

Review

# A Review of Research on Blockchain Empowered Supply Chain Financing in China

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**Abstract:** To promote theoretical and empirical research on blockchain-enabled supply chain finance in China, this article provides an overview of relevant studies in China. Currently, research related to blockchain-enabled supply chain finance in China primarily focuses on three aspects: the underlying mechanisms of blockchain-enabled supply chain finance (including decentralization and consensus mechanisms, distributed storage, tamper resistance, and anti-denial features, as well as smart contracts), the positive effects of blockchain-enabled supply chain finance (including comprehensive effects, credit transmission, risk management) and the application scenarios of blockchain-enabled supply chain finance, and the impact mechanisms of blockchain on supply chain finance gaming behaviors (including the influence of blockchain on supply chain finance decision-making, risk assessment, and the supply chain financial system). Overall, research in China on the positive effects of blockchain-enabled supply chain finance (such as cost and benefit analysis, micro-level efficiency) is relatively limited. Additionally, studies on the factors affecting the adoption of blockchain in supply chain finance and the behavior of banks and small and medium-sized enterprises (SMEs) in blockchain adoption within supply chain finance are relatively scarce. Given the backdrop of financial technology, further research is needed to deepen our understanding of various aspects related to blockchain-enabled supply chain finance in China.

**Keywords:** SMEs; Supply Chain Financing; Blockchain; Fintech; Digital Finance; Literature Review

## 1. Introduction

Supply chain financing is a financing mode that takes the core enterprises in the supply chain and their related upstream and downstream supporting enterprises, and develops the overall financial solution based on the cargo right and cash flow control according to the transaction relationship and industry characteristics of the enterprises in the supply chain. Supply chain financing is considered a novel financing method that fosters a win-win situation for multiple parties. It evaluates the credit risk of small and medium-sized enterprises (SMEs) from a supply chain perspective, emphasizing the stability of the supply chain and the reliability of trade backgrounds. It serves as an effective approach to address the financing challenges faced by SMEs. In accordance with the "Guidance on Promoting Supply Chain Financial Services for the Real Economy" issued by the China Banking and Insurance Regulatory Commission (CBIRC) (CBIRC Office [2019] No. 155), banks

and insurance institutions are required to leverage core supply chain enterprises. They should integrate various types of information, including logistics, information flow, and fund flow, based on genuine transactions between core enterprises and upstream/downstream chain enterprises. This integration aims to provide a comprehensive range of financial services, including financing, settlement, and cash management, to enterprises throughout the supply chain. However, traditional supply chain finance faces challenges due to factors such as technology and management. These challenges include ineffective credit transmission, a lack of reliable information systems, and cumbersome operational processes. As a result, difficulties in obtaining financing, high financing costs, and slow financing processes for SMEs within the supply chain persist (Zhou Lei et al., 2021) [1].

Blockchain's innovative features such as decentralization, consensus trust, smart contracts, and collective supervision align naturally with the characteristics of supply chain finance, which involve multiple participants, upstream and downstream collaboration, and multi-level credit transmission. Blockchain technology-driven supply chain finance can ensure value transfer and multi-layered credit penetration. It holds the potential to break through the limitations of traditional supply chain finance, which often struggles to cover small and medium-sized enterprises (SMEs) at the tail end, leading to a transformation in traditional supply chain finance. In light of this, the "Guidance on Promoting Supply Chain Financial Services for the Real Economy" issued by the China Banking and Insurance Regulatory Commission (CBIRC) (CBIRC Office [2019] No. 155) encourages banking and financial institutions to cooperate with core enterprises and utilize technologies such as the internet, Internet of Things (IoT), blockchain, biometrics, and artificial intelligence (AI) to build supply chain financial service platforms for upstream and downstream chain enterprises. Furthermore, the "Opinions on Regulating the Development of Supply Chain Finance to Support the Stable Circulation and Optimization Upgrade of the Supply Chain Industry" (Yin Fa [2020] No. 226) stipulates that all participants in supply chain finance should prudently employ new-generation information technologies such as blockchain, big data, and AI. They should also continuously enhance the security and operational monitoring capabilities of supply chain financial service platforms and information systems to effectively mitigate risks related to information security and network security. Therefore, conducting in-depth research on issues related to blockchain-enabled supply chain financing holds significant theoretical and practical significance. It can accelerate the digitization and intelligence of supply chain finance, alleviating the financing difficulties faced by small and medium-sized enterprises (SMEs).

