

Research on Supply Chain Finance Driven by Blockchain

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ABSTRACT

The continuous development of blockchain technology is expected to solve many problems in supply chain finance. This paper analyzes the impact of blockchain technology on all parties in supply chain finance from the operational mechanism of supply chain finance. In this paper, a game model between small-sized enterprises and core enterprises is constructed to verify how each party in the game changes its strategy choice under the influence of blockchain technology. This paper shows that after the application of blockchain technology in supply chain finance, both small-sized and core enterprises tend to choose repayment strategies.

Keywords: *supply chain finance, blockchain, game theory*

1. INTRODUCTION

In this day and age, the wave of blockchain has never failed to arouse both the academia and industry concern and at the same time attract tides of attention among entrepreneurship. Owing to the using of DLT (Distributed Ledger Technology) and intelligent contract, blockchain is becoming a core technology and playing an important role in many industries. As a new decentralized infrastructure and distributed computing paradigm, its performance in construction of programmable monetary systems and financial systems has been highly expected.

Blockchain is a distributed shared ledger and database. In an online-technology era, blockchain ensures the security and the credibility of information because of its various characteristics: decentralized, non-tampering, collectively maintained, and its openness and transparency. In this case, there is no need for a trustworthy intermediary during transactions, instead, blockchain ensures the security and credibility of transactions between suppliers and consumers hence lead to a high efficiency in financial activities. Not only relevant researchers, but also government departments and financial institutions are paying close attention to the development of blockchain technology to improve their work efficiency.

Supply chain is a network chain structure formed in the process of production and circulation. In a supply chain, there is always a core business. These central enterprises give credit to upstream enterprises, but at the same time they do not allow downstream enterprises to open credit to them. Therefore, upstream and downstream SMEs often encounter financial difficulties in supply chain transactions, and their low credit makes it difficult for them to get financial help. Supply chain finance provides an effective financing method for small and medium enterprises by making judgment based on the entire supply chain rather than a single enterprise. Therefore, the core enterprises with high credit in the supply chain help small and medium-sized enterprises to get financial help faster in the supply chain finance.

After analyzing numerous reviews of previous research on blockchain, we safely come to conclusion that blockchain technology reshapes the credit ecology of small and micro enterprises at the end of the supply chain, providing credit basis for banks to lend to MSMEs by confirming contracts, debt splitting, and associated credit. Blockchain technology reshapes the mechanism of obtaining credit for chain MSMEs^[1]. Also, blockchain technology breaks the barrier of information access for small and medium enterprises at the end of the supply chain by breaking the obstacle of information

transmission between all participants in the chain, and fundamentally solve the problem of difficult access to information and asymmetry of small and medium enterprises at the end of the chain by cross-checking the information of multiple subjects and sharing data^[2]. Additionally, blockchain technology reduces financing management risks for supply chain MSMEs via effectively confirming the right, process regulation, monitor the risk, clearly recording the enterprise contract and sales data, solving the problem of post-loan credit risk in advance and tracing and monitor the information of transaction behavior among enterprises^[3].

2. LITERATURE REVIEW

Supply chain finance (SCM) is a financing mode in which banks connect core enterprises with upstream and downstream enterprises to provide flexible financial products and services^[4]. Because supply chain finance not only solves the financing difficulties of small and medium enterprises but also broadens the loan business of banks, supply chain finance has achieved rapid development, and financial institutions engaged in supply chain finance business become more and more professional. There are three primary main part in supply chain finance, which are upstream suppliers, core enterprises and downstream distributors. In general, supply chain finance attempts to address the financial needs of the parties involved in the process in new ways, such as using receivables as collateral in contracts signed in the course of a business.

As a new data technology, blockchain technology has made progress in many aspects in recent years, for example, wireless systems^[5], health care applications^[6], education^[7], energy industry^[8], business and management^[9]. The integration of supply chain finance services and blockchain will bring great hope for the formation of new development models.

