysis relies primarily on qualitative perceptions, without incorporating large-sample quantitative data to further test the observed patterns. The absence of perspectives from head office-level decision-making also means that some aspects of strategic formulation are not fully captured.

Future research could address these limitations by expanding the dataset to include a broader range of regions, bank types, and time periods, allowing for more systematic empirical testing of the patterns identified in this study. It may also be useful to examine how emerging financial technologies and supply chain finance tools are reshaping banks' ability to respond to external trade shocks, particularly under increasingly complex geopolitical and economic conditions.

7. Conclusions

This paper examines how trade frictions affect China's banking system by focusing on the experiences of practitioners in large state-owned banks, joint-stock banks, and city commercial banks. The findings suggest that the impact of trade frictions is not primarily reflected in immediate financial market volatility. Instead, it tends to emerge more gradually through changes in real economic activity, particularly declining export orders, shifting cost structures, longer payment cycles, and the transmission of pressure along supply chains. These processes do not affect banks uniformly. Rather, risks tend to become more visible in firms and regions with weaker bargaining positions and thinner profit margins.

The interviews also suggest clear differences in how banks perceive and respond to these pressures. Large state-owned banks generally approach risk from a system-stability perspective, with an emphasis on maintaining credit continuity and absorbing fluctuations through scale and diversification. Joint-stock banks are more sensitive to market signals and tend to adjust their credit exposure more actively, making use of pricing tools, hedging instruments, and portfolio adjustments. City commercial banks, given their closer ties to local economies, tend to rely on detailed knowledge of local firms and industrial chains, which allows them to identify risks at a more granular level. Taken together, these differences point to a banking system that absorbs external shocks in a differentiated and layered manner rather than through a single uniform mechanism.

One of the main contributions of this study is to provide micro-level evidence on how trade shocks are transmitted through the banking system in practice. The findings highlight that such shocks are not confined

to direct trade-related firms but are gradually passed through networks of firms, banks, and industrial linkages. This perspective helps to complement existing macro-level analyses by showing how risk is perceived and managed at the operational level of banks.

Several limitations should be noted. The empirical basis of the study is limited to interviews with frontline staff in selected banks and regions, which restricts broader generalization. The analysis does not incorporate large-sample quantitative data, which limits the ability to formally test the observed transmission patterns. In addition, the study mainly reflects branch-level perspectives and does not fully capture decision-making processes at the headquarters or regulatory levels.

Future work could build on these findings by incorporating more diverse regional samples and combining interview evidence with bank-level and firm-level datasets. This would allow for a more systematic examination of whether the transmission patterns identified here hold more generally. It may also be useful to explore how digital technologies, supply chain finance, and evolving policy tools are reshaping how banks identify and manage risks under prolonged external uncertainty.

References

- [1] Amiti, M., Redding, S. J., & Weinstein, D. (2019). The impact of the 2018–19 trade war on U.S. prices and welfare. *National Bureau of Economic Research*. <https://doi.org/10.3386/w25672>.
- [2] Caldara, D., Iacoviello, M., Mollico, P., Prestipino, A., & Raffo, A. (2020). The economic effects of trade policy uncertainty. *Journal of Monetary Economics*, 109, 38–59. <https://doi.org/10.1016/j.jmoneco.2019.11.002>.
- [3] Huang, Y., Lin, C., Liu, S., & Tang, H. (2019). Trade networks and firm value: Evidence from the US-China trade war (CEPR Discussion Paper No. DP14173). Centre for Economic Policy Research.
- [4] Li, Z., Li, W., & Li, L. W. (2024). Three types of US uncertainty shocks, production network transmission and China's sectoral tail risk. *Journal of Financial Research*, (8), 39–57.
- [5] Acemoglu, D., Carvalho, V. M., Ozdaglar, A., & Tahbaz-Salehi, A. (2012). The network origins of aggregate fluctuations. *Econometrica*, 80(5), 1977–2016. <https://doi.org/10.3982/ECTA9623>.
- [6] Angeloni, I., Faia, E., & Lo Duca, M. (2015). Monetary policy and risk taking. *Journal of Economic Dynamics and Control*, 52, 285–307. <https://doi.org/10.1016/j.jedc.2014.12.001>.
- [7] Roy, S. (2025). Channels of stress: How trade wars hit bank balance sheets. Central Bank of Bahrain.
- [8] Carletti, E., Leonello, A., & Marquez, R. (2024). Market power in banking. *Annual Review of Financial Economics*, 16, 233–251. <https://doi.org/10.1146/annurev-financial-082123105257>.
- [9] Li, F. F., & Xue, R. L. (2025). Local government debt expansion and commercial bank risk: Based on the perspective of risk heterogeneity. *Financial Stability*, (2), 13–37.
- [10] Yue, H., & Wang, H. Y. (2020). Management competence, bank heterogeneity and bank liquidity creation: Empirical evidence from Chinese banking industry. *Journal of Hebei University of Economics and Business*, 41(6), 45–56. <https://doi.org/10.14178/j.issn.1007-2101.2020.06.006>.
- [11] National Financial Regulatory Administration. (2024). Main regulatory indicators data of the banking and insurance industries in the fourth quarter of 2024.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

The Impact of Structural Monetary Policy on Commercial Banks' Credit Risk: A Quasi-Natural Experiment Based on the Central Bank's Carbon Emission Reduction Facility

Chenlin Cai*

School of Finance, Dongbei University of Finance and Economics, Dalian 116025, China

**Corresponding author: Chenlin Cai.*

Abstract

Against the backdrop of China's "Dual Carbon" strategy, structural monetary policy has increasingly been used to support green transition while maintaining financial stability. Taking the Carbon Emission Reduction Facility (CERF), introduced by the People's Bank of China in November 2021, as a policy shock, this study examines its effect on commercial banks' credit risk. Using balanced panel data for Chinese commercial banks from 2014 to 2024, a Difference-in-Differences (DID) framework is employed, with the first group of national financial institutions participating in the CERF serving as the treatment group and local city commercial banks and rural commercial banks as the control group. The results suggest that the implementation of the CERF is associated with a decline in credit risk, but the estimated effect on the non-performing loan ratio does not reach conventional levels of statistical significance. This indicates that the policy's risk-reduction effect had not yet become fully evident during the initial stage of implementation. A possible explanation is that the benefits of lower-cost funding were offset, at least in the short run, by adjustment costs arising from green transformation, including long investment horizons and still-developing risk assessment systems. The main findings remain unchanged after controlling for bank-level characteristics and macroeconomic growth conditions. Overall, the evidence suggests that the influence of the CERF on bank risk is more gradual than immediate. The findings contribute to ongoing discussions of the transmission effects of structural monetary policy and offer insights into how commercial banks manage the balance between green credit expansion and risk control under the "Dual Carbon" agenda.

Keywords

carbon emission reduction facility, commercial banks, credit risk, difference-in-differences method, structural monetary policy

1. Introduction

China's commitment to achieving carbon peaking and carbon neutrality, announced in 2020, has placed the green transformation of the economy at the centre of national development strategy. In this process, the financial system is expected to play a crucial role by directing capital towards low-carbon activities and supporting the development of green industries.

Yet the expansion of green finance is not without challenges. Compared with conventional investment projects, many green projects are characterised by long payback periods, relatively uncertain returns, and substantial positive externalities. These features do not always fit comfortably within the traditional lending framework of commercial banks, which tends to emphasise short-term risk–return considerations. As a result, although policy support for green development has continued to strengthen, commercial banks may still face insufficient incentives to expand green lending on a large scale.

Against this backdrop, the People’s Bank of China launched the Carbon Emission Reduction Facility (CERF) in November 2021. As a targeted structural monetary policy tool, the CERF adopts a “lend first, then refinance” mechanism, under which financial institutions can obtain low-cost funding support for eligible carbon-reduction loans. By lowering funding costs and providing additional liquidity, the policy was intended to encourage banks to increase credit supply to sectors such as clean energy, energy conservation, environmental protection, and carbon-reduction technologies.

The rapid growth of green credit following the introduction of the CERF has also raised a question that deserves closer examination. On the one hand, policy support may improve asset quality by directing credit towards industries with stronger long-term growth prospects. On the other hand, the accelerated expansion of green lending may expose banks to new risks if project evaluation standards, risk identification systems, and management experience remain underdeveloped. Whether the policy ultimately improves or weakens banks’ credit quality therefore remains an empirical issue.

Existing studies have examined the relationship between green finance and bank risk from a variety of perspectives. At the enterprise level, Yao et al. find that green credit policies increase financing constraints and reduce operating performance among heavily polluting firms [1]. Focusing on commercial banks, Cui et al. show that a higher proportion of green loans is associated with lower non-performing loan ratios [2]. Building on this line of research, Huang et al. argue that the risk-reducing effect of green credit is influenced by the monetary policy environment, becoming stronger under accommodative conditions and weaker during periods of monetary tightening [3]. Cao et al. further suggest that the impact of green credit on bank risk may follow an inverted U-shaped pattern and exhibit a lagged effect [4]. Using green credit policy as a quasi-natural experiment, Gao and Guo find that green lending contributes to lower non-performing loan ratios and improved profitability over the longer term through adjustments in asset structure [5]. From a market perspective, Gong et al. report that the Carbon Emission Reduction Facility enhances the market valuation of commercial banks through signalling and reputational channels [6].

Although the literature has generated important insights into the relationship between green finance and bank performance, relatively little attention has been paid to the Carbon Emission Reduction Facility itself. In particular, evidence on whether this structural monetary policy affects banks’ credit risk remains limited. Existing studies tend to focus either on green credit in general or on market responses to policy announcements, while the direct impact of the CERF on banks’ asset quality has received less empirical scrutiny.

To address this gap, this paper uses balanced panel data for Chinese commercial banks covering the period from 2014 to 2024. Treating the introduction of the Carbon Emission Reduction Facility as a quasi-natural experiment, a Difference-in-Differences (DID) framework is employed to examine its impact on banks’ non-performing loan ratios (NPLs). Banks included in the first batch of institutions eligible for CERF support are defined as the treatment group, while city commercial banks and rural commercial banks outside the programme serve as the control group. By focusing on the credit-risk consequences of a targeted structural monetary policy, this study adds to the growing literature on green finance and provides evidence on the micro-level effects of China’s carbon-transition policies.

2. Literature Review and Theoretical Hypotheses

Existing research has reached no clear consensus on how green finance policies influence the risk profile of commercial banks.

One strand of the literature suggests that green finance contributes to risk reduction. According to this view, loans directed towards clean energy, environmental protection, and other green sectors are generally less exposed to environmental regulation risks and policy-related uncertainty. As a result, the probability of default may be lower than that associated with traditional high-pollution industries. Drawing on Chinese banking data,

Cui et al. find that a higher share of green lending is associated with lower non-performing loan ratios [2]. Di Tommaso et al. examine market reactions to green loan announcements using global banking data and find that such announcements are followed by a decline in banks' CDS spreads, suggesting that investors view green lending as a favourable signal of future stability and lower risk [7].

A different view emphasises the costs and uncertainties associated with the transition towards a low-carbon economy. Cao et al. and Zhou et al. argue that stricter environmental policies may place considerable pressure on carbon-intensive firms [4, 8]. Adjustments in lending strategies, including reductions in credit supply to traditional industries, can worsen financing conditions for affected firms and increase repayment pressure. Yao et al. find that green credit policies can tighten external financing channels for heavily polluting enterprises and weaken their operating performance [1]. These developments may, at least in the short run, increase the likelihood of loan deterioration. At the same time, evaluating green projects often requires specialised expertise and information that many banks are still developing. Limited experience in environmental risk assessment may create additional uncertainty during the early stages of green credit expansion.

Compared with general green finance policies, the Carbon Emission Reduction Facility (CERF) may influence bank risk through a somewhat different mechanism. Introduced by the People's Bank of China in 2021, the CERF provides financial institutions with access to low-cost funding for eligible carbon-reduction loans. By lowering funding costs and supporting credit expansion in targeted sectors, the policy may strengthen banks' ability to absorb potential losses and improve balance-sheet resilience. Gong et al. also note that the policy generates positive market signals and may improve investors' expectations regarding participating banks [6].

Another notable feature of the CERF is its disclosure and verification framework. Participating institutions are required to disclose the carbon-reduction performance of supported loans and undergo third-party verification. These arrangements may help improve information transparency and reduce concerns about greenwashing. In practice, compliance with such requirements often requires banks to refine internal review procedures and strengthen project evaluation standards. To the extent that these adjustments improve loan screening and monitoring, they may contribute to better asset quality over time.

At the same time, the expansion of green lending under the CERF may involve adjustment costs. Many green projects are characterised by long investment horizons and uncertain cash-flow patterns, while risk assessment standards continue to evolve. Consequently, any benefits associated with lower funding costs may not be immediately reflected in asset quality indicators.

Given these competing considerations, the direction of the CERF's effect on commercial bank credit risk remains an empirical question. Accordingly, the following hypotheses are proposed:

H1a (Risk Mitigation Hypothesis): The implementation of the Carbon Emission Reduction Facility reduces the credit risk of commercial banks in the treatment group.

H1b (Transition Pain Hypothesis): The implementation of the Carbon Emission Reduction Facility increases the credit risk of commercial banks in the treatment group in the short run.

H1c (Dynamic Hedging Hypothesis): In the early stage of policy implementation, the benefits associated with lower funding costs and the adjustment costs arising from the green transition offset one another, resulting in no statistically significant change in the credit risk of commercial banks.

3. Research Design

3.1 Sample Selection and Data Sources

The sample consists of Chinese commercial banks observed between 2014 and 2024. This period covers both the years before the introduction of the Carbon Emission Reduction Facility (CERF) and the years following its implementation, allowing a comparison of changes in credit risk before and after the policy. As the CERF was launched in November 2021, 2022 is treated as the first post-policy year.

The treatment group is identified according to the list of institutions included in the first batch of CERF-supported financial institutions announced by the People's Bank of China. Policy banks are excluded because

their operating objectives differ from those of commercial banks. In addition, Guangfa Bank, Bohai Bank, and Hengfeng Bank are removed due to data unavailability. The treatment group therefore consists of 15 large state-owned and joint-stock commercial banks included in the initial support programme (Treat = 1). City commercial banks and rural commercial banks outside the programme are used as the control group (Treat = 0).

Financial indicators and credit-risk data are obtained from the Wind Financial Terminal. To reduce the influence of extreme observations, all continuous variables are winsorized at the 1st and 99th percentiles.

3.2 Variable Definitions

(1) Dependent Variable: Credit Risk (NPL). Following Cui et al., credit risk is measured by the annual non-performing loan ratio, calculated as non-performing loans divided by total loans [2]. Higher values indicate greater credit risk.

(2) Core Explanatory Variable: Treat $\times$ Post. The key explanatory variable is the interaction between the treatment-group indicator and the post-policy indicator. It equals 1 for banks included in the first batch of CERF-supported institutions during the period from 2022 onward, and 0 otherwise. The coefficient on this interaction term captures the average policy effect.

(3) Control Variables. Following previous studies on commercial bank risk, several bank-level characteristics are included as controls: bank size (LogAsset, the natural logarithm of total assets), profitability (ROA, return on assets), capital adequacy ratio (CAR, net capital divided by risk-weighted assets), liquidity ratio (Liquidity, liquid assets divided by liquid liabilities), and financial leverage (Leverage, total liabilities divided by total assets).

(4) Macroeconomic Control Variable: GDP_Growth. The annual growth rate of China's real GDP is included to account for changes in the broader macroeconomic environment that may affect banks' credit quality.

3.3 Model Specification

To accurately identify the policy effects of the CERF, this paper constructs a classical two-way fixed effects Difference-in-Differences model:

$$NPL_{i,t+1} = \alpha_0 + \alpha_1 (Treat_i \times Post_t) + \sum \beta_j Controls_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \quad (1)$$

where i represents commercial banks and t represents years. μ_i denotes bank fixed effects, δ_t denotes time fixed effects, and $\varepsilon_{i,t}$ is the random disturbance term. The parameter α_1 is the core coefficient of greatest interest in this paper, reflecting the net impact of the Carbon Emission Reduction Facility on banks' non-performing loan ratio. If α_1 is significantly negative, it supports the risk mitigation hypothesis.

4. Empirical Results and Analysis

4.1 Descriptive Statistical Analysis

Prior to conducting the benchmark regression and formal tests, this paper first performs descriptive statistics on the main variables involved in the empirical model. The relevant data distributions are presented in Table 1.

Table 1: Descriptive Statistics of Main Variables

Variable	Observations	Mean	Std. Dev.	Min	Max	Median
GDP Growth Rate (%)	462	5.945	1.775	2.340	8.570	6.758
Non-Performing Loan Ratio (%)	462	1.350	0.371	0.640	2.710	1.340
ROA (%)	462	0.876	0.205	0.285	1.757	0.867
Log of Total Assets	462	9.449	1.704	6.429	13.098	9.242
Capital Adequacy Ratio (%)	462	13.757	1.697	9.560	19.690	13.530
Liquidity Ratio (%)	462	62.796	20.976	28.770	202.210	58.495
Financial Leverage Ratio (%)	462	6.756	1.045	2.983	10.333	6.650

As reported in Table 1, the mean non-performing loan ratio (NPL) of commercial banks during the sample period is 1.350%, with a standard deviation of 0.371. The minimum and maximum values are 0.640% and 2.710%, respectively. Although the overall level of credit risk remains relatively low, noticeable differences in asset quality can still be observed across banks.

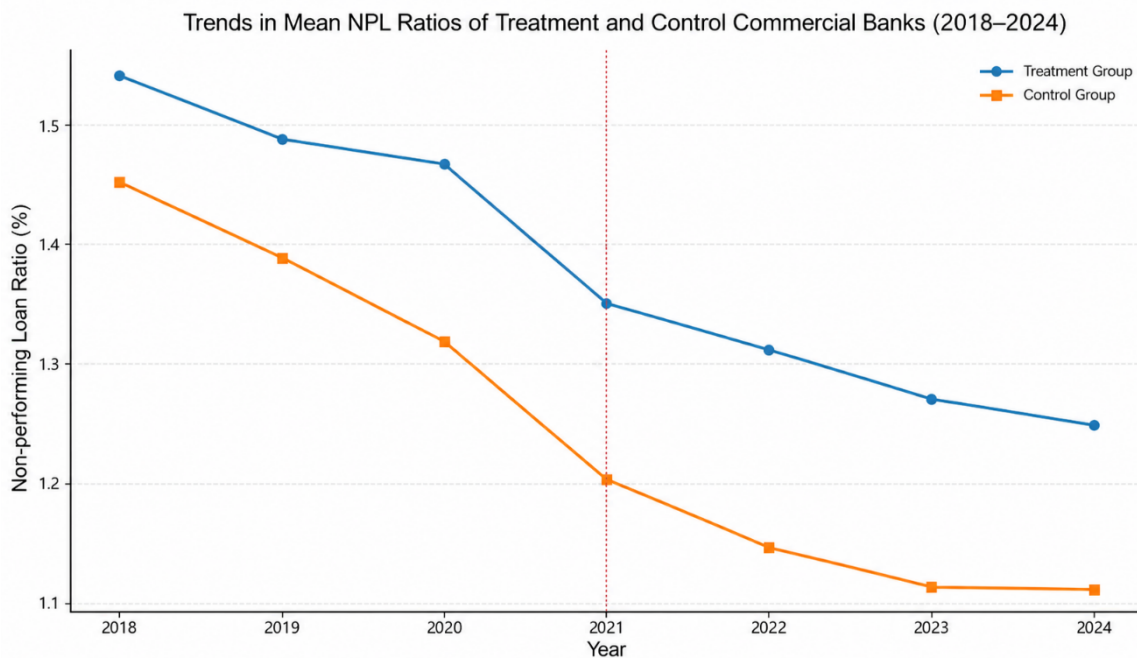
Among the control variables, the average capital adequacy ratio (CAR) is 13.757%, well above the regulatory requirements under both Basel III and China's banking supervision framework. The highest observed value reaches 19.690%, suggesting that most sample banks maintain sufficient capital buffers against potential losses. The mean return on assets (ROA) is 0.876%, with a standard deviation of 0.205, indicating some variation in profitability across banks during the sample period. These differences across institutions justify the inclusion of bank-level controls and fixed effects in the subsequent regression analysis.

4.2 Parallel Trends Test and Dynamic Effects

The validity of the Difference-in-Differences (DID) approach depends on the parallel trends assumption. In other words, absent the policy intervention, the treatment and control groups should exhibit similar trends in credit risk over time. To examine this assumption, the period from 2018 to 2024 is used as the event-study window. A visual comparison of group means is conducted first, followed by a formal econometric test.

Figure 1 plots the average NPL ratios for the treatment and control groups based on panel data obtained from the Wind database. Before the introduction of the Carbon Emission Reduction Facility in 2021, the two groups differ in their NPL levels, but their overall trajectories move in a broadly similar direction. The gap between the groups remains relatively stable, providing preliminary support for the parallel trends assumption. After 2021, NPL ratios continue to decline for both groups. At the same time, fluctuations in the difference between the two series become more apparent, suggesting that simple trend comparisons alone are insufficient to identify the policy effect and that further econometric analysis is required.

Figure 1: Evolution of Mean NPL for Treatment and Control Group Commercial Banks



This paper further reports the dynamic coefficients estimated from the event-study specification (Table 2, Table 3, and Figure 2). Prior to the introduction of the Carbon Emission Reduction Facility, the estimated interaction coefficients remain close to zero, and the corresponding 95% confidence intervals consistently cover zero. No statistically significant differences between the treatment and control groups are observed during the pre-policy period, lending support to the parallel trends assumption. Following policy implementation, the difference in non-performing loan ratios between the two groups does not exhibit a clear narrowing trend. In several post-policy periods, the gap even increases slightly. These patterns suggest that any potential impact of the policy on credit risk was limited during the initial years after implementation.

Table 2: Dynamic Effects of the Carbon Emission Reduction Facility on Commercial Banks' Credit Risk

Variable	Coefficient	Std. Err.	t-value	P-value
Treatment × 2018 (relative to 2021: -3)	-0.017	0.097	-0.174	0.862
Treatment × 2019 (relative to 2021: -2)	-0.035	0.083	-0.424	0.672
Treatment × 2020 (relative to 2021: -1)	-0.003	0.038	-0.07	0.944
Treatment × 2022 (relative to 2021: +1)	0.012	0.036	0.338	0.735
Treatment × 2023 (relative to 2021: +2)	-0.034	0.041	-0.815	0.415
Treatment × 2024 (relative to 2021: +3)	-0.05	0.051	-0.963	0.336

Table 3: Mean NPL and Differences Between Treatment and Control Group Commercial Banks

Reporting Year	Treatment Obs.	Treatment Banks	Treatment Mean NPL	Control Obs.	Control Banks	Control Mean NPL	Mean Difference (Treatment - Control)
2018	15	15	1.541	27	27	1.452	0.089
2019	15	15	1.488	27	27	1.389	0.099
2020	15	15	1.467	27	27	1.319	0.148
2021	15	15	1.351	27	27	1.204	0.148
2022	15	15	1.312	27	27	1.147	0.165
2023	15	15	1.271	27	27	1.114	0.157
2024	15	15	1.249	27	27	1.112	0.137

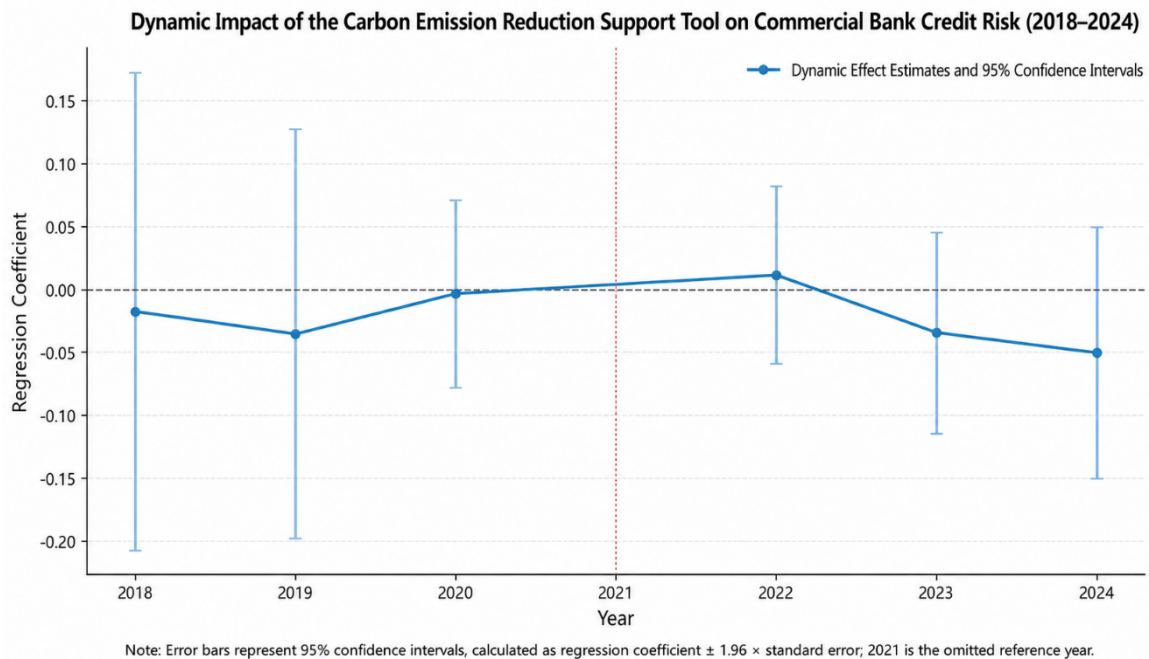
Figure 2: Event Study Regression Results of the Impact of the Carbon Emission Reduction Facility on Commercial Banks' NPL

Figure 2 also shows that although banks in the treatment group expanded their green lending activities after entering the policy framework, improvements in asset quality did not emerge immediately. The expansion of green credit and the evolution of non-performing loan ratios appear to follow different adjustment paths over the short run. One possible explanation is that the development of green finance requires corresponding improvements in risk assessment, project screening, and post-loan management. For many projects in sectors such as renewable energy, energy conservation, and environmental protection, investment horizons are relatively long and cash flows tend to be realized gradually. As a result, the benefits associated with project performance may take time to be reflected in banks' balance sheets. In addition, differences in local industrial policies and the continuing evolution of green certification standards may increase the difficulty of identifying and evaluating qualified green assets during the early stage of policy implementation. Taken together, the evidence suggests that the Carbon Emission Reduction Facility may influence bank asset quality through a

gradual adjustment process. Its effects are more likely to emerge alongside longer-term industrial transformation and the maturation of green financial practices, rather than through an immediate reduction in credit risk.

4.3 Benchmark Regression Results and Economic Interpretation

Based on the two-way fixed effects model established earlier and the micro-level financial data provided by the Wind database, this paper conducts rigorous regression estimations using the empirical panel data. The detailed results are presented in Table 4.

Table 4: Empirical Results of the Impact of the Carbon Emission Reduction Facility on Commercial Banks' Credit Risk

Variables	(1) No Controls	(2) Controls Only	(3) Two-Way Fixed Effects (Full Benchmark t+1)
Core Explanatory Variable DID (Treat $\times$ Post)	-0.110 (0.069)	-0.071 (0.068)	0.026 (0.056)
Log of Total Assets (LogAsset)		0.022** (0.010)	0.248 (0.234)
Profitability (ROA)		-0.251*** (0.083)	-0.725*** (0.156)
Capital Adequacy Ratio (CAR)		-0.088*** (0.012)	-0.006 (0.020)
Liquidity Ratio (Liquidity)		-0.004*** (0.001)	0.003** (0.002)
Financial Leverage Ratio (Leverage)		0.177*** (0.018)	0.112*** (0.024)
Macroeconomic Growth (GDP Growth)		0.028*** (0.009)	Omitted
Constant	1.370*** (0.018)	1.437*** (0.192)	absorbed
Bank Fixed Effects (Bank FE)	No	No	Yes
Year Fixed Effects (Year FE)	No	No	Yes
Clustered Robust Standard Errors	No	No	Yes (Bank level)
Observations	420	420	420
R-squared	0.006	0.257	0.760

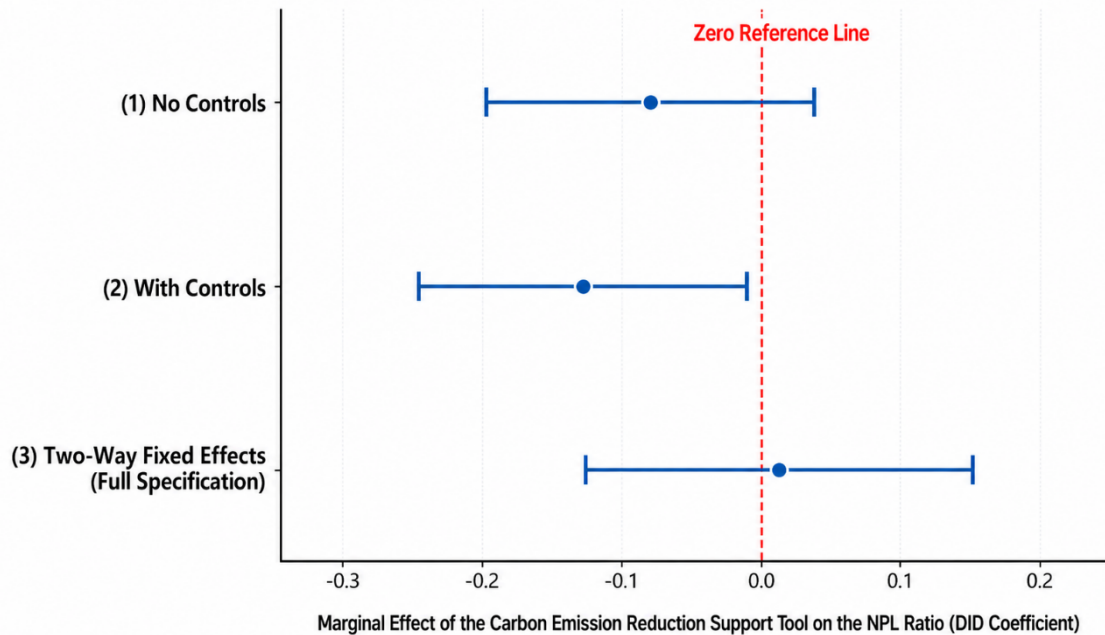
*Note: Standard errors are in parentheses; ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.*

Table 4 reports the benchmark regression results. After controlling for bank-level characteristics, macroeconomic conditions, and both bank and year fixed effects, the coefficient on the DID term (Treat $\times$ Post) remains close to 0.026 and does not reach conventional levels of statistical significance. To alleviate potential concerns regarding reverse causality, the benchmark specification further employs a one-period lag of the dependent variable. After this adjustment, the effective sample size is reduced to 420 observations. The estimated coefficient on the DID term remains around 0.026 and continues to be statistically insignificant. The result suggests that the effect of the Carbon Emission Reduction Facility on banks' non-performing loan ratios was limited during the early stage of policy implementation. Compared with city commercial banks and rural commercial banks outside the policy coverage, the first batch of national financial institutions supported by the Carbon Emission Reduction Facility did not experience a statistically distinguishable change in next-year non-performing loan ratios. Rather than indicating that the policy was ineffective, this pattern may reflect the gradual nature of green financial transformation and the time required for policy effects to be transmitted into bank asset quality.

To further assess the stability of the benchmark results, Figure 3 presents the estimated coefficients and corresponding 95% confidence intervals under different model specifications. The dots represent coefficient estimates, while the horizontal bars denote confidence intervals. The vertical dashed line marks the zero benchmark. Several patterns emerge from the sequential specifications. In Model (1), which excludes both control variables and fixed effects, the estimated policy coefficient is statistically insignificant. After adding bank-level and macroeconomic controls in Model (2), the coefficient becomes negative (approximately

−0.071), although the confidence interval still overlaps with zero. This suggests that observable characteristics alone are insufficient to isolate the policy effect. Model (3) introduces both control variables and two-way fixed effects and corresponds to the benchmark specification reported in Table 4. Under this specification, the estimated coefficient returns to a positive value of approximately 0.026, while the confidence interval continues to include zero. The result remains statistically insignificant after accounting for both time-invariant bank characteristics and common time shocks. Taken together, the findings are consistent across alternative specifications. No clear evidence is found that the Carbon Emission Reduction Facility reduced the credit risk of participating banks during the sample period. The absence of a significant short-term effect may be related to the coexistence of policy support benefits and adjustment costs associated with the early stage of green transition, with neither force appearing strong enough to dominate the other within the observed time horizon.

Figure 3: Coefficient Plot of the Carbon Emission Reduction Facility under Different Model Specifications



A possible explanation for the insignificant policy effect lies in the interaction between policy support and adjustment costs during the early stage of green transition. On the one hand, the low-cost liquidity provided through the Carbon Emission Reduction Facility may help participating banks expand interest margins and strengthen their capacity to absorb potential losses. On the other hand, green projects often involve relatively long investment horizons, uncertain cash-flow realization, and higher information requirements. At the same time, the gradual withdrawal from traditional high-carbon sectors may create additional adjustment pressures. These opposing influences may have offset one another during the sample period, resulting in a limited short-term impact on banks' credit risk. Such a pattern is broadly consistent with the dynamic hedging hypothesis proposed in this study.

Several channels may help explain this outcome. First, the central bank's refinancing support lowered funding costs for eligible institutions and provided additional financial resources that could be used to strengthen balance-sheet resilience. Second, the policy framework introduced stricter disclosure and verification requirements for carbon-reduction loans. To obtain policy support, banks were required to improve project screening procedures and strengthen the monitoring of green lending activities. These institutional arrangements may have contributed to improvements in credit allocation quality.

However, many green projects supported under the policy remain at relatively early stages of development. In sectors such as renewable energy and environmental protection, investment returns are often realized gradually, while project risks may be difficult to evaluate using traditional credit assessment frameworks. As a result, improvements in asset quality may not become immediately visible in conventional risk indicators such as non-performing loan ratios.

The findings are also consistent with Zhou et al., who emphasize the adjustment costs and transition pressures associated with green finance policies [8]. Similarly, Kacperczyk and Peydró note that changes in credit allocation induced by environmental objectives may generate short-term frictions during the transition process [9]. In particular, the reallocation of credit away from carbon-intensive sectors may not immediately translate into improvements in underlying asset quality. Meanwhile, banks must devote additional resources to developing new risk assessment frameworks and internal management procedures for green finance. These factors may help explain why the short-term policy effect remains statistically weak.

Xue et al. argue that the effectiveness of green finance policies depends not only on policy incentives themselves but also on banks' ability to adapt their internal governance, risk management, and operational systems [10]. In this context, the identification of eligible green projects, the restructuring of existing credit portfolios, and the upgrading of risk-control mechanisms are likely to require time before measurable improvements in credit quality emerge.

The estimated coefficients of the control variables are generally in line with conventional expectations. Profitability (ROA) is negatively associated with the non-performing loan ratio, with a coefficient of -0.725 that is significant at the 1% level, suggesting that more profitable banks are generally better positioned to withstand credit risk. The coefficient on the capital adequacy ratio (CAR) is also negative, although its statistical significance is limited. Bank size (LogAsset) exhibits a negative but insignificant coefficient, possibly because persistent differences across banks have already been absorbed by the fixed effects. By contrast, both the liquidity ratio and financial leverage ratio are positively associated with credit risk and remain significant at the 1% level.

Taken together, the control variables behave largely as expected, while the policy effect remains statistically insignificant. Rather than pointing to a straightforward risk-reduction outcome, the results suggest that the relationship between green finance policies and bank risk may vary across stages of the transition process, a possibility also discussed by Feng et al. [11].

4.4 Heterogeneity Analysis

Differences in capital strength, risk management capability, and information systems may affect how banks respond to the Carbon Emission Reduction Facility. Compared with city commercial banks and rural commercial banks, large state-owned and joint-stock banks generally possess stronger capital bases, more mature risk-control frameworks, and greater capacity to absorb the adjustment costs associated with green transformation. They are also more likely to establish carbon accounting and environmental risk assessment systems within a relatively short period. At the same time, banks with stronger profitability and higher capital adequacy ratios usually have greater flexibility in dealing with uncertainties arising from changes in credit structure. As a result, the influence of the Carbon Emission Reduction Facility on credit risk may vary across banks with different financial characteristics. Based on this consideration, the following hypothesis is proposed:

H2: The impact of the Carbon Emission Reduction Facility on commercial banks' credit risk differs across banks with different asset sizes, profitability levels, and capital adequacy ratios.

To examine this possibility, heterogeneity tests are conducted by dividing the sample according to the median values of bank size, return on assets (ROA), and capital adequacy ratio (CAR). Separate regressions are then estimated for each subgroup. Following the benchmark specification, bank and year fixed effects are included and standard errors are clustered at the bank level. The results are reported in Table 5.

The subgroup regressions reported in Table 5 suggest that the relationship between the Carbon Emission Reduction Facility and bank credit risk varies across banks with different financial characteristics.

With respect to bank size, the coefficient on the DID term is 0.006 for the large-bank subsample (Column 1) and remains statistically insignificant. This result indicates that the introduction of the policy was not associated with a noticeable change in the non-performing loan ratio of large banks in the short run. For the small-bank subsample (Column 2), the DID term is omitted because of perfect collinearity. This is largely attributable to the composition of the sample. Most institutions included in the first batch of the Carbon Emission Reduction Facility were large national banks, whereas smaller city commercial banks and rural commercial banks were generally outside the policy coverage. After grouping by the sample median, the small-

bank subgroup contains only control-group observations, leaving insufficient variation for coefficient estimation.

Table 5: Subgroup Regression Results Based on Bank Financial Heterogeneity

Items	(1) Large-scale Banks	(2) Small-scale Banks	(3) High-profitability Banks	(4) Low-profitability Banks	(5) High-capital-ratio Banks	(6) Low-capital-ratio Banks
Core Explanatory Variable DID	0.006	Omitted	-0.065	0.102	-0.052	0.050
	(0.082)	(-)	(0.052)	(0.086)	(0.064)	(0.081)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	210	210	210	210	210	210
R-squared	0.815	-	0.772	0.787	0.777	0.800

Note: Robust standard errors clustered at the bank level are in parentheses. Groups are strictly divided by the median of each bank's sample-period mean. Each subgroup contains 21 banks, ensuring a fully balanced regression sample.

Differences also emerge across profitability groups. For banks with relatively high profitability (Column 3), the coefficient on the DID term is -0.065, whereas the corresponding coefficient for the low-profitability group (Column 4) is 0.102. Although neither estimate is statistically significant, the direction of the coefficients is noteworthy. Banks with stronger earnings capacity may be better able to absorb the adjustment costs associated with green transformation, while banks with weaker profitability appear more exposed to uncertainties arising from changes in credit allocation and longer investment recovery periods.

A similar pattern can be observed when banks are grouped according to capital adequacy ratios. The DID coefficient is -0.052 in the high-CAR subsample (Column 5) and 0.050 in the low-CAR subsample (Column 6). While statistical significance is not achieved, the results are broadly consistent with the view that stronger capital buffers may help banks cope with risks associated with the expansion of green credit, whereas banks with relatively limited capital cushions may face greater pressure during the adjustment process.

Overall, the subgroup results suggest that the effects of the Carbon Emission Reduction Facility are unlikely to be uniform across all banks. Although the reduced sample size within each subgroup limits statistical precision, the coefficient patterns indicate that banks with stronger financial fundamentals tend to exhibit weaker risk pressures following policy implementation. This heterogeneity may help explain why the average policy effect in the full-sample regression remains statistically insignificant, as differences across bank types partly offset each other in the aggregate results.

5. Policy Implications and Future Research

The empirical results suggest that the effects of the Carbon Emission Reduction Facility on bank credit risk may take time to emerge. Against this background, several implications can be drawn for both policymakers and financial institutions.

5.1 Implications for Policymakers

First, further expansion of structural monetary policy tools may need to take into account differences in the risk-management capacity of participating institutions. Compared with large national banks, many city commercial banks and rural commercial banks have more limited experience in environmental risk assessment and green project evaluation. As policy coverage expands, complementary support measures, such as technical assistance, staff training, and capacity-building programs, may help improve the effectiveness of policy implementation.

Second, improving information infrastructure could reduce the costs associated with identifying and evaluating green projects. Greater coordination among financial regulators, environmental authorities, and other government agencies may facilitate the development of more standardized carbon-related information

systems. Better information availability would help financial institutions assess project quality and reduce uncertainty in green lending decisions.

5.2 Implications for Commercial Banks

For commercial banks, the findings highlight the importance of strengthening internal risk-management frameworks during the process of green transformation. The expansion of green credit should be accompanied by improvements in environmental risk assessment, project monitoring, and internal governance arrangements. Integrating environmental and climate-related factors into existing credit management systems may contribute to more effective risk control.

In addition, the adjustment of credit portfolios is likely to be a gradual process. While increasing support for low-carbon industries, banks may also need to consider the transition characteristics of traditional sectors. A balanced approach could help mitigate potential disruptions associated with rapid shifts in credit allocation and contribute to the stability of asset quality during the transition period.

5.3 Future Research

Several issues remain open for further investigation. One direction would be to examine loan-level data, including information on pricing, collateral arrangements, and borrower characteristics, in order to better understand how policy incentives are transmitted through banks' lending decisions. Such evidence would provide a more detailed view of the channels linking structural monetary policy and credit risk. Another promising avenue is comparative research across countries. Future studies could explore differences in the design and implementation of green monetary policy tools across jurisdictions and examine whether institutional arrangements influence their effectiveness in supporting green finance while maintaining financial stability.

6. Conclusions

Using panel data for Chinese commercial banks from 2014 to 2024 and taking the introduction of the Carbon Emission Reduction Facility in late 2021 as a policy shock, this study examines whether the policy was associated with changes in banks' credit risk. A two-way fixed effects Difference-in-Differences framework is employed to compare banks included in the first batch of policy-supported institutions with those outside the policy coverage.

The results do not provide evidence that the Carbon Emission Reduction Facility significantly reduced banks' non-performing loan ratios during the sample period. Across the benchmark specifications, the estimated coefficient of the DID term remains statistically insignificant, suggesting that the policy did not generate an observable short-term effect on credit risk. One possible explanation is that the potential benefits associated with lower funding costs and policy support were offset, at least temporarily, by adjustment costs arising from changes in credit allocation and green transformation. The heterogeneity analysis points to differences across banks with varying financial characteristics. Although most subgroup estimates do not reach conventional significance levels, the coefficient patterns suggest that banks with stronger profitability and capital positions may have been better equipped to absorb the uncertainties associated with the transition process. By contrast, banks with relatively weaker financial foundations appear to have faced greater adjustment pressures.

Taken together, the findings suggest that the influence of the Carbon Emission Reduction Facility on bank credit risk may be gradual rather than immediate. The effects of structural monetary policy on financial stability are likely to depend not only on policy design itself but also on the characteristics of participating institutions and the pace of adjustment within the broader process of green transformation.

References

- [1] Yao, S., Pan, Y., Sensoy, A., Uddin, G. S., & Cheng, F. (2021). Green credit policy and firm performance: What we learn from China. *Energy Economics*, 101, 105415.

- [2] Cui Y, Geobey S, Weber O, et al. The Impact of Green Lending on Credit Risk in China. *Sustainability*, 2018, 10(6): 2008.
- [3] Huang, F., Zhu, H., & Wu, S. (2025). Green credit, monetary policy, and bank risk-taking. *Finance Research Letters*, 79, 107289.
- [4] Cao, G. H., Gao, X. W., Wang, T. Q., & Tian, R. Z. (2024). The impact of green credit on commercial bank risk: Evidence from a multi-period difference-in-differences validation of China's banking industry. *Journal of Financial Development Research*, (2), 55-63.
- [5] Gao, X., & Guo, Y. (2022). The Green Credit Policy Impact on the Financial Performance of Commercial Banks: A Quasi-Natural Experiment from China. *Mathematical Problems in Engineering*, 2022, 9087498.
- [6] Gong, B., Zhang, B., Yang, S. Y., & Xu, Z. Y. (2024). Research on the impact of carbon emission reduction facility on the market value of commercial banks under the “dual carbon” goal. *Journal of Financial Research*, (7), 50-68.
- [7] Di Tommaso, C., Pacelli, V., & Povia, M. M. (2025). Green loans and bank risk: Navigating the path to sustainable finance. *International Review of Economics and Finance*, 101, 104138.
- [8] Zhou X Y, Caldecott B, Hoepner A G F, et al. Bank green lending and credit risk: An empirical analysis of China's Green Credit Policy. *Business Strategy and the Environment*, 2022, 31(4): 1623-1640.
- [9] Kacperczyk, M., & Peydró, J. L. (2024). Carbon Emissions and the Bank-Lending Channel. *ECGI Finance Working Paper*, N° 991/2024.
- [10] Xue J, Sun S, Zhao L. Evaluation of the effects of implementing green credit in Chinese commercial banks, based on grounded theory. *SSRN Electronic Journal*, 2024.
- [11] Feng, Y., et al. (2024). Green credit policy and bank risk-taking: Evidence from Chinese commercial banks. *Journal of Cleaner Production*, 437, 140698.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

A Brief Analysis of PROYA's Marketing Strategy Based on 4P Theory

Jiayan Song*

Business School, Tianjin University of Finance and Economics, Tianjin, 302222, China

**Corresponding author: Jiayan Song.*

Abstract

With the rapid development of domestic beauty products, digital marketing has become the core competitiveness for brands to break through. However, domestic beauty brands still face many challenges in breaking into the high-end market and building a systematic marketing system. Against this background, exploring the systematic marketing strategies of domestic beauty brands has significant practical significance for promoting the upgrading of domestic brands and enhancing the overall competitiveness of the industry. This paper takes PROYA as the research object and uses the literature research method and case analysis method to systematically analyze its marketing strategies from the four dimensions of product, price, channel, and promotion based on the 4P theory. The research finds that PROYA has achieved brand growth through precise product layout, popular pricing, full-channel layout, and diversified content promotion, but there is still room for improvement in channel operation and promotion systems. This study not only sorts out the marketing practice logic of PROYA but also provides practical ideas for the marketing upgrade of domestic beauty brands and provides a reference for the high-quality development of the industry.

