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Review

A Review of Foreign Research on Blockchain Empowered Supply Chain Financing

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Abstract: To promote theoretical and empirical research on blockchain empowered supply chain financing, this paper reviews the relevant foreign research on blockchain empowered supply chain financing. At present, foreign research on blockchain empowered supply chain financing focuses on the positive effects of blockchain on supply chain financing (including: costs and benefits, micro-efficiency, risk management, credit transmission, etc.), the factors influencing the adoption of blockchain in supply chain financing, and the impact of blockchain on the game behavior of supply chain financing (including: mechanisms of blockchain's influence on the decision of supply chain financing, mechanisms of blockchain's influence on the risk of supply chain financing) and other three aspects. In general, foreign research on the comprehensive effect of blockchain on supply chain financing and the credit transmission effect is relatively weak; in addition, foreign research on the intrinsic mechanism of blockchain-enabled supply chain financing and the blockchain upstream behavior of banks and SMEs in supply chain financing is relatively rare. In the context of financial technology, foreign research on several issues of blockchain-enabled supply chain financing needs to be further deepened.

Keywords: Supply Chain Financing; Blockchain; SMEs; Core Enterprise; Commercial Bank; Literature Review

1. Introduction

Due to their short life cycle, opaque information and lack of bank-approved collateral assets, SMEs have not been able to effectively improve their financing problems against the background of low-risk appetite in formal finance and incomplete marketisation of loan risk pricing. As most SMEs are in a vertical supply chain scenario, supply chain finance, which provides financial services to SMEs in the chain with the backing of core enterprises' credit, has become the best breakthrough to solve the "financing difficulties" of SMEs. However, due to the fact that the information between SMEs and core enterprises at the long-tail end is not connected, the information is fragmented and a set of mutual trust mechanism has not been established; the offline operation and the flow of paper documents are inefficient, the risk of fraud is high and the audit is difficult, making it difficult to achieve multi-level penetration coverage of core enterprises' credit; the risk of downstream dealers is indeed higher than the risk of upstream "underwriting" by core enterprises, etc. Traditional supply chain finance mainly serves the first-tier suppliers/distributors of core enterprises, and 70%+ of SMEs

at the long-tail end are unable to share the credit of core enterprises and find it difficult to obtain financing support.

The innovative features of blockchain, such as decentralization, consensus trust, smart contracts and collective supervision, are a natural fit with the characteristics of supply chain finance, such as multi-subject participation, upstream and downstream collaboration and level-by-level credit transmission. It is expected to break through the limitations of traditional supply chain finance in reaching the long-tail end of SMEs and transform traditional supply chain finance. Therefore, an in-depth study on several issues of blockchain empowered supply chain financing is of great theoretical and practical significance to accelerate the digitization and intelligence of supply chain finance and alleviate the difficulty of financing for SMEs.

This paper will review the current status of overseas (outside China) research on the positive effects of blockchain on supply chain financing, the factors influencing the adoption of blockchain in supply chain financing, and the effects of blockchain on the game behaviors of supply chain financing, with a view to further promoting theoretical and empirical research on blockchain empowered supply chain financing. The remainder of the paper is structured as follows: Part 2 introduces the positive effects of blockchain on supply chain financing; Part 3 introduces the factors influencing the adoption of blockchain in supply chain financing; Part 4 introduces the impact of blockchain on the game behavior of supply chain financing; and Part 5 is a brief review.

2. Research on the Positive Effects of Blockchain on Supply Chain Financing

2.1. Costs and Benefits

In terms of costs and benefits, Hofmann et al. (2018) [1] examine how blockchain technology (BCT) for supply chain finance (SCF) projects can bring companies together in partnerships and accelerate cash flow across the supply chain. BCT promises to transform the way individuals and businesses exchange value and information over the internet and is fully capable of enabling new levels of collaboration. By defining a possible blockchain-driven supply chain model, the new opportunities presented by the application of BCT in SCF financing solutions, especially reverse factoring - or approved accounts payable financing - are revealed. Applied research shows that blockchain and distributed ledger technologies can bring significant benefits to all parties involved in SCF transactions, promising to speed up processes and reduce the overall cost of financing projects. Patara (2019) [2] explores the net value of implementing blockchain technologies in supply chain financing arrangements through a cost-benefit analysis. A cost-benefit model and an operational process for both traditional and blockchain-based supply chain finance solutions is presented and applied to a real-world case study. The results show that blockchain technology increases the total net benefit between the parties involved in a supply chain finance arrangement due to increased efficiency in invoice processing; suppliers will benefit from blockchain-based supply chain finance if the benefits from unlocked working capital exceed the cost of platform fees. Alternatively, as for unlocked working capital, the buyer does not benefit from the technology.

