Research on Financial Innovation of Logistics Supply Chain Under Blockchain Technology

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Abstract. Blockchain technology makes the data information of logistics supply chain system transparent. Blockchain does not allow any data to be modified or even tampered with without permission but can be traced. The logistics supply chain financial service platform built under the blockchain technology digitizes the real right assets of the logistics supply chain, promotes the information sharing of the whole supply chain, realizes the visualization of the capital flow of the supply chain, effectively solves the trust problems existing in the traditional logistics supply chain, improves the efficiency of the operation level and reduces the financing cost of enterprises in the supply chain. Based on the practice of school-enterprise cooperation and from the perspective of logistics supply chain finance, this study combines the idea of an evolutionary game with blockchain technology and embeds it into supply chain finance to solve the authenticity and reliability of assets, credit investigation, finance and other information, effectively reduce the uncertainty in logistics supply chain and enhance the comprehensive risk management ability of logistics supply chain. Therefore this study is of great value to the theoretical research and practical application of supply chain financial risk.

Keywords: Blockchain · Logistics · Supply Chain Finance · Risk Management

1 Introduction

Blockchain is a fusion of information technology with digital encryption, point-to-point communication, distributed ledger, smart contract technology, and other fields. With the characteristics of tamper resistance and traceability of data, blockchain is unusually suitable for multi-party supply chain finance scenarios. Blockchain technology builds a trust system for small and medium-sized enterprises (SMEs) in the logistics supply chain to solve the financing problems in the supply chain. It is an improved system to settle the trust issues of financing institutions in SMEs [6].

At present, economic development has entered a new era where the competition among enterprises has shifted to the competition among supply chains. The competition among supply chains can clarify the data information and relevant interest chains of all parties through blockchain technology. In many cases, enterprises realize the operation of assets through the credit sales method called "white list" in the logistics supply chain [1]. The way for suppliers to obtain funds is the bank credit. When approving loan applications, banks strictly review the loan qualification of suppliers, so suppliers need to provide a large number of favourable materials to obtain financial support from banks. Most SMEs stagnate in follow-up business, service, operation and other links due to funding shortages [4].

Solving the problem of restricted access to credit for suppliers upstream of the supply chain has become a bottleneck for the development of logistics enterprises. The development of China's logistics supply chain finance is in an explosive period. According to the data reported by the Financial Industry Research Institute, the market scale of China's supply chain finance will reach about 14.98 trillion yuan by 2020 (Forward-looking industrial research Institute 2016) [5]. It illustrates that the innovative model of logistics supply chain finance with blockchain technology is another direction to solve the problem of enterprise financing in the future.

2 Research and Comparison of Logistics Supply Chain Finance Under Blockchain Technology

The traditional enterprise financing is mainly that the enterprise offers the operation status, financial management status, enterprise credit and other materials to the financing enterprise as the credit basis. The characteristic of logistics supply chain finance is that the enterprise operation needs to comprehensively consider the behaviour of the whole supply chain, which is the result of the interaction between enterprises in the supply chain system. Among them, core enterprise credit is an endorsement [7]. By using blockchain technology, transactions are transparent and tamper-resistant between core parties and upstream and downstream enterprises in the supply chain system. The financing, settlement and cash management businesses covered by financial services are depended on the coupling of various information nodes, so that each node of the supply chain is trustable [2].

The supply chain theory originated from the American scholar Dr Laurence Peter. The idea of supply chain finance was the first mentioned by Timme from the scholar's investigation on the capital situation of enterprises in 2000 [9]. Supply chain finance aims to help achieve the goal of the supply chain. Since then, Hoffmann put forward the view that the providers of external services are composed of more than two organizations. Organizations manage financial flows through planning, control, and implementation for co-creating value [3]. Atkinson believes that supply chain finance is a combination of service and technology, which connects the demander, supplier and financial service provider, thereby optimizing the transparency, financial cost, availability and cash delivery of the supply chain [11]. Wuttke thinks that supply chain finance is the optimization of supply chain cash flow, management and control to promote the efficiency of supply chain logistics [12].