Keywords

marketing strategy, 4P theory, PROYA

1. Introduction

The domestic beauty industry, as an important sector where domestic consumption upgrades and the digital economy converge, has witnessed explosive growth in recent years [1]. According to industry reports, the scale of China's beauty market will exceed 520 billion yuan in 2024, with domestic brands accounting for over 61% of the market share, an increase of nearly 30 percentage points compared to a decade ago. With the rise of national cultural confidence and the deep penetration of digital technologies, domestic beauty brands have gradually broken the market monopoly of foreign brands and achieved rapid breakthroughs in the mass market [2,3]. However, in terms of breaking into the high-end market, building brand premiums, and systematizing marketing strategies, domestic beauty brands still face challenges such as severe homogenization competition, a penetration rate of less than 12% in the high-end market, insufficient efficiency in digital marketing, and difficulty in maintaining long-term customer loyalty. How to achieve brand breakthrough and high-quality development through systematic marketing strategies has become a key issue that the industry urgently needs to address.

Existing research mostly focuses on single-dimensional marketing cases of domestic beauty brands or the application of digital marketing tools [3]. Although it has explored popular strategies such as live-streaming e-commerce and content marketing, there is still a lack of systematic analysis based on classic marketing theories, and there is a gap in in-depth analysis of the success logic of leading brands and the extraction of replicable experiences [3]. Based on this, this paper takes a systematic analysis of PROYA's marketing strategy based on the 4P theory as the theme, selects PROYA, a benchmark domestic beauty brand, as the research object, and uses the literature research method and case analysis method to systematically analyze its marketing strategy implementation paths and effects from the four dimensions of product, price, channel, and promotion while also identifying its existing optimization spaces [4,5]. This study aims to sort out the marketing practice logic of Poreince and provide practical ideas for the marketing upgrade of domestic beauty brands, as well as provide references for the high-quality development of the industry.

2. Overview of the PROYA

PROYA belongs to Proya Cosmetics Co., Ltd. with 'While young, go discover' as the core purpose of the brand. The brand began in Hangzhou in 2003. In the early years, it started from the offline franchise store channel and gradually expanded to the e-commerce omni-channel, forming a three-dimensional marketing network covering the whole country. On November 15, 2017, it landed on the Shanghai Stock Exchange and became the 'first stock of domestic beauty.' In 2024, the European Innovation Center was established in Paris, France. It is the first domestic beauty brand to establish a research and development center in Europe. The brand adheres to the mission of 'Beauty endures, sharing the wonderful', explores the world and pursues dreams with consumers, and provides safe and efficient skin care solutions with professional skin mechanism research and global scientific research. In recent years, it has grown into the first domestic cosmetics company, with revenue of more than 10 billion. It has won many domestic and foreign honors, such as the United Nations Annual Women's Development Contribution Award and Vogue China Brand Award. Its brand influence and industry status rank among the top domestic products.

3. Equation Analysis of Marketing Strategies Based On 4P Theory

In recent years, competition in the domestic beauty products industry has become increasingly fierce. PROYA has continuously led the industry with a clear market positioning and efficient marketing system, maintaining a leading position in brand influence and market performance [6,7,8]. Its mature channel innovation and marketing model have significant reference value for existing beauty enterprises. To systematically summarize its successful experience, this paper uses 4P marketing theory as an analytical framework, delving into the composition and operational logic of Perfect Diary's marketing strategies from four dimensions: product, price, channel, and promotion, exploring the reasons for its sustained advantage in fierce market competition.

3.1 Product

3.1.1 Efficacy-driven Key Product System

Table 1: Peraera Product Series List

Product Line	Core Positioning	Core Efficacy	Target Audience
Ruby Series	Scientific anti-aging for young mature skin	Centered on peptides and retinol to improve skin firmness	People over 25 years old who have demands for anti-wrinkle, fading lines and skin firming
Double Anti Series	Brightening & antioxidant	6Combines antioxidation and anti-glycation to brighten skin tone and improve dullness	People aged 18 to 28 who stay up late and have the need for skin brightening treatment
Energy Series	Oil-based anti-aging	Oil-based anti-aging technology to repair fatigued skin cells	People over 30 years old with sagging skin and a desire for anti-aging products
Firming Muscle Density 3.0 Series	Entry-level anti-aging firming line	Dual-action firming and anti-wrinkle/fine line reduction to boost skin elasticity	People over 22 years old who suffer from mild to moderate skin laxity and fine lines
Aqua Muscle Density Series	Basic hydration & moisturizing	Deeply hydrates and maintains skin moisture balance	People with healthy skin needing only basic moisturization

Source Power Series	Skin barrier repair	Basement membrane repair technology to strengthen the skin barrier, soothe sensitivity, and reduce fine lines	Sensitive skin, damaged barrier, redness and itching
---------------------	---------------------	---	--

PROYA has developed a multidimensional efficacy-driven single-product matrix. As shown in Table 1, the Red Diamond series effectively combats wrinkles and fine lines with peptides and supermolecular retinol; the Dual Anti series focuses on antiglycation and antioxidation, precisely addressing yellowing and brightening; the Energy series activates the skin's basal energy with mitochondrial technology; and the Source Power series strengthens the skin barrier with repair technology. Peraera covers core demands such as anti-aging, brightening, moisturizing, and repair, catering to various skin care needs.

3.1.2 Research Collaboration Drives Product Innovation

On July 22,2025, Proya Cosmetics Co., Ltd. and West China Hospital of Sichuan University officially signed a cooperation agreement to focus on 'mitochondrial anti-aging' research. They provide new intervention ideas for various diseases caused by abnormal energy metabolism by improving the energy generation efficiency of mitochondria, repairing structural damage, regulating dynamic balance and enhancing antioxidant capacity. On October 21,2025, the signing ceremony of the coconstruction agreement of the Zhejiang University School of Proya Cosmetics Co., Ltd. Joint Laboratory for Skin Health and Aging Research was held. This study provides solid scientific support for PROYA. PROYA cooperates with top hospitals and universities to develop products, strengthen consumers' trust in the brand, and thus enhance consumers' willingness to buy.

3.2 Pricing

PROYA adopts a pricing strategy that combines differentiation with key product-driven approaches, precisely targeting the mid-range efficacy skincare market. Its product price range is between 200 and 500 yuan, with specific pricing details as shown in Table 2.

Table 2: Formatting sections, subsections and subsubsections.

Product Line	Product Name	Size	Price (CNY)
Ruby Series	Ruby Anti-Wrinkle & Firming Serum	30 ml	350
Ruby Series	Vital Bright Anti-Wrinkle & Firming Toner	120 ml	220
Ruby Series	Vital Bright Anti-Wrinkle & Firming Lotion	120 ml	290
Ruby Series	Vital Bright Anti-Wrinkle & Firming Light Cream	50 g	379
Double Anti Series	Double Anti Serum	30 ml	280
Double Anti Series	Double Anti Vital Toner	150 ml	210
Double Anti Series	Double Anti Vital Lotion	120 ml	230
Energy Series	Energy Essence Toner	120 ml	359
Energy Series	Energy Essence Lotion	120 ml	389
Energy Series	Energy Essence Serum	30 ml	369

3.3 Channels

3.3.1 Consumer Sentiment Insight System

The consumer voice insight system is the core of PROYA's grasp of market demand. The system can automatically capture user evaluations on e-commerce and social platforms, complete data mining through intelligent analysis, and then generate intuitive and clear user insight reports. Based on this system, PROYA enables the brand to quickly and accurately capture the real needs of consumers that are not met and provides direct data support for the optimization of product formulation, use experience and other aspects so that product improvement is more in line with market demands.

3.3.2 AI Formula Large Model

The AI formula large model is the core innovation breakthrough of the PROYA R & D end. The brand trains the makeup AI formula model in a targeted manner, deeply integrates the makeup raw material database and consumer skin quality feedback data, and automatically generates personalized formula solutions for different consumers through algorithms. Compared with the traditional R&D model, this model greatly compresses the cycle of new product development and listing, accelerates the speed of product iteration,

enables consumers to use skin care products that are more suitable for themselves faster, and greatly improves the adaptability and R&D efficiency of products.

3.3.3 Universal Data Hub

The Universal Data Hub realizes the integration and connection of brand full-chain data. The hub builds a complete data tracking system, fully integrating the data of content promotion, influencer exposure, and user attraction to e-commerce transactions. Taking the recommended video of a star product as an example, from the consumer's interaction with the content to the final purchase, the operation personnel can clearly track through the hub and grasp the operation effect in a timely manner, promptly adjust the operation strategy, optimize the product promotion plan, and achieve data-driven refined operation.

3.4 Promotion

3.4.1 Celebrity Endorsement

PROYA levered celebrity endorsements to enhance both brand promotion and market influence. The choice of endorsers closely aligned with the brand's youthful positioning. In 2026, the global brand ambassador of PROYA was Yi Yangqianxi, and the author believes that Yi Yangqianxi's focus on young audiences can further solidify the brand's core proposition of “While young, go discover”. The global sunscreen brand ambassador of the brand is Liu Yifei, who, with her elegant and textured image, helps the brand's high-end sunscreen products and thereby increases L'Oréal's market penetration rate. The public influence of these two celebrity endorsers is extensive, and their image and temperament are highly consistent with the brand's professionalism, youthfulness, and technological sense. Through the endorsement content, brand recognition and favorability can be effectively strengthened, core consumer groups can be accurately captured, and brand influence and user stickiness can be significantly enhanced [9].

3.4.2 Social Media Marketing

Through social media, PROYA has achieved high-frequency brand exposure and user interaction. The annual reading volume of related topics exceeded 5 billion times, and the amount of user interaction exceeded 80 million. By virtue of high-heat communication and in-depth user communication, PROYA has effectively improved the brand's audience and consumption willingness and significantly enhanced market penetration and brand influence [10].

4. Suggestions for Optimizing Poreia's Marketing Strategy

4.1 Product Strategy Recommendations

PROYA currently relies on the “Early C, late A” flagship product to drive growth. Although it has the backing of scientific research collaborations, it lacks sufficient layout in niche product categories. It is recommended that PROYA consolidate its core bestsellers, such as Double Antioxidant and Red Ruby Essence, while leveraging the scientific research achievements from West China Hospital and Zhejiang University to expand into niche product lines, such as anti-aging for sensitive skin, men's skincare, and functional cosmetics. At the same time, it should apply core technologies such as “mitochondrial anti-aging” across all product categories, strengthen its scientific research brand image, reduce reliance on internet-famous bestsellers, and enhance the risk-resistance capability of its product matrix.

4.2 Pricing Strategy Recommendations

The current pricing strategy of the brand's differentiated flagship products mainly follows an affordable route, with insufficient breakthroughs in the high-end market. It is recommended that Perfect Diary optimize its tiered pricing system: retain the cost-effective mass-market line to stabilize the basic customer base, while launching a high-end anti-aging series featuring exclusive scientific research ingredients and setting mid-range to high-end prices that match the scientific research value. The introduction of exclusive pricing plans for different channels and consumer groups not only secures the mass market but also gradually breaks the stereotype of low prices for domestic beauty products, enhancing the brand's premium space.

4.3 Channel Strategy Recommendations

PROYA leads in the application of digitalization and AI tools online, but its offline channel layout is weak. It is recommended to upgrade the AI formula large model, consumer voice insight system, and all-domain data platform and to fill in the offline experience channels by setting up brand counters and beauty collection stores. At the same time, it is necessary to integrate online and offline data to achieve a closed loop of online seeding, offline experience, and all-domain transactions, avoiding PROYA's excessive reliance on online traffic. This can enhance the comprehensiveness of brand reach.

4.4 Promotion Strategy Recommendations

At present, promotions rely heavily on celebrity endorsements and social media influencer recommendations, leading to a prominent issue of marketing homogenization. It is suggested to optimize the marketing structure: reduce investment in short-term traffic-driven endorsements and enhance content marketing that focuses on scientific research and genuine user experiences. For instance, PROYA should integrate its science popularization live broadcasts and offline experience activities with key marketing events. This will transform celebrity traffic into long-term brand reputation, mitigate the effect attenuation caused by marketing homogenization, and enhance brand loyalty.

5. Conclusion

This article believes that, from the above four aspects of products, prices, channels, and promotion, PROYA, by implementing marketing strategies that align with market demands, has achieved outstanding sales results and a good brand reputation, providing effective references for the development of domestic beauty brands. The brand accurately grasps consumer needs, improves product layout, sets reasonable prices, expands sales channels, combines diverse promotion methods, and attaches importance to user experience and subsequent services, thus being able to establish a firm foothold in the market. However, compared with international renowned brands, PROYA still has gaps in brand development history, product types, and overseas market development. Facing the high requirements for product quality in the market, PROYA needs to focus on product quality as the core, increase product innovation efforts, and actively expand the international market to enhance its global brand influence.

References

- [1] Li, Z.K., & Meng, Z. (2022). Research on Online Marketing Strategies of Domestic Cosmetics: A Case Study of Peraera. *Business Economy*, (3), 69-70+149. DOI: 10.19905/j.cnki.syjj1982.2022.03.022.
- [2] He, J.P. (2019). Future Outlook, Challenges and Countermeasures of Real Estate Marketing in the 5G Era: An Analysis Based on 4P Theory. *China Real Estate*, (27), 73-79. DOI: 10.13562/j.china.real.estate.2019.27.013.
- [3] Rongjing, Y. (2024). Case Analysis of Jellycat's Marketing Strategies Based on the 4p Theory. *SHS Web of Conferences*, 207. DOI: 10.1051/SHSCONF/202420701013.
- [4] Peng, J.F., Wen, S.S., & Liu, J. (2025). Research on Digital Marketing Strategy and Optimization of Peraera. *Marketing World*, (17), 178-180.
- [5] Yuan, Q.F. (2026). Application of "4P" Marketing Theory in Anqing Petrochemical. *Cooperative Economy and Science & Technology*, (2), 46-48. DOI: 10.13665/j.cnki.hzjjykj.2026.02.013.
- [6] Yao, B.B. (2025). Innovation and Practice of English Talent Cultivation in Applied Colleges Based on 4P Model under the DeepSeek Platform in the Digital Intelligence Era. *Journal of Heilongjiang Institute of Teacher Education*, 44(12), 67-70.
- [7] Tian, Z.Y. (2025). A Brief Analysis of Peraera's "Double 11" Marketing Strategy Based on 4P Theory. *Marketing of Time-honored Brands*, (3), 94-96.

- [8] Jin, Z. (2024). Analysis of the Successful Marketing Strategy of Starbucks Based on 4P Theory. Department of Psychology, Faculty of Arts & Science, University of Toronto. DOI: 10.54254/2754-1169/85/20240830.
- [9] Wu, M. (2024). The Analysis of Luckin Coffee Using 4P and SWOT Theories. Xinchuan foreign language school. DOI: 10.54254/2754-1169/2024.19283.
- [10] Liao, J., & Chen, X. (2025). Research on the Construction of Marketing Strategy from the Perspective of Disney IP Operation. GBP Proceedings Series, EMHS2025, 179-184. DOI: 10.70088/T5KNQF94.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

The Impact of Green Finance on Corporate Green Innovation: Operating Cash Flow as a Mediating Channel

Leyan Liu*

Surrey International Institute, Dongbei University of Finance and Economics, Dalian 116025, China

**Corresponding author: Leyan Liu.*

Abstract

Against the institutional backdrop of the ongoing implementation of China's "Dual Carbon" strategy and green finance policies, this paper examines the impact of green finance on corporate green innovation from the perspective of cash flow mediation. Based on panel data of Chinese A-share listed companies from 2015 to 2024, this study uses the green finance index as the core explanatory variable and corporate green innovation as the dependent variable. A two-way fixed effects model is constructed to test the underlying mechanism, heterogeneous effects and transmission mechanism of green finance. The baseline regression results show that green finance significantly promotes corporate green innovation, indicating that the development of green finance can provide important support for enterprises to carry out green technology research and green transformation. This conclusion remains valid after several robustness tests, including replacing the dependent variable and using the lagged core explanatory variable, which confirms the reliability of the empirical results. The heterogeneity analysis further shows that the effect of green finance is more significant in state-owned enterprises, highly profitable enterprises and heavily polluting enterprises. This suggests that enterprises with stronger resource advantages, better profitability or greater environmental pressure are more likely to benefit from green finance policies. The mediation test shows that cash flow is an important channel through which green finance promotes corporate green innovation. Green finance can improve firms' operating cash flow, ease financial constraints in research and development activities, and indirectly encourage enterprises to increase green innovation investment. The results indicate that cash flow plays a partial mediating role, meaning that green finance affects green innovation through both direct and indirect channels. Overall, this paper enriches the empirical evidence on the micro-level effects of green finance and provides a reference for improving green finance policies and promoting enterprise green transformation under the "dual carbon" strategy.

Keywords

green finance, corporate green innovation, cash flow, two-way fixed effects, transmission channels

1. Introduction

Against the backdrop of mounting pressure from global climate change, promoting sustainable development has become a major issue of widespread concern for the international community. In September

2020, in his speech at the General Debate of the 75th Session of the United Nations General Assembly, President Xi Jinping announced that China aims to peak carbon dioxide emissions before 2030 and achieve carbon neutrality before 2060 [1]. Following the introduction of the "dual carbon" goals, my country's economic transition toward a green and low-carbon model has gained a clearer strategic direction, thereby highlighting the increasingly prominent role of green finance in economic development. Green finance links environmental governance with economic growth and channels more capital into low-carbon and eco-friendly sectors; it has thus become a key force in driving the green transition and achieving carbon peak and carbon neutrality goals. In terms of the policy advancement process, the development of my country's green finance system has undergone a period of sustained progress. In 2016, the People's Bank of China, together with seven other government departments, issued the *Guidelines for Establishing the Green Financial System*; this marked the first time my country formulated a relatively systematic, top-level design for the development of a green financial system at the national level. Since then, the 19th National Congress of the Communist Party of China proposed to develop green finance and build a beautiful China. The 20th National Congress of the Communist Party of China further emphasized the need to improve the financial policy and standard system to support green development. Since the beginning of 2024, the People's Bank of China, the National Financial Regulatory Administration, the China Securities Regulatory Commission, and other departments have successively issued a series of policy documents—such as the *Guiding Opinions on Further Strengthening Financial Support for Green and Low-Carbon Development*, the *Opinions on Leveraging Green Finance to Serve the Construction of a Beautiful China*, the *Implementation Plan for High-Quality Development of Green Finance in the Banking and Insurance Sectors*, the *Implementation Opinions on Capital Markets Effectively Addressing the "Five Major Tasks" in Finance*, and the *Overall Statistical System for the "Five Major Tasks" in Finance* [2]. These documents have made more arrangements for the work of green finance and brought more specific policy support to the high-quality development of green and low-carbon. After years of promotion, China's green financial policy framework has gradually formed a relatively complete system, and the scale of the green financial market continues to expand. By the end of the third quarter of 2025, the scale of China's broad green financial market has reached 48.55 trillion yuan, and the whole year is expected to be close to 50 trillion yuan [3]; Under such circumstances, enterprises have become key actors in green technological innovation and the transition toward greener production modes. Their green innovation ability will directly affect the realization effect of carbon peaking and carbon neutrality goals, and also affect the promotion of high-quality economic development; Therefore, examining the impact of green finance on corporate green innovation can, on the one hand, enrich the research on the effect of green finance policies and the reasons that drive green innovation of enterprises. On the other hand, it can also provide some practical references for improving the green financial policy system and guiding enterprises to do green transformation.

With the deepening of the concept of green finance and green development, scholars at home and abroad have made a lot of discussions on the economic and environmental effects of green finance, and the relevant research results are also relatively rich. Generally speaking, the existing literature can be understood from both macro and micro levels.

At the macro level, most of the existing studies revolve around two aspects, one focuses on the relationship between green finance and economic transformation, and the other discusses the impact of green finance on regional green development. In terms of economic transformation, Guo Xiyu (2022) found that the panel data of China's provincial administrative regions to analyze, and the results showed that the development of green finance has a significant role in promoting the transformation of low-carbon economy in the region [4]. Similarly, Meng Xiaoqian and Wu Chuanqing (2025) reported that green finance is regarded by them as promoting the green transformation of the economy, and this impact will also show a certain positive spatial spillover effect [5]. Yan Jiajia and Jie Qiongnan started from the policy of the green financial reform and innovation pilot zone and found that the policy could further promote the transformation of urban low-carbon economy by promoting the upgrading of industrial structure [6]. Su J. (2026) focuses on the transformation of industrial structure, and makes a more systematic analysis of the core mechanism, promotion mode and current shortcomings of green finance [7]. It can be seen from these studies that green finance is not only a tool to provide funds, but also has an impact on the process of low-carbon economic transformation with the help of capital allocation and industrial adjustment. Regarding the impact of green finance on regional green development, Tu Qiang, Zuo Limei and Zhang Xuying (2025) selected China's provincial panel data from 2012 to 2022, set up the green financial reform innovation pilot zone as a quasi-natural experiment, and used the double difference model for testing. Through research, their findings indicate that the pilot zone for green

financial reform and innovation can promote regional green development by stimulating green technology innovation, optimizing capital allocation and promoting industrial structure upgrading [8]. Chen Mei (2023) argued that the process of mutual integration and mutual promotion from the relationship between green finance and high-quality development of the regional economy [9]. Song C (2026) also shows that green finance can guide capital to flow into the environmental protection industry, support the research and development and application of green technology, further optimize the regional industrial structure, improve the efficiency of resource utilization, and reduce environmental pollution [10].

From the micro level, studies have focused more on enterprises, mainly discussing the impact of green finance on corporate financing, ESG performance and emission reduction behavior. In terms of enterprise financing, Tao Z (2023) found that the green finance pilot zone policy has expanded the financing scale of green enterprises on the one hand, and compressed the financing scale of polluting enterprises on the other hand [11]. Chen Yin'e and Zhao Ying (2023) further demonstrated that green finance can help small and micro enterprises ease capital constraints by improving the profitability, operating capacity and expansion of enterprises [12]; Li Ziyang (2023) further found that the policy of the green financial reform and innovation pilot zone, and also found that green finance has a significant alleviation effect on the financing constraints of enterprises in the pilot zone [13]. Regarding ESG performance, Sun Y and Wang D (2025) empirically showed that with the triple difference method based on the data of listed companies in China from 2012 to 2020. The results showed that the green financial reform innovation pilot zone policy can significantly improve the ESG performance of those seriously polluting enterprises [14]. Zhu H and Li X (2025) took A-share listed companies from 2014 to 2022 as a sample and found that the Green Finance Pilot Policy (GFPP) has a significant effect on the ESG performance of enterprises [15]. Liu Lin and Zhang Yuqing (2025) further demonstrated that ESG performance can promote green innovation of enterprises by easing financing constraints and improving information transparency, and green finance plays a positive regulatory role in this process [16]. Sun Wenyan and Xu Fangyuan (2026) analyzed the data of "specialized and innovative" enterprises and found that the more outstanding the ESG performance of such enterprises, the easier it is to get green financial support, and this mechanism is mainly manifested in both analysts' attention and green innovation [17]. Meng Jin and Zheng Rui (2025) also found that the development of green finance can significantly improve the ESG performance of energy enterprises [18]. In terms of emission reduction, Qin Yutong (2024) found that the synergy of green financial policies and the market can reverse the significant positive spatial spillover effect generated by the development of a single market, so that the carbon emission intensity of industrial enterprises in surrounding areas can be reduced [19]; Kang Cuiyu (2024) further explained that the development of green finance in China has a pronounced inhibitory effect on the intensity of carbon emissions, but this impact is not simply linear, but a "inverted V"-shaped change characteristic [20].

Generally speaking, the existing research on green finance is relatively rich, which provides a good theoretical basis and empirical reference for this article. However, judging from the existing literature, there are still some shortcomings. First, some literature pays more attention to the relationship between green finance and green development. There is still room for further deepening on how green finance directly affects the green innovation of enterprises, especially in the identification of cause and effect. Second, there have been studies that the discussion of the heterogeneity of enterprises is not systematic enough, and there are large differences between enterprises themselves. Enterprises with different property rights, profitability levels and industry attributes are not exactly the same in terms of financing constraints, policy sensitivity and innovation motivation. Therefore, the effect of green finance on different enterprises may also be different. Third, with the release of the *Overall Plan for the Reform of the Ecological Civilization System* in 2015 and the introduction of the carbon peaking and carbon neutrality ("Dual Carbon") goals in 2020, China's green finance system entered a stage of accelerated development. However, the sample periods used in some existing studies do not adequately cover this period, making it difficult to capture the most recent effects of green finance on corporate green innovation.

Based on the above considerations, this paper selects China's A-share listed companies from 2015 to 2024 as research samples to empirically test the impact of green finance on the green innovation of enterprises. This paper first builds a benchmark regression model to investigate the relationship between the two, and on this basis, the reliability of the conclusion is verified through robustness test. Then, heterogeneity analysis is carried out to study the differences in the effect of green finance in different enterprises, and finally combined with the mediating effect test to analyze the mechanism of action in the middle. The marginal contribution of this

article is mainly reflected in three aspects: First, expand the sample interval to the new stage after the dual carbon goal is put forward, so as to give updated realistic evidence; Second, a multi-dimensional heterogeneity test was carried out, which supplemented the micro-level evidence for the role of green finance in the green innovation of enterprises; Third, by using cash flow as a mediating variable, the study identifies the transmission pathways through which green finance promotes corporate green innovation, thereby offering an alternative perspective for understanding how green finance facilitates corporate green transformation.

2. Theoretical Foundation and Research Hypotheses

2.1 Relevant Theories

Green finance can be understood as an important financial institutional arrangement to promote economic and social green transformation and corporate green innovation. The G20 Green Finance Research Group proposed in the *G20 Green Finance Synthesis Report* that green finance is “investment and financing activities that can generate environmental benefits to support sustainable development”. The environmental benefits mentioned here mainly include reducing pollution emissions, reducing greenhouse gas emissions, improving resource use efficiency, and mitigating and adapting to climate change [21]. The *Guidelines for Establishing the Green Financial System* jointly issued by the People's Bank of China and other seven ministries and commissions further pointed out that green finance is mainly to support economic activities such as environmental improvement, climate change response and resource conservation and efficient utilization, and to provide financial services such as project investment and financing, project operation and risk management for environmental protection, energy conservation, clean energy, green transportation, green construction and other fields. In other words, as long as the relevant financial services can serve the goal of green development, they can be included in the discussion of green finance. In a broad sense, green finance includes not only financial resources flowing to green economic activities, but also financial support to help high-energy-consuming and high-pollution industries complete the green and low-carbon transformation, as well as financial services for the development of green technology innovation and green emerging industries; In a narrow sense, it refers more to the financial support received by economic activities with zero carbon emissions or close to zero carbon emissions [22].

Green finance primarily provides external financial and policy support, whereas green innovation represents an internal transformation undertaken by firms. When facing environmental pressure, enterprises will integrate environmental protection requirements into product development, production technology, service model and management system. Such activities are generally referred to as green innovation. Rennings (2000) explained this concept earlier. He proposed that green innovation includes new perspectives, new products, new services, new processes or new management systems for dealing with environmental problems [23]. Wu Dejun (2019) pointed out that on the one hand, green innovation reflects the "green" at the level of social responsibility, and on the other hand, it can include the content of economic development from "innovation", which can not only help enterprises deal with environmental problems and improve environmental performance, but also improve the competitiveness of enterprises by reducing production costs and adopting differentiated management [24]. Therefore, compared with general innovation, green innovation attaches more importance to combining economic benefits and environmental benefits, which is an important way for enterprises to achieve green transformation and sustainable development.

2.2 Research Hypotheses

The effect of green finance in promoting green innovation of enterprises is mainly reflected in the following aspects. First, green finance can alleviate the capital pressure faced by enterprises when carrying out green innovation. Green innovation generally requires high costs first, and the recovery cycle is long and the uncertainty is high. It is difficult to sustainably promote by relying on internal funds alone. The development of green finance can promote enterprise innovation by easing financing constraints, and has a relatively pronounced positive impact on the green non-invention patents of enterprises (Wang Yulin and Zhou Yahong, 2023) [25]. Second, green finance can guide enterprises to form a long-term green development orientation. Green finance emphasizes the unity of environmental benefits and economic benefits, and requires enterprises to pay more attention to resource utilization efficiency, pollution emission control and sustainable business ability while obtaining financial resource support. For enterprises that hope to get long-term support from

financial institutions and investors, improving the level of green development and green innovation ability will help to enhance their market recognition. Xie Xuemei and Zhu Qiwei (2021) mentioned that the practice of green innovation by enterprises is closely related to the legitimacy, green image and strategic differentiation of enterprises in society. Green innovation can help enterprises form different advantages from others in market competition [26]. Therefore, green finance can not only relieve the capital pressure of enterprises' green innovation, but also promote enterprises to integrate green innovation into their long-term development strategies. Third, green finance can improve the green innovation momentum of enterprises through information disclosure and external supervision. Green finance usually requires enterprises to disclose relevant information such as environmental management, pollution emissions, and the implementation of green projects, which helps to improve the transparency of enterprise information, and also facilitates financial institutions and investors to see what environmental risks enterprises have and whether their operations are stable. Guo Baitao et al. (2026) found that media attention can significantly strengthen the effect of green finance in promoting green innovation of enterprises [27]. In order to maintain a good green image and obtain more financial resources and market recognition, enterprises will also pay more attention to green technology research and development and green transformation activities. Therefore, under the background of the coexistence of green financial constraints and incentives, enterprises are more motivated to continue to carry out green innovation. Based on this, this paper puts forward the hypothesis:

H1: Green finance can promote green innovation of enterprises.

In the process of green finance promoting green innovation of enterprises, cash flow may play a mediating role. Green innovation has the characteristics of long investment cycle, high capital occupation, and uncertain short-term returns. Therefore, whether an enterprise has stable cash flow will directly affect the continuity of its green innovation activities. Compared with general business investment, green technology research and development and environmental protection equipment transformation rely more on long-term financial support.

The effect of cash flow in green finance affecting the green innovation of enterprises is mainly reflected in the following aspects. First, the improvement of cash flow can enhance the continuity of green innovation investment of enterprises. Short-term green innovation may only bring stage benefits, while the long-term competitive advantage of enterprises comes more from the accumulation of continuous innovation ability. Therefore, if enterprises want to form a stable green competitive advantage, they need to continue to promote green innovation activities (Tang Long and Chen Xiangguang, 2024) [28]. If the enterprise lacks stable cash flow, green research and development activities are easily interrupted by business fluctuations. The research on enterprise innovation by Wen Jun and Feng Genfu (2018) shows that enterprise innovation activities are closely related to capital conditions, and a good capital base helps enterprises to continue to carry out innovation activities [29]. Yang Guozhong and others' research on the financing constraints of enterprise green technology innovation further pointed out that there is a positive correlation between enterprise green technology innovation investment and internal cash flow, indicating that internal cash flow is an important factor affecting the investment of enterprise green technology innovation [30]. Therefore, stable cash flow can provide more sustainable financial security for enterprises' green research and development, green product development and production process improvement. Second, cash flow can affect the risk-taking ability of enterprises for green innovation. Hall (2002) pointed out that R&D activities are more likely to face financing difficulties than general investment, mainly because R&D investment has the characteristics of uncertain results, high degree of information asymmetry, and difficult mortgage of knowledge assets and intangible assets [31]. Because continuous green innovation activities require a large amount of R&D funds, the risk of early investment, R&D difficulty and output uncertainty are all large, and the R&D cycle is long, but the time to obtain relevant benefits is relatively short [28]. When the cash flow of an enterprise is tight, the management is more likely to choose projects with short return cycles and fast capital recovery, and reduce investment in green research and development. Tang Long and Chen Xiangguang (2024) pointed out that capital chain risks and liquidity risks will weaken the cash flexibility of enterprises, and insufficient cash flexibility will make enterprises' continuous green innovation activities more susceptible to external shocks, and increase the risk of interruption of innovation activities and unrecoverable investment [28]. This shows that stable cash flow and strong cash flexibility can improve the ability of enterprises to continuously carry out green innovation. Therefore, this article puts forward the hypothesis:

H2: Green finance can promote green innovation of enterprises by improving the cash flow of enterprises.

3. Research Design

3.1 Sample Selection and Data Sources

This paper selects Shanghai-Shenzhen A-share listed enterprises in China from 2015 to 2024 as research objects, and processes the samples as follows: Eliminate listed enterprises specially processed in the financial category and ST, *ST and PT categories; eliminate the samples with missing values; All continuous variables are contracted at a level of 1% to avoid the results being affected by extreme or abnormal values, and finally 12,749 observations were obtained. The data used comes from the CSMAR database, the Wind database, the China Research Data Service Platform (CNRDS platform), the Intellectual Property Office of the People's Republic of China, the National Bureau of Statistics and various statistical yearbooks.

3.2 Variable Definitions

3.2.1 Dependent Variable

Corporate Green Innovation. Drawing on the practice of Zhu Chaohui and others (2023), the number of green patent applications is adopted as the proxy variable of the green innovation level of enterprises [32]. Specifically, selecting the number of green patent applications of sample enterprises during the reporting period, standardizing the natural logarithm after adding 1, and constructing the corporate green innovation can effectively alleviate the interference of the long tail distribution to the panel regression model. Green patents can be divided into green inventions, green utility models and green appearance design patents. Because green invention patents can better reflect the innovation quality of enterprises, the number of green invention patent applications (*Innovation_inv*) is used for testing in the robustness inspection part.

3.2.2 Independent Variable

Green Finance (GF). Drawing on the research methods of Zhang Shuhui and Ren Chongtao (2025) [33] and Du Lixia (2024) [34], based on the four indicators of green credit, green securities, green insurance and green investment, the entropy value method is used to obtain the final results to measure the level of green financial development.

3.2.3 Mediating Variable

Cash Flow Ratio (*CashFlow*). It is measured as the ratio of net cash flow from operating activities to total assets.

3.2.4 Control Variables

Following existing studies, this study includes the following control variables: leverage (*Lev*), profitability (*ROA*), growth opportunities (*TobinQ*), CEO duality (*Dual*), the proportion of independent directors (*Indep*), ownership concentration (*Top1*), and firm size (*Size*). In addition, industry (*Industry*) and year (*Year*) fixed effects are controlled for.

The specific variable definitions in this article are shown in Table 1.

Table 1: Variable Definitions

Variable Type	Variable	Symbol	Measurement
Dependent Variable	Corporate Green Innovation	<i>Innovation</i>	Natural logarithm of the total number of green patent applications plus one
Independent Variable	Green Finance Development	<i>GF</i>	Green finance index
Mediating Variable	Cash Flow Ratio	<i>CashFlow</i>	Net cash flow from operating activities divided by total assets
Control Variable	Leverage	<i>Lev</i>	Measured by the debt-to-asset ratio
	Profitability	<i>ROA</i>	Measured by return on assets
	Growth Opportunities	<i>TobinQ</i>	Measured by Tobin's Q (market value/total assets)
	CEO Duality	<i>Dual</i>	Equals 1 if the chairman of the board and the CEO are the same person, and 0 otherwise
	Proportion of Independent Directors	<i>Indep</i>	Ratio of the number of independent directors to the total number of directors
	Ownership Concentration	<i>Top1</i>	Shareholding ratio of the largest shareholder
	Firm Size	<i>Size</i>	Natural logarithm of total assets at year-end

3.3 Model Specification

This study employs a two-way fixed-effects model to test the research hypotheses and establishes the following regression model, drawing on the approach of Wen and Ye (2014) [35]. Construct a model (1) to examine the impact of green finance on corporate green innovation, focusing primarily on β_1 ; if the coefficient is significantly positive, it indicates that green finance promotes corporate green innovation. Model construction (2): Examine the relationship between green finance and corporate cash flow, focusing primarily on α_1 ; if the coefficient is significantly positive, it indicates that green finance can improve the corporate cash flow position. Model construction (3): Test whether a mediating effect of cash flow exists between green finance and corporate green innovation.

$$Innovation_{i,t} = \beta_0 + \beta_1 GF_{i,t} + \beta_2 Controls_{i,t} + Year + Industry + \varepsilon_{i,t} \quad (1)$$

$$CashFlow_{i,t} = \alpha_0 + \alpha_1 GF_{i,t} + \alpha_2 Controls_{i,t} + Year + Industry + \varepsilon_{i,t} \quad (2)$$

$$Innovation_{i,t} = \gamma_0 + \gamma_1 GF_{i,t} + \gamma_2 CashFlow_{i,t} + \gamma_3 Controls_{i,t} + Year + Industry + \varepsilon_{i,t} \quad (3)$$

Here, *Innovation* is the dependent variable, representing the company's level of green innovation, while *GF* is the independent variable, representing the level of green finance development in the province where the company is located. *CashFlow* is the mediating variable, *i* and *t* denote the firm and the year respectively, and *Control* represents control variables; *Year* and *Industry* represent the time effect and the industry effect, respectively; $\varepsilon_{i,t}$ is the random error term.

4. Empirical Results and Analysis

4.1 Descriptive Statistics

The descriptive statistical results of the main variables in this article are shown in Table 2. The sample consists of 12,749 firm-year observations. And the sample scale was large. The average value of green innovation of the dependent variable enterprise is 1.085, and the standard deviation is 1.302, indicating that the overall level of green innovation of sample enterprises is not high and the individual differences are significant. The descriptive statistics indicate that the overall development of green finance is relatively high, and the standard deviation also reflects the pronounced differentiation of the green financial environment in which different enterprises are located. Each control variable is in a reasonable range, and there are no extreme abnormal values, which lays a good foundation for subsequent empirical analysis.

Table 2: Descriptive Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Innovation	12749	1.0852	1.3020	0.0000	5.2311
GF	12749	0.6685	0.2083	0.0913	0.9281
Lev	12749	0.4087	0.2016	0.0603	0.8821
ROA	12749	0.0345	0.0633	-0.2272	0.1840
TobinQ	12749	2.0678	1.3180	0.8227	7.9566
Dual	12397	0.3245	0.4682	0.0000	1.0000
Indep	12749	0.3810	0.0533	0.3333	0.5714
Top1	12749	0.3390	0.1494	0.0848	0.7272
Size	12749	22.3208	1.3667	19.9963	26.3951

4.2 Baseline Regression Analysis

In order to test the overall impact of green finance on the green innovation of enterprises, this paper gradually introduces the two-way fixed effect of control variables, time and industry for benchmark regression. The results of benchmark regression are shown in Table 3. Column (1) The control variable is not added, and the green finance GF is significantly positive at the 1% statistical level; Column (2) After adding the enterprise-level control variables, the coefficient of GF is still significantly positive at the 1% level; Column (3) further control the fixed effect of the year and industry to exclude the interference of macroeconomic shock and industry heterogeneity. The results show that the coefficient of GF is 0.14, which is significantly positive, indicating that green finance can significantly promote the improvement of the green innovation level of

enterprises. The research hypothesis of this article is verified by H1. Under the background of the dual carbon goals strategy and the continuous improvement of the green financial system, green finance has given full play to the functions of capital guidance and resource allocation, effectively guiding social capital to flow into the fields of enterprises' green research and development, technology transformation, and stimulating the green innovation vitality of enterprises.

Table 3: Baseline Regression Results

	(1)	(2)	(3)
	Innovation	Innovation	Innovation
GF	0.178***	0.359***	0.140***
	(3.372)	(7.740)	(3.159)
Lev		0.320***	0.163***
		(5.136)	(2.846)
ROA		-0.419***	-0.458***
		(-2.587)	(-3.062)
TobinQ		0.009	0.009
		(1.199)	(1.221)
Dual		0.040*	0.006
		(1.848)	(0.313)
Indep		0.336*	-0.120
		(1.682)	(-0.701)
Top1		-0.231***	0.242***
		(-3.173)	(3.654)
Size		0.452***	0.548***
		(40.714)	(54.009)
cons	0.966***	-9.449***	-11.338***
	(26.644)	(-36.619)	(-48.676)
N	12749	12397	12393
R ²	0.001	0.240	0.457
adj. R ²	0.001	0.240	0.453

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.3 Robustness Tests

In order to exclude interference such as variable measurement deviation and endogenous problems, and to ensure the reliability of the baseline regression conclusion, this paper conducts a robustness test from multiple dimensions, and the results are shown in Table 4. First, replace the dependent variable, and use the logarithm of the enterprise's green invention patent application as an alternative indicator for green innovation. The regression results show that the coefficient of the core explanatory variable green finance is 0.21, which is significantly positive, indicating that the conclusion is not affected by the measurement method of the dependent variable. Green finance can not only increase the number of green innovations, but also promote the upgrading of the quality of innovation. Second, in order to alleviate the potential endogenous problem of reverse causality, this paper returns the lag of the core explanatory variable to the first phase, and the coefficient is still significantly positive, indicating that the effect of green finance in promoting green innovation of enterprises is stable. Third, only control the year fixed effect for regression, and regress after excluding the industry fixed effect. The GF coefficient is 0.277, which is still significantly positive at the 1% level. It shows that after changing the fixed effect setting of the model, there is no substantial change in the symbol and significance of the core explanatory variable, which further verifies the robustness of the benchmark regression conclusion.

Table 4: Robustness Test Results

	(1)	(2)	(3)
	Innovation inv	Innovation	Innovation
GF	0.210*** (5.204)		0.277*** (5.864)
Lev	-0.071 (-1.373)	0.125* (1.937)	0.351*** (5.623)
ROA	-0.604*** (-4.497)	-0.600*** (-3.530)	-0.356** (-2.171)
TobinQ	0.029*** (4.191)	-0.007 (-0.720)	0.016** (1.984)
Dual	0.011 (0.608)	0.024 (1.072)	0.029 (1.332)
Indep	0.045 (0.281)	-0.215 (-1.104)	0.315 (1.579)
Top1	0.297*** (4.877)	0.226*** (2.963)	-0.189*** (-2.589)
Size	0.490*** (46.934)	0.571*** (50.072)	0.448*** (39.882)
L1_GF		0.141*** (2.710)	
_cons	-10.448*** (-43.166)	-11.767*** (-44.992)	-9.333*** (-35.646)
N	12393	9765	12397
R ²	0.406	0.474	0.245
adj. R ²	0.402	0.469	0.244

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.4 Heterogeneity Analysis

From the perspectives of ownership, industry pollution intensity, and profitability, this section examines the heterogeneous effects of green finance on corporate green innovation. The results are shown in Table 5. First, in terms of the nature of property rights, green finance plays a more significant role in promoting green innovation of state-owned enterprises, while the impact on private enterprises is relatively weak. This may be because state-owned enterprises have a natural advantage in policy response and financing, and can use green finance to promote innovation more efficiently. Second, judging from the pollution attributes of the industry, green finance has a significant role in promoting the green innovation of enterprises in heavy pollution and non-heavy pollution industries. Second, the estimated coefficient is larger for heavily polluting industries, and the significance level of non-heavy pollution industries is higher. This may be because enterprises in heavy pollution industries usually face stricter environmental supervision and higher pollution control costs, which leads to a stronger marginal promotion effect of green finance on green innovation. Enterprises in non-heavy pollution industries may be relatively less affected by business fluctuations and environmental protection policies. The investment in green innovation of enterprises is more stable, and the internal differences in the sample are lower, so that the estimated results are more stable. Third, in terms of profitability, the effect of green finance in promoting green innovation of high-ROA enterprises is more pronounced. One possible explanation is that profitable enterprises usually have a more stable capital base and stronger risk-taking capacity, and can transform green financial support into green R&D input and innovation output. In contrast,

low-ROA enterprises may face greater operating pressure and capital constraints. Even with green financial support, they are more likely to be prioritized to maintain daily operations or relieve short-term financial pressure, and it is difficult to translate into green innovation activities.

Table 5: Heterogeneity Analysis Results

	(1)	(2)	(3)	(4)	(5)	(6)
	SOEs	Private Enterprises	Heavily Polluting	Non-Heavily Polluting	High ROA	Low ROA
	Innovation	Innovation	Innovation	Innovation	Innovation	Innovation
GF	0.356*** (4.410)	0.033 (0.595)	0.200** (2.126)	0.138*** (2.760)	0.297*** (4.777)	-0.064 (-1.021)
Lev	-0.396*** (-3.543)	0.469*** (6.913)	-0.192 (-1.615)	0.288*** (4.406)	-0.091 (-1.192)	0.563*** (6.227)
ROA	-0.254 (-0.663)	-0.076 (-0.460)	-0.167 (-0.504)	-0.478*** (-2.865)	-0.162 (-0.727)	-1.045*** (-2.797)
TobinQ	0.008 (0.406)	0.006 (0.728)	0.109*** (6.353)	-0.005 (-0.596)	0.087*** (6.577)	-0.010 (-0.956)
Dual	-0.047 (-0.837)	0.051** (2.461)	-0.163*** (-4.008)	0.041* (1.916)	0.028 (0.985)	-0.006 (-0.239)
Indep	0.262 (0.836)	-0.357* (-1.776)	-0.177 (-0.470)	-0.152 (-0.797)	0.156 (0.640)	-0.486** (-2.038)
Top1	0.357*** (2.909)	-0.142* (-1.825)	0.752*** (5.427)	0.109 (1.457)	0.192* (1.943)	0.281*** (3.121)
Size	0.650*** (35.125)	0.442*** (33.448)	0.671*** (34.818)	0.512*** (43.305)	0.614*** (40.597)	0.511*** (36.508)
cons	-13.851*** (-33.532)	-8.842*** (-29.069)	-14.409*** (-32.090)	-10.504*** (-39.096)	-13.050*** (-37.567)	-10.293*** (-32.039)
N	3787	8603	2400	9978	6149	6239
R ²	0.593	0.368	0.547	0.443	0.490	0.444
adj. R ²	0.585	0.362	0.541	0.438	0.482	0.436

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.5 Mediation Effect Analysis

Table 6 reports the results of the mediation analysis examining the effect of operating cash flow. Column (1) shows that the regression coefficient of green finance is 0.140, which is significant at the statistical level of 1%, indicating that green finance can significantly promote green innovation of enterprises. Column (2) uses operating cash flow as the dependent variable. The regression coefficient of green finance is 0.005, which is significantly positive at the statistical level of 5%, indicating that the development of green finance helps to improve the operating cash flow of enterprises. Column (3) After adding green finance and operating cash flow at the same time, the coefficient of green finance is 0.143, which is still significantly positive at the level of 1%; The coefficient of operating cash flow is -0.517 , and it is significantly negative at the level of 1%, indicating that the indirect effect through operating cash flow is negative to the direct direction of green finance. After joining the operating cash flow, the green finance coefficient rose from 0.140 to 0.143, which further shows that the operating cash flow may play a negative role in the process of green finance promoting green innovation of enterprises, rather than a positive mediation effect. The positive direct effect of green finance on the green innovation of enterprises is partially offset by the negative indirect path of cash flow. The possible reasons are: First, green innovation is characterized by large investment and long recovery cycle. Enterprises increasing green research and development, paying salaries of research and development personnel and

carrying out green equipment transformation will consume operating cash flow, so enterprises with high green innovation in the current period may show low operating cash flow. Second, enterprises with abundant cash flow may not use new funds for green innovation, but may also give priority to expanding traditional business, repaying debts, paying dividends or making short-term investments. Therefore, the improvement of cash flow does not necessarily translate into green R&D investment.

