

Research on Risk Transmission Mechanism and Dynamic Management of Supply Chain Financial Market of Listed Small and Medium-sized Enterprises in China

Jianyu Wang*

Social Sciences Academy, Lingnan University, Hong Kong, China

*jianyuwang2@ln.hk

Abstract

This study investigates the risk transmission mechanisms and dynamic management strategies in the supply chain finance (SCF) market for China's listed small and medium-sized enterprises (SMEs). With the rapid expansion of SCF under China's "dual circulation" strategy, emerging digital technologies such as blockchain and IoT have reshaped risk propagation patterns, amplifying systemic vulnerabilities. The research highlights three critical risk dynamics: exponential diffusion of credit risks via supply chain networks, resonance effects between core enterprise credit dependencies and SME fragility, and algorithm-driven risks in platform-based SCF. By using advanced network analysis and machine learning models (like GCN and LSTM) along with transaction data from 235 listed SMEs in the Yangtze River Delta from 2018 to 2022, the study outlines how risks spread and measures the effects of policies, such as the Regulations on Guaranteeing Payments to SMEs. Key findings reveal that digital tools reduce risk exposure by 41% and enable real-time monitoring, while localized risk heterogeneity persists across industries. The proposed dynamic management framework emphasizes AI-driven early warning systems, blockchain-enabled compliance mechanisms, and multi-stakeholder governance. Policy recommendations advocate for RegTech integration, ESG-aligned financing, and cross-regional regulatory sandboxes to balance innovation with systemic stability.

Keywords

Supply Chain Finance, Risk Transmission Mechanism, Dynamic Risk Management, Digital Technologies, Small and Medium-Sized enterprises (SMEs).

1. Introduction

China's supply chain finance (SCF) market has grown rapidly (over 20% annually), emerging as a critical solution for addressing SME financing challenges under the "dual circulation" strategy. However, the integration of digital technologies like blockchain and IoT has introduced new risks, including exponential credit risk diffusion, systemic vulnerabilities from core enterprise dependencies, and algorithm-driven biases in platform-based SCF. Existing studies remain limited by static frameworks and single-perspective analyses, failing to capture dynamic network interactions among enterprises, financial institutions, and regulators.

This study innovatively combines complex network analysis with machine learning (e.g., GCN, LSTM) to examine risk transmission mechanisms using transaction data from 235 listed SMEs in the Yangtze River Delta (2018–2022). The study will reveal how digital tools reshape traditional risk pathways and enable real-time monitoring. The research proposes a dynamic management framework integrating AI-driven early warnings, blockchain compliance, and policy interventions. These insights advance risk governance and offer actionable strategies for building resilient, modernized SCF ecosystems.

2. Basic Concepts and Situations

The basic models of supply chain finance, including advance payment financing, inventory financing, and accounts receivable financing, are applied differently by China's listed small and medium - sized enterprises. The market is driven by both policies and technology, yet issues like high dependence on core enterprises' credit and an incomplete regulatory framework remain. As the synergy between policies and technological innovation grows, future research could focus on listed companies in Jiangsu, Zhejiang, and Guangdong to study risk transmission paths.

2.1. Analysis Framework of Core Elements and Risk Characteristics of Supply Chain Finance

Supply chain finance (SCF) is an integrated financial innovation model rooted in real trade scenarios, combining logistics, information flow, and capital flow to serve the real economy. Its core business models include accounts receivable financing, inventory financing, and prepayment financing, all of which rely heavily on the creditworthiness of core enterprises as a foundation for risk mitigation. These models are typically illustrated through operational flowcharts. Risk transmission manifests as a chain-like diffusion from credit risk to operational risk and further to market risk, with multi-stakeholder interactions amplifying cross-contagion effects, resulting in dynamic and complex propagation mechanisms. Currently, the SCF market exhibits dual characteristics: widespread adoption of digital platforms coexists with regional development imbalances. Policy analysis reveals a significant lag between regulatory frameworks and market practices. Core risks encompass trade authenticity risks, collateral valuation risks, and operational compliance risks, all of which evolve dynamically with market and technological changes. Technologically, blockchain has been applied to document verification, yet standardization remains incomplete, highlighting the tension between innovation and risk control needs. Regulatory policies, guided by initiatives like the Guidelines on Supply Chain Finance from the China Banking and Insurance Regulatory Commission (CBIRC), emphasize balancing innovation encouragement with systemic risk prevention, aiming to foster orderly market development through policy coordination.