Most domestic scholars more focus on structured trade financing and logistics finance of supply chain finance[5]. Professor Song Hua from Renmin University of China insists that supply chain finance is a management behavior and process, which is the whole process of integrating logistics operation, commercial operation and financial management [8]. Professor Chen Xiangfeng and Professor Zhu Daoli of Fudan University sort out the problems of logistics finance, mainly focusing on a series of problems such as a letter of credit guarantee, warehouse receipt pledge, alternative procurement, credit financing, buyer's credit, reverse guarantee and so on. Shenzhen Development Bank and the "supply chain finance" research group of China Europe International Business School analyze the internal transaction structure of the supply chain, carry out trade financing in the mode of self-compensating credit, introduce new risk control variables into different nodes, and conduct comprehensive financial services by means of core enterprises, logistics supervision companies, capital flow guidance and other tools to complete closed credit support, settlement, financial management and other businesses.

According to the research summary of scholars at home and abroad, most scholars discuss it from a single perspective of logistics enterprises or financial institutions through the research on the financial model of the supply chain and do not study it from the perspective of how blockchain technology couples and operates in a closed-loop between financial institutions and various links of the logistics supply chain, or from the perspective of the integrity of the logistics supply chain, especially the reality of logistics enterprises in Guangdong-Hong Kong-Macao Greater Bay Area. The financial risk management of the new logistics supply chain lacks technical support. This research cooperates with schools and enterprises in the Guangdong-Hong Kong-Macao Greater Bay Area, including SF Logistics and Yonghui Supermarket. It integrates theory with practice and has practical operability. Research focuses on how to realize the balance between relationship governance and efficiency among core enterprises, SMEs, and financial institutions in the supply chain by utilizing the coupling and closed-loop operation of blockchain technology and the supply chain.

3   Financial Model of Logistics Supply Chain Based on Blockchain Technology

Logistics supply chain finance is a dynamic empirical data of credit financing based on "white list" credit sales, and its transaction subject comes from internal members of the supply chain. According to the principle of game model, core enterprises, SMEs and financial institutions in the logistics supply chain make game decisions under the condition of "incomplete information market". We assume that in the game model, there are two choices for SMEs, core enterprises and financial institutions in the logistics supply chain system. If SMEs (loan enterprises) can repay on schedule and financial institutions can receive repayment on schedule when SMEs abide by the contract, at this time financial institutions will approve the loan application, otherwise they will not approve. In the whole process of supply chain financing, when SMEs default on loans, the core enterprise (property manager) will play the role of guarantee and jointly bear the losses of the bank. At the same time, in order to punish the dishonesty of SMEs, the core enterprise (property manager) will choose to give up continuing cooperation with SMEs.

When the dishonesty of SMEs threatens the position of core enterprises in the industry and the major interests of enterprises, core enterprises may collude with SMEs to defraud loans and conceal transaction information from financial institutions, thus resulting in damage to the interests of financial institutions. At this time, financial institutions suffer heavy losses and are at a weak position due to the impact of information asymmetry.