Table 6: Mediation Analysis Results: The Cash Flow Mechanism

	(1)	(2)	(3)
	Innovation	CashFlow	Innovation
GF	0.140*** (3.159)	0.005** (1.972)	0.143*** (3.215)
Lev	0.163*** (2.846)	-0.007* (-1.851)	0.160*** (2.781)
ROA	-0.458*** (-3.062)	0.425*** (33.562)	-0.238 (-1.465)
TobinQ	0.009 (1.221)	0.004*** (8.042)	0.011 (1.499)
Dual	0.006 (0.313)	-0.002* (-1.825)	0.005 (0.256)
Indep	-0.120 (-0.701)	-0.003 (-0.275)	-0.121 (-0.710)
Top1	0.242*** (3.654)	0.015*** (4.010)	0.250*** (3.770)
Size	0.548*** (54.009)	0.005*** (8.922)	0.550*** (54.091)
CashFlow			-0.517*** (-3.449)
cons	-11.338*** (-48.676)	-0.088*** (-7.233)	-11.384*** (-48.810)
N	12393	12393	12393
R ²	0.457	0.281	0.458
adj. R ²	0.453	0.276	0.454

t statistics in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. Conclusions and Future Prospects

5.1 Conclusions

This study uses A-share listed companies from 2015 to 2024 as a research sample to empirically examines the impact of green finance on the green innovation of enterprises, and further examines the mediating role of cash flow and the heterogeneous impact under the characteristics of different enterprises. The study mainly draws the following conclusions.

First, green finance can significantly promote the green innovation of enterprises. The baseline regression results indicate that the benchmark regression, the improvement of the level of green finance has a significant positive effect on the green innovation of enterprises. After further robustness testing through the method of variable replacement, using the one-period lagged explanatory variable and only controlling the fixed effect of the year, the core conclusion is still valid, indicating that the research results have strong robustness.

Second, the test results of the mediating effect show that green finance can improve the cash flow of enterprises and relieve the capital pressure of enterprises in the process of green innovation, thus further promoting green innovation of enterprises.

Third, there is pronounced heterogeneity in the effect of green finance in promoting green innovation of enterprises. Judging from the nature of property rights, the effect of green finance in promoting green innovation of state-owned enterprises is more significant, while the impact on non-state-owned enterprises is relatively weak. In terms of pollution attributes, green finance has a promoting effect on both heavily polluting enterprises and non-heavy polluting enterprises, but its role in heavily polluting enterprises is more prominent, which shows that green finance can accelerate the green transformation of high-pollution industries. In terms of profitability, the effect of green finance in promoting green innovation for highly profitable enterprises is more pronounced, while the impact on low-profitable enterprises is relatively weak, indicating that the enterprise's own business status may affect their ability to use green financial resources to carry out innovative activities.

5.2 Policy Recommendations

First, further improve the green financial support system and improve the accurate support ability of green finance for the green innovation of enterprises. The government and financial institutions are encouraged to continue to improve green credit, green bonds, green funds and other financial instruments to guide more funds to the fields of green technology research and development and green production transformation. At the same time, the identification of green projects and the disclosure of environmental information could also be strengthened to reduce the cost of financial institutions to identify green innovation projects and improve the efficiency of green financial resource allocation.

Second, pay attention to the support of enterprise cash flow and ease the constraints of green innovation financing. Due to the long-term and uncertainty of green innovation, enterprises are prone to financial pressure in the process of research and development. Therefore, the cash flow of enterprises could be improved through loan discounts, green special funds, tax incentives, etc., and the ability of enterprises to continuously carry out green research and development should be enhanced. Financial institutions should also design more flexible financing terms and repayment arrangements according to the characteristics of the long cycle of green innovation projects.

Third, implement differentiated green financial policies for different types of enterprises. For non-state-owned enterprises, we should further lower the threshold of green financing, improve their financing availability, and avoid excessive concentration of green financial resources in state-owned enterprises. For heavily polluted enterprises, green financial constraints and incentives should be strengthened to guide them to accelerate technological transformation and green transformation. For enterprises with weak profitability, more policy support could be provided under the premise of risk control to prevent them from giving up green innovation due to lack of funds.

5.3 Research Limitations and Future Research Directions

There are still some shortcomings in this article, and the follow-up research can be further expanded from the following aspects. First, this paper mainly adopts the two-way fixed-effects model for empirical analysis. Although some endogeneity problems have been alleviated through robustness testing, there is still room for further improvement in causal identification. Follow-up research can more accurately identify the causal effect of green finance on green innovation of enterprises by introducing the pilot zone policy of green finance reform and using the DID model to carry out quasi-natural experiments. Second, the research samples in this article are mainly A-share listed companies. The sample range is relatively limited and fails to fully cover small, medium and micro enterprises and non-listed companies. Follow-up research can further extend the sample scope and include more types of enterprises in the scope of analysis, so as to improve the micro-effect research system of green finance. Third, this article mainly examines the mechanism of green finance affecting the green innovation of enterprises from the perspective of cash flow. There is still room for expansion in the mechanism analysis. Follow-up research can expand the intermediary and adjustment path, such as further examining mediating or moderating variables such as financing constraints, research and development

investment, government subsidies, environmental regulations, etc., so as to further examine the multi-dimensional role mechanism of green finance in promoting green innovation in enterprises.

References

- [1] Li, R., & Liu, L. (2021). Green finance and corporate green innovation. *Wuhan University Journal (Philosophy and Social Sciences)*, 74(6), 126–140. <https://doi.org/10.14086/j.cnki.wujss.2021.06.012>
- [2] Li, Z., & Xu, Z. (2026). Theoretical logic, practical challenges, and implementation pathways for green finance development during China's Fifteenth Five-Year Plan period. *Journal of Xinjiang Normal University (Philosophy and Social Sciences)*, (4), 1–9. <https://doi.org/10.14100/j.cnki.65-1039/g4.20260508.002>
- [3] Guo, P., & An, G. (2026). Steady progress in the five pillars of green finance. *China Finance*, (3), 40–42.
- [4] Guo, X. (2022). The impact mechanism and empirical examination of green finance in promoting the transition to a low-carbon economy. *South China Finance*, (1), 52–67.
- [5] Meng, X., & Wu, C. (2025). The impact of green finance on the green transformation of the economy. *Ecological Economy*, 41(5), 158–167.
- [6] Yan, J., & Jie, Q. (2025). How do green finance reform and innovation pilot zone policies affect urban low-carbon economic transition? A perspective from new structural environmental economics. *Journal of Management*, 38(5), 69–83. <https://doi.org/10.19808/j.cnki.41-1408/F.2025.0049>
- [7] Su, J. (2026). Research on the development of green finance to promote the transformation and upgrading of economic restructuring. *Journal of Innovation and Development*, 14(2), 68–74. <https://doi.org/10.54097/YKKWJV49>
- [8] Tu, Q., Zuo, L., & Zhang, X. (2025). Green finance and regional green development. *Theory and Practice of Finance and Economics*, 46(4), 11–18. <https://doi.org/10.16339/j.cnki.hdxbcjb.2025.04.002>
- [9] Chen, M. (2023). The role of green finance in promoting high-quality regional economic development. *Trade Fair Economy*, (2), 143–145. <https://doi.org/10.19995/j.cnki.CN10-1617/F7.2023.02.143>
- [10] Song, C. (2026). Analysis of the impact of green finance on regional economic development. *Journal of Applied Economics and Policy Studies*, 19(2), 72–82. <https://doi.org/10.54254/2977-5701/2026.31897>
- [11] Tao, Z. (2023). Can green finance policies affect corporate financing? Evidence from China's green finance innovation and reform pilot zones. *Journal of Cleaner Production*, 419, Article 138289. <https://doi.org/10.1016/j.jclepro.2023.138289>
- [12] Chen, Y., & Zhao, Y. (2023). Can green finance development alleviate financing constraints for small and micro enterprises? Empirical evidence from Chinese listed small and micro enterprises during 2009–2020. *Journal of Changsha University of Science & Technology (Social Science Edition)*, 38(5), 101–110. <https://doi.org/10.16573/j.cnki.1672-934x.2023.05.011>
- [13] Li, Z. (2023). Green finance policies and corporate financing constraints. *Engineering Economics*, 33(12), 53–73.
- [14] Sun, Y., & Wang, D. (2025). Green finance and ESG performance of enterprises: Evidence from the Green Finance Reform and Innovation Pilot Zone. *Applied Economics*, 57(60), 11204–11218. <https://doi.org/10.1080/00036846.2025.2450383>
- [15] Zhu, H., & Li, X. (2025). Can green finance improve corporate ESG performance? Empirical evidence from Chinese A-share listed companies. *Asia-Pacific Journal of Accounting & Economics*, 32(4), 590–607. <https://doi.org/10.1080/16081625.2024.2371302>
- [16] Liu, L., & Zhang, Y. (2025). ESG performance, green finance, and corporate green innovation. *Financial Theory and Practice*, (4), 29–44.

- [17] Sun, W., & Xu, F. (2026). ESG performance of “specialized, refined, distinctive, and innovative” enterprises and green finance: Relationship and influencing mechanisms. *Finance and Accounting Monthly*, Advance online publication. <https://doi.org/10.16144/j.cnki.issn1002-8072.20260209.004>
- [18] Meng, J., & Zheng, R. (2025). The driving effect of green finance development on the ESG performance of energy enterprises under the “Dual Carbon” goals. *Coal Economic Research*, 45(12), 51–61. <https://doi.org/10.13202/j.cnki.cer.2025.12.005>
- [19] Qin, Y. (2024). *Research on the impact of green finance on carbon emissions of industrial enterprises* (Doctoral dissertation, Sichuan University). <https://doi.org/10.27342/d.cnki.gscdu.2024.000057>
- [20] Kang, C. (2024). *Research on the mechanism and effects of green finance development on carbon emissions in China* (Doctoral dissertation, Northeast Normal University). <https://doi.org/10.27011/d.cnki.gdbsu.2024.000440>
- [21] Li, N., & Lan, G. (2025). The impact of green finance on corporate green innovation. *Engineering Economics*, 35(8), 31–42.
- [22] Hu, Y., & Huang, Y. (2026). The value implications and optimization pathways for developing green finance in China during the Fifteenth Five-Year Plan period. *Reform & Strategy*, Advance online publication.
- [23] Rennings, K. (2000). Redefining innovation: Eco-innovation research and the contribution from ecological economics. *Ecological Economics*, 32(2), 319–332.
- [24] Wu, D. (2019). A review of domestic and international research on green innovation. *Friends of Accounting*, (16), 2–7.
- [25] Wang, Y., & Zhou, Y. (2023). Green finance development and corporate innovation. *Journal of Finance and Economics*, 49(1), 49–62. <https://doi.org/10.16538/j.cnki.jfe.20220615.101>
- [26] Xie, X., & Zhu, Q. (2021). How can corporate green innovation practices address the challenge of harmonious coexistence? *Management World*, 37(1), 128–149, 9. <https://doi.org/10.19744/j.cnki.11-1235/f.2021.0009>
- [27] Guo, B., Wang, S., & Xu, F. (2026). The mechanism through which green finance affects green innovation in high-tech enterprises. *Finance and Accounting Monthly*, (8), 77–81. <https://doi.org/10.16144/j.cnki.issn1002-8072.2026.08.015>
- [28] Tang, L., & Chen, X. (2024). Can digital finance mitigate the adverse effects of short-term debt financing for long-term investment on firms’ sustainable green innovation? *China Population, Resources and Environment*, 34(9), 123–131.
- [29] Wen, J., & Feng, G. (2018). Venture capital and corporate innovation: A trade-off perspective between value creation and value appropriation. *Economic Research Journal*, 53(2), 185–199.
- [30] Yang, G., & Xi, Y. (2019). An empirical study on financing constraints and corporate green technological innovation. *Journal of Industrial Technological Economics*, 38(11), 70–76.
- [31] Hall, B. H. (2002). The financing of research and development. *Oxford Review of Economic Policy*, 18(1), 35–51.
- [32] Zhu, Z., Lin, W., Zeng, A., & Hu, Y. (2023). The impact of “Green Factory” certification on corporate green innovation. *Contemporary Finance & Economics*, (7), 3–16. <https://doi.org/10.13676/j.cnki.cn36-1030/f.2023.07.002>
- [33] Zhang, S., & Ren, C. (2025). The impact of green finance on high-quality agricultural development: Evidence from threshold and mediation effect models. *Frontiers of Engineering Management Science and Technology*, 44(4), 69–75.
- [34] Du, L. (2024). Green finance, environmental investment, and corporate value: Evidence from corporate heterogeneity. *Finance and Accounting Monthly*, (23), 78–81. <https://doi.org/10.16144/j.cnki.issn1002-8072.2024.23.008>

- [35] Wen, Z., & Ye, B. (2014). Analyses of mediating effects: The development of methods and models. *Advances in Psychological Science*, 22(5), 731–745.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

The Impact of the Proportion of Independent Directors on Corporate Profitability—A Comparative Analysis Based on Wuliangye and ST Yanshi

Xinyu Zhang*

Asia-Australia Business College, Liaoning University, Shenyang, China

**Corresponding author: Xinyu Zhang.*

Abstract

There are huge differences in the governance environments of different companies in China. State-controlled companies, which follow stricter governance rules, can provide a solid institutional foundation for independent directors to do their jobs. But some privately controlled companies have highly concentrated ownership and a situation where one shareholder dominates, so independent directors often end up as ‘figurehead directors’ and struggle to effectively supervise. This study uses a comparative double-case method and concludes that this reality makes the relationship between the proportion of independent directors and company profits not simply linear, but influenced by the overall governance environment of the company.

Keywords

corporate governance, comparison of two case studies, proportion of independent directors

1. Introduction

In the real-world situation of China’s A-share market, many companies have issues like weak corporate governance, a dominant shareholder, independent directors being mostly figureheads, and insufficient independence in their duties. The actual effectiveness of independent directors in governance has long been debated, and existing research has not yet reached a consensus [1]. The independent director system is a key design for improving internal governance of listed companies, restraining management and major shareholders, and protecting the rights of small and medium investors. In theory, it should have a noticeable positive impact on earnings quality and long-term business performance [2]. Most existing literature focuses on large-sample empirical tests, and few studies intuitively break down the differences in logic between independent director ratios and profitability under different governance environments through strong-weak governance enterprise pairing or in-depth dual-case comparisons. Targeted local case studies are relatively lacking. To explore whether independent directors can effectively play their roles in companies with weakened governance, and whether increasing the proportion of independent directors in this environment can effectively improve corporate profitability, this article selects two representative companies in the liquor industry: Wuliangye, a state-controlled leading company, and ST Rock, a privately controlled delisted company, for a dual-case comparative study. These two companies both operate deeply in the liquor sector, but their corporate governance structures, independent director ratios, and equity control models are completely different. So they

are comparable in this industry. In that case, their business outcomes show a stark contrast, clearly showing that the corporate profitability might be impacted by independent director proportion, governance environment, and corporate profitability. Thus, such case study is quite typical [3]. The regulators can optimize differentiated management rules for independent directors, improving special governance for highly concentrated private equity, and standardize the cancellation of single-layer supervisory boards with this research findings. Meanwhile, when the small and medium investors want to invest to some company. It is noticeable to recognize that this findings can also offer a practical reference for them. It lead investors not just focusing on the proportion of independent directors, but also evaluating investment risk based on equity structure, supervisory framework, and the stability of actual controller performance, thereby better protecting their own interests.

2. The First Case: Wuliangye

In terms of the board of directors and independent director setup, there are 11 board members with 4 independent directors in this firm and such number keeps stable from 2023 to 2025. The independent director proportion is about 36.4%, which is higher than the minimum one-third requirement set by regulators. It must be emphasized that the independent directors are consist of professionals from accounting and legal fields, so their expertise aligns well with the company's operational and financial oversight needs, enabling the board a fairly strong level of independence. Moving on the company's profit data from 2023 to 2025, the core profit indicators are as follows: in 2023, revenue was 83.272 billion yuan, net profit attributable to shareholders was 30.211 billion yuan, and the gross margin was 75.8%, showing steady growth; in 2024, revenue reached 89.175 billion yuan, net profit attributable to shareholders was 31.853 billion yuan, and the gross margin was 77.1%, there are a stable upward trend in profit can be seen. In 2025, due to changes in revenue recognition accounting policies and the overall industry environment, revenue and reported net profit saw a short-term decline, but the gross margin remained high at 77.5%, and the company's core profitability did not materially deteriorate.

3. The Second Case: ST Rock

ST Rock is a privately-held listed company, with its shares highly concentrated in the hands of its actual controller, Han Xiao. After several adjustments, its main business has focused on the low-end liquor sector. Previous studies have shown that when ownership is highly concentrated, corporate value tends to start declining. The company has long faced issues like equity imbalance and chaotic internal management. Its business has spanned construction ceramics, real estate, internet finance, and liquor, frequently changing its main focus, earning it market nicknames like the 'Phoenix of A-shares' or the 'King of Renaming'. As of 2023, independent directors make up about 42.86%. Even though the proportion of independent directors is high, it hasn't changed the fact that the actual controller still dominates the board. In 2025, the shareholders decided to abolish the supervisory board, transferring all oversight functions to the board's audit committee, forming a governance structure of 'board self-supervision.' Relying on just three independent directors to oversee finance, internal controls, executive performance, and related-party transactions is not enough [4]. The chairman, Han Xiao, is linked to the 70 billion yuan Haisheng Wealth fundraising fraud case, and as a core member of the Han family, he was criminally detained by the police. Losses have been increasing year by year. Independent directors can't correct business deviations or prevent financial risks.

4. Comparison of Corporate Governance Environment and the Proportion of Independent Directors

From the perspective of the company's ownership characteristics, Wuliangye's actual controller is the Yibin State-owned Assets Supervision and Administration Commission. It is not only regulated by the CSRC but also bound by rules like the 'Regulations on the Honest Conduct of Leaders of State-owned Enterprises' from the SASAC. Responsibilities within the company are clearly divided, management actions are closely monitored, and the overall governance environment is standardized and transparent. The company has a mechanism for selecting management, and since executives in state-controlled enterprises are mostly appointed administratively and face performance evaluations during their terms, their behavior tends to be more cautious. At the same time, major decisions need prior review by the Party Committee, creating multiple layers of checks. This forms a multi-layered control system of 'Party Committee - Board of Directors - Management'. Although this kind of institutional restraint might reduce decision-making efficiency, it

objectively provides ‘institutional soil’ for independent directors to perform their duties — their opinions are more likely to be recorded and held accountable. A solid institutional foundation can help independent directors do their job [5]. ST Rock operates under a governance model dominated by private controlling shareholders, with overly concentrated equity and the controller holding absolute power. The checks and balances of the board of directors and the supervisory board are weakened, internal governance tends to be ‘one-man rule,’ and the external regulatory constraints on private companies are relatively weak, lacking rigid supervision measures like pre-approval from the party committee in state-owned enterprises or routine inspections of state assets. This harsh external governance environment fundamentally limits the ability of independent directors to fulfill their supervisory role [6]. Introducing the principal-agent theory to further analyze the core conflicts in two types of companies: In state-owned enterprises, the agency problem mainly shows up as an ‘absent owner’ issue, where management lacks long-term equity incentives and tends to run conservative operations and avoid risks. In highly centralized private companies like ST Rock, the main agency conflict is ‘major shareholders harming minority shareholders.’ The actual controller can use their absolute control to divert company funds and channel benefits to related parties. The case of the Han family’s Han Xiao in the Haiyin Wealth 70 billion yuan fundraising fraud and huge losses is a typical example of how controllers can hollow out listed companies. Under these two ownership models, independent directors face fundamentally different supervision challenges: in state-owned enterprises, their main job is to monitor management, while in private companies, independent directors have to check the power of controlling shareholders, making their supervision and responsibilities much tougher.

Looking at the proportion numbers, from 2007 to 2022, ST Rock had 36%, just above the regulatory red line. But because one shareholder dominated internally, independent directors only had a small amount of voting power, making it hard to effectively restrain major shareholders and the management team. After 2023, ST Rock increased the proportion of independent directors to 42.86%, but this didn’t change the fundamental internal control issues, like the ultimate controller being deeply tied to the board and management holding multiple board roles. So the effectiveness of independent directors didn’t really improve despite the higher proportion. At the same time, there’s a clear gap in professional qualifications: Wuliangye matches independent directors’ accounting and legal expertise with its high cash flow and high-margin industry to address governance risks. ST Rock’s independent directors, however, are disconnected from the company’s operational and financial supervision needs, which further magnifies governance problems caused by the insufficient proportion. In 2025, the company’s annual reports received qualified opinions from accounting firms and its internal control report was given a negative opinion, but when independent directors reviewed the reports, they still all voted in favor. Their duties were basically just for show. The combination of having too few independent directors and a flawed governance environment made them completely lose their supervisory function [7,8].

In short, the strengths and weaknesses of independent directors in the two listed companies aren’t just by chance. They’re the inevitable result of the entirely different ownership structures—state-controlled versus family-owned private companies—which create distinct institutional environments and agency conflicts. The fundamental differences in ownership shape completely different governance logics: state-owned enterprises have rigid oversight systems that restrain managers’ self-serving behaviors, while private family businesses lack effective checks and balances, leading the independent director system to have very different governance outcomes and value in different companies.

5. How the proportion of highly independent directors affects company profits under different governance

Wuliangye: High proportion of independent directors and standard governance → stable and improving profits. With good governance in a state-controlled environment, a higher proportion of independent directors creates an effective internal check-and-balance system, effectively easing principal-agent problems, restraining management from chasing short-term gains, and ensuring the implementation of the company’s long-term business strategies [9].

ST Rock: High proportion of independent directors leads to unbalanced governance → continuous decline in profitability. Even if the company later tries internally to fix governance issues like flawed financial disclosure and perfunctory review of related-party transactions by increasing the proportion of independent

directors, actions like illegal operations and benefit transfers by the actual controller can't be restrained. The company's management is chaotic, revenue keeps shrinking, and losses worsen year by year. Independent directors can't correct operational deviations or prevent financial risks. In 2023, revenue was 282 million yuan, net profit attributable to the parent company was -33 million yuan, and the company started to incur losses; in 2024, revenue was 284 million yuan, net profit attributable to the parent was -99 million yuan, with losses further expanding; in 2025, revenue sharply dropped to 39 million yuan, net profit was a loss of 266 million yuan, consecutive losses and operational disorder piled up, and in 2026, the Shanghai Stock Exchange issued a delisting notice.

This shows that when there are serious flaws in corporate governance, even though the independent directors ratio have a high level, it won't reduce operational risks and may actually accelerate a company's profit collapse [10].

6. Conclusion

Based on the above analysis, we can draw the following conclusions: First, the proportion of independent directors is a key indicator affecting board independence, and its effectiveness depends on the overall corporate governance environment. To be specific, Wuliangye, which is a state-controlled company and it has standardized governance. The higher proportion of independent directors effectively plays a supervisory and balancing role, enabling the company maintain stable long-term profits. In contrast to Rock, which is privately controlled and poorly governed, even increasing the proportion of independent directors makes no difference if one shareholder dominates, completely neutralizing the independent directors, leading to continuous losses until delisting. Second, the corporate governance environment can influence the relationship between the proportion of independent directors and company profits. A well-functioning governance environment can enhance the positive impact of independent directors, boosting profitability, whereas a poor governance environment can weaken or even negate their value, worsening profits. Third, the independent director system cannot rely solely on setting proportions; it also requires complementary mechanisms like professional staffing, performance assessment, and external supervision to truly optimize governance and improve company profitability.

Based on the conclusions from this dual-case analysis, the following suggestions are offered for listed companies with different governance types: 1. Set a reasonable proportion of independent directors and strictly follow compliance rules: All listed companies should strictly adhere to regulatory requirements, ensuring that independent directors make up at least one-third of the board, as legally required. For companies with concentrated ownership or private control, it's advisable to increase the proportion of independent directors to strengthen independent supervision. This can help break the 'insider control' pattern at the board level and provide a solid institutional foundation for stable profits. 2. Match professional talent to improve independent directors' effectiveness: Companies should hire independent directors with expertise in accounting, law, and industry operations, considering their own industry characteristics and business risks. In industries like liquor, which have strong cash flow and frequent related-party transactions, prioritizing financial and legal independent directors allows them to genuinely participate in financial oversight and risk management, indirectly protecting profitability. 3. Optimize corporate governance according to company type: State-owned enterprises should continue to deepen their existing governance strengths, leveraging the state asset supervision system to further enhance independent directors' decision-making and supervision role, focusing on long-term profit growth. Private enterprises should concentrate on improving shareholding structures, reducing excessive control by actual controllers, attracting diverse shareholders, and building a governance framework of checks and balances. This creates room for independent directors to perform their duties and prevents profit decline caused by poor governance. 4. Strengthen supervision and accountability to avoid 'token' independent directors: Regulators should intensify checks on independent directors' performance, holding accountable those directors and companies that fail to meet the required proportion, consistently miss meetings, or do not raise reasonable objections. External oversight pushes companies to take the independent director system seriously, preventing independent directors from being mere 'decorations' and ensuring the system truly supports business operations and profit growth.

Limitations and shortcomings of this study: First, only two liquor companies were selected as cases, and the sample size is small, so the research conclusions have limitations when applied across industries. Second,

the study mainly relies on qualitative case analysis and does not conduct quantitative tests through large-sample empirical models, so the conclusions lack strong statistical support. Third, the analysis only considers proportions and board performance, without fully accounting for macroeconomic factors, industry cycles, or management capabilities, meaning potential endogeneity issues aren't entirely avoided. Fourth, due to limitations in publicly available information, we couldn't access internal discussions or detailed performance data of independent directors, so the analysis depth is somewhat limited. In the future, expanding the sample size, lengthening the research period, and combining empirical analysis methods could help deepen the research further.

References

- [1] Yuan Chun, Li Yuan, Li Zhe. (2026). The Governance Effect of Independent Director Training: Evidence Based on Earnings Management, 49(4), 167-198.<https://doi.org/10.19985/j.cnki.cassjwe.2026.04.007>.
- [2] Peng Baiying. (2026). The Dilemma and Governance of the Independent Director System in China's Listed Companies. Cooperative Economy and Technology, (2), 84-86.<https://doi.org/10.13665/j.cnki.hzjjykj.2026.02.018>.
- [3] Yin Xiaolan, Tian Shen & Wu Shaotong. (2022). A study on the impact of corporate governance structure on the performance of liquor companies — Based on fsQCA analysis method. Journal of Xichang College (Natural Science Edition), 36(3), 34-39.<https://doi.org/10.16104/j.issn.1673-1891.2022.03.007>.
- [4] Sharif Mazumder & Ramesh P. Rao The Quarterly Review of Economics and Finance. (2026). Does having multiple insiders on boards enhance the effectiveness of independent directors?
<https://doi.org/10.1016/j.qref.2026.102139>
- [5] Luo Jinhui, Lin Ning & Wu Yilong. (2024). External Strict Regulation and the Functioning of Independent Directors . Economic Management, 46(11), 168-188.<https://doi.org/10.19616/j.cnki.bmj.2024.11.009>.
- [6] Dong Bin & Zhang Zhen. (2015). Ownership Structure, Board Characteristics, and Company Performance: An Endogeneity Perspective. Journal of Dalian University of Technology (Social Science Edition), 36(4), 13-22.<https://doi.org/10.19525/j.issn1008-407x.2015.04.003>.
- [7] Guan Bilin & Ge Zhisu. (2021). Analysis of the Threshold Effect of Equity Checks and Balances on Corporate Performance——An Empirical Study Based on SMEs Listed on the SME Board. Southern Finance, (12), 59-70.
- [8] Niu Luyao. (2021). Board Size, Independence, and Corporate Performance: An Empirical Study Based on Chinese Listed Family Businesses (Master's Degree Thesis, Southwestern University of Finance and Economics). Master <https://doi.org/10.27412/d.cnki.gxncu.2021.001524>.
- [9] Qin Shuai, Tan Jinsong & Kong Xiangting. (2024). Do Independent Directors Have a Governance Effect When Attending Shareholders' Meetings?—Evidence from Risk-Taking, (10), 69-81.
- [10] Zhang Siyao. (2022).Ownership Structure, Board Characteristics, and Firm Performance (Master's Degree Thesis, Jilin University of Finance and Economics). Master <https://doi.org/10.26979/d.cnki.gccsc.2022.000190>.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

ESG Performance, Financing Constraints, and Corporate Financial Performance

Tingting Luo*

School of International Economics and Trade, Xinjiang University of Finance and Economics, Urumqi 830012, China

**Corresponding author: Tingting Luo.*

Abstract

Based on the background of the dual-carbon target and the standardized ESG information disclosure mechanism of listed companies, this paper takes Shanghai-Shenzhen A-share listed companies from 2015 to 2024 as a research sample, constructs a two-way fixed-effects model to test the impact of ESG performance on the financial performance of firms, and explores the intermediary transmission mechanism of financing constraints. The study found that ESG performance has a positive effect on the financial performance of firms, and the results are robust. Financing constraints play a mediating role, and good ESG performance relieves financing constraints and improves the financial performance of firms. Heterogeneity analysis shows that the performance boost effect of ESG is heterogeneous. The research aims to provide an empirical basis for listed companies to promote ESG implementation and regulatory departments to improve green finance-related policies.

Keywords

ESG performance, corporate financial performance, financing constraints, two-way fixed-effects, mediating effect

1. Introduction

Under the global wave of sustainable investment and the United Nations SDGs development framework, ESG has gradually become the benchmark for institutional investors to evaluate enterprise value and identify business risks. At the domestic level, with the continuous improvement of the green financial system and the promotion of the dual-carbon goal, together with the top-level deployment of the “15th Five-Year Plan” for industrial green transformation and sustainable governance of firms, Huang Shizhong et al. (2023) [1] pointed out that the ESG information disclosure mechanism of A-share listed companies continues to be standardized, the ESG rating system is gradually implemented, and ESG performance has become a key criterion for measuring the long-term sustainable development potential of firms. However, the academic community has not reached a consensus on whether ESG performance can improve the financial performance of listed companies. Wang Xiaoyan and Zhou Daiqian (2025) [2] believe that good ESG performance can effectively respond to the demands of stakeholders, reduce information asymmetry, and thus improve financial performance; Yao Ye and Wang Jinfeng (2025) [3] pointed out that ESG implementation may increase short-term costs and inhibit corporate profits. Based on this, this paper measures financial performance by ROA, quantifies ESG performance with Huazheng ESG Ratings, and selects Shanghai-Shenzhen A-share listed

companies from 2015 to 2024 as a sample. By studying the impact of ESG performance on the financial performance of firms, it is intended to provide reference experience for the sustainable development practice of listed companies.

In recent years, many scholars have carried out a lot of empirical studies on the relationship between enterprise ESG rating and enterprise financial performance. The conclusions can be roughly divided into the following three types of views: positive relationship, negative effect, and nonlinear relationship. First of all, this kind of research is based on the stakeholder theory and believes that high-quality environmental governance, social responsibility investment and internal control can reduce enterprise financing constraints, reduce the risk of compliance penalties, improve market recognition, and ultimately improve long-term profitability. Zhao Jixin and Zhou Yongtao (2024) [4] believe that high-quality ESG practices are conducive to improving the financial performance of firms; Tao Quan and Ding Wenyi (2025) [5] found that the better the ESG performance, the higher the financial performance of the firm; Luo Yunxuan and Lu Jingyu (2025) [6] also confirmed that the excellent performance of firms in ESG highlights their significant positive impact on financial performance; Sun Bo (2025) [7] further pointed out that ESG ratings are significantly positively correlated with financial performance, and the higher the quality of accounting information, the stronger the positive effect. However, some scholars hold the opposite view that ESG implementation may also increase short-term costs and suppress corporate profits. Yao Ye and Wang Jinfeng (2025) [3] confirmed that the ESG greenwashing of firms will have a significant negative inhibitory effect on financial performance by exacerbating information asymmetry and weakening profitability; From the perspective of short-sightedness, Ren Qin (2024) [8] shows that when firms face strong financing constraints, the inhibitory effect of management myopia on enterprise ESG will be more significant. In addition, some scholars believe that there is no simple one-way linear relationship between the two, and the strength of the effect will be constrained by heterogeneous conditions such as industry attributes, institutional environment, enterprise property rights, scale, etc. At the same time, there are nonlinear curve relationships such as U-shaped and inverted U-shaped. Liu Shulan et al. (2024) [9] found that based on the data of the energy industry, there is a “U” relationship between green investment in China's energy industry and the financial performance of firms, which first declines and then rises; Wang Rong (2022) [10] confirmed from the perspective of cost-benefit that the impact of ESG information disclosure level on enterprise value has a threshold effect. When the ESG information disclosure level is lower than 6.358, ESG information disclosure has a negative correlation with enterprise value; Xie Meng et al. (2024) [11] pointed out from the time dimension that the performance of ESG responsibilities of firms cannot improve short-term financial performance, but it can achieve a positive improvement in performance around the third year of practice, reflecting the characteristics of time delay and continuity. The existing literature has not reached a consensus on the relationship between ESG and financial performance. Whether ESG performance can improve the financial performance of listed companies, the actual impact relationship between the two has yet to be tested.

The relationship between ESG performance and financial performance is also affected by mediating variables. Wang Xiaoyan and Zhou Daiqian (2025) [2] confirmed that the improvement of ESG performance can have a positive impact on the financial performance of firms by alleviating financing constraints; Wang Fengyun and Guo Haopeng (2026) [12] used A-share listed power generation firms as a sample to confirm that ESG performance indirectly improves the financial performance of firms by improving the quality of audit; Taka Sakura and Chifuyu (2025) [13] use analysts' attention as a mediating variable to analyze the impact mechanism of strengthening or weakening ESG ratings on financial performance; In terms of innovation channels, Luo Yunxuan and Lu Jingyu (2025) [6] confirmed that ESG rating performance can stimulate firms to increase R&D investment, thereby promoting financial performance improvement, in which R&D investment plays a mediating role; Financial mismatch can also play a mediating role between ESG performance and financial performance. Liu Gang (2024) [14] confirmed that ESG performance can promote the financial performance growth of firms by alleviating financial mismatch; Liquidity creation plays a mediating role between ESG investment and the business performance of commercial banks. Li Bo (2024) [15] takes A-share listed banks as a sample to confirm that ESG investment can indirectly promote bank business performance by improving liquidity creation; Directors' shareholding plays a mediating role between ESG performance and financial performance. Du Yu and Kong Qianxuan (2024) [16] confirmed that the increase in the shareholding ratio of directors can have a positive impact on financial performance by improving the ESG performance of the firm; In addition, Liu Yi et al. (2025) [17] found that digital transformation can improve the ESG performance of firms by enhancing innovative capital.

Studies have provided an important basis for understanding the relationship between ESG performance and corporate financial performance, but there are still shortcomings: First, there are still differences in the benchmark conclusion. The existing literature has not reached an agreement on whether the two have a positive relationship, negative effect or nonlinear relationship, and most studies focus on a single industry or a specific year, and lack systematic testing. Second, the analysis of the mechanism of ESG affecting ROA is not systematic enough. Third, heterogeneity analysis can still be further expanded.

In view of this, this paper takes Shanghai-Shenzhen A-share listed companies from 2015 to 2024 as a research sample, measures the financial performance of the firm with return on total assets (ROA), selects Huazheng ESG Ratings to measure firms' ESG performance, empirically test the impact relationship between the two with the help of the two-way fixed-effects model, and carry out heterogeneity analysis. The research conclusion can enrich the empirical research related to domestic ESG and corporate profitability, and has certain theoretical supplementary value; At the same time, it can provide a realistic reference for listed companies to balance sustainable investment and operating income, and regulatory departments to optimize ESG supporting incentive policies.

2. Theoretical Analysis and Research Hypotheses

2.1 ESG Performance and Corporate Financial Performance

According to the stakeholder theory, good ESG performance of firms can effectively respond to the demands of various stakeholders, reduce the information asymmetry between the firm and the external environment, and thus reduce transaction costs and agency costs. At the same time, based on the resource-based theory, high-quality environmental governance, social responsibility fulfillment and corporate governance level constitute the unique intangible resources of firms, which are conducive to forming differentiated competitive advantages and enhancing long-term value creation capabilities. The above theoretical logic has been empirically supported. Wang Xiaoyan and Zhou Daiqian (2025) [2], taking listed companies in China's manufacturing industry as a sample, found that the improvement of ESG performance can significantly improve the financial performance of firms, and the long-term effect is better than the short-term effect; Tao Quan and Ding Wenyi (2025) [5] verified the significant positive correlation between ESG performance and financial performance, and revealed the mediating role of debt financing costs; Sun Bo (2025) [7] further confirmed that ESG rating is significantly positively correlated with financial performance, and the higher the quality of accounting information, the stronger the positive effect. Based on this, this study puts forward the hypothesis:

H1: The better the ESG performance, the higher the financial performance of the firm.

2.2 The Mediating Role of Financing Constraints

In the sustainable development of firms, many firms have insufficient information disclosure, and it is difficult for investors to accurately judge the business status of firms. Therefore, financial institutions raise the lending threshold, and firms have problems of "difficult financing" and "expensive financing", which leads to a decline in their own financial performance. When firms optimize their ESG performance, the relevant disclosures of the dimensions of environment, social responsibility and corporate governance can enrich the business information disclosed to the public, dispel the concerns of investors, make it easier for firms to obtain credit and equity investment, and alleviate financing constraints. After having sufficient capital reserves, firms can promote R&D upgrading, expand business layout, optimize debt arrangement, and increase the operating profitability. Based on this, the transmission path is sorted out: the improvement of ESG performance will first reduce financing constraints, and then increase financial performance with the help of a relaxed capital environment. Based on this, this study puts forward the hypothesis:

H2: Good ESG performance will ultimately improve the financial performance of firms by easing financing constraints.

3. Research Design

3.1 Sample Selection

This study uses a sample of A-share listed companies from 2015 to 2024. Financial and insurance companies, ST and ST* firms, and observations with missing values are excluded from the sample. In addition, all continuous variables are winsorized at the 1% level. After the above screening, 15,159 enterprise-annual observations were finally obtained.

3.2 Data Sources

The core independent variable is firms' ESG performance, measured using Huazheng ESG Ratings. All financial indicators and corporate governance variables of firms come from the Guotaian database. The annual macro and industry classification data come from the Wind financial end and the industry classification standards of the Securities Regulatory Commission.

3.3 Variable Definitions

Dependent Variable: This study takes the return on total assets (ROA) as a measure of the financial performance of firms. This indicator can reflect the actual level of profitability of firms relying on overall assets, and can comprehensively portray the profitability of firms at the daily operation level.

Independent Variable: Taking the ESG rating of the Huazheng ESG Ratings Index as the core explanatory variable of this study, the ESG rating of Huazheng ESG Ratings covers a complete dimension and has a high update frequency. It adapts to the institutional characteristics of the domestic A-share market, and can more objectively portray the comprehensive practice level of firms in the three dimensions of environment, social responsibility and corporate governance.

Control Variables: In order to control the impact of other factors on the financial performance of the firm, this paper selects the size of the firm, Growth, liquidity, CEO duality, the proportion of independent directors, the shareholding ratio of the largest shareholder, state-owned firms, and Big Four Auditor as control variables, so as to improve the control system of the model and improve the reliability of the regression results.

Mediating Variable: This paper sets the financing constraint as the mediating variable of this study, and then uses the SA index to complete the quantitative measurement. With the help of this indicator, this study hopes to accurately measure the intermediate transmission level of ESG's role in the financial performance path.

3.4 Model Specification

To test H1, the following baseline model is constructed:

$$Roa_{i,t} = \alpha_0 + \alpha_1 ESG_{i,t} + \sum_j \gamma_j Controls_{i,t}^j + Year_t + Ind_k + \varepsilon_{i,t} \quad (1)$$

Roa represents the return on assets; *ESG* denotes the score derived from Huazheng ESG Ratings; *Controls* represents control variables; *Year* and *Ind* denote year and industry fixed effects, respectively; ε represents the random disturbance term; *i*, *t*, and *k* represent the firm, year, and industry, respectively; and $\varepsilon_{i,t}$ represents the random error.

Based on Model (1), a mediation effect model is constructed to test H2:

$$SA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \sum_j \delta_j Controls_{i,t}^j + Year_t + Ind_k + \varepsilon_{i,t} \quad (2)$$

$$Roa_{i,t} = c_0 + c_1 ESG_{i,t} + c_2 SA_{i,t} + \sum_j \mu_j Controls_{i,t}^j + Year_t + Ind_k + \varepsilon_{i,t} \quad (3)$$

Equation (2) represents the regression model of the mediating variable *SA* on the explanatory variable *ESG*, while Equation (3) represents the regression model of the dependent variable *Roa* on the explanatory variable *ESG* and the mediating variable *SA*.

4. Empirical Analysis

4.1 Descriptive Statistics

The descriptive statistical results are shown in Table 1. The average value of the total return on assets (ROA) of the explained variable is 0.029, the standard deviation is 0.07, the minimum value is -0.264, and the maximum value is 0.197, which shows that the profitability of the listed companies in the sample is highly differentiated, there is a phenomenon of loss-making firms and high-profit firms coexisting, and the overall profitability level is low. The core explanatory variable ESG average is 6.012, the standard deviation is 0.799, the minimum value is 4.41, and the maximum value is 8.26, indicating that the overall ESG performance of most firms is in the middle range, and the gap in the sustainable performance of firms is moderate. The distribution status of control variables and ROA and ESG data is suitable for subsequent baseline regression analysis.

Table 1: Descriptive Statistics

Variable	Observations	Mean	Standard deviation	Minimum	Median	Maximum
ROA	15159	0.029	0.07	-0.264	0.033	0.197
ESG	15159	6.012	0.799	4.41	5.94	8.26
Size	15159	22.415	1.304	20.064	22.223	26.395
Growth	15159	0.114	0.321	-0.57	0.076	1.591
Liquid	15159	2.397	2.13	0.381	1.684	12.874
Dual	15159	0.317	0.465	0	0	1
Indep	15159	0.379	0.053	0.333	0.364	0.571
Top1	15159	0.328	0.147	0.085	0.303	0.726
Soe	15159	0.308	0.462	0	0	1
Big4	15159	0.068	0.252	0	0	1

4.2 Baseline Regression Results

Table 2 is the regression result of the benchmark model, showing that the firms' ESG performance has a significant positive impact on financial performance (ROA), and is significant at the 10% level, and H1 is supported. Specifically: Column (1) only includes the core explanatory variable ESG and controls the two-way fixed-effects, without adding any control variables, and preliminarily verifies the positive effect of ESG on ROA; Column (2) introduces control variables at the level of firm size, Growth and liquidity management on the basis of column (1); Column (3) On the basis of column (2), further supplement control variables such as CEO duality, the proportion of independent directors, and the shareholding ratio of the largest shareholder; Column (4) includes all control variables, and adds the nature of property rights and Big Four auditor variable. The regression coefficient of the ESG rating is 0.002 and the standard error is 0.001, indicating that every time the firm's ESG score is increased by one unit, return on total assets (ROA) is increased by 0.002. The higher ESG performance can improve the profitability of the firm. The results show that the higher the ESG rating of the firm, which is conducive to reducing risks and financing costs, and can also consolidate the long-term business foundation of the firm and contribute to sustainable development.

Table 2: Baseline Regression Results

	(1) ROA	(2) ROA	(3) ROA	(4) ROA
ESG	0.002* (0.001)	0.002* (0.001)	0.002* (0.001)	0.002* (0.001)
Size		0.007** (0.003)	0.007** (0.003)	0.007** (0.003)
Growth		0.049*** (0.002)	0.049*** (0.002)	0.049*** (0.002)
Liquid		0.008*** (0.001)	0.008*** (0.001)	0.008*** (0.001)
Dual			0.001 (0.002)	0.001 (0.002)
Indep			0.007 (0.019)	0.008 (0.019)
Top1			0.031** (0.016)	0.032** (0.016)

	(1) ROA	(2) ROA	(3) ROA	(4) ROA
Soe				0.003 (0.006)
Big4				0.010* (0.006)
Observations	15159	15159	15159	15159
Number of Firms	3473	3473	3473	3473
R ²	0.021	0.121	0.122	0.122
Control Variables	No	Partial	Partial	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

Notes: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Cluster-robust standard errors at the firm level are reported in parentheses. All specifications include firm fixed effects and year fixed effects. The same applies to the following tables.

4.3 Robustness and Endogeneity Tests

In order to verify the reliability of the above results, this paper conducts robustness and endogeneity tests. The regression results are shown in Table 3.

Alternative dependent variable. This study replaces the explanatory variable with ROE. As shown in column (1), the regression coefficient of ESG performance is 0.008, which is significant at the level of 1%, indicating that after replacing the profit measurement index, ESG performance can still significantly improve the financial performance of the firm, and the benchmark results are stable.

Excluding 2020. Due to the impact of the firm's business environment caused by the global outbreak of the epidemic, this paper excludes the re-regression of the 2020 observation sample. The regression results are shown in column (2). The ESG coefficient is 0.002, which is significantly positive at the 5% level, which is completely consistent with the baseline regression coefficient and significance.

The winsorization thresholds were adjusted to 0.5% and 99.5%. Following this adjustment, the ESG performance coefficient remained stable at 0.002 and was significantly positive at the 5% level; the signs and significance of the control variables showed no substantial changes. This demonstrates that extreme values do not interfere with the core research conclusions, confirming the robustness of the results.

In order to solve the endogenous problem caused by reverse causality between ESG and financial performance, the text uses the method of lagging the core explanatory variable to re-estimate the model, as shown in Column (4). The ESG (L.ESG) coefficient of the first phase is -0.003, which is significantly negative at the 1% level. The result reflects that the previous ESG investment will occupy the current operating resources of the firm, which will have a negative impact on profits in the short term. At the same time, the lag variable effectively cuts off the reverse causal relationship of “high-profit firms increasing ESG investment in the current period”; The significance and symbol of the remaining control variables are basically consistent with the baseline regression, and the variable relationship is stable.