2.2. Micro-efficiency

In terms of micro-efficiency, Omran et al. (2017) [3] develop a conceptual framework for blockchain empowered supply chain finance (SCF) solutions aimed at facilitating the coordination of

buyer-supplier relationships and eliminating inefficiencies in the execution of discrete SCF instruments such as reverse factoring and dynamic discounting. Lahkani et al. (2020) [4] explore sustainable B2B e-commerce and blockchain-based supply chain finance issues. The study found that the use of blockchain improved the efficiency of logistics and digital documents by 74% and 75%, respectively. The main advantage of using blockchain is that it creates a secure decentralized database and also increases the speed of payments as well as the reliability and transparency of data transfer. Research by Chod et al. (2020) [5] suggests that it would be more efficient to communicate the underlying quality of a business (e.g., operational capacity) to lenders through inventory transactions. Signals sent through inventory only hold true if the inventory transactions are verifiable at a sufficiently low cost, and blockchain technology can achieve this more effectively than traditional monitoring mechanisms. By opening a window of transparency into a company's supply chain, blockchain technology offers the ability to obtain favorable financing terms at a lower signaling cost.

Logistics 4.0 has emerged against the backdrop of a booming supply chain finance and logistics industry. However, the financing capabilities of today's logistics companies are still unable to cope with the rapid growth of the supply chain. The Blockchain Financing Solution (BFS)'s efficient smart contract technology and improved privacy information query and invocation algorithms enable automatic control of the flow of private information to physical nodes, greatly simplifying the financing steps for logistics companies while protecting their data privacy, making it an important influencing factor for logistics companies to choose to adopt blockchain (Fu et al., 2022) [6].

2.3. Risk Management

In terms of risk management, Xu et al. (2021) [7] studied the mechanism of blockchain's impact on credit access, credit lines and credit regulation. From the perspective of "transportation" finance, the decay process of credit transmission in the supply chain was analyzed, two credit line assessment methods, namely self-compensation and credit guarantee, were reviewed, and the application of blockchain in different scenarios was demonstrated, examining the regulatory requirements of closed-loop transactions, closed-loop deliveries and closed-loop capital. The three major impact mechanisms on the granting of credit for transportation financing show that the application of blockchain technology can effectively improve the participation of financial institutions and the credit limits of financing for micro, medium and small transportation enterprises. The empirical analysis results of Gao (2022) [8] show that blockchain decentralization technology can be used to address the risks of supply chain finance projects and the features of blockchain can be used to improve the efficiency of supply chain financing clearing and settlement.

In essence, Supply Chain Finance (SCF) provides a flexible cash flow solution that maximizes the working capital position of key stakeholders in the supply chain. However, some of the opaque elements of SCF platforms, such as information asymmetries, lead to delays in payments to suppliers that can adversely affect SMEs. Cybersecurity risks are rapidly increasing and continue to threaten technology-dependent SCF platforms. Blockchain technology offers security advantages to commercial parties with its decentralization, transparency and immutability; elements that enable SCF platforms to increase transparency and trust and reduce the potential for transaction manipulation between participants. Through complementary decentralized applications and smart contracts, using the underlying technology of blockchain technology, the proposed solution can provide efficient, transparent and secure financing for buyers, suppliers and financial institutions in

the SCF ecosystem (Tsai, 2023) [9]. Liu et al. (2023) [10] designed and implemented a financial management platform based on blockchain and supply chain integration. Blockchain was used to integrate supply chain finance, synchronize bank account payment systems, achieve automatic flow of funds, process supervision, and automatically settle billing periods based on smart contracts. A unified modelling language was used to design the four functional modules of the system, and the model view controller architecture was selected as the main architecture of the system. The system test results show that the proposed platform can effectively improve system security and provide multi-level financing services for enterprises in supply chain finance using the information in the blockchain.