Prior research has explored the design and working mechanisms of supply chain finance as well as applications of blockchain in supply chain finance^[10-13]. However, few articles have studied from the perspective of mathematical model how blockchain technology affects the decision-making of parties in supply chain finance, making parties choose to perform their contracts. Our research makes contributions to the existing

literature by modelling game model and analyzing a supply chain finance based on blockchains.

3. SUPPLY CHAIN FINANCE BUSINESS MODEL

In supply chain finance business, several characters play the main roles in this process: the core corporation, MSMEs and the financial institutions. Core enterprises do not have concerns about credit and can meet most of their financing needs by relying only on traditional financing channels with their strong strength and credit in business; however, in most MSMEs, whose company volume is relatively small, there exists problems like difficulty in financing because of lack of credit. Indeed, the main function of supply chain is to solve the financing problem of MSMEs. Another important participator in supply chain financing is the financial institutions, whose main concerns are about the confirmation of credit of MSMEs to minimize the risks of lending during the whole process of supply chain financing.

The process of supply chain is shown in Fig. 1.

1. Upstream suppliers and core corporation negotiate the agreement regarding order, shipment and settlement.
2. The MSMEs require financing services and submit the application material up to the financing platform.
3. Financial institutions confirm the validity of receivables by fully investigating the operating conditions and financial information of small enterprises, so as to agree to lend to small enterprises.
4. Upstream supplier signs financing contracts with financial institution.
5. Finance institution makes loan and other services to the suppliers including opening a special financing account to record the finance details, etc.
6. In the end of credit term, according to their agreement, the core company needs to transfer the full amount of money to the financial institution.
7. With the money paid by core corporation, the supplier uses money in the designated account to repays the loan back to the finance institution and supply chain financing completes.

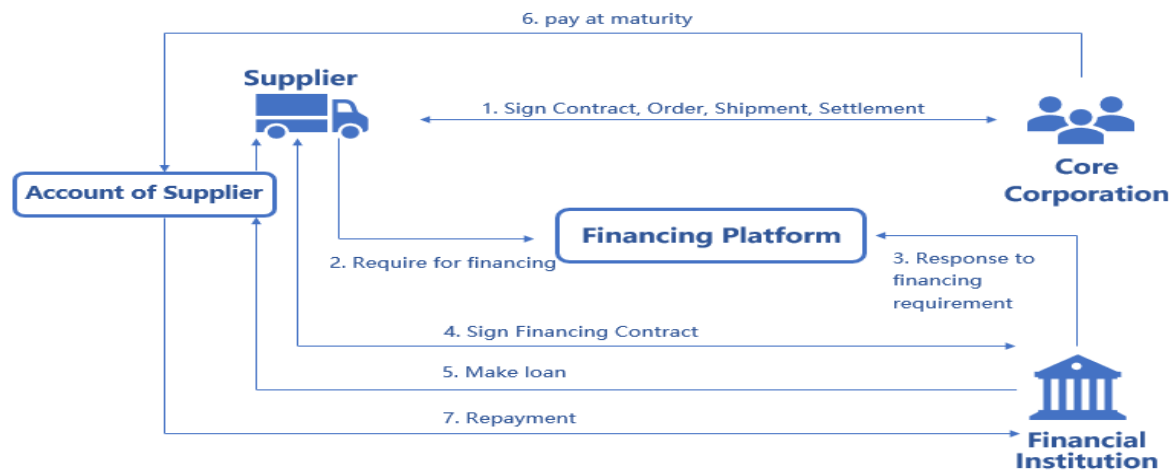


Fig. 1 Business flow chart of supply chain finance^[14]

4. STATIC GAME ANALYSIS OF CORE ENTERPRISES AND SMALL-SIZED ENTERPRISES IN SUPPLY CHAIN FINANCE

Based on the analysis of supply chain finance business model, we propose a game theory model to study the impact of blockchain technology on the strategic choice of supply chain finance parties.

4.1. Model assumptions and variable interpretation

1. As self-financing economic entities, enterprises need to calculate their investments and returns in detail to maximize their profits in order to prevent themselves from being eliminated by the market. Therefore, the game model of this paper assumes that financial enterprises, core enterprises and small-sized enterprises in the supply chain are rational economic entities and risk averse.