Table 3: Robustness and Endogeneity Tests

	(1) Alternative Measure (ROE)	(2) Excluding 2020	(3) Alternative Winsorization	(4) One-Period Lagged ESG
ESG	0.008*** (0.003)	0.002** (0.001)	0.002** (0.001)	
L.ESG				-0.003*** (0.001)
Size	0.035*** (0.009)	0.007** (0.003)	0.005 (0.003)	0.014*** (0.004)
Growth	0.106*** (0.005)	0.049*** (0.002)	0.048*** (0.002)	0.048*** (0.002)
Liquid	0.015*** (0.001)	0.008*** (0.001)	0.007*** (0.001)	0.008*** (0.001)
Dual	0.003	0.001	0.001	0.000

	(1) Alternative Measure (ROE)	(2) Excluding 2020	(3) Alternative Winsorization	(4) One-Period Lagged ESG
Indep	(0.007) 0.051	(0.003) 0.017	(0.002) 0.006	(0.003) 0.007
Top1	(0.052) 0.062	(0.021) 0.033**	(0.020) 0.030*	(0.020) 0.015
Soe	(0.048) 0.009	(0.016) 0.004	(0.016) 0.003	(0.018) 0.006
Big4	(0.018) 0.028	(0.006) 0.013*	(0.006) 0.011*	(0.006) 0.004
Observations	(0.017) 15159	(0.007) 12883	(0.006) 15159	(0.007) 11369
Number of Firms	3473	3473	3473	3018
R ²	0.086	0.126	0.109	0.127

4.4 Heterogeneity Analysis

This study conducts heterogeneity analysis from the two dimensions of the nature of property rights and whether firms are audited by a Big Four auditor. The regression results are shown in Table 4.

Heterogeneity based on the nature of property rights. Column (1) The ESG coefficient of non-state-owned firms is 0.001, and column (2) The ESG coefficient of state-owned firms is 0.002, which is significantly positive at the level of 10%. The reason may be that state-owned firms rely on policy guidance and resource advantages, and the effect of ESG implementation on improving profits can be effectively implemented; The operation of non-state-owned firms is more constrained, and the income conversion of ESG investment in the current period is not yet obvious.

Heterogeneity based on whether firms are audited by a Big Four auditor. Column (3) The ESG coefficient of firms not audited by the Big Four is 0.002, and the 10% level is significantly positive. Column (4) The ESG coefficient of firms audited by the Big Four -0.001 is not significant. The reason may be that the external supervision of firms not audited by the Big Four is weak, and ESG can be used as an internal governance supplement to improve profits; Big Four auditors themselves have formed strong supervision constraints, and the incremental improvement effect of ESG has been weakened.

Table 4: Heterogeneity Analysis

	(1) Non-SOEs	(2) SOEs	(3) Non-Big Four Auditors	(4) Big Four Auditors
ESG	0.001 (0.001)	0.002* (0.001)	0.002* (0.001)	-0.001 (0.003)
Size	0.009** (0.004)	0.007 (0.005)	0.006** (0.003)	-0.011 (0.017)
Growth	0.058*** (0.003)	0.028*** (0.002)	0.050*** (0.002)	0.038*** (0.007)
Liquid	0.008*** (0.001)	0.007*** (0.002)	0.008*** (0.001)	0.001 (0.003)
Dual	0.002 (0.003)	-0.001 (0.004)	0.002 (0.002)	-0.012* (0.007)
Indep	0.002 (0.027)	0.015 (0.021)	0.006 (0.020)	0.032 (0.043)
Top1	0.047* (0.024)	0.008 (0.018)	0.034** (0.016)	0.029 (0.038)
Soe			0.003 (0.006)	0.011 (0.020)
Big4	0.007 (0.009)	0.016* (0.009)		
Observations	10496	4663	14125	1034
Number of Firms	2618	1027	3273	279
R ²	0.142	0.084	0.122	0.151

4.5 Mediation Analysis

In order to identify the transmission mechanism of ESG's role in the financial performance of firms, this paper uses the financing constraint SA index as a mediating variable for a stepwise regression analysis. The ESG coefficient in column (1) is 0.008 and significantly positive at the level of 1%, indicating that good ESG performance can significantly alleviate the constraints of enterprise financing; Column (2) is the baseline regression, and ESG has a significant positive impact on the 10% level of ROA; Column (3) After inserting the core explanatory variables and the mediating variable synchronously, the financing constraint coefficient -0.036 is significantly negative at the level of 10%, and the ESG coefficient is still significantly positive, indicating that the financing constraint plays a partial mediating effect between the two.

Table 5: Mediation Analysis

	(1) Financing Constraints (SA)	(2) ROA	(3) ROA
ESG Performance	0.008*** (0.001)	0.002* (0.001)	0.002** (0.001)
Financing Constraints			-0.036* (0.020)
Firm Size	0.003 (0.005)	0.007** (0.003)	0.007** (0.003)
Growth	-0.002* (0.001)	0.049*** (0.002)	0.049*** (0.002)
Liquidity	0.004*** (0.001)	0.008*** (0.001)	0.008*** (0.001)
CEO Duality	0.002 (0.002)	0.001 (0.002)	0.001 (0.002)
Board Independence	-0.002 (0.016)	0.008 (0.019)	0.008 (0.019)
Largest Shareholder Ownership	0.019 (0.021)	0.032** (0.016)	0.033** (0.016)
SOE	-0.004 (0.003)	0.003 (0.006)	0.003 (0.006)
Big Four Auditor	0.006 (0.008)	0.010* (0.006)	0.010* (0.006)
Observations	15159	15159	15159
Number of Firms	3473	3473	3473

5. Conclusions and Implications

5.1 Conclusions

This study selects Shanghai-Shenzhen A-share listed companies from 2015 to 2024 to carry out empirical research to clarify the role of ESG performance on financial performance. The research results show that:

First, the better the ESG performance of the firm, the higher the financial performance of the firm, and after replacing the explained variables, eliminating special years, adjusting the tailing ratio, and lagging the core explanatory variables by one period, the conclusion is still valid.

Second, financing constraints play a mediating role between ESG performance and financial performance of firms. Good ESG performance ultimately improves the financial performance of firms by alleviating financing constraints.

Third, based on heterogeneity analysis, the performance boost effect of ESG is heterogeneous. Compared with non-state-owned firms and firms audited by a Big Four auditor, the positive impact is more prominent among state-owned firms and firms that receive non- Big Four auditor.

5.2 Policy Implications

First of all, firms should systematically optimize ESG implementation and consolidate the foundation for performance improvement. The baseline regression results indicate that ESG performance can positively

improve financial performance, so firms need to improve their own ESG system construction. Firms can set up a special ESG governance group to promote the energy-saving transformation of production links, the implementation of social responsibility and the improvement of the internal control mechanism, and expand the sustainable development of the supply chain and other voluntary disclosure contents according to the authoritative rating standards. The management should do a good job in the medium and long-term layout, smooth out the phased construction expenditure, weaken the profit fluctuations caused by short-term investment, ensure the long-term release of ESG benefits, and promote the sustainable development of firms.

Secondly, considering that financing constraints play a significant mediating role, strengthening this transmission mechanism can further amplify the revenue-increasing effect of ESG. Firms can use standardized ESG reports as financing endorsements, declare green credit and green bond-related policy benefits, and optimize the transparency of equity information to absorb institutional funds; The funds obtained from financing will be given priority to the fields of research and development iteration and business optimization. Regulatory authorities will simultaneously improve the green financing support rules, reduce the financing obstacles of high-quality ESG firms, and strengthen the stability of the transmission link.

Finally, firms can also formulate differentiated strategies based on property attributes and audit background. In terms of property rights, state-owned firms use the advantages of policies and resources to upgrade ESG implementation standards and form an industry demonstration; Non-state-owned firms should promote ESG reform step by step, give priority to low-cost optimization projects, and buffer short-term cost pressure. At the audit level, firms not audited by the Big Four rely on ESG to improve the internal control system and make up for the lack of external supervision; Relying on the mature external regulatory environment, the four major auditing firms focus on long-term green layout and tap into deeper development dividends.

References

- [1] Huang, S. Z., Ye, F. Y., Wang, P. C., & Sun, M. (2023). Strategic choices for developing China's sustainability disclosure standards. *Finance and Accounting Monthly*, 44(11), 3–7. <https://doi.org/10.19641/j.cnki.42-1290/f.2023.11.001>
- [2] Wang, X. Y., & Zhou, D. Q. (2025). The impact of ESG performance on corporate financial performance: Empirical evidence from China's manufacturing industry. *South China Finance*, (8), 20–36.
- [3] Yao, Y., & Wang, J. F. (2025). The impact of corporate ESG greenwashing on financial performance and its mechanism. *Modern Business*, (14), 188–192. <https://doi.org/10.14097/j.cnki.5392/2025.14.046>
- [4] Zhao, J. X., & Zhou, Y. T. (2025). ESG practices and corporate financial performance of listed companies in China: Evidence from advanced human capital structure and corporate life cycle. *Journal of Beijing Union University (Humanities and Social Sciences)*, 23(2), 55–70. <https://doi.org/10.16255/j.cnki.11-5117c.20241218.001>
- [5] Tao, Q., & Ding, W. Y. (2025). ESG performance, debt financing costs, and corporate financial performance. *Green Finance and Accounting*, (4), 31–38. <https://doi.org/10.14153/j.cnki.lsc.2025.04.004>
- [6] Luo, Y. X., & Lu, J. Y. (2025). ESG rating performance, R&D investment, and financial performance: Empirical evidence from A-share listed companies in China. *Commercial Accounting*, (2), 72–77.
- [7] Sun, B. (2025). ESG ratings and financial performance of listed companies: The moderating role of accounting information quality. *Communication of Finance and Accounting*, (16), 46–50. <https://doi.org/10.16144/j.cnki.issn1002-8072.2025.16.007>
- [8] Ren, Q. (2024). *Managerial myopia and corporate ESG* (Master's thesis, Nanjing University of Science and Technology). <https://doi.org/10.27241/d.cnki.gnjgu.2024.002150>
- [9] Liu, S. L., Wang, M., & Qi, J. M. (2024). Green investment, financing constraints, and corporate financial performance: Evidence from listed firms in the energy industry. *Statistics and Decision*, 40(6), 172–177. <https://doi.org/10.13546/j.cnki.tjyjc.2024.06.031>

- [10] Wang, R. (2022). ESG information disclosure and corporate value from a cost–benefit perspective. *Journal of Shanghai University of International Business and Economics*, 29(4), 74–86. <https://doi.org/10.16060/j.cnki.issn2095-8072.2022.04.005>
- [11] Xie, M., Wang, Y. Q., & Xu, Y. (2024). Economic effects of ESG responsibility fulfillment by listed companies: Evidence from long-term and dynamic perspectives. *Journal of Guangdong University of Finance and Economics*, 39(6), 54–72. <https://doi.org/10.20209/j.gcxh.441711.2024.06.002>
- [12] Wang, F. Y., & Guo, H. P. (2026). ESG performance and financial performance of power generation firms: Evidence from the perspective of audit quality. *Price: Theory & Practice*, (2), 191–196. <https://doi.org/10.19851/j.cnki.CN11-1010/F.2026.02.057>
- [13] Gao, Y., & Qian, D. B. (2025). The mechanism through which ESG ratings affect bank financial performance in the era of data-driven development. *Friends of Accounting*, (22), 35–42.
- [14] Liu, G. (2025). Corporate ESG performance, financial mismatch, and financial performance. *Statistics and Decision*, 41(16), 142–146. <https://doi.org/10.13546/j.cnki.tjyjc.2025.16.024>
- [15] Li, B. (2025). The impact of ESG investment on the operating performance of commercial banks: Evidence from A-share listed banks. *Statistics and Decision*, 41(12), 153–158. <https://doi.org/10.13546/j.cnki.tjyjc.2025.12.026>
- [16] Du, Y., & Kong, K. X. (2024). ESG performance, director shareholding, and corporate financial performance. *Communication of Finance and Accounting*, (21), 44–48. <https://doi.org/10.16144/j.cnki.issn1002-8072.2024.21.020>
- [17] Liu, Y., Ren, Y. X., & He, Z. C. (2025). Can digital transformation improve corporate ESG performance? Evidence from the mediating role of innovation capital. *Systems Engineering*, 43(1), 1–13.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

Analysis of Urban-Rural Differences and Countermeasures in Inclusive Elderly Care in Guangxi

Rui Pang*

Guangxi Normal University, Guilin, Guangxi, China

**Corresponding author: Rui Pang.*

Abstract

With the rapid development of population aging and the increasing demand for elderly care services, China's elderly care services are facing unprecedented challenges. As an economically underdeveloped region, Guangxi is characterized by a growing aging population and a prominent urban-rural inversion. For the majority of elderly people with low incomes and insufficient savings, access to affordable, accessible, and quality-assured elderly care services has become a major issue in contemporary elderly care. This paper briefly describes the current situation of inclusive elderly care services in Guangxi Zhuang Autonomous Region and explores the path of inclusive elderly care in the region. The study points out that the government needs to strengthen its leading role, break the hard constraints of elderly care operation costs, continuously promote the improvement of the basic elderly care service system, and ensure that the basic needs of China's growing elderly population for care, support, and protection are met.

Keywords

inclusive elderly care, urban-rural differences, elderly care services, accessibility, Guangxi

1. Introduction

1.1 Policy Background

China is currently experiencing an unprecedented and fastest aging process in history [1]. As an underdeveloped western region with a large ethnic minority population, Guangxi's aging issue presents three distinct characteristics: first, the aging rate is faster than the national average; second, the proportion of the rural elderly population far exceeds that of urban areas, forming a contrast of "faster aging in rural areas and slower aging in cities"; third, the increase in the number of very elderly, empty-nest, and disabled elderly has made the demand for elderly care more diverse and urgent [2].

Against such a social backdrop, China is shifting its elderly care focus from targeted support for disadvantaged seniors to universal services open to all older adults, a core priority for central and local elderly care initiatives. Outlined in the 14th Five-Year Plan for the Development of Aging Programs and the Elderly Care Service System, national policies seek to advance coordinated growth of aging-related public services and industries, build a three-tier care framework spanning home, community and institutional care, and

advance the integration of medical and nursing services. Scaling up inclusive elderly care access stands high on the national work agenda.

Against such a social backdrop, China is shifting its elderly care focus from targeted support for disadvantaged seniors to universal services open to all older adults, a core priority for central and local elderly care initiatives. Outlined in the 14th Five-Year Plan for the Development of Aging Programs and the Elderly Care Service System, national policies seek to advance coordinated growth of aging-related public services and industries, build a three-tier care framework spanning home, community and institutional care, and advance the integration of medical and nursing services. Scaling up inclusive elderly care access stands high on the national work agenda.

Documents such as the Opinions on Promoting the Development of Elderly Care Services issued by the General Office of the State Council have repeatedly emphasized the development of affordable, accessible, and quality-assured inclusive elderly care services. Guangxi has actively implemented national policies and successively issued a series of policy documents including the Regulations on Elderly Care Services of Guangxi Zhuang Autonomous Region and the 14th Five-Year Plan for the Elderly Care Service System of Guangxi. These policies focus on three goals: first, establishing a basic elderly care service system covering urban and rural areas with clear responsibilities, reasonable guarantees, and long-term stability; second, solving the problems of insufficient supply, uneven quality, and unbalanced development between regions and urban and rural areas in elderly care services; third, focusing on strengthening elderly care service capacity in rural areas, old revolutionary base areas, ethnic areas, and border areas to ensure that urban and rural elderly people can enjoy equal-quality elderly care services [3].

Inclusive elderly care, with its emphasis on affordability, accessibility, long-term stability, and reliable quality, is regarded as the key to achieving these goals. However, due to Guangxi's relatively backward economic development, limited financial investment in elderly care, large regional gaps, obvious urban-rural differences, and diverse ethnic cultures, promoting inclusive elderly care services across the region, especially in rural areas, faces many complex difficulties. Clarifying the current situation, problems, and differentiated needs of urban-rural inclusive elderly care services in Guangxi is of great significance for formulating rational policies, allocating resources appropriately, and achieving the goal of "care for the elderly" for all [4].

1.2 Research Motivation

Although Guangxi attaches great importance to the development of inclusive elderly care services at the policy level, there are still many problems to be explored in practice.

Statistics and field-based empirical findings reveal an obvious imbalance in the layout of high-end senior care resources across Guangxi. Most full-service nursing homes, skilled care workers and smart senior care devices cluster in Nanning, Liuzhou and Guilin. By contrast, counties and countryside suffer from acute shortages of available care resources. Most rural senior care sites are poorly equipped with outdated infrastructure, offer only limited types of services, and struggle to recruit qualified caregivers. Such uneven resource gaps between cities and the countryside prevent older residents in rural regions from accessing the same inclusive care benefits available to urban seniors, conflicting with the core goal of realizing equal elderly care for all.

Statistics and field-based empirical findings reveal an obvious imbalance in the layout of high-end senior care resources across Guangxi. Most full-service nursing homes, skilled care workers and smart senior care devices cluster in Nanning, Liuzhou and Guilin. By contrast, counties and countryside suffer from acute shortages of available care resources. Most rural senior care sites are poorly equipped with outdated infrastructure, offer only limited types of services, and struggle to recruit qualified caregivers. Such uneven resource gaps between cities and the countryside prevent older residents in rural regions from accessing the same inclusive care benefits available to urban seniors, conflicting with the core goal of realizing equal elderly care for all.

A range of conditions restrict local seniors' access to inclusive care, covering geographic layout, individual payment capacity, information transparency and local customs [5]. In rural Guangxi, poor transport links, low household income levels, inadequate policy outreach and deep-rooted traditions of home-based elder care

mean many older villagers cannot make practical use of newly built community care centers and senior dining services, even when such facilities exist locally [6].

Improving service quality sits at the heart of inclusive elderly care development, yet Guangxi's urban and rural care systems fall short on standardized management, with rural facilities bearing the brunt of these shortcomings. Insufficient professional caregivers, narrow service catalogs and flawed operational approaches alongside hidden health hazards all worsen seniors' daily service experience. It is therefore critical to build a targeted quality assessment and oversight framework tailored to Guangxi's local conditions and rural senior care demands [8].

The effective supply of inclusive elderly care services relies on multi-agent collaboration. At present, the collaboration mechanism in Guangxi's elderly care service sector is imperfect. The scientificity and implementation efficiency of government policy-making need to be improved. Social capital is reluctant to participate in rural areas due to long investment return cycles and high risks. The supporting roles of communities and families in service provision have not been fully utilized. Establishing a collaborative governance model suitable for local conditions and mobilizing the enthusiasm of all parties is a key path to promoting the sustainable development of inclusive elderly care [9].

Guangxi is home to a diverse mix of ethnic groups. Older adults from different ethnic communities hold distinct views on elderly care, maintain varied lifestyles and have unique care-related needs. The top-down design and resource distribution of current inclusive elderly care policies have failed to fully account for these differences. In ethnic minority villages in particular, it is critical to incorporate local ethnic features into the layout of elderly care facilities, the design of service programs and language arrangements for service staff. So far, relevant research and practical experience in this field remain limited.

Against the above background, this study intends to use systematic field investigation and quantitative analysis to explore the main contradictions in the development of urban-rural inclusive elderly care services in Guangxi, focus on analyzing the manifestations, causes, and transmission paths of urban-rural service supply gaps, and provide theoretical support and practical references for solving practical problems and building a characteristic inclusive elderly care service system.

1.3 Research Purpose

The core purpose of this study is to systematically explore the current situation, differences, influencing factors, and optimization paths of urban-rural inclusive elderly care services in Guangxi. Specific objectives are as follows:

Drawing on Guangxi's regional attributes—including its economic conditions, financial capacity, public sentiment and geographical features—this study develops a forward-looking, targeted and actionable optimization framework for inclusive elderly care services across urban, county and rural settings. By exploring strategies to narrow the urban-rural divide, expand service coverage, enhance service quality, promote multi-stakeholder participation, secure diversified funding support and highlight ethnic characteristics, the research offers scientific backing and practical guidance for government decision-making and industry practice.

Focusing on the key restrictive factors in the development of urban-rural inclusive elderly care services in Guangxi, this study systematically examines policy design and implementation, especially facility planning and targeted financial subsidies; explores financial investment volume, allocation optimization, and efficiency improvement; investigates the participation and collaboration effects of enterprises and social organizations; evaluates community service functions and elderly care network construction based on grassroots governance frameworks; and conducts detailed surveys on the economic income, health, education, values, and consumption behavior of the elderly.

This study focuses on analyzing the key factors affecting urban-rural inclusive elderly care services and their relationships, explores the deep-seated reasons for urban-rural development differences, constructs their internal connection structure, and provides empirical and theoretical support for improving public policies.

This study evaluates the implementation effects of national and regional inclusive elderly care policies in Guangxi, explores the main obstacles and mechanisms in practice, assesses their role in promoting urban-rural integrated development, and identifies potential problems.

Based on Guangxi's regional characteristics (economy, finance, public opinion, geography), this study constructs a forward-looking, targeted, and implementable optimization framework for inclusive elderly care services in urban, county, and rural areas. By analyzing urban-rural gap narrowing, service coverage expansion, quality improvement, multi-agent participation encouragement, diversified funding support, and ethnic characteristics highlighting, it provides scientific support and practical guidance for government decision-making and industry practice.

1.4 Problem Statement

The core questions this study aims to answer are: Under the background of accelerating population aging and unbalanced urban-rural development, what are the main challenges facing the development of urban-rural inclusive elderly care services in Guangxi? What significant differences exist between urban and rural areas? What key factors drive or restrict their development, especially the root causes of urban-rural differentiation? How to build an optimization path of inclusive elderly care services suitable for Guangxi's reality and effectively promoting urban-rural coordinated development? Specific research questions include:

- 1) What specific differences exist between urban, county, and rural areas in Guangxi in terms of supply scale, structure, quality, accessibility (geographical, economic, informational, cultural), and utilization efficiency of inclusive elderly care services? What is the degree of difference?
- 2) How do policy support (national, autonomous regional, local), financial investment, social capital participation, community support networks, and elderly demand characteristics (payment ability, willingness, health, concepts) affect the development of urban and rural inclusive elderly care services respectively? Are there significant differences in these impacts?
- 3) How does the urban-rural dual structure (economic, social, infrastructure, public service foundation) indirectly affect the balanced development of inclusive elderly care services through the above factors? To what extent do ethnic regional characteristics (culture, customs) shape the demand and supply model of elderly care services in specific regions?
- 4) What major hurdles and shortcomings exist in current inclusive elderly care policies and operational models when it comes to catering to the needs of urban and rural seniors and bridging service disparities?
- 5) Given the local realities of Guangxi, what differentiated, systematic strategies and measures can be adopted to elevate the quality and efficiency of urban inclusive elderly care services, extend such services down to county-level areas, and expand coverage in rural regions? How can we ultimately realize coordinated, high-quality development of elderly care services across urban and rural areas?

1.5 Research Significance

Inclusive elderly care services are key strategic measures to address population aging in China. Its theoretical framework, evaluation system, and implementation path need to be improved. Taking Guangxi as an example, this study selects regions with low economic development, diverse ethnic groups, and obvious urban-rural differences as research objects, constructs a comprehensive evaluation model including service supply, accessibility, quality assurance, and resource utilization efficiency, and uses hierarchical data analysis to comprehensively explore the development motivation and differentiation of urban-rural inclusive elderly care services. This study is conducive to deepening the understanding of the theoretical connotation of the inclusive elderly care service system with Chinese characteristics, and provides practical references for formulating targeted elderly care service policies in underdeveloped regions, with high academic value and innovative significance.

Taking urban-rural spatial pattern as the analytical framework, this study examines its impact mechanism on all aspects of inclusive elderly care services. It not only observes the manifestations of urban-rural differences in service supply, accessibility, quality, and utilization efficiency, but also explores the root causes

of urban-rural elderly care service gaps from the perspectives of policy guidance, economic foundation, and social and cultural environment. According to Guangxi's multi-ethnic characteristics, this study focuses on how traditional ethnic cultures and elderly care concepts affect the demand and supply of inclusive elderly care services, strives to include cultural compatibility into the inclusive elderly care theoretical system, constructs a practical elderly care model scheme suitable for local conditions, provides empirical support for interdisciplinary research, and shapes a theoretical framework of inclusive elderly care with local and ethnic characteristics.

Addressing the practical challenges facing inclusive elderly care in both urban and rural Guangxi, this study explores the manifestations and underlying causes of urban-rural development disparities. Through empirical research, it identifies the core drivers of these gaps and proposes targeted countermeasures—including refining inclusive elderly care policies, optimizing financial resource allocation, scientifically designing the spatial layout of elderly care facilities, innovating service delivery models, and establishing a quality supervision system. These insights aim to provide actionable references for the regional and local governments of Guangxi Zhuang Autonomous Region, supporting the achievement of basic elderly care service equalization across the region. Additionally, the study conducts a comprehensive analysis of the functional roles of multiple stakeholders involved in inclusive elderly care: government, market entities, social organizations, communities, and families. It assesses the strengths and challenges of cooperation among these actors, and puts forward specific recommendations and operational steps to promote social capital participation, enhance community service capacity, and strengthen family care effectiveness—ultimately contributing to the development of a sustainable inclusive elderly care service system.

This study hopes to build an urban-rural integrated, high-quality, balanced, and sustainable inclusive elderly care service system in Guangxi, achieve coordinated development between regions, economic levels, and ethnic groups, ensure that all elderly residents can live a dignified and high-quality life, and greatly improve the life satisfaction of the elderly in the region. As a typical representative of underdeveloped central and western regions and ethnic minority areas, Guangxi's practice in promoting inclusive elderly care provides key theoretical support and practical guidance for the field[10].

2. Literature Review

2.1 Definition of Core Variables

The core concepts involved in this study need to be clearly defined to guide the subsequent operationalization and measurement of variables.

2.1.1 Inclusive Elderly Care Services

Drawing on the national policy document 14th Five-Year Plan for the Development of the Aging Cause and the Elderly Care Service System, this study defines inclusive elderly care services as: basic elderly care services led by the government, participated by social forces, for all elderly people (focusing on groups such as economically disadvantaged, disabled, very elderly, and special family planning families), providing affordable, accessible, and quality-assured services. Its core characteristics include:

- **Affordability:** Service prices match the economic affordability of most elderly people. The government ensures that basic service items are within payment capacity through subsidies and price guidance^[11].
- **Accessibility:** Including multiple dimensions: geographical accessibility (reasonable spatial layout of service facilities, convenient transportation); economic accessibility (i.e., affordability); informational accessibility (transparent and easy-to-obtain service information); cultural accessibility (service content and methods respect local customs, languages, and non-discrimination)^[12].
- **Quality Reliability:** Services meet basic safety, health, and professional standards. Service personnel have corresponding qualifications and abilities, and the service process is standardized, effectively meeting the elderly's basic living care, medical care, and spiritual comfort needs [13].
- **Sustainability:** Service supply has long-term stable operation capacity in finance, manpower, and management [14].

The core dependent variable of this study is the development level of inclusive elderly care services, which is decomposed into the following dimensions for measurement at the operational level:

- **Service Supply:** Quantity/density of available facilities, types (community/home-based/institutional), number of beds, types of service items, number/proportion of professional personnel.
- **Service Accessibility:** Geographical distance/time cost, ratio of service price to elderly income, smoothness of information access channels, evaluation of service cultural compatibility.
- **Service Quality:** Safety and comfort of facilities, professionalism and attitude of service personnel, standardization of service processes, satisfaction of the elderly and their families.
- **Service Utilization:** Utilization rate of community elderly care facilities, occupancy rate of institutional elderly care, frequency of use of specific service items (e.g., meal assistance, bathing assistance).

2.1.2 Urban-Rural Differences

In this study, urban-rural differences refer to the systematic gaps in the development level of inclusive elderly care services (supply, accessibility, quality, utilization) due to different regional attributes (urban, county, rural). Rooted in the long-standing urban-rural dual structure, these differences are reflected in economic development, financial investment capacity, infrastructure construction, public service resource allocation, population structure and mobility, cultural concepts, etc. [18]. This study takes “urban-rural region” as a key independent variable or grouping variable for comparative analysis.

2.1.3 Service Accessibility

As mentioned above, this is a multi-dimensional concept. In this study, the focus will be on measuring:

- **Geographical Accessibility:** The shortest transportation time or distance for the elderly to reach the nearest inclusive elderly care institution/facility.
- **Economic Accessibility:** The price perception (affordability) of the elderly or their families for local inclusive elderly care services (especially institutional care and major home-based services).
- **Informational Accessibility:** The ease with which the elderly understand local inclusive elderly care services, application methods, and fee standards.
- **Cultural Accessibility:** Whether services consider and respect local ethnic customs (e.g., eating habits, religious activities), smooth language communication, and whether the service environment makes the elderly feel familiar and comfortable (no sense of discrimination).

2.1.4 Perceived Service Quality

Perceived service quality refers to the subjective evaluation and feelings of the elderly or their families on the hardware facilities, personnel services, management processes, and service effects of the inclusive elderly care services received [16]. It is an important subjective indicator to measure the “quality reliability” characteristic of inclusive elderly care.

2.1.5 Willingness to Pay

Willingness to pay refers to the maximum price or fee level that the elderly are willing to bear for obtaining specific inclusive elderly care services (e.g., institutional admission, home-based services, community rehabilitation) [15]. It reflects the elderly’s recognition of service value and the boundary of economic affordability, and is a key factor affecting service utilization.

2.2 Variable Measurement

This study will use a combination of quantitative and qualitative methods to measure core variables.

2.2.1 Development Level of Inclusive Elderly Care Services

- **Supply:** Quantitative – collect official statistical data (civil affairs departments, statistical yearbooks) to obtain the number of elderly care institutions/community facilities, number of beds, type

distribution, number of certified nurses in each region. Qualitative – interview managers to understand supply structure, gaps, and challenges.

- **Accessibility:**
 - Geographical Accessibility: Quantitative – questionnaire asks “time required to reach the nearest community elderly care service center/township nursing home (minutes)” (options: <15min, 15–30min, 31–60min, >60min). Use GIS to analyze facility service radius coverage (facility point data required).
 - Economic Accessibility: Quantitative – questionnaire asks “How do you feel about the price of local elderly care homes/main home-based services?” (options: completely unaffordable, relatively difficult, basically affordable, very easy). Calculate the ratio of service price to the local elderly’s monthly average income/median pension.
 - Informational Accessibility: Quantitative – Likert 5-point scale items such as “I can easily learn about local elderly care services”, “The application process is clear”, “Fees and subsidies are transparent”. Qualitative – interview to understand main channels and obstacles of information acquisition.
 - Cultural Accessibility: Qualitative (mainly) – interview ethnic minority elderly about their feelings on cultural and custom compatibility of services (e.g., catering, activities, language communication). Quantitative – set item “Services respect my living habits and ethnic customs” for evaluation (Likert 5-point).
- **Quality:** Quantitative – adopt adapted perceived service quality scale (based on SERVQUAL model, Parasuraman et al., 1988), including reliability, responsiveness, assurance, empathy, tangibility, evaluated by the elderly or their families who have received services (Likert 5-point) [25]. For example: “Staff always provide services on time”, “Facilities are clean and safe”, “Staff have professional knowledge and skills”, “Staff understand my special needs”. Also ask about overall satisfaction. Qualitative – in-depth interviews to explore specific evaluations, satisfactions, and dissatisfactions with service quality.
- **Utilization:** Quantitative – questionnaire asks about the frequency of community facility use (e.g., how many times a week to go to the senior canteen/activity center), whether home-based services have been used (items, frequency), institutional care willingness and actual occupancy rate (collected from institution managers).

2.2.2 Urban-Rural Differences

Directly divided according to the respondent’s permanent residence type: urban (municipal district), county (county seat and established towns), rural (administrative villages and natural villages).

2.2.3 Other Key Independent Variables

- **Policy Support:** Qualitative – analyze the completeness and innovation of local supporting policy documents; interview managers to evaluate policy implementation effects (e.g., land guarantee, subsidy distribution efficiency). Quantitative – try to use proxy indicators such as the proportion of local financial elderly care expenditure in total financial expenditure and the in-place rate of special subsidy funds (limited by data availability).
- **Social Capital Participation:** Quantitative – count the proportion of private elderly care institutions and beds, number/investment of PPP projects. Qualitative – interview enterprise/social organization leaders to understand participation motivation, obstacles, and policy demands.
- **Community Support Network:** Quantitative – questionnaire measures the activity of community elderly associations/volunteer organizations (activity frequency), neighborhood mutual assistance (Likert evaluation). Qualitative – interview community workers.
- **Elderly Characteristics:** Quantitative – questionnaire collects age, gender, ethnicity, education, marital status, health status (ADL/IADL), economic source and income level, children’s situation, elderly care concept (preference for home/institution/community), willingness to pay (see below).

- **Willingness to Pay:** Quantitative – use Contingent Valuation Method (CVM) or Choice Experiment (CE). For example, CVM: “If there is a home bathing service, 1 hour each time, operated by professional nurses, how much are you willing to pay at most per time? (provide price options or open-ended)”. Or ask the acceptable monthly fee range for institutional care.

2.3 Review of Variable-Related Research

Many studies have explored the factors affecting the development of elderly care services, especially urban-rural differences.

2.3.1 Urban-Rural Region and Inclusive Elderly Care Services

Domestic and foreign studies generally confirm the significant urban-rural inequality in elderly care resources. Lin Mingang (2025) pointed out that rural elderly care services lag behind urban areas in terms of facility quantity, quality, professional talents, and financial investment [17]. Lu Jiehua (2024) emphasized that the urban-rural dual structure is the deep institutional root of this gap [18]. The Guangxi Economic and Social Development Report 2025 also reveals the problem of elderly care resources concentrating in cities and serious shortage in rural areas.

2.3.2 Policy Support and Inclusive Elderly Care

Strong policy guidance and supporting measures are key driving forces for the development of inclusive elderly care. Yang Yansui et al. (2022) emphasized the importance of top-level design, standard setting, and supervision system [19]. The Measures for the Administration of Elderly Care Service Subsidies in Guangxi points out the impact of subsidy policy accuracy (supply-side vs. demand-side) on service affordability and market vitality. Studies also found that policies often have deviations, discounts, or “last mile” problems in grassroots implementation, especially in rural areas with long administrative chains and weak resources.

2.3.3 Financial Investment and Inclusive Elderly Care

Public finance is the main support for inclusive elderly care, especially basic and bottom-line services. Studies show that the total amount and structure of financial investment (e.g., institutions vs. community/home-based, construction vs. operation) directly affect the scale and quality of service supply [13]. As an underdeveloped region, Guangxi has limited financial capacity. How to optimize investment efficiency and leverage social capital is the core issue of sustainable inclusive elderly care [20]. Rural areas often rely more on financial investment, but investment is insufficient and sustainability is challenged.

2.3.4 Social Capital Participation and Inclusive Elderly Care

Introducing market mechanisms and social forces is an important way to expand supply and improve efficiency. Studies found that social capital faces obstacles such as difficulty in making profits (especially in rural areas), policy risks, and talent shortages when participating in inclusive elderly care [21]. How the government creates a good business environment through PPP, private operation of public facilities, tax incentives, and service procurement, especially reducing the risk and cost of social capital entering the rural market, is a research hotspot. The effect of Guangxi’s practical exploration (e.g., Nanning’s private operation of public facilities) needs in-depth evaluation.

2.3.5 Community Support Network and Inclusive Elderly Care

Communities are important carriers and platforms for elderly care services. Strong community organizations (neighborhood committees/village committees, elderly associations, volunteer organizations) can effectively link resources, organize activities, and provide informal care support [14]. Studies show that rural community “hollowing out” and weakened organizational capacity seriously restrict the function of community elderly care [22]. How to activate and empower rural communities and build a mutual assistance elderly care network is crucial for rural inclusive elderly care in Guangxi.

2.3.6 Elderly Characteristics and Inclusive Elderly Care

- **Payment Ability and Willingness:** The economic status of the elderly (pension, savings, children’s support) is a key factor determining whether they can use paid services (Hurd & McGarry, 1997). Rural elderly generally have low income, weak payment ability, and high price sensitivity ^[23].

Willingness to pay is jointly affected by economic ability, service value cognition, and traditional concepts (e.g., “raising children for old age”, unwilling to pay for services)^[15]. Rural elderly in Guangxi may have lower willingness to pay due to income and cultural concepts.

- **Health Status and Demand:** Disabled, semi-disabled, and very elderly have urgent needs for professional nursing and medical rehabilitation. Rural areas have weak health management foundations and greater pressure for disabled elderly care^[13].
- **Elderly Care Concepts:** Traditional family elderly care concepts still dominate in Guangxi, especially in rural and ethnic minority areas^[18]. Acceptance of institutional care and cognition of community services affect service utilization. Research needs to focus on concept differences and changes.
- **Ethnic Regional Particularity:** There are relatively few studies on Guangxi’s multi-ethnic characteristics. Zhu Junlin (2020) explored the elderly care culture and mutual assistance practice in Zhuang villages^[24]. Research suggests that developing inclusive elderly care in ethnic minority areas needs to respect their unique filial piety culture, living preferences, eating habits, festival activities, and language communication needs. Ignoring these cultural factors may lead to service “inadaptation” and low utilization.

Existing studies on elderly care in Guangxi mostly focus on macro policy description or single region/institution case analysis, lacking empirical research covering the whole region, penetrating urban-rural grassroots, and using standardized variable measurement and comparative analysis. The systematic measurement of urban-rural differences in multiple dimensions (supply, accessibility, quality, utilization) and its deep-seated impact mechanism (especially the interaction of policy, finance, social capital, community, and cultural factors) are insufficient. Research on how ethnic characteristics specifically affect the demand and supply of inclusive elderly care is even scarcer.

3. Research Methods

To comprehensively and deeply explore the development status and differences of urban-rural inclusive elderly care services in Guangxi, this study adopts Mixed Methods Research, combining the breadth advantage of quantitative investigation and the depth insight of qualitative interviews.

3.1 Research Scale Design

This study will design two core research tools: a structured questionnaire for the elderly and a semi-structured interview outline for key informants.

3.1.1 Structured Questionnaire for the Elderly

The questionnaire includes the following main modules. Core variable measurements adopt or adapt mature scales as much as possible, and are localized revised combined with Guangxi’s reality.

Table 1: Basic Information

Module	Dimensions and Specific Questions	Measurement Method
Demographic Characteristics	Age, gender, ethnicity, household registration type (urban/rural), permanent residence (urban/county/rural), education, marital status	Fill-in-the-blank, multiple choice
Family Status	Co-residents, number of children and living distance, main caregiver	Fill-in-the-blank, multiple choice
Economic Status	Main economic sources (pension, children’s support, labor income, subsistence allowance, etc.), monthly income range, self-assessment of family economy (affluent/general/difficult)	Multiple choice, fill-in-the-blank, choice
Health Status	Self-assessed health (very good/good/general/poor/very poor), chronic diseases, ADL, IADL	Multiple choice, scale

Table 2: Elderly Care Service Demand and Cognition

Module	Dimensions and Specific Questions	Measurement Method
Current Elderly Care Method	Living alone, with spouse, with children, institutional care, etc.	Multiple choice

Module	Dimensions and Specific Questions	Measurement Method
Future Elderly Care Preference and Reasons	Open question, record specific reasons	Fill-in-the-blank
Most Needed Elderly Care Services (Multiple Choice & Ranking)	Living care (bathing, cleaning, walking), catering (delivery, meal sites), medical care (health monitoring, home visits, rehabilitation), emergency call, spiritual comfort (chat, entertainment), legal aid, etc.	Multiple choice, ranking
Understanding of “Inclusive Elderly Care” and Channels	Open question, record specific reasons	—

Table 3: Inclusive Service Accessibility Evaluation

Module	Dimensions and Specific Questions	Measurement Method
Geographical Accessibility	“There is a community elderly care center/day care center/township nursing home near my home within XX minutes” (record XX minutes)	Likert 5-point scale (1 = strongly disagree, 5 = strongly agree)
Economic Accessibility	“I think the fees of local elderly care homes are reasonable/affordable”; “I think the fees of community XX services (e.g., meal assistance) are reasonable/affordable”	Likert 5-point scale
Informational Accessibility	“I can easily learn about local elderly care services”; “I know how to apply for these services”; “Fees and government subsidies are transparent”	Likert 5-point scale
Cultural Accessibility (Ethnic Minority Respondents)	“Services respect my ethnic habits (e.g., catering, activities)”; “Staff can communicate in my language”; “I feel comfortable and not discriminated in institutions/centers”	Likert 5-point scale

Table 4: Perceived Service Quality (Adapted from SERVQUAL, Likert 5-point)

Module	Dimensions and Specific Questions	Measurement Method
Tangibility	“Facilities are clean, tidy, and safe”; “Equipment is complete and well-maintained”	Likert 5-point (1 = completely inconsistent, 5 = completely consistent)
Reliability	“Staff provide services as promised”; “Services are stable and reliable”	Likert 5-point
Responsiveness	“Staff are willing to help and respond promptly”; “Service is not delayed”	Likert 5-point
Assurance	“Staff are trustworthy”; “Staff have professional skills”; “Services make me feel safe”	Likert 5-point
Empathy	“Staff understand my special needs”; “Services are humanized and personalized”; “Staff are friendly and patient”	Likert 5-point
Overall Satisfaction	“Overall, I am satisfied with this service”; “I am willing to continue using/recommend to others”	Likert 5-point

Table 5: Service Utilization

Module	Dimensions and Specific Questions	Measurement Method
Community Facility Usage Frequency	Never/occasionally/often/daily	Multiple choice
Home-based Service Usage	Yes/no; if yes, items, frequency, payment	Multiple choice, fill-in-the-blank
Institutional Care Experience or Willingness	Consider in X years; expected type and affordable fee	Multiple choice, fill-in-the-blank

Table 6: Willingness to Pay (WTP)

Module	Dimensions and Specific Questions	Measurement Method
Willingness to Pay	Describe a standardized inclusive service scenario; ask maximum monthly willingness to pay (options: ¥0, ¥50, ¥100, ¥150, ¥200, ¥250, ≥¥300)	Contingent Valuation Method (CVM)

Table 7: Open-Ended Questions

Module	Dimensions and Specific Questions	Measurement Method
Suggestions	Suggestions on local inclusive elderly care	Fill-in-the-blank

3.1.2 Semi-Structured Interview Outline for Key Informants

Table 8: Semi-Structured Interview Outline for Key Informants

Module	Interview Themes	Interview Objects
Current Situation	Overall evaluation of local inclusive elderly care (achievements, highlights, problems)	Civil affairs officials (2–3 per level); elderly care institution directors (3–5 per type); community/village cadres (4–6); elderly association leaders (3–4); elderly representatives (8–10)
Urban-Rural Differences	Specific gaps in supply, resources, facilities, talents, demand; main causes (policy, finance, geography, population, concepts)	—
Policy Implementation	Implementation effects; main difficulties (funding, land, approval, supervision, talents)	—
Social Capital Participation	Experience, challenges, and policy demands for rural participation	—
Community Role	Role, capacity, and difficulties in supporting elderly care	—
Operation Challenges	Main challenges (cost, fees, talents, occupancy/utilization); key quality improvement measures	—
Ethnic Service Needs	How to address ethnic elderly's special needs (language, diet, customs, beliefs)	—
Non-Usage Reasons	Reasons for not using services (price, unawareness, inconvenience, no need, distrust, cultural incompatibility); improvement expectations	—
Development Suggestions	Suggestions for future development (narrowing urban-rural gaps, improving rural services)	—

3.2 Survey Time and Location

- **Survey Time:** Questionnaire distribution and collection in July 2025; in-depth interviews in July–August 2025 (adjust according to actual situation).
- **Survey Locations:** Stratified typical sampling selects 1 central city, 1 county (including county seat and towns), and 1 typical village in Guangxi, representing different development levels, regional characteristics, and ethnic distributions.
- **Urban Level:** Nanning (capital, high resource concentration, representing urban high level). Select 1–2 districts (e.g., Qingxiu + old urban/urban-rural fringe).
- **County Level:** Liujiang District (Liuzhou) or Quanzhou County (Guilin) (representative in economic development, population structure, aging degree). Cover county seat and 2–3 towns.
- **Rural Level:** Ping'an Village, Jiazhuang Town, Bama Yao Autonomous County (typical ethnic minority village, longevity area) or a Zhuang village in Tianyang District (Baise). Select 1–2 administrative villages.
- **Selection Basis:** Regional distribution (southern, central, northwestern Guangxi), economic development gradient, ethnic composition (Han-dominated/Zhuang-concentrated/other ethnic minorities), aging degree, and representativeness of inclusive elderly care development foundation.

3.3 Respondents and Sampling Methods

3.3.1 Questionnaire Respondents

Elderly residents aged 60 and above (registered or residing for ≥ 6 months).

Sampling Methods:

- **Urban/County:** Multi-stage stratified random sampling

Randomly select 2–4 subdistricts/towns from selected districts/counties.

Randomly select 2–3 communities from each sampled subdistrict/town.

Systematically or simply randomly sample target elderly from community elderly roster or via neighborhood committee. For communities without complete rosters, use intercept interviews at activity centers, parks, health stations (note sample bias).

- **Rural:** Cluster sampling + random sampling

Randomly select 1–2 administrative villages in selected towns.

Randomly select 2–3 natural villages if scales differ greatly.

Randomly sample from village elderly list; if no list, conduct door-to-door interviews guided by cadres.

Sample Size: Total 800 questionnaires. Preliminary allocation: Nanning (urban) 320; Liujiang/Quanzhou (county 160 + towns 120 = 280); Bama/Tianyang (rural) 200. This allocation ensures sufficient samples for statistical analysis at each level.

3.3.2 Interview Respondents

Purposive and snowball sampling. Select informative informants (as listed in outline) via civil affairs, community/village cadres, or respondent referrals until data saturation.

Sample Size: 30–40 interviews (number per category see outline).

Ethical Considerations: All participants sign informed consent. Questionnaires are anonymized; interview recordings and transcripts are strictly confidential. Participants may withdraw at any time.

4. Conclusion

4.1 Theoretical Contributions

Using empirical analysis, this study is the first to include “informational accessibility” and “cultural accessibility” into the inclusive elderly care service evaluation system, tested with samples from multi-ethnic and underdeveloped regions, breaking the limitation of traditional research focusing only on physical space and economic resource accessibility. The developed or validated scale provides operational guidance for subsequent research and effectively expands the measurement dimensions of inclusive elderly care theory. When exploring urban-rural differences, this study goes beyond the simple urban-rural dual opposition, systematically explaining the mechanism and path of the “urban-rural region” variable through quantitative regression analysis and qualitative in-depth interviews.

Based on Guangxi’s multi-ethnic coexistence characteristics, this study takes key cultural elements such as language communication, dietary preferences, living arrangements, and filial piety concepts as analysis nodes, comprehensively analyzes their triggering mechanism for service demand of specific elderly groups, and deeply explores the troubles and improvement directions of inclusive elderly care service system in cultural adaptation. It also locally improves classic service quality testing tools, applies and tests them in rural and ethnic minority areas, focusing on the reliability and effectiveness of indicators such as empathy and cultural compatibility, providing empirical data and theoretical support for building a service quality evaluation system suitable for multi-cultural backgrounds.