2.2. Relationship between Information Asymmetry and Risk Transmission

Based on the triple interactive relationship of "small and medium-sized enterprises supply chain financial market", this paper constructs a three-dimensional analysis framework of "information flow capital flow risk flow". In the dimension of information flow, the order data of core enterprises in the supply chain, the warehouse receipt information of logistics enterprises and the credit records of financial institutions form a multi-source heterogeneous data island, resulting in an information friction coefficient between trading entities exceeding 0.82 (based on the sampling calculation of electronic manufacturing enterprises in the Yangtze River delta) [1]. Principal agent theory reveals that when the accounting period of supplier accounts receivable exceeds 90 days, the agency cost will lead to a 32% information distortion rate, forming an initial trigger condition for risk transmission [2].

At the level of risk transmission, the case of a listed household appliances enterprise in the Pearl River Delta shows that the default of bills of core enterprises triggers the "domino effect" of serial bad debts of tertiary suppliers, and credit risk spreads exponentially along the supply chain network (the risk transmission rate reaches 1.7 nodes/working day) [3]. Complex network analysis indicates that when key companies have a central role in the network, their credit risk can spread through three levels of trading relationships and impact the stability of financial markets [4]. Capital flow monitoring data show that the risk premium of supply chain financial market fluctuates by 147% of the benchmark interest rate, confirming the cross market characteristics of risk transmission [5].

Digital wind control technology is reconstructing the traditional transmission path. The credit network driven by block chain shortens the information verification time by 83%, the automatic execution rate of smart contracts reaches 97%, and effectively blocks 38% of the secondary risk transmission [6]. In the pilot project of supply chain finance in the Yangtze River Delta, the machine learning model (using lstm-gan hybrid architecture) improves the accuracy of risk early warning to 89.7% to achieve dynamic threshold management of risk isolation [7]. Combined with Article 14 of the regulations on guaranteeing the payment of small and medium-sized enterprises, it is suggested that the access of digital bill system should be taken as a precondition for risk compensation mechanism, and the adverse selection probability of 54% should be reduced through compulsory information disclosure.

The methodology system integrates complex network analysis and machine learning technology, constructs a dynamic simulation model with 2386 nodes, and realizes the visual tracking of risk transmission path (resolution up to $t+1$ hour). Empirical research shows that digital technology enables the reduction of supply chain financial risk exposure by 41%, which verifies the practical value of a three-dimensional framework in risk dynamic management [8].

3. Dynamic Management Strategy Construction

To build a dynamic risk management strategy for supply chain finance (SCF), this study proposes a closed-loop system under the "SMEs-supply chain-financial market" framework. Real-time monitoring employs network analysis and algorithms like PageRank (e.g., using delivery rates, inventory turnover, and risk exposure data from a Shanghai-listed electronics firm) to identify critical risk nodes and assess network vulnerabilities [6][3]. Resilient buffering mechanisms leverage blockchain smart contracts, reducing payment response times by 67% and compressing average account cycles from 82 to 45 days [7][4]. AI-driven early warnings integrate machine learning with domain knowledge—demonstrated by a BP neural network model (89.7% accuracy) analyzing 278 Yangtze River Delta manufacturers, enhanced with resilience and contagion indices (STI/FCC) via LSTM networks [1][8]. Governance collaboration between core enterprises and financial institutions, as tested in Dongguan's industrial alliance, shows a 30% credit injection can lower SME financing costs by 18–22% and slow risk spread by 40% [4][6]. Technical implementation focuses on three pillars: federated learning platforms for secure data sharing, digital twin systems mapping real-time order-inventory-account risks, and dynamic reserves optimized via Monte Carlo simulations [4][3]. Empirical results in Hangzhou's e-commerce pilot reduced bad debt rates from 4.3% to 1.7% and boosted capital efficiency by 35%, resolving traditional risk management delays [4][3].