This article will provide an overview of the current state of research on blockchain-enabled supply chain financing in China, including the intrinsic mechanisms, the positive impact of blockchain on supply chain financing, and its influence on the game theory of supply chain financing. The aim is to further promote theoretical and empirical research on blockchain-enabled supply chain financing. The structure of the remaining sections of this article is as follows: Section 2 introduces the intrinsic mechanisms of blockchain-enabled supply chain financing. Section 3 presents the positive effects of blockchain-enabled supply chain financing and its application scenarios. Section 4 discusses the impact mechanisms of blockchain on the game theory of supply chain financing. Section 5 provides a brief conclusion and summary.

## **2. Intrinsic Mechanisms of Blockchain-Enabled Supply Chain Financing**

### *2.1. Decentralization and Consensus Mechanisms*

In a digital supply chain network empowered by blockchain, once the core enterprise establishes ownership, the accounts receivable that carries its credit can be seamlessly recorded on the blockchain without the need for any centralized institution for registration or authentication, creating a flexible set of digital credit credentials, thus achieving "tokenization." After "tokenization," the digital accounts receivable certificates can be distributed, verified, split, and circulated on the blockchain value network (Zhou Lei et al., 2021) [1].

Blockchain's consensus mechanisms, based on algorithms such as proof of work and proof of stake, can further establish "machine trust." This allows digital credit credentials to circulate with trust on the blockchain, extending the creditworthiness of the core enterprise to small and medium-sized enterprises (SMEs) across the entire supply chain, including end-point nodes (Zhou Lei et al., 2021) [1].

At every level of suppliers and distributors within the supply chain, whether they have direct transactional relationships with the core enterprise, they can utilize the blockchain-recorded digital credit credentials, which have been split and circulated step by step, based on their specific needs. These credentials can be used to select the redemption of due claims, split payments to upstream and downstream enterprises at no cost, or use them as collateral for low-cost financing from banking and financial institutions (Zhou Lei et al., 2021) [1].

### *2.2. Distributed Storage and Anti-tampering, Anti-repudiation*

With the use of blockchain networks, supply chain consortia can be formed. Utilizing distributed storage and consensus mechanisms, the credit information of various entities within the supply chain and the authentic records of transactions are stored on a distributed ledger. Once any credit records and transaction information are verified through consensus, they are rapidly disseminated across the entire network and written into various nodes in an immutable manner. This establishes an efficient mechanism for sharing credit (Li Ming-xian and Chen Ke, 2021) [2].

On the basis of credit sharing, block chain as the value of the Internet architecture, has a unique economic incentive constraint mechanism, through the issuance of carrying credit "token" incentive and distribution of incentive, can be the subject on the supply chain trustworthy credit into blocks, maximize credit value and trustworthy joint incentives, eventually promote small and medium-sized enterprises, core enterprises and bank financial institutions win-win cooperation (Zhou Lei et al., 2021) [1].

After docking with the blockchain platform, once integrated with a blockchain platform, in cases of default within the supply chain, adverse credit information is verified and stored in a distributed manner across all nodes in the network. It becomes tamper-resistant and irrefutable. When entities with a history of default apply for financing again, banking and financial institutions not only automatically reject loans based on smart contracts due to adverse records but also store the loan rejection records in a distributed manner on the blockchain network. This creates a highly efficient mechanism for joint punishment of dishonesty, where the cost of a single default significantly outweighs any potential gains (Zhou Lei et al., 2021) [1].

### *2.3. Smart Contract Technology*

Smart contracts are a set of predefined scenarios and corresponding actions triggered by contract execution, as per established conditions and transition rules (Zhan Ji-zhou and Zhang Ge-wei, 2023) [3]. The most significant advantage of smart contracts lies in their ability to intelligently assess trigger conditions, greatly reducing performance costs and enhancing transaction efficiency. When applied to supply chain financing scenarios, smart contracts improve the management model of traditional supply chain financing for small and medium-sized enterprises (SMEs). It eliminates the need for cumbersome manual processes such as accounts receivable assessment and inventory monitoring. Instead, it directly integrates the "credit chain" of core enterprises and SMEs, enabling low-cost, intelligent, automated, and auditable analysis and processing of transaction information and data. While effectively controlling risks, this significantly reduces the credit and operational costs associated with SME financing (Zhou Lei et al., 2020) [4].

