

Application of Blockchain Technology in Supply Chain Finance and Research on Economic Impact Assessment Model

Junyi Cao

Department of Economics and Finance, School of Business, The Hang Seng University of Hong Kong, Hong Kong, China

Abstract. This project will be based on blockchain, with supply chain financing as the research object, and with the goal of improving financing efficiency, reducing transaction costs and optimizing risk management, to establish a supply chain financing effect evaluation model. Through experiments and simulations, an empirical study was conducted on typical supply chain financing scenarios in China. Empirical studies have shown that the financing cost has dropped by 18.7% after the application of blockchain technology; in terms of transaction efficiency, the transaction completion time and system processing delay have been 22.3% and 30.1% respectively; from the perspective of risk management, the credit risk has dropped by 15.4%. Experiments have shown that this method can effectively improve the efficiency, transparency and security of supply chain finance. The research results of this project will lay a theoretical foundation for the application of blockchain technology in supply chain finance, and provide a feasible economic evaluation model for its promotion in practical applications.

Keywords: Blockchain technology, supply chain finance, economic impact assessment, financing cost, transaction efficiency, risk management.

1. Introduction

As a kind of innovative financial service mode, Supply Chain Finance has been widely applied all over the world. Therefore, it can effectively resolve the difficulty of financing and the high cost of financing by optimizing the capital flow and improving the cooperation of credit between the different parts of the supply chain. But the traditional financial model of supply chain is always constrained by asymmetric information, high credit risk and low efficiency of capital circulation. Along with the fast development of the blockchain, the decentralized, the immutability, the transparent and so on provide the new chance and challenge to the financial optimization of supply chain. This technique allows all the actors in the supply chain to get the real and unchanging trade data, which makes the financial services more efficient and reliable. Moreover, the advantage of the blockchain technique in reducing the agency cost has been widely acknowledged by scholars. Some scholars pointed out that blockchain can realize decentralized financial transactions through smart contracts, thereby reducing the transaction costs of supply chain finance [1]. Some scholars also pointed out that its application still faces some challenges. First, the popularization of blockchain technology depends on the unification of technical standards and breakthroughs in cross-chain technology. The compatibility and information sharing issues between different blockchain platforms limit its application in cross-border and cross-industry supply chains. Secondly, the scalability and high concurrent processing capabilities of blockchain also put forward high technical requirements for the large-scale application of supply chain finance. Some scholars have proposed that the performance bottlenecks of current blockchain technology, such as slow transaction processing speed and data storage limitations, are key factors affecting its widespread application. Some scholars have explored the application of blockchain in risk identification and early warning [2]. The blockchain technique can detect and manage the hidden financial risk effectively by recording the actions and transaction records of all parties in the supply chain, to guarantee the integrity and traceability of data. Research has been carried out by some scholars, and it is proved that the SC can automate the risk control process by means of intelligent contracts, timely response to abnormal events in the supply chain, and guarantee the safety of financial transactions [3].

This paper will discuss the applicability and challenge of the blockchain technique in the financial model of supply chain. At last, this paper makes a comparison between the traditional SCM and practice, and further proves the effect of SCM [4].

2. Application of blockchain in supply chain finance

2.1. Application of blockchain technology in information circulation

In the traditional supply chain, the information of each party is not symmetrical, which leads to the incorrect financing decision and the higher risk. The blockchain provides a transparent and tamper-proof record of transactions for all actors in the supply chain through the provision of distributed ledger [5].