2. Small-sized enterprises and core enterprises make their own decisions in the game theory model, which means they are independent of each other.

3. We assume that the account receivable of small-sized enterprises from core enterprises is R , the bank factoring service rates is k , and financing project investment of small-sized enterprises return is r_2 . If the supply chain works well, small-sized enterprises choose repayment and core enterprises choose repayment, the profit of both small-sized enterprises and core enterprises from the supply chain is A . The loan interest rate of the bank is r_0 . The probability that small-sized enterprises choose repayment is p_1 , and the default cost is C_1 . The probability that core enterprises choose repayment is p_2 , and the default cost is C_2 .

4.2. Analysis and results

When the financial institution chooses a loan, the

income matrix of the small-sized enterprises and core enterprise is shown in Table 1 (from top to bottom, core enterprises, and small-sized enterprises). Core enterprises and small-sized enterprises face two choices: repayment and non-repayment. Both sides want to maximize their incomes. If the income of repayment is higher than non-repayment, the optimal strategy of the enterprise is repayment.

If core enterprises choose “repayment”:

$$R(\text{repayment}) - R(\text{non-repayment}) = kR(r_2 - r_0) + A - (kR(1 + r_2) - C_1) = A + C_1 - kR(1 + r_0) \quad (1)$$

If core enterprises choose “non-repayment”:

$$R(\text{repayment}) - R(\text{non-repayment}) = kR(r_2 - r_0) - (kR(1 + r_2) - R - C_1) = C_1 - kR(1 + r_0) \quad (2)$$

As can be seen from formula (1) and (2), as long as the penalty for default is high enough, small-sized enterprises will only choose repayment, regardless of whether core enterprises choose repayment or non-repayment. If small-sized enterprises choose “repayment”:

$$R'(\text{repayment}) - R'(\text{non-repayment}) = Rr_1 + A - (R(1 + r_1) - C_2) = A + C_2 - R \quad (3)$$

As can be seen from formula (3), if $A + C_2 > R$, the optimal strategy of the core enterprises is also “repayment”.

The above analysis is based on pure strategy game. However, the actual situation is that there is usually no pure strategy in this game, regardless of whether there is supply chain finance or blockchain involved. Financial institutions need to pay a lot of labor and time costs to investigate enterprises in need of funds so as to reduce the probability of default of enterprises in need of funds. Therefore, this game is usually a mixed strategy game, and the correlation analysis is as follows:

For small-sized enterprises:

Expected value revenue of repayment:

$$R(\text{repayment}) = p_2 [kR(r_2 - r_0) + A] + (1 - p_2) [kR(r_2 - r_0) - R]$$

Expected value revenue of non-repayment:

$$R(\text{non-repayment}) = p_2 [kR(1 + r_2) + C_1] + (1 - p_2) [kR(1 + r_2) - R - C_1]$$

When $R(\text{repayment}) \geq R(\text{non-repayment})$, rational small-sized enterprises will choose repayment:

$$p_2 [kR(r_2 - r_0) + A] + (1 - p_2) [kR(r_2 - r_0) - R] \geq p_2 [kR(1 + r_2) + C_1] + (1 - p_2) [kR(1 + r_2) - R - C_1]$$

$$p_2 \geq \frac{kR(1 + r_0) - C_1}{A} \quad (4)$$

If $\frac{kR(1 + r_0) - C_1}{A}$ closes to 0, the formula (4) is workable with higher probability, which makes small-sized enterprises choose repayment with higher probability. In this case, smaller kR and bigger A and M makes $\frac{kR(1 + r_0) - C_1}{A}$ become smaller.

It can be concluded that the larger the difference between trust-keeping income and default income of small-sized enterprises, the more likely they will choose trust-keeping behavior. At this time, the smaller the loan amount kR is, the more trustworthy they will be. In the case of trustworthiness, the greater the supply chain income A is, the more trustworthy small-sized enterprises will be. In the case of default, the larger the default loss C_1 is, the more restrictive the trustworthy behavior of small-sized enterprises will be.