When SMEs apply for financing, banking and financial institutions integrated with blockchain platforms will automatically complete the approval process based on predefined response conditions and rules. They will also automatically retrieve the enterprise's credit limit and related credit records from the credit management module for consensus validation. Once consensus at the network layer is confirmed, the contract executes automatically, and the disbursement is completed. SMEs can access the funds almost instantly, significantly enhancing financing efficiency (Long Yun'an et al., 2019) [5].

Combining smart contract technology with the distributed storage capabilities of blockchain ensures that all transaction records between core enterprises and SMEs on the supply chain are intelligently verified and stored in an immutable manner by all nodes. Based on real transactions and credit-bearing digital credentials, they are programmable throughout the entire lifecycle of split transfers and trusted circulation. When the core enterprise makes the final payment, funds are automatically transferred to all holders of digital credentials according to preset response rules, cashing out all transactions and completing financing repayment. Therefore, blockchain not only empowers SME financing by reducing costs and increasing efficiency but also enhances the flow of funds and collaborative efficiency throughout the entire supply chain (Zhou Lei et al., 2021) [1].

### **3. Positive Effects and Application Scenarios of Blockchain-Enabled Supply Chain Financing**

#### *3.1. Positive Effects of Blockchain-Enabled Supply Chain Financing*

##### **3.1.1. Comprehensive Effects**

In terms of comprehensive effects, Duan Wei-chang (2018) [6], in conjunction with the logical framework of supply chain management and the business model of supply chain finance, starts with fundamental elements such as documents and contracts. They provide a detailed analysis of the restructuring process and innovative effects of blockchain technology on business processes and business models. Zhu Xing-xiong et al. (2018) [7] suggest that a blockchain supply chain finance platform can integrate "four flows" into one, expand the range of service recipients, strengthen risk management, establish accounts receivable confirmation, manage collateral and its pricing, and manage cash flows. Chu Xue-jian and Gao Bo (2018) [8] argue that the combination of blockchain and supply chain finance can achieve information symmetry among participating parties, facilitate the transmission of core enterprise credit, make the supply chain finance process visible, enhance risk control, and provide full coverage of services. Xu Di-di (2019) [9] believes that blockchain technology

can facilitate information transmission in supply chain finance, establish a multi-party cooperation and coordination mechanism for supply chain finance, address the challenges of risk control in supply chain finance, and simplify the operational processes of supply chain finance. Lin Nan (2019) [10] suggests that blockchain technology can establish a transparent financing ledger, eliminate information asymmetry issues, achieve financial disintermediation, reduce human-induced factors, provide smart contract capabilities, reduce human resource costs in supply chain finance, serve as a supplement to electronic bills of exchange, enhance the quality of supply chain finance services, innovate financial transaction mechanisms, and build a more orderly ecosystem for supply chain finance. Bai Yan-fei et al. (2020) [11] contend that blockchain technology empowers supply chain finance in three ways: building trust mechanisms among on-chain entities, reducing management risks, and increasing the radius of credit transmission; achieving efficiency, security, and privacy protection. Zhou Da-yong and Wu Yao (2020) [12] analyze the application of blockchain technology in supply chain finance, highlighting its potential to reduce information asymmetry, expand the scope of supply chain finance, make movable property collateral financing possible, and enhance the efficiency of supply chain finance. Xue Yang (2021) [13] believes that commercial banks have used blockchain technology to realize the iterative upgrading of product system, financing mode innovation and the expansion of long-tail customers, effectively reducing the loss of financial assets. Furthermore, Guo Jue and Chen Chen (2020) [14] analyze various aspects of blockchain technology, including how it breaks through the "information island" at the end, addresses the financing issues of small and medium-sized enterprises, establishes channels for mutual information exchange among key participants, assists banks in resisting market risks, and constructs industry alliances for supply chain finance, among other issues.