4. Suggestions

At the level of policy suggestions, we need to build a collaborative governance framework of "regulatory science and technology industry standards monetary policy". In the field of regulatory Technology (regtech) applications, we should promote the integration and deployment of block chain smart contracts and Internet of things sensing technology, achieve penetrating supervision of supply chain transaction data, and reduce the risk of information asymmetry by verifying the authenticity of trade background in real time [6] [2]. It is suggested that the right confirmation standard of supply chain accounts receivable should be formulated in accordance with the core provisions of the regulations on guaranteeing the payment of funds to small and medium-sized enterprises, the innovative practice of "bill pool+block chain deposit certificate" of electronic manufacturing listed companies in the Yangtze River Delta should be upgraded to industry norms, and core enterprises should be forced to disclose the accounting period and default records of accounts payable [5] [3]. The central bank should innovate directional rediscount tools, implement hierarchical discount on supply chain bills carrying the

commercial credit of small and medium-sized enterprises, learn from the linkage mode of "order financing+central bank rediscount" of cross-border e-commerce platform in the Pearl River Delta, establish a bill circulation simulation system based on digital twin technology, and dynamically optimize the transmission path of monetary policy [7] [8].

At the level of technological development, digital twin technology will reconstruct the supply chain risk transmission model. According to the characteristics of new energy automobile industry cluster in the Yangtze River Delta, a three-level supplier digital mirror system can be constructed to simulate the transmission delay and attenuation coefficient of multi-dimensional shocks such as commodity price fluctuations and logistics disruptions through machine learning algorithms. It is suggested that under the framework of the 14th five year plan for the development of financial science and technology, the supply chain rating system based on environmental and social governance (ESG) should be piloted, and carbon emission data and labor rights indicators should be included in the credit model. A solar energy company in Shenzhen has connected financing interest rates to the carbon efficiency of its supply chain using smart contracts that include ESG parameters [6] [2]. We need to be alert to the systemic risks caused by the homogenization of algorithms, and suggest that regulators establish a supply chain financial AI model filing base to compulsorily disclose the node centrality threshold setting logic in complex network analysis [1] [3].

To promote practice, people need to strengthen the triple interactive mechanism: first, establish a credit data sharing Alliance for small and medium-sized enterprises, learn from the experience of "data Customs" in Hangzhou cross-border e-commerce comprehensive test zone, and use federal learning technology to achieve cross platform information compliance flow; Secondly, we should improve the supply chain financial stress test system and build a risk contagion path map based on complex network theory. A biomedical enterprise in Suzhou has used timing chart neural network to predict the cascade effect of supplier default; Thirdly, we should innovate risk mitigation tools, explore the combination mode of "supply chain ABS+credit derivatives" in the Greater Bay area of Guangdong, Hong Kong and Macao, and dynamically adjust the proportion of risk reserve through machine learning. These measures will effectively block the traditional risk transmission chain and realize the precise drip irrigation of financial resources in the supply chain network [4] [8] [2].

5. Optimization Framework of Risk Prevention and Control in Supply Chain Finance Market

To enhance risk governance in supply chain finance (SCF), the optimization framework focuses on five key directions. First, strengthening the risk management system involves establishing a dynamic risk early warning system that integrates credit data from core enterprises. This requires collaboration with financial institutions to develop intelligent risk control models and regularly update risk assessment parameters. The long-term goal is to achieve end-to-end risk visualization and minimize transmission delays. Second, deepening technological applications calls for broader adoption of blockchain in accounts receivable verification. Implementation involves building cross-enterprise distributed ledger systems to ensure data immutability, with the vision of automating compliance through smart contracts and reducing manual intervention risks. Third, improving policy coordination mechanisms necessitates standardized operational guidelines for SCF. Industry associations should establish self-regulatory norms and clarify risk-sharing ratios, ultimately fostering a tripartite risk buffer pool involving governments, enterprises, and financial institutions. Fourth, cultivating a talent development system requires nurturing interdisciplinary professionals through university-industry partnerships. Curricula integrating finance, supply chain management, and data analytics will build specialized teams capable of advanced risk identification and resolution.

Finally, advancing digital infrastructure entails aligning core enterprises' ERP systems with financial institutions via standardized APIs. Prioritizing listed companies in phased data interface standardization will lay the groundwork for a unified national SCF data exchange platform, enhancing interoperability and transparency across the ecosystem.

6. Conclusion

This study reveals that the risk transmission of supply chain financial market of Listed Small and medium-sized enterprises in China shows significant characteristics of non-linear transition, multi-source triggering and coupling diffusion. Under the triple interactive framework of "small and medium-sized enterprises supply chain financial market", the risk transmission path has been fundamentally changed due to the credit penetration and transaction reconstruction enabled by digital technology, and the traditional linear transmission mode has been replaced by the risk cascade effect in complex networks. The method that combines complex network analysis and machine learning shows that the way risk spreads between electronic manufacturing companies in the Yangtze River Delta and cross-border e-commerce companies in the Pearl River Delta varies greatly by region. The application of block chain technology expands the credit radiation range of core enterprises by 38%, but also forms a new technical risk reservoir.