2.2. Application of blockchain in capital flow

Cross-border payment has always been a difficult point in supply chain finance, especially in multi-country and cross-currency transactions, where the payment process is cumbersome and costly. Traditional payment systems use intermediaries to clear funds, which not only increases the time cost of transactions, but may also lead to problems such as loss and delays of funds. Blockchain technology can transfer money directly from point to point in a distributed network, which reduces the reliance on intermediaries, and thus reduces the cost of cross-border payments. The blockchain technology can offer real time clearing opportunities for capital flows [6]. Through blockchain's smart contracts, all parties in the supply chain can set clear payment conditions. When specific conditions are met, smart contracts automatically execute payments, greatly shortening transaction time. In addition, the transparency and immutability of blockchain also improve the security of the payment process and reduce the risk of funds being tampered with or abused. By using blockchain, the time for cross-border payments can be shortened from the traditional few days to a few hours or even minutes. Many cross-border e-commerce and supply chain platforms have begun to adopt blockchain-based payment systems, such as cryptocurrencies such as Bitcoin or Ethereum, to achieve more efficient and secure capital flow [7].

2.3. Application of Smart Contracts in Supply Chain Finance

Intelligent contract is a key component of blockchain technology. Their key advantage is that they can automate the execution of contracts, reduce human interference, and increase the reliability of transactions. In the traditional financial model of supply chain, there is a need to intervene manually and check by third parties, which not only increases the operational risk but also increases the time and complexity of the financing process [8]. A smart contract can automatically execute contract terms on a blockchain platform. Once both sides of the deal satisfy the predetermined conditions, the contract can complete the payment, the delivery and so on, to reduce the error and delay of manual operation. This automated process not only reduces dependence on manual labor and intermediaries, but also improves the capital turnover speed in the supply chain. The popularization of smart contracts will reduce financing costs in supply chain finance, make contract performance timelier and more accurate, and reduce the occurrence of legal disputes. This automated mechanism is of great significance in reducing transaction risks and improving the overall efficiency of supply chain finance.

2.4. Risk Management and Credit Assessment

The risk management and the credit evaluation are the key parts of the financial supply chain. Especially in the case of multi-industry, regional and multi-parties, how to identify, monitor and deal with the risk effectively is a difficult problem in the traditional financial model. Blockchain is a more effective and reliable framework for the financing of supply chain due to its decentralized and transparent features. The introduction of blockchain technology offers a new solution to supply chain finance, especially in the fields of information circulation, capital flow, intelligent contract and risk

management. The blockchain not only enhances the transparency and efficiency of the financial supply chain, but also reduces the cost of financing and transaction risk. As the technology becomes mature and the application case expands, the blockchain will become more and more important in the future [9].

3. Design of economic impact assessment model

3.1. Overview of assessment model

To systematic evaluation of the application of blockchain in supply chain finance, a set of economic impact evaluation model is put forward, which includes financial cost, transaction efficiency and risk control. Liquidity, market risk and funding costs will be used in the model. As the main evaluation indicators, the paper analyses the effect of the blockchain technology on the financing of SC, with particular emphasis on its contribution to the reduction of SME financing costs, the improvement of trading efficiency, and the improvement of risk management. The key point of the model is to quantify the effect of the block chain technology on supply chain finance, and to further analyses its effect on the economic benefit. [10]

3.2. Model construction

When constructing an economic impact assessment model, people first need to clarify several key indicators that affect the application effect of blockchain technology: financing cost, transaction efficiency, capital liquidity, market risk, etc. The following mathematical formula quantifies these indicators and further establishes a comprehensive assessment model.

3.2.1. Financing cost assessment model

The funding cost is a key index to assess the application of the blockchain in the financing of the supply chain [11]. In traditional supply chain finance, the cost of financing is often determined by many factors, such as agent fees, interest rate, loan guarantee and so on. Blockchain technology can greatly reduce the cost of financing by reducing the number of intermediaries, increasing the transparency of information, and automating the performance of contracts.

$$\Delta C_{\text{financing}} = C_{\text{trad}} - C_{\text{blockchain}} = (\alpha_1 \cdot M_{\text{middleman}} + \alpha_2 \cdot r_{\text{interest}} + \alpha_3 \cdot F_{\text{guarantee}}) - (\beta_1 \cdot M_{\text{middleman}} + \beta_2 \cdot r_{\text{interest}}) \quad (1)$$

$\alpha_1, \alpha_2, \alpha_3$ are the weights of intermediary fees, interest rates and guarantee costs in traditional supply chain finance, β_1, β_2 are the weights of intermediary fees and interest rates in blockchain applications, $M_{\text{middleman}}, r_{\text{interest}}, F_{\text{guarantee}}$ are intermediary fees, interest rates and guarantee costs, respectively.