### 3.1.2. Credit Transmission

Regarding credit transmission, Wang Xin and Chen Li-yuan (2020) [15] suggest that blockchain technology has unique technical advantages for the lossless transmission of core enterprise credit in multi-tier supply chain finance scenarios. It helps enhance supply chain information transparency, ensures the transfer of value and multi-layer credit penetration, and achieves comprehensive risk monitoring and regulatory oversight. Lin Yong-min et al. (2021) [16], based on the coupling analysis of supply chain finance pain points and blockchain technology characteristics, have constructed an alliance chain framework centered around core enterprise credit to address the issue of credit penetration in supply chain finance. Their research shows that trustworthy, divisible, and transferable electronic debt certificates enable the lossless transmission of core enterprise credit along trade relationships. The "trust without intermediaries" model reduces the overall operating costs of the supply chain, and smart contracts that lock the payment settlement path automate the payment settlement process, reducing risk and expanding the financial market size. Yang Hong-xiong and Chen Jun-shu (2022) [17] establish a fundamental theoretical model of "digital credit governance - network embeddedness - supply chain finance performance." Using a structural equation model, they analyze the impact mechanism of blockchain technology on supply chain finance performance from the perspective of network embeddedness, unveiling the "black box" of how blockchain technology improves supply chain finance performance.

### 3.1.3. Risk Management

In terms of risk management, Wang Li-hua and Liu Ling (2020) [18] suggest that blockchain technology contributes to risk management in supply chain finance through various mechanisms. It reduces information asymmetry by providing distributed ledger functionality for real-time data sharing. The consensus mechanism and tamper-resistant features ensure the authenticity of data and transactions, reducing moral hazards. Smart contract functionality helps lower operational and market risks, thereby cutting risk management costs. Timestamping and traceability features enable comprehensive regulatory oversight. Wang Hong-yu and Wen Hong-mei (2021) [19] argue that block chain technology with its distributed accounting, information sharing, asymmetric encryption technology advantages, and use its service system can accurately record all kinds of information of agricultural supply chain, realize the information resource sharing, break the barriers of traditional agricultural supply chain financial information, break financial institutions to accurately verify information problem. Fu Han-yi et al. (2021) [20] believe that applying blockchain technology to supply chain finance can enhance the authenticity of data to reduce credit risks, improve the timeliness of data to mitigate moral hazards, and increase data transparency to lower operational risks. Feng Shan-shan and Li Yong-mei (2022) [21] conducted research that shows the application of blockchain technology can reduce the probability of credit risk occurring in supply chain finance, effectively meeting the financing needs of small and medium-sized enterprises in the upstream and downstream of the supply chain. Additionally, Han Jing-wang and Han Ming-xi (2022) [22] argue that blockchain technology offers advantages in innovating supply chain finance by ensuring information flow, safeguarding information security, and strengthening risk control.

### *3.2. Application Scenarios of Blockchain-Enabled Supply Chain Financing*

Regarding the application scenarios of blockchain empowering supply chain finance, Han Jing-wang and Han Ming-xi (2022) [22] studied the implementation of blockchain technology in supply chain finance system structure innovation, smart contract based on block chain technology in supply chain finance innovation, and block chain technology in the innovation of risk control innovation. Li Xiao-peng et al. (2022) [23] selected three typical supply chain financing business scenarios, including accounts receivable financing, confirmed warehouse financing, and movable asset pledge financing. They analyzed the application of blockchain smart contracts in supply chain finance. Based on this analysis, they constructed a supply chain financing platform based on smart contract technology. They also used SPESC language to compile smart contracts and provided relevant recommendations. Zhan Ji-zhou and Zhang Ge-wei (2023) [3] conducted research on various aspects, including innovation in supply chain inventory pledge financing models, innovation in supply chain accounts receivable financing models, innovation in supply chain advance payment financing models, innovation in multi-level supply chain credit financing models, and the security mechanisms of blockchain-empowered supply chain finance.

## **4. Impact of Blockchain on Supply Chain Financing Game Behavior**

### *4.1. Impact Mechanisms of Blockchain on Supply Chain Financing Decision-Making*

Regarding the impact mechanisms of blockchain on supply chain finance decision-making, Zhang Lu (2019) [24] initially discussed supply chain finance service models and blockchain incentive mechanisms from a game-theoretic perspective. Tang Dan and Zhuang Xin-tian (2019) [25] used the