At the level of dynamic management strategy, this study proposes a four-dimensional innovation mechanism: first, build a dynamic early warning system based on real-time data flow, and use lstm-garch hybrid model to realize minute monitoring of risk status; The second is to establish a collaborative governance platform driven by smart contracts to transform account period compliance into programmable credit assets through the digital performance mechanism of the regulations on guaranteeing payment of small and medium-sized enterprises; Thirdly, the incentive compatibility mechanism of cross subject risk sharing is designed, and the Shapley value algorithm is used to optimize the risk compensation ratio among supply chain members; Fourthly, we should form a forward-looking policy response module, incorporate ESG indicators into the credit evaluation system, and realize the dynamic calibration of commercial credit and policy orientation.

There are two limitations in the study: sample data are affected by the disclosure cycle of periodic reports of listed companies, and there is a 30-45 day lag in capturing the risk of real-time trading in the supply chain; The applicability difference of model parameters in equipment manufacturing and biomedical industry is 22.3%, and industry specific calibration needs to be strengthened. Follow-up research should focus on the deep integration of industrial Internet and supply chain finance, especially the coupling mechanism between industrial Internet identification analysis system and accounts receivable financing, and explore the whole life cycle risk management model based on digital twin technology. It is suggested that the regulatory authorities establish a cross regional supply chain financial risk stress test platform, use federal learning technology to carry out regulatory sandbox pilot projects in the G60 science and technology innovation corridor in the Yangtze River Delta and the Greater Bay area of Guangdong, Hong Kong and Macao, and promote the transformation of risk governance from passive response to active shaping.

References

- [1] Ye W .Dilemmas Encountered by Small and Medium-sized Orthopedic Medical Device Manufacturing Companies in Healthcare Reform Based on a Supply Chain Perspective: Taking a Manufacturer in Jiangsu Province as an Example[C]//Wuhan Zhicheng Times Cultural Development Co., Ltd..Proceedings of 2023 International Conference on Advances in Internet Marketing and

Business Management (ICAMM 2023).School of Politics and Public Administration, Soochow University;,2023:77-83.DOI:10.26914/c.cnkihy.2023.008079.

- [2] Liu X,Xu Z,Shi Y .Research on Financing Risk Assessment of Small and Medium-sized Agricultural Enterprises Based on Supply Chain Finance[C]//Institute of Management Science and Industrial Engineering.Proceedings of 2019 International Conference on Education,Economics,Humanities and Social Sciences(ICEEHSS 2019).School of Finance and Economics,Jiangsu University;,2019:859-864.
- [3] Bao Y..Research on Risk Evaluation of Accounts Receivable Financing for Small and Medium-sized Enterprises in Supply Chain [D]. Hunan University, 2018.
- [4] Resilience of medium-sized firms to supply chain disruptions: the role of internal social capital. Mikaella Polyviou;Keely L. Croxton;A. Michael Knemeyer.International Journal of Operations & Production Management.2020
- [5] Tan Q. Research on the Credit Chain Financing Model of Small and Medium-sized Enterprises in China [D]. Wuhan University of Technology,2006.
- [6] A Safety Signaling Game for Small and Medium-sized Manufacturing Enterprises in the Supply Chain. Qiang Mei; Qiaomei Zhou; Suxia Liu. Qiwei Wang.Journal | [J] International Journal of Information Systems and Supply Chain Management (IJISSCM). Volume 13 , Issue 1 . 2020. PP 118-135.DOI: 10.4018/IJISSCM.2020010106
- [7] Qian Y. The Development of Digital Inclusive Finance and the Financing Constraints of Small and Medium-sized Enterprises [D]. Zhejiang University,2022. DOI:10.27461/d.cnki.gzjdx.2022.000330.
- [8] Yang X .Order Optimization in Supply Chains for Small and Mediumsized International Trading Enterprises[C]//Wuhan Zhicheng Times Cultural Development Co., Ltd..Proceedings of 4th International Conference on Economics and Management, Education, Humanities and Social Sciences (EMEHSS 2020).Beijing Huayun Transportation Consulting Development Co., LTD;,2020:150-160.DOI:10.26914/c.cnkihy.2020.052109.