4.2 Practical Contributions

This study provides an operable strategic framework for the development of inclusive elderly care services in the urban-rural integration process of Guangxi and even the whole country. For urban elderly care services, promote refined quality improvement, diversified function expansion, and in-depth application of smart elderly care technology, guiding resources to meet diverse needs. As a key node of urban-rural integration, counties

and towns should accelerate the construction of comprehensive elderly care service centers, enhance their service radiation to surrounding areas, especially rural areas, and form a core support system for rural elderly care services within the county.

4.3 Research Deficiencies and Limitations

This study uses stratified sampling for data collection. Limited by time and cost, sample acquisition is cumbersome, making it difficult to fully reflect the overall situation of each hierarchical district. Analyzing data at a specific time point can find correlation rules but cannot establish causal relationships. Many important factors such as local policy details and regional cultural characteristics are not included, and unconsidered factors may cause errors. Key independent variables such as perceived service quality, accessibility, and willingness to pay basically rely on respondents' subjective judgments, easily affected by social desirability, memory bias, and comprehension ability. Even with standardized questionnaires, errors and interference cannot be completely eliminated. The Contingent Valuation Method (CVM) is based on hypothetical scenarios; respondents' stated willingness to pay (WTP) may differ from real market behavior (hypothetical bias). Research results mostly reflect potential demand and price sensitivity.

4.4 Future Research Directions

Future research can conduct wider-coverage and typical sample longitudinal tracking studies to explore the dynamic characteristics and underlying reasons of inclusive elderly care development. For the cultural adaptability of inclusive elderly care in ethnic regions, formulate suitable service models and evaluation index systems, form an innovative mechanism to promote social capital injection into rural inclusive elderly care, and improve supporting policy toolkits. Rely on big data and artificial intelligence to improve the accuracy of inclusive elderly care services, strengthen quality supervision effects, and improve operation efficiency. Strengthen comprehensive evaluation research on the implementation of inclusive elderly care policies, focusing on the actual role of policies in narrowing urban-rural development gaps.

References

- [1] National Development and Reform Commission, Ministry of Civil Affairs, Ministry of Natural Resources. Official Answers to Several Measures to Promote the High-Quality Development of Inclusive Elderly Care Services[J]. China Industry & Economy, 2025(04):8–10.
- [2] Chen Youhua, Sun Yongjian. Development of the Silver Economy: Problems and Prospects[J]. Journal of Sichuan University (Philosophy and Social Science Edition), 2025(03):5–14+226.
- [3] Research Group of Guangxi Department of Finance. Research on Rural Elderly Care in Guangxi under the Background of Common Prosperity[J]. Economic Research Reference, 2024(06):103–117.
- [4] Huang Liqiang, Su Zongmin. Research on Intergenerational Support of Rural Family Elderly Care in Guangxi[J]. Cooperative Economy and Science & Technology, 2024(07):163–165.
- [5] Li Caili, Pan Qini, Huang Dongmei, et al. Elderly Care Service Needs and Influencing Factors of Elderly People in Elderly Care Institutions in Guangxi Zhuang Autonomous Region[J]. Evidence-Based Nursing, 2023, 9(13):2436–2439.
- [6] Li Jing, Yan Zhenliang. Historical Narrative and Practical Path of Chinese Rural Elderly Care from the Perspective of Structuration Theory[J/OL]. Journal of Northwest University (Philosophy and Social Sciences Edition), 1–12.
- [7] Zhang Lingquan, Gao Zixi. Main Trends and Tasks of Elderly Social Work Development in the 15th Five-Year Plan Period[J/OL]. Journal of Gansu Open University, 1–7.
- [8] Fan Qinglin, Huo Zenghui. Research on Optimizing Government Governance Path of Integrated Medical and Elderly Care Services in China[J/OL]. Health Soft Sciences, 1–6.
- [9] Xiong Jie, Huang Xin. The Impact of Digital Inclusive Financial Development on the Supply of Social Elderly Care Institutions: Empirical Analysis Based on Provincial Panel Data[J]. Northern Forum, 2023(06):83–92.

- [10] Mu Guangzong. How to Make Inclusive Elderly Care Truly Inclusive[J]. People's Tribune, 2019(36):70–71.
- [11] Wang Chaocai, Zha Ziyan. Have Comprehensive Medical Reform Pilot Areas Alleviated the “Difficult and Expensive Medical Treatment” Problems?[J]. Public Finance Research, 2021(12):79–92.
- [12] Wang Dianli, Wang Wenying. How to Improve the Accessibility of Elderly Care Services: Research Based on People's Livelihood Complex[J/OL]. Public Governance Research, 1–12.
- [13] Research Group of China National Ageing Research Centre, Zhang Kaiji, Sun Lujun, et al. A Study on the Status of Disabled Elderly People in Urban and Rural Areas of China[J]. Disability Research, 2011(02):11–16.
- [14] Yang Tuan. Correctly Understanding “Urban-Rural Integration”[J]. Theory Guide, 2024(04):50–51.
- [15] Zhang Bin, Ma Jie, Sun Wen, et al. Research on Willingness to Pay for Elderly-Friendly Transformation Based on Double-Bounded Dichotomous CVM[J]. Journal of Engineering Management, 2024, 38(01):83–88.
- [16] Rui Zhengyun, Ma Xifang. The Impact of Perceived Service Quality on User Knowledge Behavior in Crowdsourcing Community Services: A Multiple Mediation Model[J]. Operations Research and Management Science, 2020, 29(12):125–132.
- [17] Lin Mingang. Historical Changes and Modern Reconstruction of Chinese Elderly Care: An Investigation from the Perspective of “Family-Country Integration”[J]. Zhejiang Social Sciences, 2025(01):92–99+158.
- [18] Lu Jiehua, Gu Yuchen. Practical Orientation, Key Issues and Transformation Path of Chinese Elderly Care[J]. Population & Economics, 2024(05):1–12.
- [19] Yang Yansui, Zhang Qiang. Highlights, Pain Points and Development Elements of the New Stage of Elderly Care Services in China[J]. Administration Reform, 2022(03):29–35.
- [20] Guangxi Issued Measures for the Administration of Elderly Care Service Subsidies[J]. China Social Work, 2025(05):7.
- [21] Huang Jianyuan, Jia Linxia. Research on the Balanced Development of Social Elderly Care Service Models under the Main Social Contradictions[J]. Guangxi Social Sciences, 2018(09):148–152.
- [22] He Xuefeng. Village Hollowing Out and Appropriate Village-Level Governance[J/OL]. Hebei Academic Journal, 1–9.
- [23] Lin Bao. Developing the Silver Economy to Meet Diversified Elderly Care Needs[J]. People's Tribune, 2024(13):17–19.
- [24] Zhu Junlin, Xie Aihong, Li Dingchang, et al. Analysis of the Current Situation and Needs of Urban and Rural Elderly Care in a Minority Area of Guangxi Zhuang Autonomous Region[J]. Preventive Medicine Tribune, 2024, 30(05):348–353+367.
- [25] Alam S. A Study on Service Quality and Customer in Bangladesh Tourism: a Paradigm Relationship Marketing[D]. Wuhan University of Technology, 2013.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

Risk Control: A Multi-Dimensional Review of Risk-Taking, Liquidity Creation, and Green Credit with ESG

Mingxuan Shuai*

Institute of Nankai University, Tianjin, China

**Corresponding author: Mingxuan Shuai.*

Abstract

This paper explores the multi-dimensional impact of FinTech on commercial banks' risk control from the perspectives of risk-taking, liquidity creation, and green credit with ESG. Based on a review of existing literature and theoretical analysis, this study finds that FinTech exerts a dual effect on bank risk management. On the one hand, technologies such as big data and artificial intelligence improve risk identification efficiency, optimize liquidity allocation, and enhance green credit and ESG performance by alleviating information asymmetry between banks and borrowers. On the other hand, intensified market competition may induce excessive risk-taking, while technical integration barriers, data governance defects, and regulatory lag constrain the positive role of FinTech. The effects also exhibit significant heterogeneity across banks with different ownership structures, scales, and digital capabilities, with state-owned banks generally better positioned to leverage the advantages of FinTech than small private banks. The synergy between internal governance and external supervision is therefore critical for balancing FinTech innovation and risk control. This study enriches the theoretical framework linking FinTech and bank risk control and provides practical references for commercial banks to strengthen risk management and for regulators to formulate targeted policies that promote the healthy integration of FinTech and traditional banking.

Keywords

FinTech, commercial banks, risk-taking, liquidity creation, green credit

1. Introduction

The rapid penetration of FinTech, represented by technologies such as big data, artificial intelligence, and blockchain, into the banking sector has triggered intense academic and practical debate regarding its net impact on systemic risk and bank performance. A critical theoretical and policy gap remains in understanding how FinTech reshapes financial stability amid increasingly complex market competition and diversified risk factors. Liu et al. [1] find that FinTech amplifies systemic risk by altering banks' credit allocation strategies and leverage levels, with significant heterogeneous effects across different types of banks, including state-owned and private institutions. Notably, their research also indicates that despite heightened risk-taking behavior, FinTech can still improve banks' risk-adjusted performance through efficiency optimization. Elekdag et al. [2] further confirm that greater FinTech presence in the financial market is associated with increased risk-taking by financial intermediaries, thereby strongly supporting the competition-fragility hypothesis. However, they also emphasize that strong domestic supervision and sound internal governance mechanisms can effectively

mitigate this negative effect. In contrast, Fan and Zhu [3] present an opposing perspective, demonstrating that FinTech capability can significantly reduce systemic risk by improving banks' investment efficiency, with this stabilizing effect being particularly prominent for state-owned banks during periods of economic expansion. These conflicting findings reveal unresolved tensions in the literature: some studies regard FinTech as a risk amplifier [1,2], whereas others identify it as a stabilizing force [3]. Existing studies have not fully reconciled these competing perspectives or adequately explored how regulatory instruments, such as the regulatory sandbox model proposed by Liu et al. [1], interact with FinTech's dual effects. Against this background, this paper re-examines the multi-dimensional impact of FinTech on systemic risk by explicitly analyzing the mechanisms underlying these contradictory conclusions. Drawing on the core insights of studies [1-3], this paper develops an integrated analytical framework to comprehensively examine both the risk-taking incentives and efficiency gains associated with FinTech, with the ultimate goal of providing theoretical support and practical guidance for the formulation of more balanced and effective financial regulatory policies.

2. Theoretical Background

The theoretical foundation of FinTech's influence on banks is primarily based on two core frameworks: the competition-fragility/efficiency trade-off hypothesis and the resource-based view (RBV) of the firm. These theories explain how technological adoption reshapes bank performance, risk profiles, and competitive dynamics, while cross-country evidence reveals divergent outcomes associated with different regulatory environments and organizational capabilities. The competition-fragility hypothesis focuses on market dynamics and emphasizes how intensified competition influences banks' risk-taking behavior, whereas RBV highlights the importance of internal resources and organizational capabilities in determining a bank's ability to utilize new technologies effectively. The interaction between these two perspectives is crucial for understanding the dual effects of FinTech on banks, as technological innovation simultaneously intensifies market competition and provides strategic resources that improve operational efficiency. From the perspective of competition, Kalai and Toukabri [4] argue that FinTech adoption expands opportunities for regulatory arbitrage and creates asymmetric impacts across markets. In fragmented regulatory systems such as that of the United States, FinTech generates stronger performance gains for commercial banks, while integrated sandbox frameworks in Canada slow adoption rates, reflecting the tension between innovation promotion and financial stability oversight. This finding is consistent with the competition-fragility hypothesis, according to which FinTech-driven competition pressures banks to assume greater risks in order to maintain market share, particularly in less regulated environments where profit margins are more vulnerable to digital entrants. From the RBV perspective, Bian et al. [5] demonstrate that FinTech adoption functions as a strategic resource, with heterogeneous effects linked to organizational capabilities such as digital infrastructure, talent reserves, and technological integration capacity. Their analysis of Chinese banks shows that FinTech's performance-enhancing effects are more pronounced in banks with technologically capable management teams, as these institutions are better equipped to utilize technological resources to optimize operations and capture market share. This argument is further supported by Goel and Kashiramka [6], who use Indian banking data to show that FinTech directly improves cost efficiency, especially among private and small banks that are more flexible in adopting new technologies to streamline processes and reduce operational costs compared with large state-owned banks characterized by more rigid decision-making systems. Taken together, these studies help reconcile the dual theoretical perspectives. While competition-driven pressures may increase risk under certain conditions, FinTech as a strategic resource can also generate efficiency gains that mitigate such risks. The divergent findings across countries further highlight the critical role of regulatory and institutional factors in determining whether FinTech acts as a destabilizing force or a performance-enhancing capability for banks, thereby bridging the gap between theoretical frameworks and real-world banking practices [4-6].

3. Literature Review

3.1 FinTech Development and Its Influence on Commercial Banks' Risk-Taking Behavior

FinTech exerts a complex two-sided influence on bank risk-taking, with empirical findings often conflicting and challenging theoretical consistency. This complexity arises from heterogeneous FinTech applications and differences in bank characteristics such as scale, ownership, and digital maturity, making a unified conclusion difficult. On the risk-reducing side, Ngo et al. find that FinTech tools such as AI and big data analytics

significantly enhance banks' ability to assess borrower risk, enabling more accurate pricing and portfolio allocation, thereby reducing excessive risk-taking [7]. Their study of Vietnamese banks shows that FinTech improves cost efficiency and real-time monitoring, lowering the probability of poor lending decisions in emerging markets. Similarly, Duan and Liu demonstrate that FinTech combined with green credit policies reduces bank risk-taking in China and strengthens the risk-mitigating effect of green finance initiatives [8]. In contrast, other studies highlight risk-enhancing effects. Li et al. argue that FinTech increases competitive pressure by eroding traditional banking margins, especially in retail banking, prompting banks to engage in higher-risk lending to maintain profitability [9]. Wu et al. further show that while FinTech may reduce insolvency risk, it increases credit and liquidity risk in Chinese banks, particularly joint-stock banks under performance pressure [10]. These contrasting findings indicate that FinTech simultaneously operates as a risk-control tool and a competition-driven risk amplifier, requiring further synthesis of underlying mechanisms.

3.2 FinTech Applications in Promoting Green Credit and ESG Performance of Commercial Banks

FinTech applications in commercial banks often suffer from a range of challenges, including inconsistent integration frameworks, mismatched data governance standards, and heterogeneous regulatory requirements across regions and institutions. These practical obstacles hinder the deep integration of technology and green finance, as banks lack unified norms for connecting FinTech systems with green credit business processes, leading to disjointed data flow and inefficient operation. Moreover, these issues significantly impact the reliability of green credit allocation and ESG performance evaluation of banking institutions, unstandardized data governance makes it difficult to accurately quantify the environmental benefits of green projects, while fragmented regulations lead to inconsistent standards for ESG assessment. In the context of global sustainable development, such issues not only reduce the operational efficiency of green finance but also weaken the guiding role of banks in green transformation, failing to effectively guide social capital to flow into high-quality green projects. According to Cicchiello et al., the positive effect of FinTech acquisitions on banks' ESG performance has a significant lag effect, which means short-term evaluation cannot fully reflect real improvement, creating great uncertainty in performance measurement and making it hard for banks to adjust their green strategies in a timely manner [11]. Sassi stressed that disparities in technological capacity and resource input across banks have resulted in imbalanced FinTech penetration, which further leads to diverging performance and uneven progress in sustainable finance. This issue is more prominent in emerging markets with inadequate infrastructure and regulatory frameworks, where small and medium-sized banks are generally incapable of deploying sophisticated FinTech solutions [12]. Furthermore, Qian et al. noted that the restraining influence of banking FinTech on corporate greenwashing displays distinct firm-level and regional discrepancies. It exerts a more pronounced effect on large firms with standardized information disclosure practices compared with micro and small enterprises, and works more efficiently in developed regions than in underdeveloped areas, thereby generating evident heterogeneity in the quality and practical outcomes of green credit initiatives [13]. Beyond that, You and Liu further pointed out that inappropriate or excessive adoption of FinTech may fail to curb excessive risk-taking behaviors in green finance businesses. Overdependence on technological tools tends to overlook the inherent risks embedded in green projects, which in turn undermines the long-term sustainable development of green credit [14]. In summary, the application of FinTech in green credit and ESG practice is restricted by multiple problems, including technical integration barriers, data governance defects, and regulatory inconsistencies. These limitations collectively indicate that it is urgent to build robust standardized frameworks and improved regulatory mechanisms to unify standards for FinTech integration and data management, regulate the rational application of technology, and clarify regulatory requirements across regions. Only in this way can we ensure the effectiveness of FinTech in promoting green credit and ESG performance, laying a solid foundation for further in-depth analysis and empirical testing on the synergistic development of FinTech and green finance.

3.3 The Effect of FinTech on Bank Liquidity Creation and Stability

Existing studies on the relationship between FinTech and bank liquidity creation and stability remain highly divided and yield inconsistent empirical conclusions across different national contexts, research samples and time periods. The divergence mainly stems from differences in the measurement of FinTech development, the selection of bank samples (such as the distinction between listed and non-listed banks, large and small banks), and the differences in macroeconomic environments of various countries, which makes it difficult to form a

unified theoretical consensus and unified practical policy implication. Therefore, it is necessary to sort out and synthesize representative research findings in this field, clarify the core mechanisms and influencing factors behind the inconsistent conclusions, and provide a clear theoretical basis for subsequent research and practical guidance. This paper briefly reviews four key existing studies to clarify the heterogeneous effects and contradictory mechanisms of FinTech affecting bank liquidity creation and operational stability, and lays a foundation for reconciling the differences in existing research. Fang et al. adopt the panel data of Chinese listed banks covering the period 2007–2021, and their empirical results reveal that FinTech development, including big data risk assessment, intelligent customer service and digital loan processing, can significantly promote the overall level of bank liquidity creation by improving service efficiency and expanding service coverage. Meanwhile, such liquidity expansion effect also stimulates banks' latent risk-taking behavior through the intermediary channel of asset-liability business adjustment, as banks may relax lending standards to further expand credit scale and enhance liquidity creation capacity [15]. Liao et al. focus on the sample of Chinese commercial banks from 2009 to 2023, and further illustrate that FinTech optimization effectively alleviates bank liquidity mismatch. It achieves this positive effect by driving non-interest income growth (reducing reliance on traditional interest income), expanding rational credit scale expansion (avoiding blind credit expansion), and upgrading internal risk management capability (reducing the probability of liquidity risks caused by bad debts) [16]. Grover and Aggarwal carry out relevant research based on Indian commercial banks during 2016–2022, and confirm that FinTech adoption, such as digital payment systems and online lending platforms, remarkably enhances banks' liquidity creation capacity, and such improvement is mainly reflected through on-balance sheet business activities, including increasing short-term loans and optimizing the structure of deposit and loan business [17]. By contrast with the viewpoint of Fang et al., Wang et al. hold an opposite conclusion, pointing out that bank digitalization, as the core component of FinTech, tends to reduce banks' willingness to take excessive risks by improving risk identification and control capabilities, thereby restraining excessive liquidity creation that may bring liquidity pressure, and ultimately helping strengthen the overall financial stability of the banking sector [18].

4. Discussion

4.1 Comparative Analysis

FinTech exhibits clear dual effects across the dimensions of risk-taking, liquidity creation, and ESG/green credit. These heterogeneous outcomes are mainly driven by differences in institutional environments, ownership structures, internal digital capabilities, and regulatory intensity. In terms of risk-taking, FinTech compresses traditional banking profit margins in the digital era. Under weak regulatory conditions, some banks expand high-risk assets to compensate for losses, thereby amplifying risk exposure. In contrast, banks with mature digital risk management systems leverage big data and AI to improve risk identification and constrain excessive risk-taking. For liquidity creation, banks with strong digital capabilities expand service coverage and accelerate capital turnover, thereby increasing liquidity creation. However, banks lacking effective monitoring systems under loose supervision may expand excessively, resulting in hidden risks. The alignment between digital capacity and regulatory strength is essential for operational stability. In green credit and ESG, large banks with sufficient resources build advanced evaluation systems and actively promote green finance projects. However, uneven digital adoption, inconsistent regulatory frameworks, and insufficient investment in small banks hinder FinTech's effectiveness, leading to obvious structural disparities. In summary, FinTech's dual effects stem from mismatches between internal capabilities and external regulatory environments.

4.2 Challenges

The application of FinTech in commercial banks' risk control faces multiple prominent challenges that hinder its in-depth integration and effective implementation. Firstly, technological integration barriers exist, as many banks' traditional risk control systems are incompatible with new FinTech tools, leading to disjointed data flow and inefficient risk management. Secondly, data security and privacy risks are prominent; the extensive use of big data and AI requires collecting massive user information, which may trigger data leakage and violate privacy protection regulations. Thirdly, regulatory lag is a critical issue, FinTech develops rapidly, while relevant regulatory frameworks and standards update slowly, resulting in regulatory arbitrage and unclear responsibility division. Additionally, the lack of professional talents with both financial and

technological literacy restricts banks' ability to optimize FinTech applications, making it difficult to fully exploit the technology's potential in risk control. These challenges collectively affect the stability and effectiveness of FinTech-driven risk control.

4.3 Future Research Directions

Future research can focus on several key directions to address existing gaps and promote the in-depth integration of FinTech and commercial bank risk control. Firstly, it is necessary to explore more scientific measurement methods for FinTech's impact, to accurately quantify its dual effects on risk-taking and efficiency, considering the dynamic changes of the market environment. Secondly, research can focus on the heterogeneous effects of FinTech in different types of banks, clarifying how factors like ownership, scale and regional development level affect its application effect. Thirdly, further study on the coordination mechanism between FinTech applications and regulatory policies is needed to provide more targeted suggestions for regulatory optimization. Additionally, exploring the application of emerging technologies in green credit and ESG risk control, and how to solve data governance and technical integration problems, will be important research directions to promote the sustainable development of banks. These directions can enrich the research system and provide more practical guidance for banks' digital risk control transformation.

5. Conclusion

This study investigates the multi-dimensional impact of FinTech on commercial banks' risk control from the perspectives of risk-taking, liquidity creation, and green credit with ESG. The findings reveal that FinTech exerts a dual effect on bank risk control, acting as both a risk stabilizer and a potential risk amplifier, with heterogeneous outcomes across different bank types and regulatory environments. Specifically, state-owned banks with stronger institutional advantages and technical reserves tend to better leverage FinTech's risk-mitigating effects, while small and private banks are more vulnerable to competition-driven risk-taking pressures. Technologically, FinTech empowers banks with big data and AI to enhance risk identification, optimize liquidity allocation, and facilitate green credit evaluation, thereby alleviating information asymmetry and improving risk-adjusted performance. However, intensified market competition driven by FinTech may push banks to expand high-risk businesses, while inconsistent technical standards and regulatory lags restrict the effectiveness of FinTech in green finance and ESG governance. These constraints are particularly prominent in emerging markets, where inadequate digital infrastructure and fragmented supervision hinder the full play of FinTech's positive role. The reconciliation of these dual effects relies on the synergy between internal bank capabilities and external supervision. Sound digital infrastructure and governance enable banks to leverage FinTech's efficiency gains, while robust regulation mitigates excessive risk-taking and regulatory arbitrage. Banks should strengthen digital talent cultivation and technological integration, while regulators need to update regulatory frameworks in a timely manner to keep pace with FinTech development. This research enriches the integrated analytical framework of FinTech and bank risk control, offering practical guidance for commercial banks to optimize risk management systems and balance innovation with stability. It also provides evidence-based implications for regulators to formulate targeted policies, promoting the sustainable and integrated development of FinTech and commercial banking risk control. Limitations of this study and directions for future research are also briefly noted, laying a foundation for further in-depth empirical exploration.

References

- [1] Liu, Y., Wang, D., & Fan, X. (2026). Fintech, systemic risk and bank performance: Based on the perspective of systemic-risk-adjusted performance. *Pacific-Basin Finance Journal*, 95, Article 103006. <https://doi.org/10.1016/j.pacfin.2025.103006>
- [2] Elekdag, S., Emrullahu, D., & Ben Naceur, S. (2025). Does FinTech increase bank risk-taking? *Journal of Financial Stability*, 76, Article 101360. <https://doi.org/10.1016/j.jfs.2024.101360>
- [3] Fan, Z., & Zhu, L. (2026). FinTech capability and systemic risk in banking. *International Review of Economics & Finance*, 108, Article 105173. <https://doi.org/10.1016/j.iref.2026.105173>

- [4] Kalai, L., & Toukabri, M. (2024). Risks, regulations, and impacts of FinTech adoption on commercial banks in the United States and Canada: A comparative analysis. *Thunderbird International Business Review*, 66, 609–641. <https://doi.org/10.1002/tie.22404>
- [5] Bian, W., Wang, S., & Xie, X. (2024). How valuable is FinTech adoption for traditional banks? *European Financial Management*, 30, 1065–1093. <https://doi.org/10.1111/eufm.12424>
- [6] Goel, R., & Kashiramka, S. (2026). FinTech advancement in the banking industry: Is it driving efficiency? *International Journal of Finance & Economics*, 31(1), 842–868. <https://doi.org/10.1002/ijfe.3170>
- [7] Ngo, X. T., Le, K.-A., Nguyen, T. T., & Nguyen, K. D. (2025). Does FinTech curb bank risk-taking? Insights from an emerging economy. *Finance Research Letters*, 86(Part F), Article 108722. <https://doi.org/10.1016/j.frl.2025.108722>
- [8] Duan, D., & Liu, K. (2025). Development of fintech, green credit, and risk taking in commercial banks. *Finance Research Letters*, 86(Part E), Article 108687. <https://doi.org/10.1016/j.frl.2025.108687>
- [9] Li, C., Li, Y., Xu, Y., & Sun, G. (2025). Research on the impact of financial technology on risk-taking of commercial banks. *Research in International Business and Finance*, 76, Article 102804. <https://doi.org/10.1016/j.ribaf.2025.102804>
- [10] Wu, X., Jin, T., Yang, K., & Qi, H. (2023). The impact of bank FinTech on commercial banks' risk-taking in China. *International Review of Financial Analysis*, 90, Article 102944. <https://doi.org/10.1016/j.irfa.2023.102944>
- [11] Cicchiello, A. F., Foroni, C., Monferrà, S., & Torluccio, G. (2025). Do FinTech acquisitions affect banks' ESG performance? Evidence from global M&As. *Journal of International Financial Markets, Institutions and Money*, 105, Article 102229. <https://doi.org/10.1016/j.intfin.2025.102229>
- [12] Sassi, H. (2025). ESG and bank performance: Does fintech matter? In N. Apergis (Ed.), *Encyclopedia of monetary policy, financial markets and banking* (1st ed., pp. 691–693). Academic Press. <https://doi.org/10.1016/B978-0-44-313776-1.00326-3>
- [13] Qian, S., Yang, Z., & Fang, X. (2025). Bank fintech and corporate green transformation quality improvement: Based on greenwashing governance perspective. *Economic Analysis and Policy*, 87, 401–423. <https://doi.org/10.1016/j.eap.2025.06.017>
- [14] You, W., & Liu, B. (2025). ESG performance, bank fintech and risk-taking. *Finance Research Letters*, 74, Article 106776. <https://doi.org/10.1016/j.frl.2025.106776>
- [15] Fang, Y., Wang, Q., Wang, F., & Zhao, Y. (2023). Bank fintech, liquidity creation, and risk-taking: Evidence from China. *Economic Modelling*, 127, Article 106445. <https://doi.org/10.1016/j.econmod.2023.106445>
- [16] Liao, X., Li, Q., & Wang, W. (2025). The research on the impact of FinTech development on liquidity mismatch in banks. *Managerial Finance*, 51(11), 1724–1741. <https://doi.org/10.1108/MF-10-2024-0779>
- [17] Grover, N., & Aggarwal, P. (2025). Impact of fintech on liquidity creation: Evidence from Indian banks. *Managerial Finance*, 52(3), 540–555. <https://doi.org/10.1108/MF-05-2024-034>
- [18] Wang, L., Zhao, X., & Wan, L. (2025). Analysis of the impact of bank digitization process on liquidity creation and risk-taking. *Finance Research Letters*, 79, Article 107234. <https://doi.org/10.1016/j.frl.2025.107234>

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

Baseline Price Rigidity and Promotional Adjustment in Digital Distribution Platforms: Empirical Evidence from the Steam-Epic Rivalry

Junyi Liu*

School of Digital Economy and Management, Nanjing University, Suzhou, China

**Corresponding author: Junyi Liu.*

Abstract

This paper asks why Epic Games Store's 18-percentage-point commission advantage over Steam did not produce durable pass-through into Steam's current list prices, and how identity-bound ecosystem assets sustain this rigidity. Using a monthly panel of 547,518 Steam RPG title observations from January 2020 to March 2026, the study combines matched-sample staggered PSM-DID, lifecycle controls, price-margin decomposition, event-study evidence, and a 1,000-iteration permutation placebo test. Three results stand out. First, Steam's current list price does not respond significantly once lifecycle dynamics are modeled ($\beta = 0.0238$, $SE = 0.0194$, $p = 0.2205$), while the effective transaction price declines significantly ($\beta = -0.1194$, $SE = 0.0215$). Second, this decline operates through the promotional margin: discount depth increases by 6.46 percentage points ($SE = 0.0081$), and promotion probability increases by 5.12 percentage points ($SE = 0.0113$). Third, achievement-based lock-in emerges as the primary mechanism sustaining list-price rigidity: the achievement interaction is positive and significant ($\beta = 0.0269$, $p = 0.0016$), whereas workshop and playtime dimensions are not. These findings imply that lowering platform commission fees is insufficient to discipline an incumbent whose pricing power rests on non-portable identity assets rather than cost structure alone.

Keywords

digital distribution platforms, price rigidity, promotional adjustment, fee pass-through, achievement-based lock-in

1. Introduction

The digital PC game market has recently transitioned from Steam's unipolar dominance toward multi-platform coexistence, featuring storefronts including the Epic Games Store (EGS), GOG, and the EA App. According to standard price theory, market prices should converge as search costs decline and price transparency increases. Yet following Epic's market entry with a commission rate reduced from 30% to 12%, game prices on Steam have exhibited no pronounced decline — a phenomenon that deviates substantially from theoretical expectations.

This paper addresses a more precise question: why did Epic's low-commission strategy fail to generate durable pass-through into Steam's baseline prices, and why did competitive pressure instead manifest primarily as an adjustment in discount tactics? We argue that inter-platform competition operates not merely through

pricing, but more fundamentally through identity-bound ecosystem depth and the switching costs it generates — a mechanism that insulates list prices from commission-based entry even when promotional behavior responds.

December 2018 marked an important competitive turning point in the digital distribution market. Epic Games launched its proprietary storefront and drastically cut the platform commission rate, disrupting the market's prolonged equilibrium. Despite Epic's aggressive exclusivity deals and free game giveaways, Steam largely retained its pricing architecture, supported by a deep community ecosystem and entrenched player switching costs.

This study addresses three core research questions. First, does Steam's baseline list price exhibit rigidity in the face of Epic's commission-based entry, and does competitive pressure redirect to the promotional margin instead? Second, does achievement-based lock-in — specifically non-transferable achievement histories rather than more portable asset dimensions — explain why this list-price rigidity persists? Third, what does this pass-through failure imply for the conditions under which commission-based competition can constitute effective competitive discipline?

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature and develops the hypotheses. Section 3 describes the data, variables, and matched staggered PSM-DID design. Section 4 presents descriptive fixed-effects evidence on Steam price-premium patterns. Section 5 develops the main causal argument by combining matched-sample PSM-DID, lifecycle attenuation, and price-margin separation. Section 6 reports diagnostic and robustness tests. Section 7 discusses implications, and Section 8 concludes.

2. Literature Review and Theoretical Hypotheses

2.1 Prior Research and Core Hypotheses

Research on digital distribution platforms has largely examined the allocation of bargaining power within two-sided markets — specifically, how platforms leverage control over consumer traffic to extract pricing power from content developers [1,2]. Complementary work on network externalities and switching costs demonstrates that platform-specific assets, such as achievement systems and community-generated content, can significantly reduce consumer price sensitivity and erect durable exit barriers [3,4].

However, the precise mechanisms by which these forces sustain price rigidity even in the face of strong competitive entry remain underexplored through large-scale micro-empirical analysis. This study also speaks to recent platform and ecosystem strategy research that treats platform competition as an ecosystem-level process rather than a simple price rivalry [5-8]. Prior ecosystem theory clarifies how interdependence among complements, users, and platform sponsors creates ecosystem-level constraints on firm strategy [5-7]. A systematic review of 333 platform-competition articles further emphasizes network effects, complementor strategy, and ecosystem orchestration as recurring mechanisms in platform competition [8]. In the gaming context, social product features on Steam can shape diffusion outcomes, reinforcing the relevance of non-price platform assets [9].

Based on these gaps, this paper proposes the following hypotheses:

H1 (Directional price premium hypothesis): Compared with multi-platform games, Steam-exclusive RPG games have a directional price premium, but this premium is statistically insignificant after controlling for strict fixed effects.

H2 (Achievement-based lock-in hypothesis): Non-transferable achievement histories, functioning as identity-bound sunk assets, should strengthen Steam's list-price rigidity more reliably than more portable or lifecycle-sensitive platform asset dimensions such as workshop activity or playtime records.

H3 (Limited list-price pass-through hypothesis): Cost-based competitive entry, as represented by Epic's commission reduction and game-level entry into EGS, is unlikely to generate durable pass-through into Steam's current list-price measure once lifecycle dynamics and ecosystem lock-in are accounted for. In this paper, durable pass-through is defined operationally as a statistically significant negative DID coefficient for `ln_current_list_price` after lifecycle controls, title fixed effects, time fixed effects, and clustered inference.

Competitive effects may still appear through the effective transaction price, discount depth, or promotion probability without constituting durable list-price pass-through.

Note on H3: The empirical design therefore does not treat any post-entry price decline as self-evident proof of effective competition. Instead, the matched DID estimate is interpreted jointly with lifecycle controls, event-study timing, price-margin decomposition, and placebo evidence.

From an identity-economics perspective, platform-specific achievements, historical play records, and community traces can operate as psychological sunk assets rather than purely functional metadata. This interpretation extends identity-economics and switching-cost logic [3,10]: players and developers may both treat these platform-bound histories as value-bearing assets, muting the transmission of competitive price signals.

2.2 Digital Antitrust Context

The policy relevance of this question is clear in formal digital-antitrust scholarship. Existing work argues that network effects, data concentration, and platform intermediation can entrench incumbents in ways that strain conventional competition tools [11]. Related expert analysis similarly frames large digital platforms as gatekeeping intermediaries for which ex ante obligations may be needed when standard ex post enforcement struggles to restore contestability [12].

Commission-fee research provides a closer bridge to the pass-through question. Platform-commission models explicitly link commission revenues and pass-through to seller prices [13]. Recent work on Epic Games' entry into the PC game market documents heterogeneous complementor reactions, which supports the present paper's focus on margin-specific responses rather than a uniform competitive effect [14].

2.3 Quantitative Research on Social Assets and Non-Price Competition

Recent ecosystem-oriented competition research also emphasizes that platform power can arise at the level of the wider ecosystem rather than a single narrowly defined product market. Complementor dependence and customer lock-in create bottlenecks that matter for competition analysis [15]. This perspective motivates the present paper's decision to examine achievements, workshop participation, and playtime not simply as engagement metrics, but as candidate mechanisms behind price rigidity.

Steam-specific empirical studies further motivate the paper's price-margin decomposition. Prior Steam-based empirical work uses Steam price histories to identify sales events when studying game reviews, while related promotion research directly examines promotions and endogenous consumer reviews on Steam [16,17]. These studies support treating promotional pricing as a distinct empirical margin rather than as a mechanical proxy for durable list-price pass-through. Research on Steam meta-gaming and achievements further supports the interpretation that platform-bound achievements can act as non-transferable identity assets rather than ordinary engagement metrics [18].

3. Research Design and Model Construction

3.1 Data Sources and Sample Processing

The dataset was obtained via a custom automated scraping pipeline, covering comprehensive dynamic panel data from the Steam platform from January 2020 to March 2026. Three screening criteria were applied to ensure sample homogeneity and mitigate endogeneity. First, the sample is restricted to games tagged RPG on Steam, yielding 547,518 observations; this genre restriction controls for heterogeneous social attribute intensities across game categories and aligns with the strong community interaction features central to the theoretical framework. Second, observations where the current price equals zero (Free-to-Play) are excluded. Third, games with fewer than six months of continuous pricing records are excluded to ensure sufficient temporal coverage for panel estimation.

Cross-platform availability data were scraped from the public game libraries of the Epic Games Store and GOG. The key baseline comparison variable is `Steam_Exclusive_dummy`, which equals 1 if a title is available only on Steam and 0 if the title is listed on Steam and at least one competing platform. This coding makes the coefficient

directly interpretable as the Steam-exclusivity price premium. In the causal specification, a separate staggered Epic-entry treatment indicator is used for titles that enter EGS during the January 2020–March 2026 observation window.

3.2 Variable Definition

The price-margin analysis separates four pricing outcomes: $\ln_current_list_price$, the logarithm of the current list-price measure; $\ln_price$, the logarithm of the observed effective price; $real_discount_rate$, the realized discount depth; and $is_discounted$, an indicator for whether a title is in a promotional period. The variable $real_discount_rate$ is measured on a 0–1 scale, so a coefficient of 0.0646 corresponds to a 6.46-percentage-point change in discount depth; $is_discounted$ is a binary indicator, so a coefficient of 0.0512 corresponds to a 5.12-percentage-point change in promotion probability.

The baseline exclusivity variable, $Steam_Exclusive_dummy$, is a binary indicator equal to 1 for Steam-exclusive titles and 0 for comparable multi-platform titles. The Social Asset Index (SAI) is a baseline composite moderator constructed from three observed platform-specific sub-dimensions: log achievement counts ($\ln_achievements$), log workshop activity ($\ln_workshop$), and log average playtime ($\ln_playtime$). The baseline index is specified as:

$$SAI = 0.5 \times \ln_achievements + 0.3 \times \ln_workshop + 0.2 \times \ln_playtime \quad (1)$$

This weighting scheme is used as an exploratory composite baseline rather than a structural estimate; the primary mechanism variable in the causal analysis is the achievement interaction term directly ($SteamOnly \times \ln_achievements$), not the composite SAI. Robustness checks re-estimate achievement-heavy alternative weights and a PCA-based index to verify sensitivity. The manual and PCA indices are highly correlated ($r = 0.9458$), but the moderation result is strongest under achievement-heavy weights and becomes statistically weak under PCA aggregation, confirming that the mechanism is achievement-dominated.

The observable covariates used in matching and ancillary regressions are $\ln(Total\ Reviews)$, $Review\ Score$, Is_Indie , and $Is_Multiplayer$. In the two-way fixed-effects price-premium regressions, time-invariant game characteristics are absorbed by entity effects and are therefore not separately identified.

3.3 Model Specification

To control for time-invariant game heterogeneity and common time shocks, the core fixed-effects specification is:

$$\ln_price_{it} = \alpha + \beta_1 SteamOnly_{it} + \beta_2 (SteamOnly \times SAI)_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

For causal identification, we employ a staggered PSM-DID framework treating a game's entry into EGS during the observation window as the relevant competitive shock. The treatment group comprises games entering EGS between January 2020 and March 2026, while the control group consists of comparable games that remain outside EGS during the same observation window. Matching is performed on $\ln(Total\ Reviews)$, $Review\ Score$, Is_Indie , and $Is_Multiplayer$.

4. Descriptive Evidence on STEAM Price-Premium Patterns

4.1 Descriptive Fixed-Effects Evidence

Table 1 presents descriptive fixed-effects evidence on the Steam price-premium pattern. Because only 493 of 11,028 games (4.47%) change platform status over the sample period, within-title variation is limited and the estimates should be read as directional rather than precisely identified. The point estimate on $SteamOnly$ is positive (0.0539), consistent with a directional price-premium pattern, but clustered inference renders it statistically imprecise. The composite interaction $SteamOnly \times SAI$ is similarly positive but not stable enough under alternative weighting to support a strong standalone claim.

Once the social-asset composite is unpacked, the picture becomes clearer: the achievement interaction is positive and statistically significant ($\beta = 0.0269$, $p = 0.0016$), whereas the workshop and playtime components are not. The best-supported interpretation is therefore not that every form of social asset reinforces price rigidity equally, but that non-transferable achievement histories are the main identity-based mechanism in this sample.

Table 1: Baseline fixed-effects estimates: Steam price premium and social-asset mechanisms

Variable	Coefficient	Std. Error	p-value
SteamOnly	0.0539	0.0401	0.1784
SteamOnly $\times$ SAI	0.0073	0.0047	0.1159
SteamOnly $\times$ Achievement	0.0269***	0.0085	0.0016
Entity FE	Yes	—	—
Time FE	Yes	—	—
Observations	547,518	—	—
R-squared	0.0009	—	—

Note: Clustered standard errors are reported. Time-invariant game characteristics are absorbed by entity fixed effects. The low within-model R-squared is expected: only 493 of 11,028 games (4.47%) change SteamOnly status over time.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

5. Baseline Price Rigidity and Promotional-Margin Adjustment

5.1 Main Causal Specification: Matched-Sample PSM-DID

The main causal specification is the matched-sample staggered PSM-DID. This design is preferred over the full-sample DID for a specific reason: the full-sample estimate cannot be cleanly separated from lifecycle dynamics (Section 6.1), whereas matching on observables and adding nonlinear lifecycle controls allows us to isolate the pass-through channel more credibly.

Table 2 reports the matched-sample DID coefficient of -0.0576^{***} (SE = 0.0183), indicating a surface-level price decline of approximately 5.8% among matched treated games following EGS entry. This is the starting point of the analysis, not the conclusion.

The empirical interpretation proceeds in three steps. First, the matched DID estimate provides the reduced-form surface pattern: treated games experience an observed post-entry price decline. Second, lifecycle adjustment and multi-outcome decomposition show why this surface decline should not be interpreted as durable list-price pass-through. As reported in Table 3, once an explicit lifecycle control is included, the current list-price coefficient is small and statistically insignificant ($\beta = 0.0238$, SE = 0.0194, $p = 0.2205$), whereas the effective price declines significantly ($\beta = -0.1194$, SE = 0.0215). Third, the same decomposition identifies the operative margin of competition: discount depth rises significantly by 6.46 percentage points and promotion probability rises significantly by 5.12 percentage points.

Taken together, Table 2 and Table 3 establish the paper's central empirical finding: staggered EGS entry is associated with surface-level price movement, but the durable list-price channel is weak. Competition appears most clearly through discount depth and promotion probability rather than through current list-price pass-through.

Table 2: PSM-DID estimates: Epic entry and Steam baseline prices

Explanatory variable	Coefficient (β)	Std. Error	t-value
Treat $\times$ Post (DID)	-0.0576^{***}	0.0183	-3.14
Matched games	1,460	—	—
Observations	77,235	—	—

Note: Clustered standard errors are reported. The DID estimate should be interpreted together with lifecycle controls, placebo evidence, and the price-margin decomposition. *** $p < 0.01$.

Table 3: Lifecycle-controlled price-margin decomposition

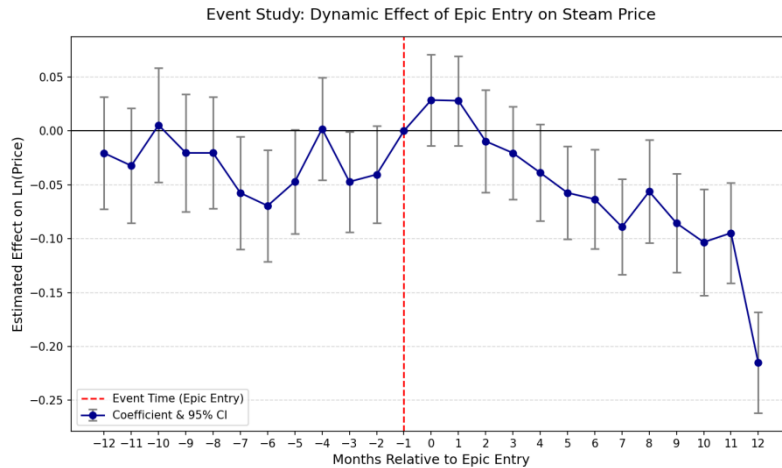
Dependent variable	DID coeff. (clustered SE)	p-value	Interpretation
Current list price (ln_current_list_price)	0.0238 (0.0194)	0.2205	No significant list-price response
Effective price (ln_price)	-0.1194^{***} (0.0215)	< 0.001	Effective price declines significantly
Discount depth (real_discount_rate)	0.0646^{***} (0.0081)	< 0.001	Discount depth increases significantly
Promotion frequency (is_discounted)	0.0512^{***} (0.0113)	< 0.001	Promotion probability increases significantly

Note: All four specifications use 308,255 observations, title fixed effects, month fixed effects, game-level clustered standard errors, and age_sq as a lifecycle control. real_discount_rate is on a 0–1 scale; is_discounted is a binary indicator. *** $p < 0.01$.

5.2 Dynamic Effects and Parallel Trend Verification

Figure 1 reports the matched-sample event-study estimates around EGS entry. The evidence is broadly consistent with a post-entry decline, but it does not support an overly strong parallel-trends claim. Most pre-entry coefficients remain moderate, yet months -7 and -6 are statistically negative. Because these two leads cluster immediately before eventual Epic listing rather than appearing throughout the entire pre-period, they are most plausibly interpreted as anticipation or selection effects tied to pre-launch contracting and pricing preparation. Accordingly, the event study is treated as supportive but not dispositive, and the paper's identification argument relies more heavily on matching, lifecycle controls, and placebo analysis.

Figure 1: Dynamic effects of EGS entry on Steam prices



Post-entry coefficients become more negative over time and reach approximately -0.21 by month 12. Consistent with the anticipation reading, an anticipation-adjusted DID that advances treatment by six months yields only -0.0310 ($p = 0.1165$), which is smaller in magnitude and statistically insignificant.

5.3 Heterogeneity Analysis: AAA Publishers Vs. Independent Studios

Subgroup regressions show larger price responses for non-indie/AAA titles (-0.1273 , $p < 0.0001$) than for indie titles (-0.0718 , $p = 0.0084$). The direction is consistent with the view that larger publishers adjust multi-platform pricing more aggressively, but these differences should still be interpreted alongside the lifecycle and placebo evidence rather than as proof of differential pass-through alone.

Table 4: Heterogeneity regression results based on publisher size

Variable	Model (3): AAA / Non-Indie	Model (4): Indie
Treat $\times$ Post (DID)	-0.1273^{***}	-0.0718^{***}
Std. Error	(0.0224)	(0.0273)
p-value	< 0.0001	0.0084
Observations (N)	199,821	347,697
R-squared	0.0015	0.0002

Note: Clustered standard errors are reported. *** $p < 0.01$.