We analyze the application of each participant in logistics supply chain financing from the game theory and theory of Simon's bounded rationality, design the game hypothesis in the "complete information market", establish a nonlinear random game model, analyze and compare the behavior of each subject in supply chain finance, and choose the strategy to obtain the optimal income of supply chain. In order to stabilize the evolution of logistics supply chain finance, we assume that the subject S (core enterprises, SMEs, financial institutions and regulators) in the logistics supply chain finance is a mixed strategy matrix with pure strategy game, and suppose that most of the individual selection strategies of supply chain financing subjects are p* ∈ △s, while only a small number of individuals choose the variable strategy P ∈ △S, and among them, P*and P are mixed strategy combinations. After strategy selection and iteration, S's strategy tends to reach p*.Ap* ≥ p.Ap*, and p ≠ p* and p*.Ap* = p.Ap*, then we can say p*.Ap > p.Ap, so P* is Ess strategy set to reach a new Nash equilibrium. Firstly, assuming that the evolutionary game starts from the initial strategy point S, the evolutionary subject can randomly choose one of the strategies to form the initial situation. In order to reach the Nash equilibrium, it is necessary to choose the secondary strategy. Supposing that under the new equilibrium, the new return is greater than the original return, the new equilibrium situation will be replaced by the original equilibrium situation. Secondly, it is assumed that there is a random disturbance deviation probability under the ESS strategy, which means that the static equilibrium is destroyed. To restore to the new Nash equilibrium again, it needs to be completed by optimal replication dynamics. If the equilibrium cannot be reached, it needs to be cycled repeatedly and finally reaches the Nash equilibrium to meet the stop criterion. In the optimization method of evolutionary game, the subject of game strategy combination is s, whose particle solution is x, the objective function of strategy combination utility can be expressed by u (s), and the optimal equilibrium state (ESS) of particle evolutionary game is Gbest. The game subject s will seek the optimal strategy, and the change of particle X in space is the evolutionary game process. Global Evaluation Function (GEF) is the evaluation guidance function for the system, and it is the evolution state of the whole individual (global). Local Evaluation Function (LEF) is a guiding function that uses individual state evaluation to guide subject evolution. In addition, the Local Evaluation Function is also very similar to the Individual Utility Function. The difference is that the UF (Utility Function) allows the use of the evolution state information of all individuals (global), while LEF can only use individual information.

If the effects of UF and GEF are consistent, the following constraints should be met.

If $\forall S \in \Omega$ and $\forall S \in N$, we can find $\mathrm{sgn}(E_{GEF}(S^{'}) - E_{GEF}(S)) = \mathrm{sgn}(E_{UF}^{i}(S_{-i}, S^{i}) - E_{UF}^{i}(S_{-i}, S))$.

It can be seen that the consistency of target values leads to the optimal value of Utility Function and TSP problem.

When the problem P of an optimal combination and the Utility Function UF is given, and if it is true for the hypothesis:

$\forall s \in \Omega, \forall s'_i \in A_l, i = 1, 2, ..., n, E^i_{UF}(S_{-i}, s_i) \geq E^i_{UF}(S_{-i}, s'_i)$ it is about the Nash equilibrium between P and strategy subject S. So the solution set obtained can be expressed as: N (P, E_{UF}). If $s \in \Omega$ and $\forall S' \in N^1_s$, we can find $E_{LEF}(S) \geq E_{LEF}(S')$, that is, when the problem P obtains the local optimal value, the subject S is obtained, and then the local optimal solution set is L (P, E_{LEF}). If $\forall S, S' \in \Omega$ and $E_{GEF}(S) \geq E_{GEF}(S')$, the global optimal value S of problem P can be obtained. The global optimal solution set can be expressed as: G (P, E_{GEF}).

We define the local optimal operation as:

If $S \in \Omega, S' \in N^1_S$ and it is true for the following two hypothesis: $\forall s'' \in A_l, E^i_{UF}(S_{-i}, s') \geq E^i_{UF}(S_{-i}, s'')$ and, $\forall s'' \in A_l, E^i_{UF}(S_{-i}, s') \geq E^i_{UF}(S_{-i}, s'')$ the change process of the system from S to S' is the local optimal operation.

Corollary 1: when the Utility Function takes the maximum value, the result will be consistent with the optimal value of TSP problem.

Corollary 2: in order to solve the TSP problem, using the Utility Function as the Index Function, we can draw a conclusion: $G(P, E_{GEF}) \subseteq N(P, E_{UF})$, and then GEF is the global optimal goal of TSP.

The conversion formula of the algorithm is:

$$f^*(x) = \alpha f + \beta$$

f* Will change the speed of evolution, but the evolutionary path is unchanged. So we can find:

$$\overset{\bullet}{x} = x(f^* - \bar{f^*}) = x[(\alpha x + \beta) - \overline{\alpha x + \beta}] = \alpha x(f - \bar{f})$$

By improving the optimization algorithm of particle swarm, starting with the introduction of evolutionary game idea, this paper selects a more optimized evolutionary game optimization algorithm of particle swarm to enhance the ability of particle search.