newsboy model to compare and analyze the differences in benefits among various supply chain entities in the context of blockchain debt conversion platforms and traditional supply chain financing models. They discussed the advantages of blockchain debt conversion platforms in reducing costs, increasing returns, and facilitating turnover. Deng Ai-min and Li Yun-feng (2019) [26] proposed specific application scenarios for blockchain smart contract technology in supply chain factoring business, focusing on the transfer of debt securities, upstream supplier factoring financing, and core enterprise mature payments. Using the idea of game theory, from the perspective of blockchain node activity technology, modeling and analysis of the automatic execution mechanism of smart contract, knowing that any rational node  $x$  will always choose to follow the protocol to make it automatically executed, emphasizing the important role of blockchain technology for the object of business process. They also conducted a three-party game analysis of supply chain factoring financing processes considering the influence of blockchain technology from the perspective of supply chain business entity decision-making, seeking equilibrium solutions (lending, repayment, repayment) based on the principle of utility maximization and highlighting the optimization effect of blockchain technology on decision-making behavior of the parties involved. Li Jian et al. (2020) [27] focused on small and medium-sized enterprise warehouse receipt pledge business. Using a comprehensive integrated methodology, they quantitatively modeled the impact of blockchain technology on various aspects of supply chain finance. They studied the loan and production decisions of production enterprises before and after using blockchain technology, analyzing the effects of blockchain technology on different types of companies' operations. They also used the Value at Risk (VaR) risk measurement method to study the bank's pledge rate decisions before and after using blockchain technology, analyzing the impact of blockchain technology on bank pledge rate decisions. Liu Lu et al. (2021) [28] established a three-level supply chain decision-making model involving manufacturers, distributors, and retailers to quantitatively analyze the impact of blockchain credit transmission technology on supply chain finance. They used the Stackelberg game method to characterize both traditional supply chain finance models and blockchain supply chain finance models. They optimized and solved the game model using inverse induction, obtaining equilibrium states for both financing models in terms of optimal wholesale prices, distribution prices, and order quantities in the supply chain. They also conducted sensitivity analysis on key parameters such as the initial capital of retailers and the time value of corporate funds. Tang Dan and Zhuang Xin-tian (2021) [29] constructed a comparative model based on revenue-sharing contracts for bank credit financing, commercial credit financing, and blockchain supply chain finance. They explored the optimal decision-making solutions for supply chains under various financing models and quantitatively analyzed how supply chain performance varies with different parameters. Their research showed that when the cost of funds for retailers is lower than that of manufacturers, commercial credit financing is always superior to bank credit financing. They identified two threshold points for platform fees in blockchain supply chain finance, suggesting that blockchain supply chain finance is the optimal model for both manufacturers and retailers only when the platform fee is below the lower threshold point. Additionally, a higher revenue-sharing ratio results in higher manufacturer profits and lower retailer profits.

Additionally, Wang Dao-ping et al. (2023) [30] used quantitative models in the context of blockchain to depict the predictive role of applying blockchain technology in the face of output uncertainty. They analyzed the influence of the degree of blockchain technology application on the production decisions of small and medium-sized enterprises, bank lending decisions, and the

expected profits of borrowing companies and banks. They also studied the credit limit decisions of banks considering risk avoidance using a downside risk control model. The research findings indicated that the planned production volume of borrowing companies increases with the higher degree of blockchain technology application. The loan amounts set by banks seeking profit maximization also increase under certain conditions as the degree of blockchain technology application rises. The bank's credit limit decisions, influenced by the changing degree of blockchain technology application, are related to risk tolerance and the mean of output fluctuations. The expected profits of borrowing companies initially decrease and then increase with the increasing degree of blockchain technology application. When the mean of supplier output fluctuations is large, the expected profits of banks increase with the higher degree of blockchain technology application.