Supply chain finance (SCF) provides credit to small and medium-sized enterprises with low credit limits and small financing sizes. However, traditional SCF management schemes use third-party platforms and centralized designs, and the high confidentiality and privacy of financial credit data and related business transaction data cannot be guaranteed to be reliably and securely stored (Li et al., 2023) [11]. Wu et al. (2023) [12] constructed a non-linear integer programming model and designed an ant colony algorithm to solve the blockchain system optimization problem in order to better trade-off the security, operational cost and efficiency of the blockchain system. In order to better trade-off the security, operational cost and efficiency of the blockchain system, to reduce the risky or uneconomic dilemma of the financial institution-led supply chain finance (SCF) system and achieve the overall optimality of the SCF system in terms of security, cost and efficiency. Blockchain systems can also address information asymmetries among participating companies in supply chain operations, preventing credit risks from being extended or even passed on to the entire supply chain (Xiao et al., 2022) [13].

2.4. Credit Transmission

In terms of credit transmission, the innovative development of supply chain finance driven by blockchain technology has played a positive role in overcoming the trust deficit, giving rise to a multi-level supply chain finance system aimed at solving the financing problems of SMEs. Small and medium-sized manufacturing enterprises have chosen this multi-level supply chain finance system to solve the financing contradiction of "strong demand" and "weak trust" that they have been facing for a long time, to overcome the fact that under the traditional supply chain finance system, the high credit of the core enterprises in the manufacturing industry chain cannot pass on to secondary to primary suppliers in the long-tail market (Jiang et al., 2022) [14]. By providing support in terms of trustworthiness and transparency, multi-party verification and consensus mechanisms, automatic execution of smart contracts, data sharing and interconnection, blockchain can help strengthen credit identity and trust among parties in the supply chain, thus facilitating smooth credit transmission.

3. Research on the Factors Influencing the Adoption of Blockchain in Supply Chain Financing

Kabir et al. (2021) [15] used a structured questionnaire to collect data, processed by partial least squares method of structural equation modelling, to uncover the blockchain determinants of supply chain financing acceptance in a financing company called IPDC in Bangladesh. The results showed that convenience and behavioral intention to use together explained 88.7% of the variation in blockchain usage behavior in supply chain financing. Arief (2021) [16] explored how the adoption of blockchain technology can address the SCF problem using a multi-case approach based on the

Technology Acceptance Model (TAM). A purposive sampling method was used to select 30 cases based on perceived usefulness and perceived ease of use. The results show that trust, validity and distributed ledger transaction data as perceived usefulness are the main drivers of blockchain adoption as it provides solutions to SCF automation problems such as Know Your Customer (KYC), accounting and transaction settlement. Smart contracts provide simple and fast transactions, such as those in letter of credit export processing. Of the 30 blockchain projects, 21 offer automated accounts receivable financing, 15 offer easy-to-use purchase order financing and eight offer easy-to-use inventory financing processes. Asante et al. (2023) [17] explored the technical organization and environment of blockchain supply chain finance adoption by SMEs in Ghana using a partial least squares structural equation modelling approach and a non-linear non-compensatory approach driver. The findings indicate that relative advantage, cost and complexity significantly influence the adoption of blockchain supply chain finance by SMEs. However, competitive pressures, market dynamics and support from SME owners/managers did not have a statistically significant impact on SMEs' intention to adopt blockchain supply chain finance. According to real-time hits, web traffic and the most frequently asked questions about blockchain, blockchain technology can improve the digitization and efficiency of supply chains and is the reason for blockchain as a disruptive technology in supply chain finance (Kucukaltan et al., 2022) [18].