6. Robustness Tests

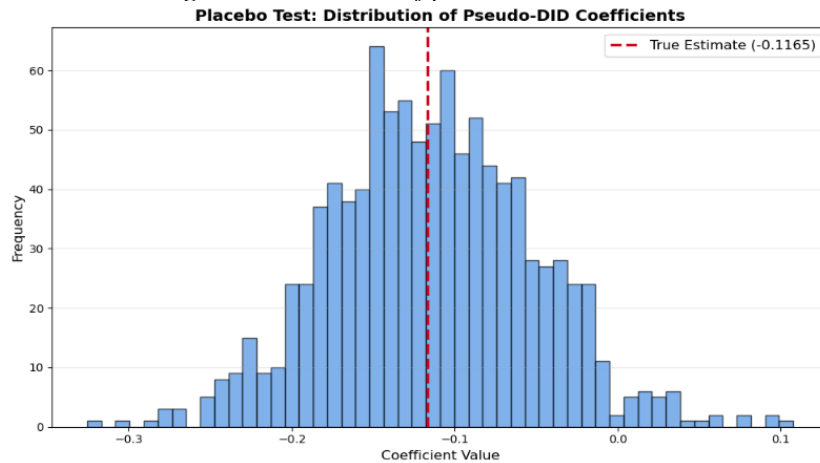
6.1 Monte Carlo Permutation Placebo Test and Lifecycle Decomposition

The full-sample permutation placebo test serves a specific diagnostic role in this paper: it explains why the full-sample raw DID is not used as the primary identification strategy, and why the matched-sample design with lifecycle controls is necessary. We conducted a 1,000-iteration permutation test that randomly reassigned treatment status at the game level while preserving the original post-period structure.

As shown in Figure 2, the resulting pseudo-effect distribution is centered at -0.1181 , with the actual full-sample DID estimate (-0.1165) located at the 52.6th percentile of that distribution. This result is not a failure

of the paper's identification strategy — it is precisely the diagnostic that motivates using the matched-sample PSM-DID with lifecycle controls as the primary specification. The raw full-sample DID is indistinguishable from lifecycle-driven price trajectories that arise even under random reassignment, which is why we do not treat it as causal evidence.

Figure 2: Distribution of placebo DID estimates



The implication is not that Epic had zero influence, but that the full-sample raw DID cannot be interpreted as clean evidence of current list-price pass-through. The lifecycle-controlled price-margin regressions show that Epic's influence is transmitted through effective prices, discount depth, and promotion frequency rather than the current list-price measure.

6.2 Sample Sensitivity Analysis

Within the matched panel, no titles exit before the sample endpoint, so a delisting-based exclusion is unnecessary in the retained dataset. First, excluding the top 1% most price-volatile titles (cutoff = 1.0848; 15 titles and 954 observations removed) yields DID = -0.0613 ($p = 0.0009$). Second, restricting the sample to non-indie publishers yields DID = -0.0742 ($p = 0.0013$). The direction and significance of the result therefore remain intact under these alternative sample restrictions.

6.3 Robustness of Social Asset Sub-Dimensions

Decomposing the social-asset mechanism yields a clearer and more defensible pattern. The achievement interaction is positive and statistically significant ($\beta = 0.0269$, $p = 0.0016$), while the workshop and playtime interactions are economically small and statistically insignificant.

Weight-sensitivity tests reinforce this interpretation. Achievement-heavy composite weights remain positive and significant, the effect becomes only marginal under more balanced weights, and the PCA-based interaction is statistically weak ($p = 0.2927$) despite a high correlation between the manual and PCA indices ($r = 0.9458$). The mechanism evidence should therefore be framed as achievement-dominated rather than as a uniformly robust composite-SAI result.

6.4 Controlling for Concurrent Policy Interference

The observation window spans January 2020 to March 2026 and includes substantial publisher-level strategic adjustment. To absorb time-varying publisher-specific pricing shocks, the analysis re-estimates the matched-sample specification with AppID fixed effects and Publisher $\times$ Month fixed effects. Under this stronger control, the DID coefficient becomes -0.0222 ($p = 0.3490$), suggesting that once publisher-specific monthly pricing strategies are absorbed, the remaining effect on Steam prices is economically small and statistically indistinguishable from zero.

7. Discussion

7.1 The Anchoring Effect of Social Assets on Price Rigidity

The evidence points to a specific version of social-asset lock-in rather than a blanket story about every platform metric. Achievement histories appear to act as the strongest identity anchors in this sample, while more portable or lifecycle-sensitive dimensions do not reliably reinforce price rigidity. This result refines the general switching-cost argument [3,4] by showing which platform-bound assets matter most: not all accumulated data are equally capable of muting competitive price signals.

From an identity-economics perspective [10], achievements function as non-transferable records of self-investment in a platform-specific identity. Unlike workshop uploads or playtime logs — which may be partially observable or replicable across platforms — achievement histories are structurally locked to Steam's backend and carry symbolic as well as functional value. This distinction explains why the achievement interaction produces a robust and statistically significant moderation effect while the composite SAI yields weaker and less stable results. The finding extends Steam-specific work on meta-gaming and achievement systems [18] by linking these assets directly to pricing rigidity, rather than to engagement or platform participation alone.

7.2 Promotional Adjustment as the Margin of Competition

A key insight from the price-margin decomposition is that competition did not disappear; it shifted margins. Table 3 shows that the current list-price measure does not respond significantly to EGS entry, while effective prices fall through both deeper discounts and a higher probability of promotion. The competitive response therefore operates through the intensive promotional margin (discount depth) and the extensive promotional margin (promotion incidence), rather than through durable current list-price pass-through.

This result is consistent with recent Steam promotion research showing that sales events and consumer-review dynamics are important strategic margins for developers [17], and complements research on complementor reactions to EGS entry, which emphasizes heterogeneity rather than uniform migration away from Steam [14]. The present study adds a price-margin interpretation: developers can respond to cross-platform competition without abandoning Steam's list-price architecture, by adjusting temporary discounts that preserve long-run reference prices.

7.3 Contributions and Implications for Platform Competition Theory

The central empirical lesson is not that all competition failed, but that commission competition translated mostly into promotional adjustment rather than durable list-price change. Relative to platform-commission models that focus on seller prices and fee pass-through [13], this paper shows that pass-through can be fragmented across price margins: a reduction in platform fees may influence effective transaction prices while leaving list prices sticky.

Relative to ecosystem strategy research [5-7,15], the paper provides micro-level evidence that non-portable identity assets can limit the transmission of cost-based platform competition. Platforms that succeed in embedding users within identity-bound ecosystems gain pricing insulation that goes beyond conventional network effects. Relative to platform-promotion studies [19], the results show that selective promotion and discounting are not only marketing tools but also a strategic adjustment channel under inter-platform rivalry. The disappearance of the residual DID effect after absorbing Publisher $\times$ Month fixed effects further suggests that observed price movements are closely tied to publisher-level promotional strategies rather than to a durable platform-wide shift in Steam's baseline pricing architecture.

7.4 Policy Implications

The policy implication is that commission reduction alone may be too narrow as a remedy for entrenched platform power. If users and developers remain locked into non-portable achievement histories, community traces, and accumulated platform identity, lower fees on a rival platform may not generate durable list-price competition. Regulators concerned with platform contestability should therefore consider measures that improve portability and interoperability of identity-bound assets, specifically:

(1) Standardized and portable achievement record formats that allow users to carry verified play histories across platforms; (2) Open APIs or data export rights covering user libraries, playtime logs, and social graph data; (3) Cross-platform promotional parity obligations to prevent incumbents from selectively conditioning discount access on exclusivity; and (4) Interoperability requirements for platform-specific community features such as workshop content and review histories. Such measures would target the lock-in mechanism more directly than fee regulation alone, and are consistent with emerging digital-markets regulation that emphasizes contestability and data portability alongside price-based remedies [11,12].

8. Conclusion

Using monthly panel data from January 2020 to March 2026, this paper reframes the Steam-Epic rivalry as a study of price rigidity rather than price pass-through. The central question is not whether Epic's entry reduced Steam prices, but why cost-based entry failed to shift the baseline price architecture while still reshaping promotional behavior. Three conclusions follow.

First, Steam's current list-price architecture exhibits strong rigidity in the face of Epic's commission-based entry. The current list-price coefficient is small and statistically insignificant in lifecycle-controlled regressions, while the full-sample placebo diagnostic indicates that raw observed price declines are not cleanly separable from lifecycle-driven trajectories.

Second, achievement-based lock-in is the primary mechanism sustaining this rigidity. Non-transferable achievement histories function as identity-bound sunk assets that mute competitive price signals; workshop and playtime dimensions do not replicate this pattern, and PCA-based aggregation confirms the mechanism is achievement-dominated rather than uniformly composite.

Third, Epic's competitive pressure manifested primarily as promotional adjustment rather than durable list-price change. The lifecycle-controlled decomposition shows no significant current list-price response, but it does show a significant effective-price decline, a 6.46-percentage-point increase in discount depth, and a 5.12-percentage-point increase in promotion probability.

The paper's central contribution is an explanation of why commission-based entry fails to generate list-price pass-through when the incumbent controls identity-bound ecosystem assets. For competition policy, the implication is direct: lowering platform fees is an insufficient remedy when price rigidity is sustained by non-portable achievement histories and ecosystem lock-in. Effective competitive discipline may require portability mandates for platform-specific assets rather than — or in addition to — fee regulation.

References

- [1] Armstrong, M. (2006). Competition in two-sided markets. *The RAND Journal of Economics*, 37(3), 668–691.
- [2] Rochet, J.-C., & Tirole, J. (2003). Platform competition in two-sided markets. *Journal of the European Economic Association*, 1(4), 990–1029.
- [3] Farrell, J., & Klemperer, P. (2007). Coordination and lock-in: Competition with switching costs and network effects. *Handbook of Industrial Organization*, 3, 1967–2072.
- [4] Klemperer, P. (1995). Competition when consumers have switching costs. *The Review of Economic Studies*, 62(4), 515–539.
- [5] Adner, R. (2017). Ecosystem as structure: An actionable construct for strategy. *Journal of Management*, 43(1), 39–58.
- [6] Kretschmer, T., Leiponen, A., Schilling, M., & Vasudeva, G. (2022). Platform ecosystems as meta-organizations: Implications for platform strategies. *Strategic Management Journal*, 43(3), 405–424. <https://doi.org/10.1002/smj.3250>
- [7] Jacobides, M. G., Cennamo, C., & Gawer, A. (2018). Towards a theory of ecosystems. *Strategic Management Journal*, 39(8), 2255–2276.

- [8] Rietveld, J., & Schilling, M. A. (2021). Platform competition: A systematic and interdisciplinary review of the literature. *Journal of Management*, 47(6), 1528–1563.
- [9] Rietveld, J., & Ploog, J. N. (2022). On top of the game? The double-edged sword of incorporating social features into freemium products. *Strategic Management Journal*, 43(6), 1182–1207.
- [10] Akerlof, G. A., & Kranton, R. E. (2000). Economics and identity. *The Quarterly Journal of Economics*, 115(3), 715–753.
- [11] Fletcher, A., Crémer, J., Heidhues, P., Kimmelman, G., Monti, G., Podszun, R., Schnitzer, M., Scott Morton, F. M., & de Streel, A. (2024). The effective use of economics in the EU Digital Markets Act. *Journal of Competition Law & Economics*, 20(1–2), 1–19.
- [12] Cabral, L. M. B., Haucap, J., Parker, G., Petropoulos, G., Valletti, T. M., & Van Alstyne, M. W. (2021). The EU Digital Markets Act: A report from a panel of economic experts. Publications Office of the European Union.
- [13] Etro, F. (2023). Platform competition with free entry of sellers. *International Journal of Industrial Organization*, 89, 102903.
- [14] Loh, J., & Elsas-Nicolle, A. (2026). Platform competition and strategic trade-offs for complementors: Heterogeneous reactions to the entry of a new platform. *Strategic Management Journal*, 47(6), 1671–1729.
- [15] Jacobides, M. G., & Lianos, I. (2021). Ecosystems and competition law in theory and practice. *Industrial and Corporate Change*, 30(5), 1199–1229.
- [16] Lin, D., Bezemer, C.-P., Zou, Y., & Hassan, A. E. (2019). An empirical study of game reviews on the Steam platform. *Empirical Software Engineering*, 24(1), 170–207.
- [17] Cao, J., & Wang, X. (2024). Endogenous consumer reviews and promotion incentives: Evidence from an online game platform. Working paper, National University of Singapore.
- [18] Rizani, M. N., Khalid, M. N. A., & Iida, H. (2023). Application of meta-gaming concept to the publishing platform: Analysis of the Steam games platform. *Information*, 14(2), 110.
- [19] Rietveld, J., Schilling, M. A., & Bellavitis, C. (2019). Platform strategy: Managing ecosystem value through selective promotion of complements. *Organization Science*, 30(6), 1232–1251.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Data and Code Availability Statement

The large-scale dynamic panel dataset (547,518 observations) was collected from public Steam-facing interfaces via a custom automated pipeline. All preprocessing steps, matching routines, lifecycle-control regressions, sample-sensitivity checks, placebo results, weighting-sensitivity outputs, and the lifecycle-controlled price-margin decomposition are archived in a reproducible replication package. The codebase used to generate the results reported here is available from the corresponding author upon reasonable request.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

Analysis of the Success and Challenges of Chinese Entrepreneurs in Semporna, Malaysia

Shuyang Fan¹, Fumitaka Furuoka², and Suteng Lee^{3*}

¹*Asia Europe Institute, University of Malaya, Kuala Lumpur, Malaysia*

²*Asia-Europe Institute, University of Malaya, Malaysia*

³*Faculty of Business and Economics, University of Malaya, Malaysia*

**Corresponding author: Suteng Lee.*

Abstract

This qualitative study explores the practical entrepreneurial experiences, operational issues, and adaptive behaviors of Chinese small and medium enterprises (SMEs) in Semporna, Malaysia. Drawing from field investigations and one-to-one interviews of local Chinese tourism practitioners, this paper examines the development of cross-border tourism ventures in terms of the influences of institutional regulations, market fluctuations and cross-cultural disparities. The empirical findings point to three main constraints faced by immigrant entrepreneurs: restrictive financial entry policies and continuous cash flow pressure, intensive market competition and seasonal tourism volatility, and cultural integration barriers due to language barriers and different religious and social practices. In response to these multidimensional challenges, Chinese entrepreneurs have adopted context-specific adaptive strategies, including value chain-oriented portfolio investment, reliance on ethnic business associations and transnational social ties, local talent recruitment, digital tourism promotion, and proactive community engagement. This study extends the literature by comparing entrepreneurial ecosystems in China and Malaysia, and clarifies how institutional and contextual differences shape firms' strategic judgments and operational outcomes. It contributes to the mixed embeddedness framework by further detailing the role of digital-based transnational social resources in supporting migrant business development in peripheral tourism destinations. In practice, this study offers targeted operational guidance for Chinese SMEs to expand into Southeast Asia and provides practical references for local tourism governance and cross-border economic cooperation.

Keywords

Chinese small and medium-sized enterprises, Chinese entrepreneurs, expatriate performance, Semporna, Malaysia, entrepreneurial success and failure

1. Introduction

This study aims to explore the entrepreneurial environment of Chinese small and medium entrepreneurs in the district of Semporna, Malaysia. This paper adopts a qualitative approach to examine the entrepreneurial environment, social support, organizational network, operational flexibility and entrepreneurial performance

of Chinese entrepreneurs in Malaysia thru their venture creation process. The study utilizes semi-structured interviews and fieldwork data collected from multiple entrepreneurs.

The empirical results show that the nascent Chinese entrepreneurs encounter three main challenges in the early stage of entrepreneurship, namely capital constraints, barriers to market entry, and difficulties in cultural adaptation. As entrepreneurs' ventures grow they create a series of targeted strategies that help them realize business goals. To systematically manage operational risks, many Chinese entrepreneurs resort to formal local organizations, including national and provincial Chinese chambers of commerce, when starting businesses in Malaysia. Such institutional support allows entrepreneurs to adapt to the local Malaysian culture, develop inter-entrepreneur networks, build local social ties and gain access to the market, all of which contribute to entrepreneurial success.

The external environment for Chinese entrepreneurs in overseas ventures is multi-layered. It is important to consider engagement with local political institutions and political parties, evaluation of regional economic development, interpretation of local social contexts, technological progress, cultural discrepancies and diverse religious norms and customs, as well as adaptation to local educational norms and work practices. In addition, entrepreneurs have to deal with region-specific industrial policies. Successfully responding to these contextual factors is the key to creating a supportive business ecosystem and achieving sustainable entrepreneurial outcomes.

The study also shows significant differences between the entrepreneurial ecosystems in China and the local institutional environments in Malaysia. Such cross-border environmental differences are expected to affect the strategic decisions of entrepreneurs and the subsequent performance of the venture. To summarize, Chinese small and medium-sized enterprises (SMEs) in Semporna are facing a mixed bag of challenges and opportunities. Language barriers, cultural differences, diverse legal systems and intense local market competition pose critical threats to entrepreneurial success.

Chinese entrepreneurs can tap into the strong China-Malaysia diplomatic relations, local policy incentives, a favorable geographical location, improving business infrastructure and accessible talent pools against the backdrop of China's Belt and Road Initiative. These comparative advantages enable entrepreneurs to capitalize on emerging commercial opportunities and achieve entrepreneurial success. Qualitative inquiry enables this research to give in-depth understanding of the intertwined challenges and opportunities to Chinese SMEs in Semporna. The findings offer practical coping methods and operational guidance for Chinese SMEs to conduct entrepreneurial activities in Malaysia.

2. Review of Literature

2.1 Entrepreneurship of Migrant and Ethnic Groups

Ethnic entrepreneurship literature has shown that business ownership is a common strategy for economic mobility for immigrants, especially when labour-market opportunities are not available or appealing [1, 2, 3]. Explanations have shifted gradually from cultural traits to opportunity structures, that is, market conditions, institutional rules, and competitive environments that determine what ventures are feasible [4, 5, 6]. Synthesizing these developments [7] argued that ethnic entrepreneurship should be understood in terms of the interaction of group characteristics, social structures and context. A related literature interprets ethnic enterprise in terms of resource mobilization. Entrepreneurs rely on family labor, co-ethnic finance and community networks to compensate for their lack of access to mainstream institutions [8, 9, 10, 11].

2.2 The Mixed Embeddedness

The mixed embeddedness framework [12, 13] argues that migrant entrepreneurs are embedded at the same time in social networks and in the politico-institutional structures of the host economy, such as regulations on market entry, licensing, immigration status, and ownership. Most importantly, opportunity structures are shaped not only by social networks but also by institutional constraints: rules about who can invest, how much capital must be deposited, and how much ownership shares foreigners can hold directly condition migrant venture creation. This insight is important for the current study, because the rules in Malaysia – such as the capital-deposit requirement attached to investor entry and majority local-ownership requirements for foreign

small firms – are the institutional side of mixed embeddedness, within which Chinese entrepreneurs in Semporna have to operate.

2.3 Social Capital, Guanxi and Networking

Social capital, the resources that can be accessed thru network ties, is a central concept in entrepreneurship research [14, 15, 16]. Social networks provide new entrepreneurs with information, finance, legitimacy and emotional support [17, 18]. Guanxi, understood as reciprocal obligation and trust-based interpersonal relationships, has long been recognized as a structuring principle of economic exchange in Chinese business contexts [19, 20, 21]. Network ties between home and host countries provide access to investment information, partnerships and markets for both overseas Chinese and new Chinese immigrants [22, 23, 24]. Chambers of commerce and business associations institutionalize these ties, transforming interpersonal trust into organizational infrastructure for market entry [25].

2.4 Entrepreneurship Beyond Borders

Transnational entrepreneurs migrate and keep economic and social linkages in origin and destination countries, and their ventures benefit from this dual embeddedness [26, 27, 28]. [29] argue that the best way to understand transnational entrepreneurship is from a network perspective, whereby ventures mobilize resources across borders. [30] reveal that the internationalization strategies of transnational entrepreneurs vary according to their practice-based ties. The Chinese entrepreneurs studied here are typical of this type; their ventures are physically located in Malaysia, but their customer acquisition, marketing channels, supplier relationships and reference frames remain substantially anchored in China. This is similar to the “circulatory” patterns noted among new Chinese migrants [31, 32]. These ventures also illustrate the institutional perspective of international entrepreneurship, that is, how entrepreneurial behavior across borders is jointly shaped by home- and host-country institutions [33].

2.5 Chinese Business in Southeast Asia and Malaysia

The Chinese business in Southeast Asia has been widely studied, with debates ranging from cultural explanations [19] to institutional and political-economic explanations [34, 35, 21]. The ethnic Chinese in Malaysia have traditionally been dominant in commerce within an institutional framework that has been shaped by policies favoring the Bumiputera majority [34, 36]. This established diaspora is different from the phenomenon of PRC nationals establishing SMEs in Malaysian tourism examined in this paper, where the entrepreneurs are first generation migrants and their primary networks, sources of capital and customer bases are in China [31, 37, 38]. The Belt and Road era has enhanced China-Malaysia economic ties, improving the macro-level climate for such ventures [39, 40], but has left micro-level entry barriers—visa capital thresholds, ownership rules, credit access—unchanged.

2.6 Crisis, COVID-19 and Tourism SMEs

Small tourism firms are structurally vulnerable to external shocks: they operate with thin capitalization, high fixed costs, and demand that disappears when travel is restricted [41]. The shock of this kind was never experienced before, until the COVID-19 pandemic. In Malaysia, the MCO was a long period of border closure and restriction of tourism, which had serious consequences for the sector [42]. Research on entrepreneurship in the pandemic showed that venture survival was associated with financial reserves, adaptability and network support [43, 44]. This literature sets the context for understanding why some Chinese businesses in Semporna exited during the pandemic, while others survived.

3. Method

3.1 Design of Research

Given the exploratory nature of the research questions and the absence of previous systematic documentation of Chinese entrepreneurship in Semporna, a qualitative single-case study design with embedded units of analysis (individual ventures) [45, 46] was adopted. Qualitative methods are appropriate

where the goal is to understand the experiences, meanings and strategies of actors in context [47, 48] and case study logic lends itself to theory building from rich, contextualized evidence [49].

3.2 Participants and Design

The case is set in the Semporna district of Sabah, Malaysia, an internationally known island tourism and diving destination. The participants were Chinese nationals who had founded or co-founded SMEs in Semporna in tourism-related sectors (catering, hotels and hostels, cruise and boat services, island-tour customization). Participants were recruited using purposive and snowball sampling, initiated thru local business associations and chambers of commerce [50]. [Author's note: please insert the final number of interviewees, their distribution by sector and the fieldwork period, e.g. "Between March 2022 and December 2023 twelve entrepreneurs were interviewed."] Sampling continued until near thematic saturation was reached, a recommended criterion for interview sufficiency in qualitative research [51].

3.3 Data Collection

Data collection was thru semi-structured interviews and field observation. Interviews covered entrepreneurs' decisions to start up, financing, ownership structures, market conditions, competition, relationships with local institutions and communities, cultural adaptation and the impact of the COVID-19 pandemic. Interviews were conducted in Mandarin, lasting approximately [60–90] minutes, and were audio-recorded and transcribed verbatim (with participants' consent). Field observation during site visits to participants' premises (restaurants, hostels, jetties and tour operations) provided contextual and triangulating evidence [45].

3.4 Data Analyzes

Interview transcripts and field notes were analyzed using thematic analysis [52] employing a hybrid inductive-deductive procedure. An initial coding frame was developed based on the literature (financial, market, and institutional constraints; network and cultural-adaptation strategies) and refined thru open coding of the transcripts. Codes were grouped into the themes presented in Section 4. This analysis was supported by qualitative data management procedures recommended by [53]. The data structure was organized based on established practices to demonstrate qualitative rigor [54].

3.5 Credibility and ETHICS

The trustworthiness of the study was established using the criteria of credibility, transferability, dependability, and confirmability [55] by triangulation of data across interviews and observation, thick description of setting, member audit, and peer debriefing by the author team. The purpose of the study was explained to the participants who took part voluntarily and are reported anonymously; all identifying details have been omitted.

4. Results

4.1 The Entrepreneurial Model: Investment Cascade in the Tourism Value Chain

Chinese entrepreneurship in Semporna is focused on tourism-related sectors – catering, hotels and budget hostels, cruise and boat operations, diving and customized island tours, reflecting the district's identity as one of Malaysia's premier island destinations. We found a noticeable pattern among the interviewed entrepreneurs, which we refer to as cascade investment: instead of running a single business, they invested into complementary links of the tourism value chain (food, accommodation, transport and tour services) aiming to offer visitors an integrated, customized experience and capturing spending at multiple points. This is consistent with the patterns of network-based opportunity exploitation described in the ethnic entrepreneurship literature [8] and the practice-based internationalization strategies of transnational entrepreneurs [30].

The entrepreneurial community in Semporna is still loosely organized. Unlike established Chinese business communities in other parts of Southeast Asia [25], the district does not have a strong, comprehensive chamber of commerce and aggregate information on Chinese investment in the area is correspondingly fragmentary. Therefore, entrepreneurs made extensive use of personal networks, such as co-national contacts, provincial

associations and ad hoc business circles, as sources of information and partnerships, confirming the relevance of informal social capital where formal associational infrastructure is weak [56, 17].

“The COVID-19 period was a selection event. During Malaysia’s Movement Control Order, tourism inflows fell off a cliff [42] and some of the Chinese ventures, especially those that had limited business scopes and high daily operating and maintenance costs, failed and exited the market. The surviving ventures were those that had relatively strong financial capital and therefore could survive over two years of little revenue. This pattern is consistent with pandemic research that finds slack resources and adaptability distinguish survivors from exits among small firms [43, 44]. As travel resumes, survivors have also positioned themselves to benefit from the rebound of Chinese outbound tourism, cooperating with major Chinese online travel and content platforms like Ctrip, Tuniu, Mafengwo and Douyin (TikTok) to achieve targeted marketing to Chinese tourists, whose rising incomes and changing preferences toward international island vacations represent a massive demand base.

4.2 Economic Problems

The most frequently cited and fundamental barrier that Chinese SMEs encountered in Semporna when starting operations was access to capital. Local financing difficulties are shaped by three layered institutional and operational constraints that together determine the financial vulnerability of foreign entrepreneurial entrants. First, the strict regulatory regime for entry of investors in Malaysia requires a high level of capital for foreign entrepreneurs. Under existing immigration and investment policies, foreign investors need to open local bank accounts and deposit a minimum of RM 1 million to qualify for investment visa approval. Some residence schemes, such as the Malaysia My Second Home (MM2H) program, raise the threshold to RM 2 million in fixed deposits. The official purpose of these mandatory capital requirements is to check investor solvency and to reduce speculative risks. However, these create considerable liquidity pressure for resource-constrained start-ups. To compound the problem, the full institutional approval process usually takes two to six months of administrative review. This long clearance period leads to long standing cash-flow pressure to new firms with no formal sources of income, which severely limits the operational stability and growth of firms during the early stages.

Second, strict local equity ownership requirements are a major structural barrier for Chinese entrepreneurs. Malaysian policy requires that for most service and tourism sectors, host country citizens should have a minimum 50-51% majority shareholding in foreign invested SMEs. Field interviews confirm that one of the most intractable entry barriers for new Chinese ventures is finding credible, stable and trustworthy local partners. Many entrepreneurs are in a state of operational uncertainty and frustration, because it is difficult to find reliable local co-owners, even if they have enough initial capital investment and resource preparation.

Third, foreign SMEs are systemically disadvantaged in terms of access to formal bank finance. The rules governing domestic banks in Malaysia are designed to safeguard local businesses and job security for citizens, which leads to strict lending rules for foreign companies. Chinese entrepreneurs also face long and complex procedures and high rejection rates when applying for bank loans, which further restricts access to formal financial channels. Hence, early-stage Chinese ventures depend heavily on informal private investment and ethnic network financing, which in turn requires entrepreneurs to prove credible investment qualifications and stable operational potential within transnational social networks to secure external funding.

These conditions are an example of the politico-institutional side of mixed embeddedness [13]. Opportunity structures are defined as much by regulation as by markets. Entrepreneurs relied on two main channels to cope: to mobilize capital from co-national networks and private investors—which involved demonstrating credibility within those networks [8, 57]—and to structure ventures with trusted Malaysian partners to satisfy ownership rules. Undercapitalized entrants were especially susceptible to the chronic cash-flow pressure of the start-up phase, heightened by lengthy institutional approval delays, a structural fragility brutally exposed during the extended pandemic lockdowns.

4.3 Challenges in the Market

The small-town economy of Semporna, with a tourism orientation, presents unique and multi-layered market challenges for incoming Chinese SMEs. First, demographic and linguistic segmentation limits local market penetration. The overwhelming majority of the local population in Semporna is of Malay and

Indonesian maritime ethnic origin and the Malay language is the main language of daily commerce. Such linguistic and cultural differences create serious operational challenges for Chinese companies trying to serve domestic local consumers, and so most Chinese tourism ventures have to focus their service systems primarily on international tourists, particularly outbound travelers from China.

Second, homogeneous industrial structures lead to more intense competition in the multi-source market. Since the town's economic development is highly dependent on tourism, the local business layouts of catering, accommodation, marine tourism and recreational services are highly convergent. Chinese entrepreneurs are squeezed between long-established local operators and other foreign investors and new Chinese ventures. One of the most persistent operational challenges, interviewees said over and over, is differentiating service positioning, brand characteristics and customer value propositions. In an effort to sustain their competitive advantage, [58] suggest that firms are required to systematically monitor the market, analyze the strategies of competitors, identify their unique service advantages and develop targeted branding and specialized marketing channels.

Third, immature industrial governance causes serious market seasonality and price volatility. There is no standardized industrial supervision and unified pricing mechanism for Semporna's tourism industry. The significant fluctuations between peak and off-season market demand allow individual merchants to engage in opportunistic pricing behavior, which damages the overall quality of service, the destination's collective market reputation and the local business ecosystem. Beyond market competition, entrepreneurs must also guaranty that all marketing and operational practices are in full compliance with local government regulations, legal structures, and cultural conventions. Any breach of local institutional norms could harm the credibility of individual firms and the collective brand image of Chinese business communities.

Faced with such constraints on the market, the successful Chinese entrepreneurs locally focus on complete market adaptation strategies, including: precise product and service optimization, building stakeholder relationships with local suppliers and customers, standardized cost control, improved operational efficiency, and continuous service quality optimization. This hybrid approach of market differentiation and institutional compliance suits the competitive logic of differentiation under institutional constraint [59].

4.4 Problems of Cultural Adjustment

Entrepreneurs have to cope with language, religious, customary and value differences that have a direct impact on business decisions, communication with interested parties, and daily social interaction [60, 61]. Semporna is a multi-ethnic region in Malaysia which is Islam-dominant where the religious norms, local customs and social values are significantly different from Chinese cultural traditions. A basic requirement for Chinese ventures to successfully integrate locally is therefore a structured knowledge of local religious taboos, community conventions and social operational logic, combined with a functional command of the Malay language.

Three common cultural adaptation practices adopted by the local Chinese entrepreneurs were identified in the field research. First, strategic local employment is a primary mechanism of cross-cultural adaptation. By hiring local staff, firms can ease government liaison, daily business negotiations and market expansion, while effectively overcoming language barriers and cultural misunderstandings. Entrepreneurs consider cultural learning to be a continuous and long-term process, rather than a one-time adaptation task. It involves the constant observation and understanding of local social characteristics and community norms.

Second, entrepreneurs develop cross-cultural embeddedness thru their involvement in industrial associations and community networking. Active participation in local chambers of commerce and industry groups helps Chinese firms build stable networks with local business groups, get contextualized economic information and mitigate cross-cultural operational risks. Some interviewed entrepreneurs mentioned that they created informal "cultural adaptation teams," made up of local Malaysian employees and Chinese managerial members, to provide real-time cultural interpretation, local market analysis, and targeted business consulting for the operations of the venture.

Thirdly, firms achieve bridging of organizational and technological thru hybrid management practices. Many Chinese SMEs transfer mature domestic corporate culture and institutional routines such as weekly operational meetings, monthly performance reporting and organizational cultural activities to strengthen

internal team cohesion and stabilize overseas organizational atmosphere. Entrepreneurs also use Chinese digital management ecosystems, including DingTalk, Tencent platforms and WeChat, for remote team coordination, staff training and systematic performance evaluation, achieving notable success in cross-cultural communication efficiency. In the external dimension, social media and online tourism platforms are employed to enlarge transnational social networks, strengthen local market influence, and boost industrial competitiveness.

Respondents' accounts suggest that successful cultural adaptation requires consistent resource allocation, long-term cultural learning, and proactive community integration. "Only thru continuous cultural integration, institutional compliance and relational building can transnational tourism ventures solve cross-cultural frictions and achieve stable local development" (p. 10).

4.5 Success Approach

Across cases, successful entrepreneurs combined five strategies: (1) anchoring in co-ethnic and associational networks—national or provincial chambers of commerce and business federations (including the Malaysia–China entrepreneurs' associations)—to overcome entry obstacles, integrate into Malaysian commercial culture, and expand market reach [25, 20]; (2) cultivating local relationships through employment of local staff, community engagement, and partnership with Malaysian co-owners [13]; (3) exploiting China's digital ecosystem—online travel platforms and short-video/social-media marketing—for precise, low-cost customer acquisition targeting Chinese tourists, an approach analogous to the new-media-driven destination marketing observed in recent Chinese domestic tourism phenomena; (4) cascade investment across the tourism value chain to diversify revenue and raise the switching value of their service bundles; and (5) environmental stewardship—reminding tourists to protect the marine environment, avoid disturbing marine life, and manage waste responsibly—both as an ethical commitment and as protection of the natural asset on which Semporna's tourism value depends. Entrepreneurs also highlighted the need for constructive engagement with the municipal authorities to minimize barriers to commerce and the need for maintaining service integrity to avoid damaging the collective reputation of the destination.

5. Discussion

5.1 Discussion

The results corroborate and further develop the mixed embeddedness framework. Chinese entrepreneurs in Semporna are embedded at once in co-national social networks—provincial associations, chambers, digital platforms—and in the Malaysian politico-institutional structure of visa capital thresholds, ownership rules, and credit regulation [12, 13]. Importantly, the "ethnic resources" these entrepreneurs rely on differ from those in classic ethnic-enclave accounts [1, 3]: they emerge predominantly in the home country rather than in a settled host-country diaspora, and they are transmitted thru digital platforms and transnational associations rather than spatially concentrated communities. Such a configuration is characteristic of transnational entrepreneurship [26, 29] and indicates that transnational, digitally mediated social capital can replace – at least partly – the local co-ethnic infrastructure assumed by earlier models [22, 24].

Pandemic evidence speaks to debates about crisis and small-firm resilience. Survival in Semporna was more about financial depth and network strength than formal planning. These findings resonate with findings that resource slack and adaptive capacity influence small-firm survival in the face of systemic shocks [43, 44] and that tourism SMEs are particularly vulnerable to demand-side shocks [41, 42]. The cascade investment pattern adds a contextual nuance to internationalization theory. While the Uppsala model highlights incremental commitment with increasing market knowledge [62, 63], and international new venture theory highlights early cross-border integration of resources [64, 65], Semporna's Chinese entrepreneurs commit across a local value chain rapidly but in small increments, hedging demand risk within a single destination, a micro-level diversification logic closer to portfolio entrepreneurship than to classic stage models.

Finally, the findings highlight the dual orientation of these ventures: institutionally and legally Malaysian, but commercially and digitally oriented toward Chinese demand. This duality comes with both opportunity – privileged access to the world's largest outbound tourism source market – and fragility, as dependence on a single demand origin was shown during China's prolonged border closures. Diversifying demand sources and

deepening local embeddedness are strategic priorities in line with contextualized accounts of entrepreneurship [66, 59].

5.2 Implication

The study suggests that Chinese entrepreneurs and SMEs targeting Malaysia should secure capitalization well above visa-deposit minima; invest early in trustworthy local partnerships to satisfy ownership rules; join chambers of commerce and entrepreneurs' associations; hire and empower local staff; adapt management practices to local norms; and combine China's digital marketing ecosystem with compliance with local regulations and respect for local culture and religion. The findings suggest to Malaysian policymakers and local authorities that transparent, streamlined approval procedures and accessible information for small foreign investors might capture more of the investment and employment these ventures generate, whilst destination-level governance of pricing and environmental practice would protect the collective tourism asset. Weakness of formal organization in peripheral districts like Semporna represents an opportunity for business associations to provide information, collective representation and liaison services.

5.3 Limitations and Future Research

The study is a qualitative case study of a single district using a purposive sample. Findings are analytically generalizable, not statistically generalizable [45, 55]. Interviews were conducted in Mandarin and translated/analyzed by the authors, which may have interpretation effects. Reliance on entrepreneur self-reports may understate failures, due to survivorship bias in who remained available to interview. Future research should: (1) compare Semporna with other Malaysian destinations (e.g., Kota Kinabalu, Langkawi, Kuala Lumpur) to test the transferability of the cascade-investment and network patterns; (2) include the perspectives of local partners, employees, and authorities to triangulate the institutional account; (3) undertake longitudinal work following ventures thru the post-pandemic recovery; and (4) explore quantitatively how transnational digital platforms mediate the relationship between network embeddedness and venture performance.

6. Conclusion

Chinese migrant entrepreneurs in Semporna establish enterprises at the juncture of Chinese transnational networks and Malaysian institutional structures. They encounter significant financial, market and cultural challenges – capital-deposit and ownership rules, limited credit, a small and seasonally volatile tourism market and exacting cultural adaptation – but employ unique strategies in response: cascade investment along the tourism value chain, chamber-of-commerce anchoring, local partnership and employment, digital-ecosystem marketing and environmental responsibility. The COVID-19 pandemic revealed the logic of selection in this environment, rewarding capitalization and depth of networks. Theoretically, the case extends mixed embeddedness and social capital perspectives to a digitally mediated, transnationally-oriented migrant entrepreneurship population. Practically, it provides grounded guidance for Chinese SMEs internationalizing into Southeast Asia. With the continuing deepening of China-Malaysia economic ties in the Belt and Road framework, such micro-level entrepreneurial linkages will continue to be an important, and under-researched, part of the bilateral relationship.

References

- [1] Light, I. H., & Bonacich, E. (1988). *Immigrant entrepreneurs: Koreans in Los Angeles, 1965–1982*. University of California Press.
- [2] Aldrich, H. E., & Waldinger, R. (1990). Ethnicity and entrepreneurship. *Annual Review of Sociology*, 16, 111–135. <https://doi.org/10.1146/annurev.so.16.080190.000551>
- [3] Portes, A., & Zhou, M. (1992). Gaining the upper hand: Economic mobility among immigrant and domestic minorities. *Ethnic and Racial Studies*, 15(4), 491–522. <https://doi.org/10.1080/01419870.1992.9993761>

- [4] Waldinger, R., Aldrich, H., & Ward, R. (1990). *Ethnic entrepreneurs: Immigrant business in industrial societies*. Sage.
- [5] Rath, J. (Ed.). (2000). *Immigrant businesses: The economic, political and social environment*. Macmillan.
- [6] Ram, M., & Jones, T. (2008). Ethnic-minority businesses in the UK: A review of research and policy developments. *Environment and Planning C: Government and Policy*, 26(2), 352–374. <https://doi.org/10.1068/c0722>
- [7] Zhou, M. (2004). Revisiting ethnic entrepreneurship: Convergencies, controversies, and conceptual advancements. *International Migration Review*, 38(3), 1040–1074. <https://doi.org/10.1111/j.1747-7379.2004.tb00228.x>
- [8] Aldrich, H., & Zimmer, C. (1986). Entrepreneurship through social networks. In D. L. Sexton & R. W. Smilor (Eds.), *The art and science of entrepreneurship* (pp. 3–23). Ballinger.
- [9] Light, I. H., & Gold, S. J. (2000). *Ethnic economies*. Academic Press.
- [10] Volery, T. (2007). Ethnic entrepreneurship: A theoretical framework. In L.-P. Dana (Ed.), *Handbook of research on ethnic minority entrepreneurship* (pp. 30–41). Edward Elgar.
- [11] Dana, L.-P. (Ed.). (2007). *Handbook of research on ethnic minority entrepreneurship: A co-evolutionary view on resource management*. Edward Elgar.
- [12] Kloosterman, R., Van der Leun, J., & Rath, J. (1999). Mixed embeddedness: (In)formal economic activities and immigrant businesses in the Netherlands. *International Journal of Urban and Regional Research*, 23(2), 252–266. <https://doi.org/10.1111/1468-2427.00194>
- [13] Kloosterman, R., & Rath, J. (2001). Immigrant entrepreneurs in advanced economies: Mixed embeddedness further explored. *Journal of Ethnic and Migration Studies*, 27(2), 189–201. <https://doi.org/10.1080/13691830020041561>
- [14] Coleman, J. S. (1988). Social capital in the creation of human capital. *American Journal of Sociology*, 94(Supplement), S95–S120.
- [15] Burt, R. S. (1992). *Structural holes: The social structure of competition*. Harvard University Press.
- [16] Adler, P. S., & Kwon, S.-W. (2002). Social capital: Prospects for a new concept. *Academy of Management Review*, 27(1), 17–40. 10.5465/amr.2002.5922314
- [17] Davidsson, P., & Honig, B. (2003). The role of social and human capital among nascent entrepreneurs. *Journal of Business Venturing*, 18(3), 301–331. [https://doi.org/10.1016/S0883-9026\(02\)00097-6](https://doi.org/10.1016/S0883-9026(02)00097-6)
- [18] Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review*, 23(2), 242–266. <https://doi.org/10.2307/259373>
- [19] Redding, S. G. (1990). *The spirit of Chinese capitalism*. Walter de Gruyter.
- [20] Tong, C. K., & Yong, P. K. (1998). Guanxi bases, xinyong and Chinese business networks. *The British Journal of Sociology*, 49(1), 75–96. <https://doi.org/10.2307/591262>
- [21] Hamilton, G. G. (2006). *Commerce and capitalism in Chinese societies*. Routledge.
- [22] Lever-Tracy, C., Ip, D., & Tracy, N. (1996). *The Chinese diaspora and mainland China: An emerging economic synergy*. Macmillan.
- [23] Yeung, H. W.-c., & Olds, K. (Eds.). (2000). *Globalization of Chinese business firms*. Macmillan.
- [24] Ma, L. J. C., & Cartier, C. (Eds.). (2003). *The Chinese diaspora: Space, place, mobility, and identity*. Rowman & Littlefield.
- [25] Menkhoff, T., & Gerke, S. (Eds.). (2002). *Chinese entrepreneurship and Asian business networks*. RoutledgeCurzon.

- [26] Drori, I., Honig, B., & Wright, M. (2009). Transnational entrepreneurship: An emergent field of study. *Entrepreneurship Theory and Practice*, 33(5), 1001–1022. <https://doi.org/10.1111/j.1540-6520.2009.00332.x>
- [27] Patel, P. C., & Conklin, B. (2009). The balancing act: The role of transnational habitus and social networks in balancing transnational entrepreneurial activities. *Entrepreneurship Theory and Practice*, 33(5), 1045–1078. <https://doi.org/10.1111/j.1540-6520.2009.00334.x>
- [28] Sequeira, J. M., Carr, J. C., & Rasheed, A. A. (2009). Transnational entrepreneurship: Determinants of firm type and owner attributions of success. *Entrepreneurship Theory and Practice*, 33(5), 1023–1044. <https://doi.org/10.1111/j.1540-6520.2009.00333.x>
- [29] Chen, W., & Tan, J. (2009). Understanding transnational entrepreneurship through a network lens: Theoretical and methodological considerations. *Entrepreneurship Theory and Practice*, 33(5), 1079–1091. <https://doi.org/10.1111/j.1540-6520.2009.00335.x>
- [30] Terjesen, S., & Elam, A. (2009). Transnational entrepreneurs' venture internationalization strategies: A practice theory approach. *Entrepreneurship Theory and Practice*, 33(5), 1093–1120. <https://doi.org/10.1111/j.1540-6520.2009.00336.x>
- [31] Liu, H. (2005). New migrants and the revival of overseas Chinese nationalism. *Journal of Contemporary China*, 14(43), 291–316. <https://doi.org/10.1080/10670560500065611>
- [32] Wang, G. (1991). *China and the Chinese overseas*. Times Academic Press.
- [33] Yeung, H. W.-c. (2002). Entrepreneurship in international business: An institutional perspective. *Asia Pacific Journal of Management*, 19(1), 29–61. <https://doi.org/10.1023/A:1014897920821>
- [34] Jesudason, J. V. (1989). *Ethnicity and the economy: The state, Chinese business, and multinationals in Malaysia*. Oxford University Press.
- [35] Gomez, E. T., & Hsiao, H.-H. M. (Eds.). (2001). *Chinese business in South-East Asia: Contesting cultural explanations, researching entrepreneurship*. Curzon.
- [36] Gomez, E. T. (1999). *Chinese business in Malaysia: Accumulation, ascendance, accommodation*. Curzon.
- [37] Pan, L. (Ed.). (1999). *The encyclopedia of the Chinese overseas*. Harvard University Press.
- [38] Suryadinata, L. (Ed.). (1997). *Ethnic Chinese as Southeast Asians*. Institute of Southeast Asian Studies.
- [39] Liu, W., & Dunford, M. (2016). Inclusive globalization: Unpacking China's Belt and Road Initiative. *Area Development and Policy*, 1(3), 323–340. <https://doi.org/10.1080/23792949.2016.1232598>
- [40] Liu, H., & Lim, G. (2019). The political economy of a rising China in Southeast Asia: Malaysia's response to the Belt and Road Initiative. *Journal of Contemporary China*, 28(116), 216–231. <https://doi.org/10.1080/10670564.2018.1511393>
- [41] Gössling, S., Scott, D., & Hall, C. M. (2021). Pandemics, tourism and global change: A rapid assessment of COVID-19. *Journal of Sustainable Tourism*, 29(1), 1–20. <https://doi.org/10.1080/09669582.2020.1758708>
- [42] Foo, L.-P., Chin, M.-Y., Tan, K.-L., & Phuah, K.-T. (2021). The impact of COVID-19 on tourism industry in Malaysia. *Current Issues in Tourism*, 24(19), 2735–2739. <https://doi.org/10.1080/13683500.2020.1777951>
- [43] Kuckertz, A., Brändle, L., Gaudig, A., Hinderer, S., Reyes, C. A. M., Prochotta, A., Steinbrink, K. M., & Berger, E. S. C. (2020). Startups in times of crisis: A rapid response to the COVID-19 pandemic. *Journal of Business Venturing Insights*, 13, e00169. <https://doi.org/10.1016/j.jbvi.2020.e00169>
- [44] Ratten, V. (2020). Coronavirus (COVID-19) and entrepreneurship: Changing life and work landscape. *Journal of Small Business & Entrepreneurship*, 32(5), 503–516. <https://doi.org/10.1080/08276331.2020.1790167>
- [45] Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). Sage.