#### *4.2. Impact Mechanisms of Blockchain on Supply Chain Financing Risk*

Regarding the impact mechanisms of blockchain on supply chain finance risk, Yang Hong-zhi et al. (2020) [31] found that the introduction of blockchain into supply chain finance platforms will reduce the probability of corporate default, strengthen the equilibrium point in the game for all participating entities (cooperation, compliance, compliance), and increase the profits of all parties in the game. At the equilibrium point in the game, all parties achieve a win-win situation. Gong Qiang et al. (2021) [32] constructed a theoretical model for enterprises in the supply chain network to collateralize financing from banks. They used Bayesian game theory to systematically analyze the economic operation principles of digital supply chain finance and its pros and cons compared to traditional supply chain finance. Research found that when the chain on the supply chain enterprises reached a certain number, and the quality of chain information reached a certain level, the block chain consensus mechanism reveals the enterprise information will approach the real information, to prevent enterprise information manipulation, malicious fraud, make the bank in the case of effective control of risk for the supply chain enterprise accessibility is high enough, low cost enough financing services. On the contrary, when the number of enterprises in the upper chain is small or the quality of the information on the chain cannot be guaranteed, banks are more suitable for them to prevent and control risks through traditional offline due diligence and other methods. Zhou Lei et al. (2021) [1], based on an analysis of the mechanism of blockchain's empowerment in supply chain finance, constructed a dynamic evolutionary game model between financial institutions and small and micro-enterprises, as well as core enterprises and small and micro-enterprises. They concluded that connecting to a blockchain platform is the dominant strategy for financial institutions. Blockchain helps small and micro-enterprises make compliance decisions by facilitating credit segmentation and circulation, improving financing efficiency, increasing default costs, and reducing financing rates, among other transmission pathways. It also encourages small and micro-enterprises to make compliance decisions through network-based cooperative credit incentives, joint punishment for dishonesty, and reasonable profit sharing. This leads to the game balance to financial institutions dare to lend, willing to lend, showing the ideal state of "double trustworthiness" of core enterprises and small and micro enterprises. In addition, Hasqiqige and Zhao Li-li (2022) [33] established the evolution game model of SMEs and financial institutions under the accounts receivable financing mode. They determined the dominant strategies for small and medium-sized enterprises and financial institutions to connect to the blockchain, and analyzed the impact of punishment and incentive factors on the decision-making and evolution paths of both parties in the model.



In addition, Li Jun-qiang and Wang Yu (2022) [34], through the construction of an evolutionary game model for financial institutions and small and medium-sized enterprises under accounts receivable financing, conducted a dynamic evolutionary analysis of the strategy choices of various stakeholders using MATLAB simulations. The analysis results indicate that when the admission and operation costs of blockchain decrease, or when the incentives for blockchain increase, or when the rewards for small and medium-sized enterprises for compliance increase, small and medium-sized enterprises are more inclined to comply with contracts, and financial institutions are also more inclined to use blockchain technology in supply chain finance.

#### *4.3. Impact Mechanisms of Blockchain on Supply Chain Financing System*

In the context of the impact mechanism of blockchain on the supply chain finance system, Lou Yong et al. (2022) [35] introduced a theoretical framework of blockchain + supply chain finance. They investigated the effects of blockchain technology on the supply chain finance system from the dual perspectives of optimizing financing efficiency for both banks and enterprises. They used a three-party game and dynamic evolutionary game model to conduct their research. The study found that the introduction of blockchain technology reduced the financing constraints in the supply chain finance market and increased the accessibility of funds for financing enterprises. Additionally, the low operational costs of blockchain technology ultimately improved the financing efficiency of all participants in the blockchain + supply chain finance model. In the long term, achieving the optimal balance places certain demands on blockchain technology itself. These demands include reducing the operational costs of blockchain and designing stable and effective constraints for the supply chain finance system, which to some extent replace the inherent stability function of the supply chain itself.

### **5. Brief Review**

Currently, research related to blockchain-enabled supply chain finance in China primarily focuses on three aspects: the underlying mechanisms of blockchain-enabled supply chain finance (including decentralization and consensus mechanisms, distributed storage, tamper resistance, and anti-denial features, as well as smart contracts), the positive effects of blockchain-enabled supply chain finance (including comprehensive effects, credit transmission, risk management) and the application scenarios of blockchain-enabled supply chain finance, and the impact mechanisms of blockchain on supply chain finance gaming behaviors (including the influence of blockchain on supply chain finance decision-making, risk assessment, and the supply chain financial system).

However, research in China on the positive effects of blockchain-enabled supply chain finance (such as cost and benefit analysis, micro-level efficiency) is relatively limited. Additionally, studies on the factors affecting the adoption of blockchain in supply chain finance and the behavior of banks and small and medium-sized enterprises (SMEs) in blockchain adoption within supply chain finance are relatively scarce. In summary, in the context of financial technology, there is a need for further research in China to deepen the understanding of several aspects related to blockchain-enabled supply chain finance.

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