For core enterprises:

Expected value revenue of repayment:

$$R'(\text{repayment}) = p_1 (Rr_1 + A) + (1 - p_1) * 0$$

Expected value revenue of non-repayment:

$$R'(\text{non-repayment}) = p_1 [R(1 + r_1) - N] + (1 - p_1) [R(1 + r_1) - C_2]$$

When $\pi_3 \geq \pi_4$, rational core enterprise will choose repayment:

$$p_1 (Rr_1 + A) + (1 - p_1) * 0 \geq p_1 [R(1 + r_1) - C_2] + (1 - p_1) [R(1 + r_1) - C_2]$$

$$p_1 \geq \frac{R(1 + r_1) - C_2}{Rr_1 + A} \quad (5)$$

If $\frac{R(1 + r_1) - C_2}{Rr_1 + A}$ closes to 0, the formula (5) is workable with higher probability, which makes core enterprise choose repayment with higher probability. In this case, bigger A and C_2 makes $\frac{R(1 + r_1) - C_2}{Rr_1 + A}$ become smaller.

It can be concluded that the larger the difference between the core enterprise's repayment income and non-repayment income is, the more the core enterprise will choose repayment behavior. In this case, the greater the supply chain income A is, the more the core enterprise will abide by the repayment agreement. In the case of non-repayment, the larger the default loss N is, the more the core enterprise's repayment behavior will be constrained.

Table 1 Game revenue matrix of supply chain finance

Revenue		Small-sized enterprises	
		Repayment (p_1)	Non-repayment ($1 - p_1$)
Core enterprises	Repayment (p_2)	$Rr_1 + A,$ $kR(r_2 - r_0) + A$	$0, kR(1 + r_2) - C_1$
	Non-repayment ($1 - p_2$)	$R(1 + r_1) - C_2,$ $kR(r_2 - r_0) - R$	$R(1 + r_1) - C_2, kR(1 + r_2) - R - C_1$

5. CONCLUSION

After establishing the game model of all parties in the supply chain and analyzing the benefits of all parties, the influence of the following parameters on the game model can be obtained.

Firstly, the account receivable R affects the income from supply chain finance of small-sized enterprises and core enterprises in the supply chain. The increase of R increases the loans available to small-sized enterprises, which increases the probability of small-sized and core enterprises taking the risk of default. Therefore, financial

institutions should strictly supervise the supply chain financial business of large receivables to avoid default risk.

Secondly, the payoff A of keeping contract between small-sized enterprises and core enterprises has positive influence on strategy choice. As can be seen from the game income model, the bigger A is, the more likely small enterprises and core enterprises will choose repayment. Therefore, supply chain finance should be developed quickly so that trustworthy enterprises get loans and promote the benign economic development. Blockchain technology can record a company's record of keeping promises and increase its credit rating to make it

easier to get loans from financial institutions.

Thirdly, penalty for breach of contract determines the strategy choice of both small-sized enterprises and core enterprises. A smaller penalty will increase the probability of non-repayment, while a larger penalty will make small-sized and core enterprises choose repayment. Complete blockchain technology will record the default information of each enterprise, so that financial institutions can quickly obtain relevant information. In addition, due to the high cost of modifying information in blockchain, it is difficult for enterprises to modify or conceal the default information. Therefore, after the introduction of blockchain technology, supply chain finance can effectively increase the default risk of enterprises, making it difficult for enterprises to obtain loans once they default.

It can be concluded that the development of blockchain technology is conducive to the development of supply chain finance, and the probability of enterprise performance is increased mainly by increasing the earnings of enterprise performance and the punishment for breach of contract. Blockchain technology will improve the low informatization level of traditional financial business, speed up information communication and reduce the cost of supervision of financial institutions. It can be predicted that with the maturity of blockchain technology, all parties in supply chain finance will benefit - enterprises can obtain loans through trustworthy technology, and financial institutions can increase business income through lending.

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