4. Research on the Impact of Blockchain on Supply Chain Financing Gaming Behavior

4.1. Mechanisms of Blockchain Impact on Supply Chain Financing Decisions

In terms of the mechanism of blockchain's impact on supply chain financing decisions, Dong et al. (2021) [19] developed a three-tier supply chain model and used a game-theoretic approach to compare how deep blockchain-based financing options affect the optimal risk mitigation and financial strategies of financially constrained supply chains. The results found that while increased visibility through the adoption of blockchain helps manufacturers to make informed supply chain financing decisions, the ability to benefit all supply chain members depends on the financing option used. Blockchain delegated financing can only increase risk mitigation investments and benefit all three tiers of the supply chain when Tier 2 capital is severely constrained and working capital is below a threshold. As delegated financing gives intermediate tier 1 suppliers leverage over manufacturers, efficiency inhibits win-win outcomes when tier 2 suppliers are not severely capital constrained. Liu et al. (2021) [20] consider a three-tier supply chain consisting of manufacturers, distributors and capital-constrained retailers and explore the operation of a blockchain-enabled supply chain financing model-blockchain platform financing (BPF) strategy. The optimal decision solution is obtained through decision and parameter sensitivity analysis; the conditions for the application of the BPF model are derived through a comparison of the BPF and the Small and Medium Enterprise Independent Financing (SIF) model; and risk sharing is found to improve the financing efficiency of the BPF model. Thus, it provides a theoretical basis for decision makers to implement blockchain supply chain finance at three levels: joint financing and operation decision, financing model selection and financing efficiency enhancement. Zheng et al. (2022) [21] proposed the application scenarios of blockchain-based smart contract technology in supply chain factoring business from three aspects: splitting and transfer of debt documents, factoring financing for upstream suppliers, core enterprise The application of blockchain-based smart contract technology in the supply chain factoring business

is presented from three aspects: splitting and transfer of debt documents, factoring financing for upstream suppliers, and payment due from core enterprises, and its implementation process is explained. In addition, the key technical implementation mechanisms of smart contracts are analyzed from the perspective of game theory to verify whether the nodes on the blockchain will follow the relevant protocols to execute them automatically. A three-party game analysis of the supply chain factoring process is also conducted to obtain an equilibrium solution based on the principle of utility maximization, highlighting the optimizing effect of smart contract technology on the decision-making behavior of each entity in the supply chain.

Luo et al. (2022) [22] took the financing warehouse in supply chain finance as an example, and studied the game between the capital provider and the capital demander, constructed the revenue matrix and calculated the Nash equilibrium for pure and mixed decisions respectively. The game behaviors of participants in traditional supply chain finance and supply chain finance on the blockchain are also compared, as well as the differences in the mixed-decision Nash equilibrium with or without the inclusion of blockchain rewards and penalties. It is shown that the probability of supply and demand parties choosing to cooperate is closely related to the amount of reward and penalty transaction information in the blockchain. By encouraging transaction information to be recorded in the blockchain and increasing the level of sharing of transaction information, the willingness of both parties to cooperate can be promoted. Therefore, promoting the application of blockchain technology in the field of supply chain finance and strengthening the cooperative behavior of participants is conducive to the healthy and rapid development of supply chain finance, and can better solve the financing problems in the supply chain and improve the efficiency of supply chain financing decisions. The emergence of blockchain has created new possibilities for solving the fraud problem in supply chain finance. Zhao et al. (2023) [23] constructed a game model to verify the strategic choice of financial supply chains in an uncertain environment. Without considering blockchain, the financial model of a supply chain dominated by a core firm depends on the firm's reputation. In contrast, blockchain technology can reduce the risk of fraud in supply chain finance by providing transparency, traceability, smart contracts and decentralization.

4.2. Mechanisms of Blockchain's Impact on Supply Chain Financing Risk

In terms of the mechanisms of blockchain impact on supply chain financing risk, Choi (2020) [24] examines supply chain financing in fashion product supply chains. Analytical models of traditional supply chains and blockchain-enabled supply chains were developed in a standard newsboy problem setting with a revenue sharing contract between a single manufacturer and a single retailer. Optimal covenants and volume decisions in each supply chain are obtained through Nash bargaining between the manufacturer and the retailer. The analysis shows how revenue sharing covenants can coordinate the two types of supply chains. The optimal system performance of the two supply chains is compared. It is demonstrated that blockchain empowered supply chains generate lower operational risk than traditional supply chains. If banks' service fees are high enough, the adoption of blockchain technology is an average risk-led policy that will result in higher expected profits and lower risks for the supply chain and its members. Sun et al. (2021) [25] given the risks involved in supply chain finance, the factors that influence the decisions of supply chain finance participants are analyzed using the evolutionary game approach to construct the evolutionary game model between SMEs and financial institutions was constructed. By comparing the changes in evolutionary stabilization