- [46] Stake, R. E. (1995). *The art of case study research*. Sage.
- [47] Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). Sage.
- [48] Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research: A guide to design and implementation* (4th ed.). Jossey-Bass.
- [49] Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of Management Review*, 14(4), 532–550. 10.5465/amr.1989.4308385
- [50] Patton, M. Q. (2015). *Qualitative research and evaluation methods: Integrating theory and practice* (4th ed.). Sage.
- [51] Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods*, 18(1), 59–82. <https://doi.org/10.1177/1525822X05279903>
- [52] Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- [53] Miles, M. B., Huberman, A. M., & Saldaña, J. (2020). *Qualitative data analysis: A methods sourcebook* (4th ed.). Sage.
- [54] Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking qualitative rigor in inductive research: Notes on the Gioia methodology. *Organizational Research Methods*, 16(1), 15–31. <https://doi.org/10.1177/1094428112452151>
- [55] Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage.
- [56] Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. *American Journal of Sociology*, 91(3), 481–510. <https://doi.org/10.1086/228311>
- [57] Portes, A., & Sensenbrenner, J. (1993). Embeddedness and immigration: Notes on the social determinants of economic action. *American Journal of Sociology*, 98(6), 1320–1350. <https://doi.org/10.1086/230191>
- [58] Shane, S., & Venkataraman, S. (2000). The promise of entrepreneurship as a field of research. *Academy of Management Review*, 25(1), 217–226. 10.5465/amr.2000.2791611
- [59] Bruton, G. D., Ahlstrom, D., & Li, H.-L. (2010). Institutional theory and entrepreneurship: Where are we now and where do we need to move in the future? *Entrepreneurship Theory and Practice*, 34(3), 421–440. <https://doi.org/10.1111/j.1540-6520.2010.00390.x>
- [60] Hofstede, G. (2001). *Culture's consequences: Comparing values, behaviors, institutions and organizations across nations* (2nd ed.). Sage.
- [61] Ward, C., Bochner, S., & Furnham, A. (2001). *The psychology of culture shock* (2nd ed.). Routledge.
- [62] Johanson, J., & Vahlne, J.-E. (1977). The internationalization process of the firm: A model of knowledge development and increasing foreign market commitments. *Journal of International Business Studies*, 8(1), 23–32. <https://doi.org/10.1057/palgrave.jibs.8490676>
- [63] Johanson, J., & Vahlne, J.-E. (2009). The Uppsala internationalization process model revisited: From liability of foreignness to liability of outsidership. *Journal of International Business Studies*, 40(9), 1411–1431. <https://doi.org/10.1057/jibs.2009.24>
- [64] Oviatt, B. M., & McDougall, P. P. (1994). Toward a theory of international new ventures. *Journal of International Business Studies*, 25(1), 45–64. <https://doi.org/10.1057/palgrave.jibs.8490193>
- [65] McDougall, P. P., Shane, S., & Oviatt, B. M. (1994). Explaining the formation of international new ventures: The limits of theories from international business research. *Journal of Business Venturing*, 9(6), 469–487. [https://doi.org/10.1016/0883-9026\(94\)90017-5](https://doi.org/10.1016/0883-9026(94)90017-5)
- [66] Welter, F. (2011). Contextualizing entrepreneurship: Conceptual challenges and ways forward. *Entrepreneurship Theory and Practice*, 35(1), 165–184. <https://doi.org/10.1111/j.1540-6520.2010.00427.x>

- [67] Buckley, P. J., Clegg, L. J., Cross, A. R., Liu, X., Voss, H., & Zheng, P. (2007). The determinants of Chinese outward foreign direct investment. *Journal of International Business Studies*, 38(4), 499–518. <https://doi.org/10.1057/palgrave.jibs.8400277>
- [68] Chen Kai Hui. Sarawak Chinese family business inheritance [D]. Huaqiao University, 2022.
- [69] Child, J., & Rodrigues, S. B. (2005). The internationalization of Chinese firms: A case for theoretical extension? *Management and Organization Review*, 1(3), 381–410. <https://doi.org/10.1111/j.1740-8784.2005.0020a.x>
- [70] Deng, P. (2012). The internationalization of Chinese firms: A critical review and future research. *International Journal of Management Reviews*, 14(4), 408–427. <https://doi.org/10.1111/j.1468-2370.2011.00323.x>
- [71] He, Y. J. (2018). The enlightenment of college entrepreneurship education in ASEAN countries to China [Master's thesis]. Southeast University.
- [72] Luo, Y., & Tung, R. L. (2007). International expansion of emerging market enterprises: A springboard perspective. *Journal of International Business Studies*, 38(4), 481–498. <https://doi.org/10.1057/palgrave.jibs.8400275>
- [73] Mathews, J. A. (2006). Dragon multinationals: New players in 21st century globalization. *Asia Pacific Journal of Management*, 23(1), 5–27. <https://doi.org/10.1007/s10490-006-6113-0>

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

An Analysis of the Effects of Trade Policy Uncertainty on Corporate Green Investment: The Viewpoints of Market Competition and Green Innovation

Yixin Chen*

School of Economics and Management, Beijing Forestry University, Beijing, 100083, China

**Corresponding author: Yixin Chen.*

Abstract

Trade policy uncertainty is changing the logic of decision making of corporate operations in the context of the constant reconfiguration of the global trading system. In this paper, Chinese A-share listed companies over the period of 2017-2024 are chosen as the research sample to analyze the impact of trade policy uncertainty on corporations' green investment and the transmission mechanisms behind it. The results show that trade policy uncertainty has a strong positive driving impact on corporate green investment, and the result is unchanged even after a sequence of robustness tests. The mechanism analysis shows that trade policy uncertainty can affect corporate green investment in two ways, which are based on the level of market competition and green innovation. The heterogeneity tests indicate that this effect is especially strong in the case of polluting companies, companies in the east, and companies in high-tech sectors. The current study will add a new twist to the study of corporate sustainable development, considering the macro-policy-making environment and offer recommendations to the companies to develop green transformation strategies in the face of uncertainty.

Keywords

trade policy uncertainty, green investment, degree of market competition, green innovation

1. Introduction

In recent years, the world economy has experienced significant changes, and the growing unilateralism as well as repeated trade conflicts have seen trade policy uncertainty as a significant external variable that has been impacting the operations of companies. Particularly, since 2018, the occurrence and further increase of the Sino-US trade friction have significantly enhanced the level of external operating environment uncertainty of Chinese businesses. Increased trade policy uncertainty can be associated with an increase in export prices and the need to adjust supply chains, but also with the change in investment plans and the processes of technological innovation, and thus impact the competitiveness of industries and the performance of firms. Under these circumstances, there has emerged the question of how companies are changing their business strategies and optimizing resource allocation during times of uncertainty, as both academia and industry focus on it.

Meanwhile, due to the growing threat of climate problems and the popularity of sustainable development principles, green investment has increasingly become one of the most important ways that companies can

pursue high-quality development. Besides being a symbol of corporate environmental responsibility, green investment is also seen as a strategic tool to improve long-term competitiveness and move towards sustainable development. Since China announced the objectives of carbon peaking and carbon neutrality in 2020, the green transformation of enterprises has faced the emergence of new opportunities as well as new challenges. Due to increased trade policy uncertainty, companies could either reduce green investment to relieve short-term operating stresses or increase green spending to strengthen long-run resilience. Such trade-off should be researched thoroughly both theoretically and empirically.

The economic implications of trade policy uncertainty have been widely explored in the current literature. Other researchers have discovered that trade policy uncertainty tends to have a negative effect on both corporate investment and innovation [2, 13], but some have claimed that uncertainty will instead trigger a sense of crisis awareness in companies, causing them to increase their competitiveness when faced with external shocks. In terms of corporate green investment, the available research largely focuses on two directions: its internal features and external context. In an internal setting, the level of executives' environmental awareness, the nature of ownership, and the quality of corporate governance have all been demonstrated to impact green investment behaviour significantly [9, 5, 8]. Externally, the environmental regulation, media coverage, and green finance development are considered as the most important drivers [4, 3, 7]. Nevertheless, there is a lack of attention to the issue of how trade policy uncertainty at the macro-level impacts green investment of businesses. Besides, the ways in which trade policy uncertainty impacts green investment are not clear, and this is the main question that this paper seeks to answer.

The research sample of this paper consists of Chinese A-share listed companies over the years 2017-2024 and it examines how trade policy uncertainty impacts corporate green investment and its transmission mechanisms. It can be seen that trade policy uncertainty significantly drives green investment, and such an influence does not change even after the inclusion of control variables, the substitution of fixed effects, and the application of clustered robust standard errors. The mechanism analysis indicates that trade policy uncertainty impacts green investment via two paths, i.e., increasing the level of market competition and promoting green innovation. The heterogeneity test shows that the impact is stronger among heavily polluting companies, companies in the eastern region, and companies belonging to the high-tech industry.

Summarizing the marginal contributions of the presented study, it could be stated as follows. To begin with, it adds to the limits of the investigation of the economic impact of trade policy uncertainty by being among the initial studies that have chosen to concentrate on its implications on corporate green investment, thus expanding the angle of analyzing the relationship between the macro-policy context and corporate sustainable development. Secondly, it helps open the black box of the dual transmission channels through which trade policy uncertainty impacts green investment, namely, the level of market competition and the stimulation of green innovation, adding to the existing body of literature on the mechanisms of action of trade policy uncertainty on corporate green investment. Thirdly, it explores moderating roles of heterogeneity in the base regression using firm-level, regional-level, and industry-level aspects, offering theoretical frameworks to various types of firms developing diversified green development strategies.

2. Theoretical Analysis and Research Hypotheses

2.1 The Impact of Trade Policy Uncertainty on Corporate Green Investment

Uncertainty in trade policy is an important external environmental factor that companies encounter, and it has a strong impact on their strategic decisions and resource allocation. In the context of the increasing tendency towards green and sustainable development, the analysis of how trade policy uncertainty impacts the behavior of corporations in making green investments has important theoretical implications to learn the interactive nature of the macro-policy environment and micro-level corporate decisions. This part examines the process of how trade policy uncertainty impacts corporate green investment based on strategic management theory and stakeholder theory and looks at the issue from two points of view- as a risk management strategy and as a stakeholder engagement strategy.

The growth of trade policy uncertainty from the risk management point of view significantly increases the level of uncertainty in the operating environment, and at the same time raises the market risk, operational risk, and compliance risk. Based on the theory of strategic management, in the case of radical changes in the external

environment, companies are likely to reactively change their strategies to enhance their capability to prevent risks and develop organizational resilience to resist shocks of uncertainty [14]. Green investment as part of the corporate sustainable development approaches is not only helpful to help businesses comply with more and more strict environmental regulation rules, but also plays a significant role of an «insurance» in uncertain conditions, to prevent possible environmental compliance and policy risks. The tightening of environmental regulations is inevitable as the concept of green development is deepened further and the dual carbon objective is introduced in China. Given such external shocks due to trade policy uncertainty, companies have the opportunity to effectively minimize the penalties of environmental violations by promoting green investments and thus become more flexible and resilient in an uncertain environment. Also, green investment helps to increase the efficiency of resource allocation, decrease energy consumption and production expenses, and hence promote competitive advantage in the long term under conditions of uncertainty. The study by Zhou et al. [9] also demonstrates that corporate environmental investment can be used effectively to improve the ability of the firms to deal with environmental risks. Therefore, trade policy uncertainty could lead firms to diversify external risks and solidify the basis of long-term sustainable development via higher green investment, according to the risk management viewpoint.

According to stakeholder theory, when there is trade policy uncertainty, companies should be more proactive in responding to the needs of different stakeholders in order to achieve a continued supply of resources and recognition of legitimacy. The stakeholder theory proposed by Freeman [15] suggests that the growth of an enterprise depends on the inputs and engagement of various stakeholders, and that firms need to consider the overall interests of all stakeholders and not just those of shareholders. With increased trade policy uncertainty, the issue of corporate environmental performance being raised by stakeholders, including governments, investors, consumers, and communities, has become much more prominent. On the government front, as a reaction to trade tensions, China has rolled out a wave of policy initiatives that support green development, which allows firms to realign their policies with government directions and access both policy backing and resource allocation through green investment. On the investor front, due to the widespread adoption of the concept of ESG investments, institutional investors are now putting more focus on corporate environmental performance, and green investment is gradually emerging as a major signal of attracting long-term capital [1]. On the consumer front, the increase in green consumption consciousness has given environmentally friendly products more market competition power. Moreover, the study conducted by Wang and Yang [5] shows that good ESG performance helps firms to acquire reputational capital and win stakeholder confidence. Thus, in a scenario where trade policy uncertainty prevails, the increase of green investment to meet the demands of stakeholders, ensure recognition of legitimacy, and acquire resource support is a crucial strategic choice of companies on the way to sustainable development.

The given analysis shows that in the context of an increase in trade policy uncertainty, companies have enough incentives and reasons to invest more in green investment to become competitive and achieve sustainable development. Therefore, the following hypothesis has been suggested:

H1: Trade policy uncertainty exerts a positive driving effect on corporate green investment.

2.2 Mechanisms of the Impact of Trade Policy Uncertainty on Corporate Green Investment

In reference to the transmission channels of how trade policy uncertainty impacts corporate green investment, this paper will consider two factors, namely the extent of market competition and green innovation.

In terms of the level of market competition, trade policy uncertainty increases the level of market competition and forces companies to invest in green investment. In particular, trade policy uncertainty causes important shifts in the international trade environment, and hence, changes the competitive environment within which companies are working. On the one hand, trade frictions increase the market access barriers of exporting companies, forcing others to move into the domestic market, which further increases the domestic market competition. On the other hand, trade policy uncertainty makes firms vulnerable to more uncertain international market demand, forcing them to develop differentiation strategies to retain their shares. The intensification of competition leads to green investment becoming a significant tool of differentiation strategy implementation by firms. Firstly, green investment helps to create the environmental image and the brand value of the company, enabling it to become preferable to consumers in the intense competition. The dissemination of green consumption ideas and the enforcement of environmental legislation have enabled

green products to occupy more of the market premium space, and companies can use green investment to earn green premiums and increase profitability. Secondly, green investment will allow companies to develop green supply chain management systems, thus minimizing the risks in the supply chain and enhancing the efficiency of operations. Due to increased competition in the market, companies signal positively to the market by investing in green projects, indicating their ability to achieve sustainable growth and potential to create value over time, which helps them get competitive benefits in financing as well as in product markets. Moreover, according to the research conducted by Li et al. [2], trade policy uncertainty increases inter-firm competition, and forces companies to respond to environmental changes with technological innovation and strategic adaptation. Intense market competition drives firms to increase green investment and acquire competitive advantages by using differentiated green strategies, as Zhang and Wang [8] also report. Thus, trade policy uncertainty, as increasing market competition, pushes companies to enlarge green investments in order to achieve differentiation advantages in competition. Thus, the next hypothesis is offered:

H2: The uncertainty of trade policy can encourage investment in green projects in corporations by increasing the level of market competition.

In regard to green innovation, trade policy uncertainty tends to be associated with increased green trade barriers, and companies must then use green innovation to satisfy the environmental standards of international markets and improve long-term competitiveness. Green innovation is a vital route to sustainable development that assumes a significant mediating role in the context of trade policy uncertainty. To begin with, trade policy uncertainty puts more green trade barriers on firms' exports, and the tightened environmental regulations and carbon tariff measures of developed countries force them to become reliant on green technological innovation to comply with the international market access requirements. Through the increase of green research and development spending and the creation of environmentally friendly products and clean production technologies, firms can not only break down green trade barriers but also enhance the competitiveness of their products in worldwide markets. Secondly, green innovation has both dual externality properties, including knowledge spillover effects, which are beneficial to technological progress, and environmental spillover effects, which are detrimental to pollution emissions. In a setting of trade policy uncertainty, it is possible to attain win-win situations of environmental protection and enhanced competitiveness through green innovation. Chen and Zhang [1] have shown that green innovation may be facilitated by trade policy uncertainty due to better corporate ESG performance, and green patent application growth is a direct indication of greater investment in green technology R&D. Works by Shen and Huang [4] also indicate that environmental pressures from outside can also be successful in prompting a firm to engage in green technological innovation efforts. Finally, the fact that green patents have grown is a key indicator of corporate green innovation output, indicating that there is more investment in green technology R&D and causing an overall increase in the level of green investment. Patents and intellectual property gained through green innovation allow companies to create technological barriers in uncertain environments, improving their core competitiveness and position in the market. This means that trade policy uncertainty leads firms to increase green investment because of green innovation promotion. Based on this, the following hypothesis is offered:

H3: Trade policy uncertainty promotes corporate green investment by fostering green innovation.

3. Research Design

3.1 SAMPLE Selection and Data Sources

The study chooses Chinese A-share listed companies between 2017 and 2024 as the research sample. The reason behind selecting such a time is that in the past years, especially after the start of the Sino-US trade friction in 2018, there has been a notable increase in trade policy uncertainty in China, offering an ideal natural experimental environment to conduct this study. The screening process of the sample is conducted as follows: (1) financial listed companies are not included because they may be affected by industrial-specific characteristics which can affect the results of the research; (2) ST and *ST companies are excluded to guarantee the regular operational conditions of the sample companies; (3) the observations containing missing values of the key variables are excluded; (4) the continuous variables are winsorized to the 1st and 99th percentile to remove the effect of outliers. Post the screening mentioned above, the final sample is 29,477 firm-year observations.

- 3.2 The data considered in this paper are mainly taken from the following databases: (1) the trade policy uncertainty data originate in the China Trade Policy Uncertainty Index developed by Baker et al. [12] and it is measured as the frequency of news reports in popular media, e.g., the South China Morning Post, and could also be well indicative of the level of uncertainty in the Chinese trade policy ; (2) corporation green investment data are manually collected using the data on corporate green investment and green R&D spending, where the data are retrieved through the CSMAR database and the Wind database; (3) corporations finance data are retrieved based on the information available in the CSMAR database; and (4) green patent data are retrieved based on the information available in the CNRDS database, such as total green patent applications, green invention patent applications, and green utility model patent applications.

3.3 Variable Definitions

The dependent variable is Corporate green investment (Green Invest). This study adopted the same approach used by other researchers in that it also measures the level of corporate green investment through the ratio of environmental investment to operating revenue of companies [1, 9]. The indicator is very effective in showing the investment intensity in environmental protection of a company, and its large values indicate high levels of corporate green investment.

Independent variable: Trade policy uncertainty (TPU). The current research uses the China Trade Policy Uncertainty Index developed by Baker et al. [12] as a composite measure that is measured through both textual analysis approaches and can effectively capture the extent of uncertainty in China trade policies. Higher values of such an index mean that there is a greater degree of trade policy uncertainty.

Variables of the mechanism: (1) Market competition degree (HHI). It is measured by the Herfindahl–Hirschman index in this study as it measures the level of market competition encountered by firms [10]. The greater the HHI value, the greater the level of market competition experienced by the firm. (2) Green innovation (Green Patent). It is measured by the natural logarithm of one plus the total number of green patent applications in this study to determine the level of corporate green innovation [11]. Green patents are a significant measure of the output of corporate green innovation as they show the investments and results in green technology research and development.

Control variables. The following factors that can impact corporate green investment are controlled in this study: firm size (Size): measured as the natural logarithm of total assets; leverage ratio (Lev): measured as the ratio of total liabilities to total assets; return on assets (ROA): measured as the ratio of net profit to total assets; gross profit margin (Gross Profit): measured as the ratio of (operating revenue - operating costs) to operating revenue; current ratio (Liquid): measured as the ratio of current assets to current liabilities; quick ratio (Quick): measured as the ratio of (current assets - inventory) to current liabilities; cash flow ratio (Cash Flow): measured as the ratio of operating cash flow to total assets; and financial leverage (FL): measured as the ratio of long-term liabilities to total assets. Also, year fixed effects and industry fixed effects are adjusted to exclude the effects of time trends and industry features on the research results.

Table 1: Variable Definitions

Variable Name	Symbol	Definition
Corporate green investment	Green Invest	Environmental investment / Operating revenue
Trade policy uncertainty	TPU	China Trade Policy Uncertainty Index
Degree of market competition	HHI	Herfindahl–Hirschman Index
Green innovation	Green Patent	$\ln(\text{Total green patent applications} + 1)$
Firm size	Size	Natural logarithm of total assets
Leverage ratio	Lev	Total liabilities / Total assets
Return on assets	ROA	Net profit / Total assets
Gross profit margin	Gross Profit	$(\text{Operating revenue} - \text{Operating costs}) / \text{Operating revenue}$
Current ratio	Liquid	Current assets / Current liabilities
Quick ratio	Quick	$(\text{Current assets} - \text{Inventory}) / \text{Current liabilities}$
Cash flow ratio	Cash Flow	Operating cash flow / Total assets
Financial leverage	FL	Long-term liabilities / Total assets

3.4 Model Specification

In order to analyze how trade policy uncertainty may affect corporate green investment, the benchmark regression model given below is developed:

$$GreenInvest_{i,t} = \alpha_0 + \alpha_1 TPU_{i,t} + \alpha_2 Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}$$

where $GreenInvest_{i,t}$ denotes the level of green investment of firm i in year t ; $TPU_{i,t}$ denotes the trade policy uncertainty faced by firm i in year t ; $Controls_{i,t}$ is a set of control variables; $Year$ and $Industry$ represent year fixed effects and industry fixed effects, respectively; and $\varepsilon_{i,t}$ is the random error term. The sign and significance of the coefficient α_1 are the primary focus. If α_1 is significantly positive, it indicates that trade policy uncertainty promotes corporate green investment, thereby supporting Hypothesis H1.

In order to examine the process by which trade policy uncertainty influences corporate green investment, this paper will adopt the mechanism testing approach suggested by Jiang [6] and will develop the following mechanism testing model:

$$M_{i,t} = \beta_0 + \beta_1 TPU_{i,t} + \beta_2 Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}$$

where $M_{i,t}$ represents the mechanism variable, which consists of the level of market competition (HHI) and green innovation (Green Patent) and the rest of the variables are defined similar to those in the baseline regression model. When it is significant, it implies that there is a mechanism effect, i.e., trade policy uncertainty impacts corporate green investment via this mechanism variable.

4. Empirical Results and Analysis

4.1 Descriptive Statistics

The descriptive statistics of the main variables are given in Table 2. The table indicates that the average value of corporate green investment (Green Invest) is 0.3794, and the standard deviation is 0.4853, and the minimum and maximum values are 0 and 1, respectively, which means that the green investment levels of the sample firms differ widely, and there are some sample firms that have not engaged in any green investment. The average value of trade policy uncertainty (TPU) is 346.8980, and the standard deviation of TPU is 157.3137, with a minimum of 201.4487, and a maximum of 687.6163, and this means that there is high variability in trade policy uncertainty during the sample period, and it will be adequate to use this in this study.

Table 2: Descriptive Statistics

Variable	Observations	Minimum	Maximum	Mean	Median	Standard Deviation
Green Invest	29477	0.0000	1.0000	0.3794	0.0000	0.4853
TPU	29477	201.4487	687.6163	346.8980	277.8678	157.3137
Size	29477	20.1922	26.4153	22.3804	22.1661	1.2881
Lev	29477	0.0584	0.8939	0.4128	0.4061	0.1999
ROA	29477	-0.2611	0.1984	0.0320	0.0357	0.0672
Gross Profit	29477	-0.0268	0.8501	0.2910	0.2586	0.1789
Liquid	29477	0.3578	15.1755	2.5571	1.7378	2.4577
Quick	29477	0.2130	13.9470	2.0961	1.3353	2.2625
Cash Flow	29477	-0.1421	0.2380	0.0501	0.0487	0.0648
FL	29477	-1.0420	5.9314	1.1695	1.0192	0.7770

4.2 Baseline Regression

The regression findings on the effects of trade policy uncertainty on company green investment are presented in Table 3. Column (1) has only year and industry fixed effects, whereas column (2) contains all control variables. It is observed that the regression coefficient of trade policy uncertainty (TPU) is significant at the level of 1 percent (the coefficient = 0.0004, t-value = 3.3414), which means that trade policy uncertainty has a strong positive influence on corporate green investment, which validates Hypothesis H1. Economically, a one-standard-deviation rise in the trade policy uncertainty index (about 157.3137) is related to approximately 0.0629 percentage-point growth in the amount of corporate green investment. Given the magnitude of the

change in the trade policy uncertainty index within the sample period (201.4487-687.6163) this effect has important economic importance.

Table 3: Baseline Regression

Variable	(1)	(2)
TPU	0.0004*** (3.3414)	0.0004*** (3.3414)
Size		0.0509*** (19.7993)
Lev		-0.0337 (-1.5426)
ROA		0.1591*** (3.2175)
Gross Profit		-0.3204*** (-15.4688)
Liquid		-0.0042 (-0.6092)
Quick		-0.0079 (-1.0675)
Cash Flow		0.1166** (2.4849)
FL		0.0051 (1.5069)
Constant	-0.7405*** (-11.5005)	-0.7405*** (-11.5005)
Year FE	Yes	Yes
Industry FE	Yes	Yes
Observations	29,477	29,477
R-squared	0.191	0.191
Adj. R2	0.188	0.188

Note: *t*-statistics are reported in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

4.3 Robustness Checks

In order to test the robustness of the conclusions of the research, this paper performs robustness tests based on three viewpoints, which are shown in Table 4.

Then, new control variables are added. In order to exclude the influence of factors like ownership type, loss position, and capital expenditure, this paper introduces three control variables-the state-owned enterprise dummy variable (SOE), the loss dummy variable (Loss), and capital expenditure (CAP)-to the baseline model to be re-estimated. Column (1) indicates that the regression coefficient of trade policy uncertainty (TPU) is 0.0004, which is significantly positive at the 1 percent level (*t*-value = 3.3907), implying that the conclusion still holds true even with the inclusion of control variables.

Secondly, fixed effects are substituted. This paper substitutes industry fixed effects with province fixed effects in order to control unobservable variables on the regional level to re-estimate. Column (2) demonstrates that the regression coefficient of TPU is 0.0003, which is significantly positive at the 5 percent significance level (*t*-value = 2.0213), which implies that the conclusion is resilient after substitution of the fixed effects.

Fourthly, the clustered robust standard errors are included. In order to eliminate possible violations of the homoscedasticity assumption, this paper re-estimates the baseline model with firm-level clustered robust standard errors. As it is shown in column (3), the regression coefficient of the TPU is 0.0004, which is statistically significant at the significance level of 1 per cent (*t*-value = 3.6155), which means that even after adding clustered robust standard errors, the research conclusion remains unchanged.

Table 4: Robustness Checks

Variable	(1) Additional control variables	(2) Replacement of fixed effects	(3) Addition of clustered robust standard errors
TPU	0.0004*** (3.3907)	0.0003** (2.0213)	0.0004*** (3.6155)
Size	0.0421*** (15.4257)	0.0475*** (18.5618)	0.0509*** (9.6073)
Lev	-0.0422* (-1.8681)	-0.1220*** (-5.5540)	-0.0337 (-0.8846)
ROA	0.1645*** (3.1356)	0.3060*** (5.9775)	0.1591** (2.3263)
Gross Profit	-0.2921*** (-13.4859)	-0.3697*** (-20.7239)	-0.3204*** (-8.6205)
Liquid	-0.0034 (-0.4649)	-0.0156** (-2.3367)	-0.0042 (-0.3559)
Quick	-0.0106 (-1.3651)	0.0004 (0.0558)	-0.0079 (-0.6246)
Cash Flow	0.1194** (2.4397)	0.2703*** (5.5665)	0.1166** (1.9644)
FL	0.0050 (1.4626)	0.0096*** (2.6791)	0.0051 (1.2207)
SOE	0.0798*** (11.8411)		
Loss	-0.0075 (-0.8457)		
CAP	-0.0001 (-0.7612)		
Constant	-0.5683*** (-8.3752)	-0.5821*** (-9.0778)	-0.7405*** (-6.0881)
Year FE	Yes	Yes	Yes
Industry FE	Yes	No	Yes
Province FE	No	Yes	No
Observations	27,509	29,477	29,477
R-squared	0.196	0.093	0.191

Note: The t-statistics are given in parentheses and * ** and ** indicate the significance of the statistics at 1, 5, and 10 per cent levels, respectively.

5. Mechanism Tests

This analysis indicates that there is a significant positive impact of trade policy uncertainty on corporate green investments. The present section also explores the transmission processes of the effect, such as the extent to which the level of market competition (HHI) and green innovation (Green Patent) are intermediary routes between trade policy uncertainty and corporate green investment. As per the concept of causal inference developed by Jiang [6], this paper will use a two-stage methodology to test the mechanism. The first stage is the baseline regression that has already been reported above and has already established the significant and positive effect of trade policy uncertainty on corporate green investment. The second stage is the testing of the mechanism variables using trade policy uncertainty.

The results of the mechanism tests are reported in Table 5. The baseline regression results are presented in Column (1), Column (2) tests the impact of trade policy uncertainty on the extent of market competition, and Column (3) tests the effect of trade policy uncertainty on green innovation.

(1) Market competition mechanism. Column (2) indicates that the regression coefficient between the trade policy uncertainty and the degree of market competition (HHI) is 0.0129, which is statistically significant at the 1 percent level (t-value = 15.4971). It means that trade policy uncertainty exerts a strong positive impact on the level of market competition. One explanation may be that when there is a situation of trade policy uncertainty, the competitive environment changes and the companies experience more severe competitive pressures. In order to achieve benefits in competition, companies are more likely to increase their green

investment as a strategy of differentiation, thus improving the corporate image and market competitiveness. At the same time, increased competition drives companies to focus more on long-term sustainable growth and to strive to obtain recognition and support of stakeholders by investing in green initiatives. The finding confirms Hypothesis H2.

(2) Green innovation mechanism. Column (3) indicates that the regression coefficient of trade policy uncertainty with respect to green innovation (Green Patent) is 0.0016 and significant at the 1 percent level (t -value = 6.0698). It means that trade policy uncertainty plays a substantial role in driving corporate green innovation. The reason behind this could be that trade policy uncertainty usually goes along with the increasing green trade barriers, making it necessary for firms to depend on green innovation to achieve international environmental standards. Besides, in the presence of external uncertainty, companies can enhance investments in green innovation to ensure competitiveness over the long term. As an important indicator of corporate green innovation production, the significant rise of green patents demonstrates that companies have actually increased their R&D spending on green technologies under the trade policy uncertainty circumstances, and this increases the amount of green investment. The obtained finding confirms Hypothesis H3.

The presented analysis suggests that trade policy uncertainty is an effective mechanism for increasing the level of corporate green investment via two channels, namely, the intensity of market competition and green innovation. It is this finding that explains the main transmission channels through which a change in the macro-policy environment influences corporate sustainable development activities.

Table 5: Mechanism Tests

Variable	(1)	(2)	(3)
	Invest	HHI	Green Patent
TPU	0.0004*** (3.3414)	0.0129*** (15.4971)	0.0016*** (6.0698)
Size	0.0509*** (19.7993)	0.0076 (0.4209)	0.5846*** (103.2212)
Lev	-0.0337 (-1.5426)	-0.0976 (-0.6388)	0.0386 (0.8018)
ROA	0.1591*** (3.2175)	-0.9690*** (-2.8014)	-0.0784 (-0.7207)
Gross Profit	-0.3204*** (-15.4688)	0.3006** (2.0748)	-0.0559 (-1.2265)
Liquid	-0.0042 (-0.6092)	0.0705 (1.4465)	-0.0867*** (-5.6562)
Quick	-0.0079 (-1.0675)	-0.0894* (-1.7251)	0.0765*** (4.6923)
Cash Flow	0.1166** (2.4849)	0.4781 (1.4563)	-0.1671 (-1.6177)
FL	0.0051 (1.5069)	0.0261 (1.0925)	-0.0529*** (-7.0485)
Constant	-0.7405*** (-11.5005)	4.3938*** (9.7545)	-12.3820*** (-87.3706)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Observations	29,477	29,477	29,477
R-squared	0.191	0.895	0.460

*Note: t-statistics are reported in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.*

6. Heterogeneity Analysis

The above discussion shows how trade policy uncertainty can have a positive impact on corporate green investment in general. Nevertheless, companies of various nature may behave in a different way towards trade policy uncertainty. The present section performs heterogeneity analyses by three dimensions, i.e., the pollution attributes of the firm, regional disparities, and industry attributes, to define the heterogeneous nature of the relationship between trade policy uncertainty and corporate green investment.

6.1 Firm-Level Heterogeneity Analysis

The two types of firms, polluting and non-polluting, are greatly different in relation to environmental regulation pressures and social responsibility fulfilment, which can cause them to respond to trade policy uncertainty differently. The sample in this research is divided between polluting and non-polluting firms depending on whether they are considered a polluting or non-polluting firm, and subsample regressions are performed. The results of the regression are shown in Table 6. Column (1) indicates that the regression coefficient of trade policy uncertainty (TPU) is 0.0007 in the polluting firm subsample and statistically significant at 1% (t-value = 2.6275). Column (2) indicates that the regression coefficient of TPU in the non-polluting firm subsample is 0.0003 and statistically significant at 5 percent (t-value = 2.4022). These findings show that the motivating influence of trade policy uncertainty on green investment is greater among the polluting firms. An explanation could be that the pressure imposed by environmental regulations on polluting firms is stronger, and under conditions of trade policy uncertainty, they are more motivated to increase green investment to address the demands of environmental policies and at the same time enhance their environmental performance to receive policy backing.

Table 6: Firm-Level Heterogeneity Analysis

Variable	(1)	(2)
	Polluting firms	Non-polluting firms
TPU	0.0007*** (2.6275)	0.0003** (2.4022)
Size	0.0661*** (12.1881)	0.0452*** (15.4147)
Lev	-0.0153 (-0.3221)	-0.0254 (-1.0294)
ROA	0.4144*** (3.3863)	0.1286** (2.3822)
Gross Profit	-0.4574*** (-9.1464)	-0.3037*** (-13.3251)
Liquid	0.0471*** (2.7293)	-0.0131* (-1.7229)
Quick	-0.0707*** (-3.7944)	0.0036 (0.4506)
Cash Flow	0.3573*** (3.3699)	0.0485 (0.9283)
FL	0.0015 (0.2255)	0.0054 (1.3552)
Constant	-0.9301*** (-6.6697)	-0.6608*** (-9.0909)
Year FE	Yes	Yes
Industry FE	Yes	Yes
Observations	6,557	22,920
R-squared	0.139	0.118

Note: t-statistics are reported in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

6.2 Regional-Level Heterogeneity Analysis

The degree of economic development, openness, and political environment of different regions vary greatly, and this can cause regional differences in the impact of trade policy uncertainty on green investment. The research splits the sample into three categories, i.e., eastern, central, and western regions, dependent on the registration of the firm's location, and runs the regression separately. Regression outcomes are given in Table 7. Column (1) indicates that in the eastern region subsample, the regression coefficient of trade policy uncertainty (TPU) equals 0.0004, and it is statistically significant at the 1 percent level (t-value = 2.6870). Column (2) and (3): The regression coefficients of trade policy uncertainty in the central and western region subsamples are insignificant. The findings suggest that the driving effect of trade policy uncertainty on green investment is largely focused on the companies that belong to the eastern region. One possible reason is that eastern region companies are more integrated into international value chains and react more strongly to changes in trade policies. Also, the eastern region has a more advanced green finance system and stronger

environmental policy backing, which allows businesses to make better use of green investment in reaction to external environmental factors.

Table 7: Regional-Level Heterogeneity Analysis

Variable	(1)	(2)	(3)
	Eastern	Central	Western
TPU	0.0004*** (2.6870)	0.0005 (1.4849)	0.0005 (1.6002)
Size	0.0441*** (14.7688)	0.0560*** (7.5387)	0.0637*** (9.0634)
Lev	-0.0528** (-2.0517)	-0.0200 (-0.3373)	-0.1043* (-1.8180)
ROA	0.1269** (2.2546)	0.3419** (2.4485)	0.2189 (1.5221)
Gross Profit	-0.3289*** (-13.4585)	-0.4683*** (-8.2411)	-0.2645*** (-4.8557)
Liquid	-0.0047 (-0.5887)	-0.0113 (-0.6106)	-0.0352* (-1.6656)
Quick	-0.0078 (-0.9114)	0.0070 (0.3571)	0.0163 (0.7241)
Cash Flow	0.0797 (1.4673)	-0.0184 (-0.1467)	0.7129*** (5.3769)
FL	0.0042 (0.9901)	0.0044 (0.5683)	-0.0039 (-0.4665)
Constant	-0.6109*** (-8.1901)	-0.7558*** (-4.1477)	-0.8886*** (-4.9845)
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Observations	21,370	4,493	3,614
R-squared	0.167	0.232	0.312

Note: The t-statistics are shown in parentheses; *, ** and *** indicate the significance of 1, 5, and 10 percent, respectively.

6.3 Industry-Level Heterogeneity Analysis

The technological innovation capacity and the intensity of R&D investments of high-tech industries and non-high-tech industries vary significantly, which can result in different reactions to trade policy uncertainty. The current research separates the sample into two groups, high-tech and non-high-tech, depending on the industry to which the firm belongs, and estimates them separately. Table 8 provides the results of the regression. Column (1) indicates that in the high-tech industry subsample, the regression coefficient of trade policy uncertainty (TPU) is 0.0005, and it is statistically significant at the 1 percent level (t-value = 3.3177). Column (2) indicates that in the non-high-tech industry subsample, the regression coefficient of trade policy uncertainty is insignificant. These findings show that trade policy uncertainty is a stronger motivator of green investment for high-tech industry companies. One possible reason could be that high-tech companies focus more on long-term development and technological innovations and have higher R&D capacity and technological resources. In the presence of external uncertainty, they are also more prone to improve their core competitiveness by investing more in green investment and green innovation.

Table 8: Industry-Level Heterogeneity Analysis

Variable	(1)	(2)
	High-tech industries	Non-high-tech industries
TPU	0.0005*** (3.3177)	0.0002 (0.9342)
Size	0.0552*** (16.6202)	0.0424*** (10.4108)
Lev	-0.0024 (-0.0847)	-0.0848** (-2.4451)
ROA	0.1983*** (3.2917)	0.0958 (1.1012)
Gross Profit	-0.4376***	-0.1168***

Variable	(1)	(2)
	High-tech industries	Non-high-tech industries
	(-16.7094)	(-3.4077)
Liquid	-0.0158*	0.0095
	(-1.6766)	(0.9243)
Quick	0.0097	-0.0308***
	(0.9680)	(-2.7701)
Cash Flow	0.0959	0.1295*
	(1.6216)	(1.6767)
FL	0.0083*	0.0012
	(1.7820)	(0.2452)
Constant	-0.8394***	-0.5245***
	(-10.1830)	(-5.0643)
Year FE	Yes	Yes
Industry FE	Yes	Yes
Observations	18,754	10,723
R-squared	0.174	0.227

Note: *t*-statistics are reported in parentheses; ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

On the whole, the test results of heterogeneity suggest that trade policy uncertainty has a significant impact on the green investment of corporations mainly within the framework of polluting companies, companies operating in the eastern region, and companies working in high-tech industries. The result is useful to different kinds of firms in coming up with diverse green development policies.

7. Conclusions and Implications

7.1 Research Conclusions

The present research is based on Chinese A-share listed companies during the period 2017-2024 as a sample population to investigate the impact of trade policy uncertainty on corporate green investment and associated transmission channels. The results are: Firstly, trade policy uncertainty has a strong positive impact on corporate green investment and it holds even when a sequence of robustness tests is conducted. Secondly, trade policy uncertainty influences corporate green investment by two mechanisms: the extent of market competition and green innovation. Thirdly, this promoting effect is stronger in the polluting firms, the firms in the east region, and the firms in high-technology industries. The present study explains the main channels through which macro-policy environment changes influence corporate sustainable development and theoretically supports the practice and offers practical guidance to the firms to respond to external uncertainty and develop green development strategies.

7.2 Policy Implications

To start with, governments ought to enhance the policy framework that facilitates the corporate green transformation. Since companies have an endogenous drive to increase green investment, governments can use the incentives of taxes, green finance, and other mechanisms to lower the cost of green transformation, direct companies to incorporate green development in their business plans, and provide more encouragement on corporate R&D in green technologies so that companies may be able to surmount the green trade barriers.

Secondly, a differential policy support system of green development needs to be put in place. Various kinds of businesses react to the uncertainty of trade policy in different ways; thus, governments need to develop specific green innovation support policies towards the polluting firms and high-tech firms with the aim of increasing the accuracy of the policy interventions.

7.3 Limitations and Future Research Directions

The study has the following limitations. Firstly, the trade policy uncertainty index is evaluated at a macro level and cannot reflect the heterogeneity of perceptions of uncertainty by firms on an individual basis. Secondly, the sample size selected is restricted to Chinese A-share listed companies, and additional tests are

needed to make the conclusions more generalizable. Future studies may develop trade policy uncertainty indicators at the firm level, explore the details of the micro mechanisms influencing the corporate green investments, and perform country comparison analyses to add more value to the relevant theory and practice.

References

- [1] Fang Chen, Zhicheng Wang. (2025). Trade Policy Uncertainty, ESG Rating and Corporate Green Innovation. *Journal of Anhui University(Philosophy and Social Sciences Edition)*, 49 (2), 143-153.
- [2] Meng Wang. (2023). Trade policy uncertainty and enterprise innovation: an empirical study on listed companies in manufacturing industry. Master's thesis, Zhongnan University Of Economics And Law.
- [3] Yufang, Xu. (2023). Media attention and corporate green investment: Reputation management or performance management. *Communication of Finance and Accounting*, (5), 48-52.
- [4] Zhiwei Wang, & Hui Sun. (2022). Impact and impact mechanism of market-oriented environmental regulation on enterprise green technological innovation. *Science and Technology Management Research*, 42 (8), 208-215.
- [5] Dayu Huang, Huobao Xie, & Mengting Zou. (2023). The road to green: Corporate ESG performance and environmental investment—Empirical evidence from China's green finance innovation policies. *Shanghai Journal of Economics*, (10), 92-111.
- [6] Ting Jiang. (2022). Mediating Effects and Moderating Effects in Causal Inference. *China Industrial Economics*, 5, 100-120.
- [7] Rong Li, & Luqian Liu. (2021). Green finance and enterprises' green innovation. *Wuhan University Journal (Philosophy & Social Sciences)*, 74 (6), 126-140.
- [8] Shuliang Liu, & Xiaoke Fan. (2024). The impact of board failure tolerance on environmental investment efficiency. *Journal of Industrial Technological Economics*, 43 (2), 126-134.
- [9] Lei Zhou, Min Zhao, et al. (2025). A Study of Impact of CEO Green Experience on Corporate Environmental Investment. *Journal of Xinjiang University of Finance & Economics*, 2, 52-58.
- [10] Xia Wang, Xiaodong Xu. (2016). Competition Heterogeneity, Management Moral Cognition and Firm Eco-innovation. *Journal of Shanghai University of Finance and Economics*, 18 (4): 52-66+96.
- [11] Hua Zhan, Mengting Hou, Feifei Fan. (2022). Influence of intelligentization on enterprise green innovation: Evidence from listed companies of new energy industry in China. *Resources Science*, 44 (5): 984-993.
- [12] Baker, S. R., Bloom, N., & Davis, S. J. (2016). Measuring economic policy uncertainty. *The Quarterly Journal of Economics*, 131 (4), 1593–1636.
- [13] Handley, K., & Limão, N. (2017). Policy uncertainty, trade, and welfare: Theory and evidence for China and the United States. *American Economic Review*, 107 (9), 2731–2783.
- [14] Porter, M. E. (1980). *Competitive strategy: Techniques for analyzing industries and competitors*. Free Press.
- [15] Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Pitman.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

Recognition of Data Assets in Financial Statements: A Systematic Literature Review on Concept Discrimination, Accounting Treatment and Management Systems

Ruzhen Zhang*

Accounting Major, School of Management, Shenyang University of Technology, Shenyang, Liaoning, 110000, China

**Corresponding author: Ruzhen Zhang.*

Abstract

In the context of the rapidly growing digital economy, data has become an essential component of production, and the recognition of data assets in financial statements and the related accounting problems have also drawn much of the attention of scholars and the business world. It is through this research that a systematic literature review methodology is used to follow the conceptual development and definitional requirements of data assets in the local, as well as in global environments, defining the conceptual distinctions among data assets, digital assets, and information assets. Viewing this study through the lens of managerial accounting, the research synthesizes a management structure of data assets and summarizes the pragmatic approaches followed by companies in various ownership structures. Moreover, it is a systematic overview of the available literature on the issue of the recognition of data assets, their evaluation, further measurement, and reporting, and analyzes the practical value of the recognition of data assets in financial statements. There are a number of weaknesses in existing research indicated by the findings, such as: no uniform operating principles of rights and allocation of rights in the sphere of data assets; the absence of industry-based specific details of accounting measurement, as well as amortization and impairment; inadequate detailing and low practicality of the disclosure system; and the lack of empirical experiments and various case studies that can be used to facilitate the introduction of management systems. In turn, the present study suggests directions for further research. The result of refining the basic theoretical framework of data assets and filling the gaps in the research in the field is to offer practical references to the financial-statement recognition of data assets in Chinese enterprises and the development of industry-specific accounting standards.

Keywords

recognition of data assets in financial statements, data assets, accounting recognition and measurement, management accounting, disclosure of information

1. Introduction

The global digital economy wave keeps evolving in its depth, and China's national economic and social development have now fully shifted to a new stage where the digital transformation process as well as high-quality development go hand in hand. Data has gone beyond being a source of information resources to become

a fundamental part of production that generates economic growth, changes the structure of industries, and supports high-level development. The essential strategic worth of data assets is becoming more apparent, and the leading world economies, such as China, are concentrating on the market-driven distribution and uniform regulation of data as a production factor, and introducing systematic support policy documents consecutively.