Under the condition of complete rationality, assuming the existence of Nash equilibrium, when the two sides of the game play the game once, the Nash equilibrium can be maintained without copying the dynamics many times. The result does not need dynamic adjustment and has nothing to do with the initial state of the market. However, there is no complete rationality in evolutionary game theory. It is necessary to introduce blockchain technology into the supply chain system to build an information platform that establish a connection between core enterprises, SMEs and financial institutions, thereby realizing the evaluation and control of financial risks in the supply chain by reconstructing the blockchain information platform. As shown in Fig. 1, logistics supply chain finance takes the real trade background as the premise, relies on the real right pledge, employs the way of self compensatory trade financing, closes the capital flow or controls the real right through professional means such as accounts receivable pledge registration and third-party supervision, and provides comprehensive financial products and services to upstream and downstream enterprises of the supply chain.
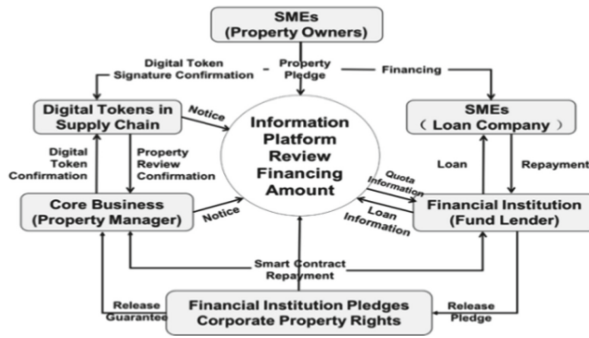
Fig. 1. Logistics supply chain financial model (Photo credit: Original).

With the support of blockchain technology, the actual data generated in the supply chain is controlled and coupled with the financial services provided by financial institutions to form the closed-loop operation of module systems based on blockchain technology, such as monitoring system, upgrade system, node management system, contract management system, etc. [10]. Through the ERP platform, we can connect the whole process from production to management and collect node data. With the Internet platform, we can connect the transaction parties and retain such information as payment, logistics, and so on. By analyzing the data precipitated by the multi-party cooperation of supply chain enterprises and funders, we will combine artificial intelligence, blockchain, big data and other technologies with the supply chain scenario to create a "new technology + finance + scenario" cross-border integrated solution of supply chain financial service, such as E-letter of credit, E-finance of credit, E-bill of credit, etc. In this way, the ability to obtain funds will be improved for enterprises in the supply chain, and the operation efficiency of the industry will be increased, so as to realize the closed-loop operation of supply chain financing, as shown in Fig. 2. Around the core enterprise "1", supply chain finance provides financial services to its upstream supplier "M" and downstream dealer "N" based on the real transaction process, forming a "M + 1 + N" comprehensive financial service platform.

In the financial activities of the blockchain logistics supply chain financial model platform in Fig. 2, financial service providers obtain the overall evaluation of enterprises participating in the supply chain through big data (the basic information of enterprises, supply chain capacity and industry credit, etc.). Aiming at the assets with poor liquidity (inventory, prepayment, accounts receivable, etc.) owned by enterprises in the operation of various channels of the supply chain, taking the determined future cash flow generated by assets as the direct repayment source, with the application of rich financial products, the closed capital operation mode and the channel advantages of intermediary enterprises, the financial service providers offer personalized financial service schemes and comprehensive financial services for enterprises, channels and supply chains, to improve the synergy of supply chains and reduce their operatingcosts.
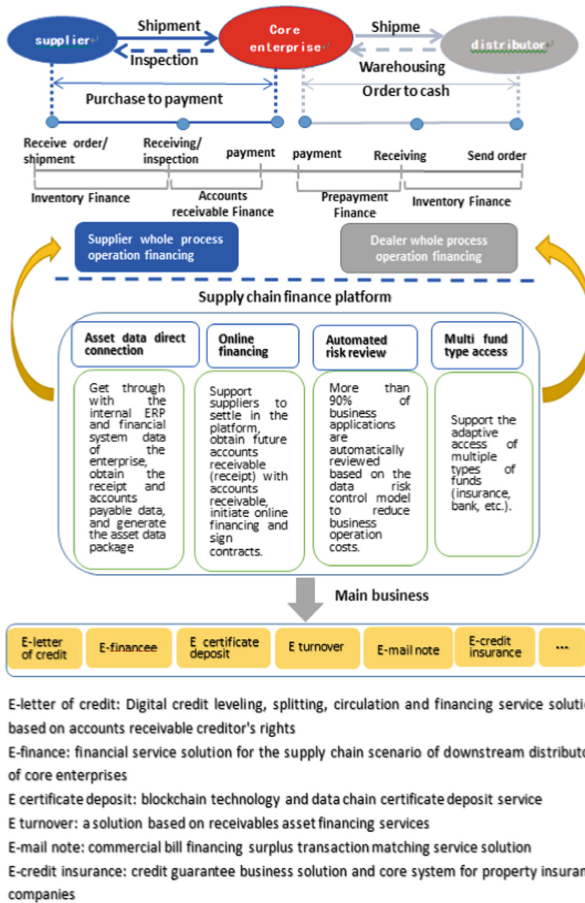
Fig. 2. Blockchain logistics supply chain financial model (Photo credit: Original).