strategies before and after the introduction of blockchain technology, the mechanism of blockchain to solve the risks in supply chain finance was analyzed. It is found that blockchain technology can reduce the credit risk of financial institutions and increase their business revenue. The strict regulatory environment created by blockchain technology keeps the default of SMEs and core enterprises in a high-risk state. SMEs will not choose to default regardless of the percentage of profit distribution they receive through collusion, which effectively solves the paradox of SMEs being unable to obtain loans from financial institutions with increased probability of compliance.

Zhao and Hu (2021) [26] analyzed and discussed the supply chain finance financing game under the traditional trading platform in view of the financing risk problem of the commodity trading platform. Combining the technical characteristics of blockchain such as invariance and process transparency, a supply chain finance game model of blockchain trading platform was established. The results show that the application of blockchain technology can optimize the financing model of traditional trading platforms, break the "information silos" between enterprises, reduce financing risks and establish a safer supply chain finance financing platform. In the blockchain platform, enterprise financing is related to the stable income, credit accumulation and penalty of the supply chain. By increasing stable revenue and credit accumulation and setting a reasonable number of fines, the evolutionary game can achieve an optimal strategy. Applying blockchain to supply chain financing is an effective way to solve the problems of difficult, expensive and slow financing for SMEs. Combined with the technological innovation framework of blockchain, the supply chain financing strategy problem is transformed into a game problem of financial institutions, core enterprises and three parties, the constraints and incentives on the supply chain financing of participants in the game process are discussed, and the influence of different key factors on the supply chain financing strategies of three parties is analyzed, which can broaden the ideas and methods to solve the supply chain financing problem (Su et al., 2022) [27].

5. Brief Review

At present, foreign research on blockchain empowered supply chain financing mainly focuses on the positive effects of blockchain on supply chain financing (including: costs and benefits, micro-efficiency, risk management, credit transmission, etc.), the factors influencing the adoption of blockchain in supply chain financing, and the impact of blockchain on the game behavior of supply chain financing (including: mechanisms of blockchain's influence on supply chain financing decisions, mechanisms of blockchain’s influence on supply chain financing risk) and other three aspects. In terms of the positive effects of blockchain on supply chain financing, scholars generally believe that blockchain technology can effectively reduce the cost of supply chain financing projects, improve the profitability of project participants, and provide efficient services by virtue of its decentralization, transparency and immutability. At the same time, the use of blockchain technology reduces the risk of supply chain finance projects and facilitates smoother credit transmission. In terms of factors influencing the adoption of blockchain in supply chain finance, convenience, trust, effectiveness, protection of privacy and helping to solve challenges that cannot be solved by the traditional supply chain finance system will be the reasons why various companies choose to adopt supply chain finance facilitated by blockchain technology. In terms of the impact of blockchain on the game behavior of supply chain financing, the theoretical analysis of game theory concludes that blockchain technology can optimize supply chain financing decisions and bring higher profits and lower risks to supply

chain financing.

However, foreign research on the comprehensive effect of blockchain on supply chain financing and the credit transmission effect is relatively weak. In addition, foreign research on the intrinsic mechanism of blockchain empowered supply chain financing and the blockchain on-chain behavior of banks and SMEs in supply chain financing is relatively rare. At present, blockchain has become a widely used information system technology, and its applications in various fields such as supply chain, finance, healthcare, education and energy consumption are increasingly realizing the development of an internet-based "distributed database". It is foreseeable that the future of blockchain empowered supply chain financing is promising, and with the continuous advancement of technology and application, blockchain will play a more important role and contribute to sustainable development and social responsibility. In summary, in the context of fintech, foreign research on several issues of blockchain empowered supply chain financing needs to be further deepened.

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