Domestically, the development of the top-level design of China's data element sector has been ongoing, and the system is slowly developing. On 16 December 2015, the Second World Internet Conference initially came up with the concept of Digital China, which outlines the main line of digital development; the Fourth Plenary Session of the 19th CPC Central Committee incorporated data within the list of factors of production for the first time; and by 2023, Interim Provisions on Accounting Treatment of Enterprise Data Resources of the Ministry of Finance was officially implemented, signaling the beginning of a stage of standard implementation of the recognition of data assets in financial statements; subsequently, in 2025, the state further promoted the development of a Digital China by making it the central route to the creation of new-quality productive forces. On the international scene, the digital economy has been transformed into one of the central elements of the national strategy in many economies,¹ and the standardized accounting of the data assets is also recognized as a world consensus. In the System of National Accounts 2025 (2025 SNA), data is explicitly divided into a subcategory of intellectual property products, whereas the Organization for Economic Cooperation and Development (OECD) has continued to publish reports on the measurement of the digital economy and the accounting of data assets, searching for a common methodological structure in measuring data as a production factor statistically. In practice, the size of the digital economy in China continued to grow at a steady pace in 2024 to reach 59.2 trillion yuan (or 43.8 percent of GDP), up by one percentage point compared to the previous year. Total factor productivity of the digital economy was very useful in supporting stable economic growth, and its contribution to economic growth remained on the rise. Simultaneously, digital transformation may play an important role in helping businesses save money and increase profit margins in addition to its role in cost optimization in R&D and production and management being especially notable.² The listing of data assets in financial statements has numerous practical advantages: it not only enhances optimized corporate financial analysis structures and enhances operation and financing capabilities but also gives more power to government macroeconomic regulation and helps to enhance other systems that are connected to the data factor. Being valuable in terms of both theoretical studies and practical use, this subject has been a focal point of mutual concern among scholars and professionals alike.

According to the given policy background and present state, the paper will review the existing research in a systematic way concerning the definition of data assets, accounting recognition and measurement, valuation, disclosure, and management systems, and suggest further research areas as a means of guidance for improving the practical application of the recognition of data assets in financial statements and enhancing the conceptual framework in question.

The possible contributions of the study include: Firstly, the paper brings in a management accounting view to the literature of data asset recognition in financial statements. The current literature has mostly focused on the financial level of accounting and valuation only, with few studies on the creation of data asset management systems. Through the analysis of appropriate theoretical frameworks and the practice of companies under a management accounting perspective, the research adds to the extent of studies on the recognition of data assets in financial statements. Secondly, it defines future research orientation within the sphere of data assets, which not only can be used by enterprises to refer to the standardized management and practical accounting treatment of data assets but also by the regulatory authorities to develop literature support and conceptual understanding in order to refine the respective standards and guidelines and by scholars to perform further in-depth research. Third, it examines the definitions and defines the borders of data assets, digital assets, and information assets, which serve as the theoretical basis of data assets standardization and unification of the basic theoretical framework, as well as conceptual coherence in future research.

¹ China Academy of Information and Communications Technology, Annual Observation Report on Global Digital Economy and Trade Rules (2025) [R/OL], Beijing: CAICT, 2026-03.

<https://www.caict.ac.cn/kxyj/qwfb/ztbg/202603/P020260324613314950584.pdf>

² China Academy of Information and Communications Technology, Research Report on the Development of China's Digital Economy (2025), Beijing: CAICT, 2026-03.

<https://www.caict.ac.cn/kxyj/qwfb/bps/202603/P020260323736507370748.pdf>

It should be mentioned that the paper reviews systematically research on the recognition of data assets on financial statements by focusing more on literature related to traditional accounting, asset valuation, and management theory. The discussions on practical details, including the coordination between recognizing data assets and existing enterprise accounting standards, specific methods of accounting treatment of various kinds of data assets, and consistency among cross-departmental regulations, are quite sparse; thus, the degree of practical use of the research can be further improved.

2. Analysis of Core Concepts and Theories of Data Assets

2.1 Definition of Data Assets

Since the digital economy keeps on evolving, the conceptual interpretation of data assets has changed over time as the initial, immature perceptions have been replaced by the standardized and uniform models, the agreement on which was reached in both national and foreign academic communities, as well as the industry associations.

The concept of data assets was defined quite early in other countries, and followed a trend of generalization to specialization, and relevant studies were gradually increasing and improving with time. The concept was first presented by Richard Peters [1], who defined it as financial assets owned by businesses, including government bonds, corporate bonds, and physical bonds, which formed the basis of future studies on the subject. On account of this, Gargano and Raggad [2] pointed out that useful data that can be obtained via data mining may become data assets, which are worth using as a source of making decisions. This model was later improved by Rowley [3], who focused on data assets as merely the data that have been defined, assessed, and controlled strictly, and that have some utility value. Fisher [4] addressed previous constraints by making a close connection between data assets and business processes by explaining that data assets represent the respective systems, applications, and their output files that companies use to create income. The value implications of Bughin et al. [5] went beyond this, as it is seen as a smart asset that could improve the effectiveness of processes and offer new capabilities to products; Liu et al. [6], in a technical sense, added to this by stating that data assets are data that are made up of quintuple arrays that react to changing needs, which adds to the definition dimensions.

The existing domestic literature has also revealed that there are two dominant views concerning the concept of data assets. The first view utilizes the traditional formulation of accounting assets, which considers the data assets as data resources. According to the China Academy of Information and Communications Technology (CAICT), in 2018, the first official definition was given, according to which data assets are data resources owned or controlled by an enterprise with the ability to create economic value in the future and are documented in physical or electronic form;³ This was further developed by Rongsheng Qin [7], who stated that data assets are data resources that an enterprise controls due to past events; Yanying Hou [8] emphasized that data resources should be clearly owned, tradeable, independently identifiable, and dynamically growing so as to be considered as assets.

The second viewpoint, which centers on the fundamental requirements of assetization, describes data assets by means of the critical requirements and inherent properties needed by data, to become an asset. Yangyong Zhu and Yazhen Ye [9] suggest that data assets should meet four core requirements: clear ownership, realizable value, measurable cost, and readability; according to Junrui Zhang et al. [10], based on the principles of accounting, data assets are defined as assets in digital form, identifiable, and non-monetary; three core features of assetization include controllability, quantifiability, and realizability, identified by Dan Ma and Xia Yu [11]; Xianchun Xu et al. [12], referring to the characteristics of factors of production, define data assets as data with a particular application context and can be reused or used over time in the production process during more than one year; On the contrary, Qi Kang et al. [13] point out that a data asset needs to have the property of a data asset and be able to generate value so as to be qualified as a data asset.

³ China Academy of Information and Communications Technology, White Paper on Data Asset Management Practice (Version 3.0), Beijing: CAICT, 2018-12.
<https://www.caict.ac.cn/kxyj/qwfb/bps/201812/P020181214608773379834.pdf>

2.2 Distinguishing Related Concepts

Theoretical studies of the digital economy commonly define the terms data assets, digital assets, and information assets in overlapping fashion. To scientifically differentiate the meanings of the three concepts and demarcate their limits is essential to correctly define the theoretical position of data assets and prevent conceptual confusion, cognitive biases.

2.2.1 Evolution of the Concept of Digital Assets

The academic debate about digital assets started quite early with Helen Meyer introducing it in 1996, and the definition being constantly improved since then [14]. In 2006, Albert Van Niekerk suggested, in terms of digital encoding, that text and media carriers that have been transformed into binary code and given usage rights are all digital assets [15]. The authors Alp Toygar et al. pointed out in 2013 that digital assets are in binary format and owned, and the main idea behind them is the data created and saved on smart devices, digital devices, and in the cloud [16]. In 2017, Rod Genders and Adam Steena stated that every asset that may be accessed and maintained online in digital form could also be incorporated within the digital asset framework [17]. An analysis of the available literature shows that binary form and legal ownership or usage rights are the main features of digital assets.

2.2.2 Core Definition of Information Assets

The idea of information assets could be identified as early as 1977 when Stuart Kaback initiated it on the background of indexing systems [18]. The first ever formal definition of information assets was made in 1994 with the publication of the Holly Report by the KPMG IMPACT project, which defined information assets as data that is recorded or ought to be recorded and has value or potential value [19]. Having developed this fundamental definition, the Gartner IT Glossary elaborated and specified the boundaries of information assets, indicating that they are also a set of tacit knowledge about business processes, different kinds of structured and unstructured data, and information assets outside the company [20]. After that, information became officially recognized as an asset at the regulatory level by the international standard ISO/IEC 27000:2018 (E), which provided that it must be reasonably safeguarded, similar to other valuable assets [21].

2.2.3 Distinguishing Data Assets from Related Concepts

Data assets are not necessarily defined exclusively in terms of their digital nature but rather put more weight on the asset nature of the resources and the worth of production factors. The digital assets have a wider range than the data assets, which are more specialised and have specific accounting features. In comparison with information assets, which are oriented towards the value of content and informational usefulness, data assets are more consistent with the logic of accounting recognition, focusing on the concepts of controllability, measurability, and long-term value in use. These are the fundamental data resources that have acquired the asset status and play a central role in the data resource system.

3. Research on Data Asset Management Systems from a Management Accounting Perspective

The successful introduction of data asset recognition in financial statements depends on the presence of a scientific and holistic data asset management system, and the development of such a system is crucial to meet this requirement and bring about the systematic implementation of data asset recognition based on management accounting viewpoint.

3.1 Representative Framework and Models

The combination of the four main roles of management accounting, which are budgeting, costing, performance, and strategy, has led academics to create a multi-faceted approach to data asset management that in totality can be used to support the essential steps involved in identifying data assets as an asset in financial statements.

According to Yan Wang and Da Yang [22], in light of the fact that data is considered an asset, the management accounting system needs to be reformed to fit into the digital world, which results in formulating a model of a so-called Chinese-style shared value management accounting system. This model also helps

stimulate the vitality of the data factor market, helps transform data into services, and uses management accounting tools to unlock the value of data assets, such as rights clarification and measurement, to increase shared value. It has a very different structure compared to the Western systems because it centers on the concept of shared values, based on the institutional context of China, and utilises national policy support and the benefits of digital infrastructure to attain the simultaneous growth of corporate economic interests and social and environmental values. China Southern Power Grid's practice can be used as a good illustration of the Chinese-style shared value management accounting system. The company has actually attained win-win benefits to both the enterprise and society in the shared value paradigm by taking advantage of its large power big data, well-developed management strategies, and the close integration of business, finance, and data, and the scalability of data assets.

According to Guohe Li et al. [23], there is a three-dimensional architecture that involves organization, governance, and systems platforms that can be effectively integrated into management accounting functions through the clear definition of the division of responsibilities between the dimensions and the enhancement of technical support. A four-stage, eleven-step full-lifecycle system was created by Haisheng Liu et al. [24]. Following the principle of combining business, finance, and data, the system is able to explain the logic of the evolution of data assets and is consistent with the end-to-end control philosophy of management accounting, offering a clear path in the recognition and measurement of data assets in financial statements.

3.2 Practical Implementation and Insights

The management accounting view of a data asset management system is one of the vital protections to be taken into consideration when recognizing data assets in financial statements. To get the interdependence between the management system and the recognition of the data assets in financial statements, enterprises must develop a customized model that takes into account the industrial specificity of the organization. From the point of implementation, state-owned enterprises can use policy benefits to create a system of shared-values, taking full advantage of institutional incentives provided by the state as well as the effectiveness of digital infrastructure to achieve economic, social, and environmental values. On the contrary, non-state-owned enterprises may concentrate on creating value via data operations, enhance the use of management accounting tools, and facilitate the close link between digital strategy and management transformation.

In particular, the research by Yan Wang and Da Yang [22] shows that the assetization of data is an impetus behind a twin revolution in management accounting with a main emphasis on enhancing the application of management accounting systems to manage data assets and improving assessment techniques of data asset values; Weipei Yao [25] also notes that as enterprises move towards more advanced usage of data and product development, the market trade in data assets will be more active, and the procedures, models, and even the procedural mechanisms of their valuation will be a hot issue of research in the future. At the same time, Weipei Yao also notes that compliance, value creation, and marketization constitute the essence of data asset management. The current practice should focus on this core to address the issue of valuation, promote innovation in management accounting tools, provide proper and organized management of data assets, and facilitate the overall growth of data asset recognition in financial statements, and eventually contribute to the establishment of the Chinese independent management accounting system.

4. Accounting for Data Assets and Information Disclosure

4.1 Recognition of Data Assets

With the help of combining the results of the available studies, the paper classifies the recognition criteria of data assets in two broad categories, namely: core basic criteria and additional details criteria.

4.1.1 Core Fundamental Conditions

Academicians have acknowledged that the identification of data assets depends on three main fundamental conditions that are also critical conditions to consider in identifying data assets as assets. The first condition is the controllability of ownership. It is the initial condition of recognizing data assets, where the fundamental condition is that the enterprise has lawful ownership or control over the data resources, and their origin is known. The enterprise may obtain the necessary rights by using legal mechanisms, including licensing

agreements or procurement contracts, and provided that the enterprise has control over the data and can receive all the economic gains associated with it, the recognition requirement is satisfied even with no legal ownership of the data. The second condition is the certainty of benefits. A factor of production, the value of data is its capacity to produce real or potential economic benefits to the enterprise, and the likelihood of such benefits coming true should be relatively high. The third condition is the quantifiability of value. It is a key condition in bringing about data assets into the books of accounts, highlighting that the cost or value of data assets should be measurable and quantifiable in monetary terms. Valuing data assets does pose some challenges, but businesses need to come up with reasonable measurement approaches so that their costs or values can be quantified in a reliable way meeting the minimum criteria of accounting recognition.

4.1.2 Supplementary and Detailed Criteria

Considering the individuality of data assets, the paper examines the current literature and classifies the particular requirements addressed in it as supplementary information not falling within the basic fundamental requirements, as shown below: Mei Luo et al. [26] highlight that data assets should be practical to develop and based on previous transactions or events of an enterprise; Fangli Liu [27] states that data assets should be distinct in comparison with other assets, and able to be identified independently to define the borders of recognition; Rui Wang et al. [28] suggest that the data asset needs to meet both the conditions of ongoing profitability and lawful ownership, i.e., have the ability to create ongoing cash flows using market-related activities and be subject to the control of the enterprise that is law-abiding and compliant; Data assets should have a realization potential, and organizations should come up with value-adding mechanisms to appropriately show how and what chances there are in achieving assumed economic benefits, says Rui Sun [29].

4.2 Valuation Methods for Data Assets

There is an established variety of valuation models that are currently used in academia and industry which fall into three broad categories depending on the differences in valuation logic and technical methods: traditional valuation models and their optimization, theory-based new valuation models as well as valuation models made possible by intelligent technologies.

4.2.1 Traditional Valuation Methods and Their Optimization

The cost method, income method, and market method, which are frequently employed ways of valuing intangible assets traditionally, make up the backbone of data asset valuation. In view of the particularities of data assets, the specialists have done certain specific modifications and improvements to the three approaches. These three methods are also explicitly mentioned as the basic methodologies of data asset valuation by the China Association of Valuation (2019), in its Expert Guidance on Asset Valuation No. 9 - Valuation of Data Assets.

The foundational idea of the cost approach is to ascertain the value of data assets using the expenses made to create them; it mainly comes in two categories, namely, the historical cost approach and the replacement cost approach. The authors, Lin and Wu [30], who were interested in the cost aspect, integrated the purchasing expenses, operational expenditures, and maintenance expenses as well as the deployment conditions of data assets and came up with a data asset valuation model using the Analytic Hierarchy Process (AHP); The authors, Zhigang Zhang et al. [31], used the results of studies on the valuation of intangible assets and added the features of data assets to develop the Analytic Hierarchy Process (AHP) to form an indicator assessment system, thus creating a data asset valuation model that involves both cost and usage factors.

The main idea behind the income approach is to determine the present value of the anticipated future earnings that data assets have the potential to produce. According to Mark Berkman [32], it can be said that the income approach is the best way to evaluate data assets. The fundamental of this approach is to isolate the excess returns of data assets and establish a scientifically credible discount rate. Yuxin Si [33] started out with the business lines that use data assets within Internet companies and chose the incremental income approach as the model of valuation and creatively developed a valuation model to evaluate the value of Internet companies' data assets in terms of income. Fang Chen and Qian Yu [34] considered comprehensively the specific risks related to ambiguity of data asset property rights and data security and separated the discount rate of data assets from the general discount rate of intangible assets. Then, they created a multi-period excess

return model using the residual approach and assessed the value of data assets in companies that are experiencing digital transformation.

The market approach is mostly based on the market transaction prices of comparable data assets, and its main essence is the quantification and allowance of the differences between comparable data and the data to be valued. The market approach was used by Qi Liu et al. [35] to determine the value of data assets considering the critical indicators such as data technical specifications, value density, and data capacity, and developed various specialized adjustment coefficients to improve the valuation outcomes. Yonghong Li and Shuwen Zhang [36] used the Analytic Hierarchy Process (AHP) to derive factor weights in assessing the value of data assets and then used the Grey Correlation Analysis method to derive the correlation coefficients among data assets. They then computed the correlation degree using these weights and chose the most correlated data assets as comparable data assets. Eventually, they estimated the weights of comparable assets using their correlation coefficients based on the market approach and developed a model of valuation of data assets using the market approach.

4.2.2 New Theory-Integrated Valuation Methods

The further development of interdisciplinary studies has seen game theory, real options theory, and so on being slowly combined with the valuation of data assets and overcoming the restrictions imposed by the conventional valuation systems to offer novel perspectives and directions in valuation during complicated situations.

The valuation approaches based on game theory should mainly be viewed as a solution to the information asymmetry of transaction partners, which enables accurate valuation through the examination of strategic interaction among them. Through a review of the characteristics of big data, Li Zhao and Jie Li [37] applied the replacement cost approach and the present value of future cash flows approach to come up with a range of prices of big data assets. Using a bargaining model of big data assets, they used a feedback-driven pricing strategy to facilitate rational pricing of big data assets; Chongrun Wang et al. [38], extended the bargaining model and combined the concepts of game theory, incorporated the idea of the probability of buyer speculation to derive a utility function in case of information asymmetry, and hence evaluated the worth of data assets; Rihui Ouyang and Wei Gong [39] built a game theory-based analytical framework to develop an incentive-compatible data bidding mechanism. Their use of the rules of strategic interaction allowed them to eliminate information asymmetry and differences in valuation across the parties involved in the transaction and led participants to optimize their strategic decisions independently and eventually converge towards a Nash equilibrium, making the value of data assets manifest in the market.

The techniques of valuation that depend on real options theory are one of the important tools that have been developed to meet the peculiarities of the data assets. The relevant studies include: Systematic study of the shortcomings of the Black-Scholes (B-S) model regarding the valuation of the data assets, introduction of fuzzy set theory to address parameter bias in the model, and the development of the fuzzy-enhanced B-S valuation framework were conducted by Yanqing Guo and Peiyuan Sun [40]. The sample of listed internet finance companies was chosen to determine the value of their data assets; Jing Wang and Juan Wang [41] used the Black-Scholes theoretical model along with the Analytic Hierarchy Process (AHP) to develop an evaluation indicator system of the data assets of internet finance companies. They measured the weights of various factors in a scientific manner, calculated the correlation between data assets and the evaluation indicator system with the help of the model, and empirically demonstrated the accuracy of the model in evaluating; Jiaqi Li [42] enhanced the B-S model by integrating the dividend payout ratio and introducing the multi-period excess return approach to build the evaluation portfolio model. The current valuation procedure involved the use of the GM(1,1) fuzzy forecast model to estimate the future excess returns of the company, which reduced the effect of subjective factors. Finally, the total worth of the data assets was obtained using the developed evaluation portfolio model.

4.2.3 Valuation Methods Empowered by Intelligent Technologies

High speed growth of technologies like artificial intelligence and deep learning have introduced completely new technical support of data asset valuation, addressing the drawbacks of conventional valuation approaches when dealing with multidimensional and nonlinear factors of influence and increasing the quality and efficiency of valuation activities. Intelligent technologies have enabled data asset valuation techniques to

develop in many directions: Yuan Ni et al. [43] developed the AGA-BP neural network model to assess the worth of data resources. The model takes into account all the nonlinear relations between various factors that influence the value of data resources. It is able to overcome issues like low convergence of the traditional BP neural network, and consequently enhance the accuracy of value estimation; Chi Zhang [44] examined the factors determining the value of data assets, came up with five feature dimensions of measuring the value of data assets, and created a data asset value analysis model framework on the basis of these feature dimensions, and gave a universal approach to the quantification of data asset value. The study was built using the deep learning technology to calculate the values of feature dimensions and quantify the value of data assets.

4.3 Subsequent Measurement of Data Assets

The scholarly body has created an abundance of research results on follow-up measurement models, amortization and impairment, and treatment of follow-up expenditures, as listed below.

In terms of choosing further measurement models, Rongsheng Qin [7] has suggested that companies are likely to use the historical cost method, whereas the fair value method can be chosen in exceptional cases. The further suggestion made by Jing Cheng [45] is a dual measurement model, whereby the choice of the measurement method depends on the reason why the data asset is kept: the cost model ought to be used when the asset is intended to be kept over a long term but not sold, and the fair value model should be applied where the asset is kept to sell, and it is actively traded. Zehong Li and Xiaoyun Tan [46] indicated that the historical cost method cannot capture the appreciation nature of data assets; with the emergence of data trading markets, the market approach will take the lead in estimating the value of data assets.

The concept of amortization and impairment is key to further measurement. Data assets can be considered particularly time sensitive and therefore should have relatively short service lives. According to Yu Liu [47], the amortization term cannot exceed five years; due to their time-sensitive character, they might be subject to accelerated amortization procedures, including the sum-of-the-years digits approach. Also, in case the future economic benefits can be accurately estimated, economic benefits matching approach might be implemented as well. On the other hand, Xue Zhang et al. [48] divide data assets into two groups depending on the way they are used: assets held by an organization to use and assets held by an organization to trade. Among those in the first category, there are two sub-categories which include assets of finite useful life and assets of infinite useful life. The former need amortization, whereas the latter do not need amortization, but must be tested periodically to determine whether they are impaired; likewise, data assets held to trade are not amortized and only require periodic impairment testing throughout their useful life.

Concerning the handling of the subsequent costs, Xuran Lu [49] divides them into two groups, namely, management costs such as data storage and maintenance which should be expensed, and recognized in the current period profit or loss, whereas costs related to the collection and processing of new data should be capitalized, adding to the carrying amount of the asset. Furthermore, Zehong Li and Xiaoyun Tan [46] discussed the accounting treatment of changes in measurement models and suggested that, based on the model of investment property, a switch between the cost model and the fair value model should be regarded as a change in an accounting policy.

4.4 Disclosure of Information on Data Assets

Disclosing the information about data assets is one of the critical bridges between the treatment of accounting and the decision-making of stakeholders. The current studies in academia tend to recognize that the information disclosure of data assets needs to be done through the development of a diversified system of disclosure which includes both reporting in and supplements to financial statements, as they ensure both standardization and flexibility.

The presentation has been clarified by scholars who have different points of emphasis but are complementary. According to Rongsheng Qin [7], companies may consider creating a new sub-item, namely, Data Assets, in the Non-current Assets category on the balance sheet to provide a comprehensive view of the data asset changes and the data asset holdings at the end of the reporting period. Conversely, Yu Liu [47] claims that the book value of the data assets on the closing date can be disclosed as an item of the "Intangible Assets" line item and at the same time the disclosure can be enhanced in the financial statement notes to resolve the limitations of the one reporting approach. Moreover, Wenyan Nie et al. [50] state that companies must also

create a subsidiary account named Provision for Impairment of Data Assets to represent the impairment of data assets in the holding period, and Jiayu Zeng and Zhigang Zhao [51] suggest that data-driven companies may create another main level account of Data Assets to account for non-data-driven companies' simplification of their reporting in accordance with the principle of materiality.

The disclosures form the backbone of the data asset presentation, and most academic groups tend to believe that the classification and disclosure of data assets should be done according to whether the data asset is recognized in financial statements. On the topic of data assets recorded in financial statements, Wenjing Xiao [52] suggests that three main areas of notes to the financial statements must be addressed: basic information, risk information, and technical information such as the classification of data assets, impairment testing, ownership status, and technical support; Wenyan Nie et al. [50] also indicate that more disclosures are required concerning the source of data asset classification, changes in amortization methodology, and disposal-related information. In the case of unrecognized data resources, Wenjuan Fu and Jinjin Mei [53] advise that their acquisition processes, utilization conditions, and risks should be reported in the management report; whereas Yuanjun Xue and Gang Lu [54] focus on the necessity to provide an in-depth disclosure of their value models and the influences of value change to eliminate the shortcomings of reporting in financial statements.

Moreover, there are other researchers who believe that the single disclosure structure is not enough to indicate the worth of data assets, and there is a need to create a diversified and complementary disclosure mechanism. The increasing relevance of data assets prompted the authors, Junrui Zhang and Yanlin Wei [55], to suggest that the traditional financial statements do not correspond to the non-financial nature of the data assets, and that a fourth statement, which will complement the balance sheet, must be introduced. With regard to the formulation of the fourth statement, Wuxing Tian and Shuangshuang Dai [56] proposed creating it in the form of a Statement of Changes in Key Value Indicators, which would allow enterprises to have a certain level of flexibility in preparation in the transitional period and gradually approach the standardization of reporting forms. In contrast, Xiaoyan Xue [57] pointed out that internet companies must focus on users in their disclosures and report indicators concerning users, products, channels, and social responsibility.

5. The Significance of Recognizing Data Assets in Financial Statements

The overall implementation of the acknowledgment of data assets in financial statements is useful in many aspects, which are essential, and their fundamental value has been confirmed by the available studies of different approaches to the issue, such as the macro perspective of the country, the meso perspective of the industry, and the micro perspective of the enterprise.

Based on the viewpoint of government regulation and the macroeconomic development of the country, Qiang Li [58] discusses macroeconomic policy regulation and claims that financial statement treatment may add new policy space to the central bank, allowing it to use different types of monetary policy instruments in order to control market financial capital and thus influence the flow and direction of data in order to better correspond to the goals of macroeconomic regulation. Fiscal transformation-wise, Zhigang Zhao [59] suggests this treatment can be used to harness the catalytic and empowering effect of accounting to enable local governments to become independent of land-based fiscal income, offering a feasible pathway to the shift towards data-driven fiscal governance. Also, Qinhong Huang and Ting Chen [60] suggest that such treatment has a strong potential to release the value of current state-held public data and corporate-owned data, increase the benefits of public data, reduce government debts, and relieve debt stress through the implementation of data-driven fiscal policies. At the same time, it can activate the dynamism of the data market, attract science and technology innovation-oriented and data-intensive companies to open businesses in the area, adding new impetus to economic growth. On the topic of institutional and mechanism building, Zhiyun Zou [61] states that inclusion in financial statements may be useful to enhance other systems like data rights clarification and price, where the valuation requirements can bring about uniformity in the order of data asset transactions and circulation, whereas its measurement requirements will push the field to do more research and develop measurements of data technologies and encourage cooperation between the industry, academia, and research institutes to create uniform and standardized measures of data.

Xinxin Zhang and Zhixiang Miao [62] take the perspective of the development of an industry and factor markets and state that acknowledging data assets in financial statements can rejuvenate the data resources of the industry, increase the asset base of publishing organizations, diversify the financing options of industry

players, and streamline the process of data resource allocation, eventually making it possible to move towards the digital publishing industry. This is where Yong Wang [63] observes that the act of putting data assets in financial statements can release the highest potential of data as a factor of production, direct the leading companies and internet platform businesses to give examples and encourage the rest, and synchronize the adoption of data assetization, data industrialization, and industrial digitization, which will then promote the transformation and upgrading of the traditional industries. In addition, Zhigang Zhao [59] asserts that encouraging the practice of including data assets in financial statements contributes to the creation of leading data companies and extremely influential data service providers, hence speeding up the process of industrial upgrading. Zhiyun Zou [61] looking at the issue through the eyes of factor allocation and circulation efficiency states that recognizing data assets in financial statements can optimize the distribution of industrial data resources and create the desire to conduct research and development of data across the industry. At the same time, this recognition measures and displays the worth of the data in question; using the data valuation systems, it fills the gap between the participants involved in the industrial chain, directs the effective circulation of the higher quality data resources, and motivates enterprises to integrate and link the upstream and downstream sectors using methods such as mergers and acquisitions, thus increasing the overall efficiency of data utilization within the society as a whole.

On the side of micro-enterprises, according to Zhigang Zhao [59], financial statement recognition is not just the optimizer of the financial statements of data-driven and data-resource-based enterprises and the booster of the corporate valuations but also supports the overall improvement of the corporate awareness of data asset management and contributes to the perfection of the suitable systems and mechanisms of financial statement recognition. Similarly, Yuanfei Ni [64] also highlights, concerning the value of corporate assets, that financial statement recognition may increase the amount of a company's book assets and optimize the structure of its assets, which subsequently reinforces the company's base and increases its value and financing potential. In addition, Jingshan Qu et al. [65] also hold the financial accounting view that financial statements recognition will prompt the process of optimizing the standards of recognizing corporate data assets, measurement techniques, and disclosure of information in financial statements, enrich the aspects of financial analysis, and assist in the perfection of the financial analysis framework. As to data governance and business decision-making, Jinlin Li [66] believes that data assets could be added to financial statements to enhance data accuracy and dependability, offer reliable support to business decision-making, enable businesses to release the commercial value of data, and extend their competitive edge in the market. Simultaneously, this would help create corporate value and encourage innovation. Looking at the digital transformation, Yuanfei Ni also observes that putting the data assets in financial statements enables the enhancement of a company's capability to manage and apply data information, guarantees the authenticity of data assets, and thus facilitates the steady implementation of corporate digital transformation.

The presence of such value relationships in various entities, industries, and levels has obviously turned out to be the main point of concern among academia and practitioners because these value relationships have been found to exist among different entities, industries, and levels.

6. Research Conclusions and Outlook

6.1 Research Conclusions

The paper initially explicitly states the main concepts and their associated connotations of data assets and subsequently reviews the existing literature on the topic by both domestic and international researchers in fields like the identification and quantification of data assets, valuation, asset management, information disclosures, among others. The research includes all the core elements like the primary theory of data assets, accounting approach, valuation approaches, management systems, and practical value, and can serve as useful sources of references and information about data assets that could be explored academically or practically. However, despite the current research, there are many gaps in these domains that should be filled in the future by conducting more detailed research.

6.2 Future Research Directions

Considering the modern situation of the high-quality development of the digital economy, the market-oriented distribution of data as a production factor, and the move of data assets to financial statements into a stage of uniform execution, and filling in the gaps of the current research and shortcomings in fields like ownership delineation, accounting measurement and amortization/impairment, the creation of information disclosure systems, and their implementation, there is potential scope for conducting future studies from the dimensions of theoretical perfection, methodological improvement, and practical application, among other dimensions.

To begin with, it is necessary to improve the theoretical base and practice of defining ownership. Later, researchers may perform theoretical modeling and analysis of several cases in relation to the concept of data asset ownership and carefully consider the rationale underlying the allocation of data rights and interests across various stakeholders as well as derive practical and measurable principles of determining data asset ownership and dispute resolution mechanisms through empirical studies and case studies of typical situations which will theoretically justify the accounting recognition and practical implementation of data assets.

In the second place, optimize industry segmentation and practical suitability of the accounting measurement system. In the next few years, researchers have an opportunity to perform comparative research and empirical analysis of the accounting measurement of data assets across industries. Based on the operational features and value change trends particular to data assets in different industries, they may come up with specialized measurement frameworks, amortisation strategies, and conceptual frameworks of impairment testing and ensure the high level of integration and tight fit between accounting theory and industry practice by means of extensive empirical research and detailed case studies.

Thirdly, enhance the uniformity in the information disclosure process and the ancillary reporting structure. Scholars may also consider undertaking systematic theoretical and empirical investigations that will be devoted to the weaknesses of the information disclosure of data assets. First of all, further investigate the standardization of data asset information disclosure, especially the data asset risk information, valuation models and parameters, and non-financial value indicators. Perform normative analysis, empirical testing, and cross-case comparative studies to create a unified and comparable set of disclosure rules and an indicator system. Secondly, develop the theoretical background and statistical studies of the so-called fourth financial statement. Make theoretical research into its framework design, indicator building, and preparation logic and perform empirical testing and case analysis based on multiple industry data to develop the verifiable and generalizable academic research framework. Third time, enhance the study of the interrelations and logical connections between financial statements. Theoretical modeling, empirical investigation, and mechanism testing should focus on the internal connection between the book value of data assets and non-financial indicators to create a scientific and rigorous system of interrelationships and value verification mechanisms.

In conclusion, the attempt should be made to develop empirical testing and optimization of the data asset management system structure. Future researchers can do comparative research and quantitative research that focuses on the flexibility of the data asset management system framework. Depending on the operational features of various application situations and various stakeholders, it is possible to create a systematic performance evaluation system and an optimization paradigm of the framework. Using both large-sample-based analysis and multidimensional case studies, the limits of applicability and benefits of various management systems could be elucidated, which would help in filling the research gap of current theoretical frameworks, which are not practically verified.

References

- [1] Peterson, R. E. (1974). A cross section study of the demand for money: The United States, 1960–62. *The Journal of Finance*, 29 (1), 73–88. <https://doi.org/10.1111/j.1540-6261.1974.tb00025.x>.
- [2] Gargano, M. L., & Raggad, B. G. (1999). Data mining—a powerful information creating tool. *OCLC Systems & Services: International Digital Library Perspectives*, 15 (2), 81–90. <https://doi.org/10.1108/10650759910276381>.

- [3] Rowley, J. E. (2007). The wisdom hierarchy: Representations of the DIKW hierarchy. *Journal of Information Science*, 33 (2), 163–180. <https://doi.org/10.1177/0165551506070706>.
- [4] Fisher, T., & Booksx, I. (2009). The data asset: How smart companies govern their data for business success. Wiley Publishing. <https://doi.org/10.1002/9781119204282>.
- [5] Bughin, J., Chui, M., & Manyika, J. (2010). Clouds, big data, and smart assets: Ten tech-enabled business trends to watch. *McKinsey Quarterly*, (4), 26–43.
- [6] Liu, X., Jiang, Y., & Pan, L. (2018). Application of data assets. In 2018 2nd IEEE Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC) (pp. 2414–2418). IEEE. <https://doi.org/10.1109/IMCEC.2018.8469446>.
- [7] Rongsheng Qin. Identification, Measurement and Report of Enterprise Data Assets. *Accounting and Economics Research*, 34 (6), 3-10. <https://doi.org/10.16314/j.cnki.31-2074/f.2020.06.001>.
- [8] Yanying Hou. (2021). Accounting Recognition of Data Assets and Market-oriented Allocation of Production Factors.. *Friends of Accounting*, (17), 2-8.
- [9] Yangyong Zhu, Yazhen Ye. (2018). Defining data assets based on the attributes of data. *Big Data Research*, 4 (6), 65-76.
- [10] Junrui Zhang, Yanlin Wei, and Xiaoyue Song. (2020). Research on the Accounting Treatment and Information Presentation of Enterprise's Data Asset. *Accounting and Economics Research*, 34 (3), 3-15. <https://doi.org/10.16314/j.cnki.31-2074/f.2020.03.001>.
- [11] Dan Ma, Xia Yu. (2020). Data Assets: Concept Evolution and Accounting Method. *Journal of Statistics*, 1 (2), 15-24. <https://doi.org/10.19820/j.cnki.issn2096-7411.2020.02.002>.
- [12] Xianchun Xu, Zhongwen Zhang, Yaru Hu, (2022). Research on Deriving Measures of Data Assets in National Accounts. *Journal of Management World*, 38 (2), 16-30+2. <https://doi.org/10.19744/j.cnki.11-1235/f.2022.0030>.
- [13] Qi Kang, Yong Han, Wenjing Chen, et al,. (2015). Big Data Capitalization. *Information and Communications Technologies*, 9 (6), 29-35.
- [14] Meyer, H. (1996). Tips for safeguarding your digital assets. *Computers & Security*, 15(7), 588. [https://doi.org/10.1016/S0167-4048\(97\)88123-0](https://doi.org/10.1016/S0167-4048(97)88123-0).
- [15] Niekerk, A. V. (2006). A methodological approach to modern digital asset management: an empirical study. Allied Academies Annual Congress.
- [16] Toygar, A., Rohm, C. E. T., Jr., & Zhu, J. (2013). A new asset type: Digital assets. *Journal of International Technology and Information Management*, 22 (4), Article 7. <https://doi.org/10.58729/1941-6679.1024>.
- [17] Genders, R. & Steen, A. (2024). Financial and Estate Planning in the Age of Digital Assets: A Challenge for Advisors and Administrators. *Financial Planning Research Journal*, 3(1), 75-80. <https://doi.org/10.2478/fprj-2017-0005>.
- [18] Kaback, S.M. (1977). A User's Experience with the Derwent Patent Files. *J. Chem. Inf. Comput. Sci.*, 17, 143-148. <https://doi.org/10.1021/ci60011a009>.
- [19] KPMG/IMPACT Group. (1994). Information as an asset: The board agenda. <https://core.ac.uk/outputs/40778462/>.
- [20] Oppenheim, C. (1998). Valuing information assets in British companies. *Business Information Review*, 15(4), 209–214. <https://doi.org/10.1177/0266382984236920>.
- [21] International Organization for Standardization. (2018). Information technology Security techniques- Information security management systems-overview and vocabulary (ISO/IEC 27000:2018). ISO. <https://www.iso.org/standard/73906.html>.
- [22] Yan, Wang., & Da Yang. (2024). China's unique path to management accounting system change: Transforming data elements into data assets. *Journal of Management World*, 40(10), 171–189. <https://doi.org/10.19744/j.cnki.11-1235/f.2024.0111>.

- [23] Guohe Li, Zheng Feng, Zhuoyong Wang, et al. (2019). Practical exploration on the construction of data asset management system. *Telecommunications Science*, 35 (2), 105–112. <https://doi.org/10.11959/j.issn.1000-0801.2019039>.
- [24] Haisheng Liu, Jun Wang, & Lan Huang. (2024). Data asset management: Evolutionary logic and system framework. *Friends of Accounting*, (21), 147–154.
- [25] Weipei Yao. (2023). Data asset management trends. *Communication Enterprise Management*, (12), 58–59.
- [26] Mei Luo, Jinpu Li, & Ke Tang. (2023). *Journal of Tsinghua University (Philosophy and Social Sciences)*, 38 (5), 195–209+226. <https://doi.org/10.13613/j.cnki.qhdz.003290>.
- [27] Fangli Liu. (2024). Research on Accounting Recognition and Measurement Issues of Data Assets. *Business Observation*, 10(6), 33–36.
- [28] Rui Wang, & Kaiping Liu. (2025). A study on the recognition and measurement issues of data assets in accounting. *Dual Use Technologies & Products*, (5), 46–52. <https://doi.org/10.19385/j.cnki.1009-8119.2025.05.009>.
- [29] Rui Sun. (2026). Research on Accounting Recognition of Enterprise Data Assets in the Digital Intelligence Era. *Chinese Township Enterprises Accounting*, (4), 31–33.
- [30] Lin, Z., & Wu, Y. (2016). Research on the method of evaluating the value of data assets. In *Proceedings of the 2016 International Conference on Education, E-learning and Management Technology*. Atlantis Press, 488–492. <https://doi.org/10.2991/iceemt-16.2016.95>
- [31] Zhigang Zhang, Dongshu Yang, & Hongxia Wu. (2015). Research on the model and application of data asset value evaluation. *Modern Electronics Technique*, 38(20), 44–47+51. <https://doi.org/10.16652/j.issn.1004-373x.2015.20.044>.
- [32] Berkman, M. (2002). Valuing intellectual property assets for licensing transactions. *Licensing Journal*, 28(4), 16.
- [33] Yuxin Si. (2019). Research on the valuation model of data asset value in internet enterprises [Master's thesis, Capital University of Economics and Business]. <https://doi.org/10.27338/d.cnki.gsjmu.2019.000946>.
- [34] Fang Chen, & Qian Yu. (2021). Construction of data asset value evaluation model: Based on multi-period excess return method. *Finance and Accounting Monthly*, (23), 21–27. <https://doi.org/10.19641/j.cnki.42-1290/f.2021.23.003>.
- [35] Qi Liu, Yang Tong, Yongchang Wei, & Fangyu Chen. (2016). Application of market approach in big data asset valuation. *Appraisal Journal of China*, (11), 33–37.
- [36] Yonghong Li, & Shuwen Zhang. (2018). Construction of data asset value evaluation model. *Finance and Accounting Monthly*, (9), 30–35. <https://doi.org/10.19641/j.cnki.42-1290/f.2018.09.005>.
- [37] Li Zhao, & Jie Li. (2020). The pricing research of big data asset: Analyzed based on the bargaining model. *Price: Theory & Practice*, (8), 124–127+178. <https://doi.org/10.19851/j.cnki.cn11-1010/f.2020.08.325>.
- [38] Chongrun Wang, Wenjing Wang, & Dongnuan Zhao. (2023). Research on big data asset pricing based on the bargaining model. *Friends of Accounting*, (6), 20–29.
- [39] Rihui Ouyang, & Wei Gong. (2022). Data element pricing mechanism based on value and market evaluation contribution. *Reform*, (3), 39–54.
- [40] Yanqing Guo, & Peiyuan Sun. (2022). Research on data asset evaluation of internet enterprises based on real option theory. *Journal of Business Research*, 29(1), 77–84.
- [41] Jing Wang & Juan Wang. (2019). Research on value evaluation of data assets of internet financial enterprises—Based on B-S theoretical model. *Journal of Technical Economics & Management*, (7), 73–78.

- [42] Jiaqi Li. (2023). Research on the value assessment of data assets in IoT enterprises based on improved income approach [Master's thesis, Liaoning University]. <https://doi.org/10.27209/d.cnki.glniu.2023.001683>.
- [43] Yuan Ni, Zifeng Li, & Jian Zhang. (2020). Research on data resources value assessment model based on AGA-BP neural network in the background of network platform transaction. *Information Studies: Theory & Application*, 43(1), 135–142. <https://doi.org/10.16353/j.cnki.1000-7490.2020.01.020>.
- [44] Chi Zhang. (2018). Research on data asset value analysis model and transaction system [Doctoral dissertation, Beijing Jiaotong University].
- [45] Jing Cheng. (2022). Exploration on accounting recognition and measurement of data assets in the era of digital economy. *Journal of Anhui Business and Technology College*, 21(1), 44–47. <https://doi.org/10.13685/j.cnki.abc.000614>.
- [46] Zehong Li & Xiaoyun Tan. (2018). Accounting recognition, measurement and reporting of big data assets. *Finance & Accounting Newsletter*, (10), 58–59+129. <https://doi.org/10.16144/j.cnki.issn1002-8072.2018.10.015>.
- [47] Yu Liu. (2014). A brief discussion on the recognition and measurement of big data assets. *Commercial Accounting*, (18), 3–4.
- [48] Xue Zhang, Yiqi Liu, & Wuqing Wu. (2022). Research on accounting measurement of data assets: Taking big data enterprises as an example. *Finance & Accounting Newsletter*, (19), 10–14+20. <https://doi.org/10.16144/j.cnki.issn1002-8072.2022.19.024>.
- [49] Xuran Lu. (2019). Discussion on measurement issues of big data assets. *Finance & Accounting Newsletter*, (10), 59–63. <https://doi.org/10.16144/j.cnki.issn1002-8072.2019.10.013>.
- [50] Wenyan Nie, Yajing Yue, & Li Yao. (2024). Recognition, measurement and reporting of data assets: From theory to practice. *Commercial Accounting*, (11), 32–36.
- [51] Jiayu Zeng & Zhigang Zhao. (2023). Progress and prospect of research on accounting standards for data assets. *The Chinese Certified Public Accountant*, (12), 67–73. <https://doi.org/10.16292/j.cnki.issn1009-6345.2023.12.004>.
- [52] Wenjing Xiao. (2023). Research on accounting treatment and disclosure of data assets in internet enterprises. *Commercial Accounting*, (4), 73–76.
- [53] Wenjuan Fu & Jinjin Mei. (2022). Research on financial accounting of data assets. *Finance and Accounting*, (8), 46–50.
- [54] Yuanjun Xue & Gang Lu. (2025). Research on the recognition, measurement and disclosure of data assets. *Business Observation*, 11(5), 33–37.
- [55] Junrui Zhang & Yanlin Wei. (2021). Data asset accounting: Concept analysis and financial statement presentation. *Finance and Accounting Monthly*, (23), 13–20. <https://doi.org/10.19641/j.cnki.42-1290/f.2021.23.002>.
- [56] Wuxing Tian & Shuangshuang Dai. (2018). On the enterprise's "fourth statement" in the context of the internet economy. *Friends of Accounting*, (13), 122–124.
- [57] Xiaoyan Xue. (2024). Research on optimization of data asset information disclosure in internet enterprises [Master's thesis, Lanzhou University of Finance and Economics]. <https://doi.org/10.27732/d.cnki.gnzsx.2024.000433>.
- [58] Qiang Li. (2024). Development Trends of Data Asset Recognition in Financial Statements. *China Finance*, (14), 22–24.
- [59] Zhigang Zhao. (2024). Strategic significance, problems and suggestions of data assets entering financial statements. *Friends of Accounting*, (3), 2–6.
- [60] Qinrong Huang & Ting Chen. (2024). Practice and challenges of data asset valorization and financial statements entry. *Communications World*, (13), 18–21. <https://doi.org/10.13571/j.cnki.cww.2024.13.005>.

- [61] Zhiyun Zou. (2025). Using the Inclusion of Data Assets in Financial Statements as an Opportunity to Accelerate the Process of Data as a Factor of Production. *Industry, Information Technology, Finance and Economics*, (1), 70–77.
- [62] Xinxin Zhang & Zhixiang Miao. (2024). Publishing Data Asset Entry: Connotation, Realistic Challenges and Path Exploration. *Digital Publishing Research*, 3(4), 38–48.
- [63] Yong Wang. (2024). Significance, Problems and Countermeasures of Enterprise Data Asset Recognition in Financial Statements. *Shandong State-owned Assets*, (9), 22–24.
- [64] Yuanfei Ni. (2024). Analysis of Difficulties and Optimization Strategies in the Recognition of Data Assets in Financial Statements. *Investment and Entrepreneurship*, 35(22), 86–88.
- [65] Jingshan Qu, Nan Zhao, & Zimeng Guo. (2025). Research on the Impact of Data Asset Financial Statements Recognition on Corporate Financial Accounting. *Time-honored Brand Marketing*, (9), 181–183.
- [66] Jinlin Li. (2024). A Brief Analysis of the Impact of Data Asset Financial Statements Recognition on Unlocking the Value of Enterprise Data Resources. *Enterprise Reform and Management*, (1), 148–150. <https://doi.org/10.13768/j.cnki.cn11-3793/f.2024.0011>.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).