4 Conclusion

Building a logistics supply chain financial service platform under blockchain technology can effectively solve the trust problem among enterprises and between enterprises and financial institutions. Blockchain has the potential for innovation and breakthrough in terms of financing convenience and financing cost because of its technical characteristics such as the tampering resistance and traceability of its data. The goal of supply chain finance development is to rely on the core enterprises of the supply chain to provide comprehensive financial services to relevant enterprises upstream and downstream of the industry, finally reducing the operation cost of the whole supply chain. In addition, through the cooperation of financial capital and the real economy, it aims to build the industrial ecology of sustainable development and the mutually beneficial coexistence of banks, enterprises and supply chains. Also, the characteristics of blockchain technology and supply chain finance have natural matching. With the frequent introduction

of national financing policies to support small, medium-sized and micro enterprises, the developmental trend of supply chain finance is becoming mature. By means of blockchain technology, we can effectively solve problems for SMEs, such as the difficulty and high cost of financing, the supply-side optimization and the destocking, to ensure the stability of the capital chain and the efficiency of the capital flow of SMEs in the supply chain, help the vigorous development of SMEs, and improve the competitiveness of the supply chain.

References

1. Chen Xiangfeng, Zhu Daoli.(2008). Study on system value of logistics providers in capital-constrained supply chain. Systems engineering, 23(06) : 666–673.
2. Chod, J. , Trichakis, N. , Tsoukalas, G. , Aspegren, H. , & Weber, M. . (2017). On the financing benefits of supply chain transparency and blockchain adoption. Social Science Electronic Publishing.
3. E.Hofmann.(2005)."Supply Chain Finance-some Conceptual Insights".Beitrge ZuBeschaffung Und Logistik, 1(1):203–214.
4. Fu Lin, Jin Aihua.(2018) Risk evaluation and prevention of supply chain finance of small and micro enterprises in circulation industry [J] Business economics research, (8).
5. http://www.chinawuliu.com.cn/xsyj/201602/19/309625.shtml.
6. Liu Jingyi, Wang Weijing, Wang Jingsi. (2019).Construction of credit risk evaluation system for small and medium-sized enterprises under supply chain mode [J] Financial development research, 11.
7. Michael L.(2007). A supply chain finance prime[J].Supply Chain Finance,4,.
8. Song Hua,Innovation trend of supply chain finance based on Industrial Ecology [J] China's circulation economy, 2016, 30 (12)
9. Timme,S.G.,and C.Williams-Timme.(2000)"The Financial-SCM Connection".Supply Chain Management Review, 4(2):33–40.
10. Treleaven, P. , Brown, R. G. , & Yang, D. . (2017). Blockchain technology in finance. Computer, 50(9), 14–17.
11. W.Atkinson.(2008)."Supply Chain Finance:The Next Big Opportunity".Supply Chain Management Review, 12(3):57–60.
12. Wuttke,D.A.,Blome,C.,and K.Foerstl. (2013). "Managing. the Innovation Adoption of Supply Chain Finance—Empirical Evidence from Six European Case Studies".Journal of Business Logistics, 34(2):148–166.