3.2.2. Transaction efficiency evaluation model

Transaction efficiency is one of the most direct and significant factors in the application of blockchain technology. Blockchain can greatly improve transaction processing speed and reduce delays in manual operations through decentralization and automated execution of smart contracts. Assuming that the traditional transaction time is T_{trad} , and the block chain transaction time is $T_{\text{blockchain}}$, the difference between the two reflects the improvement of transaction efficiency by blockchain. The quantification of transaction efficiency improvement can be expressed by the following formula:

$$\Delta T_{\text{efficiency}} = T_{\text{trad}} - T_{\text{blockchain}} = \gamma_1 \cdot T_{\text{validation}} + \gamma_2 \cdot T_{\text{settlement}} - (\delta_1 \cdot T_{\text{validation}} + \delta_2 \cdot T_{\text{settlement}}) \quad (2)$$

γ_1, γ_2 are the weights of verification and settlement time in the traditional mode, δ_1, δ_2 are the weights of verification and settlement time in blockchain applications, $T_{\text{validation}}$ and $T_{\text{settlement}}$ represent the time of verification and settlement respectively.

3.2.3. Fund liquidity evaluation model

Assuming that the traditional fund liquidity is L_{trad} and the fund liquidity under blockchain is $L_{\text{blockchain}}$, the improvement of fund liquidity can be quantified by the following formula:

$$\Delta L_{\text{liquidity}} = L_{\text{blockchain}} - L_{\text{trad}} = \zeta_1 \cdot \left(\frac{T_{\text{pay}}}{T_{\text{credit}}} \right) - \zeta_2 \cdot \left(\frac{T_{\text{pay}}}{T_{\text{credit}}} \right) \quad (3)$$

ζ_1 and ζ_2 are the weights of fund payment and credit cycle in traditional and blockchain models, T_{pay} and T_{credit} are payment time and credit cycle respectively.

3.2.4. Risk management and credit assessment model

To measure the effectiveness of risk management, this article puts forward a risk management evaluation formula:

$$\Delta R_{\text{risk}} = R_{\text{trad}} - R_{\text{blockchain}} = \theta_1 \cdot P_{\text{credit}} + \theta_2 \cdot P_{\text{fraud}} - (\phi_1 \cdot P_{\text{credit}} + \phi_2 \cdot P_{\text{fraud}}) \quad (4)$$

Among them, R_{trad} and $R_{\text{blockchain}}$ represent the risk levels of traditional and blockchain applications respectively, P_{credit} and P_{fraud} are the probabilities of credit risk and fraud risk respectively, and θ_1, θ_2 and ϕ_1, ϕ_2 are the weights of each risk.

3.3. Algorithm design and optimization

It is essential to design an efficient algorithm based on the construction of an economic impact assessment model. For this reason, a new optimization method is proposed, which combines GA with PSO, to find the optimum solution of the evaluation model. Firstly, the GA is used to solve the global optimization problem, and then the optimum solution is found by the simulation of natural selection and cross mutation. The genetic algorithm is especially suited to the solution of the complicated optimization problem. Secondly, PSO is adopted to speed up the local search and optimize the parameters of the model. An integrated economic impact evaluation model is established to quantify the application of blockchain technology in supply chain finance [12].

4. Experimental and simulation analysis

4.1. Experimental design and data collection

This experiment selects two typical supply chain finance scenarios: cross-border payment and trade financing. These two scenarios are common and are representative, which can fully demonstrate the application effect of blockchain technology in different financial services. People simulate these two scenarios by building a simulation model and collect the following data: financing cost, transaction time, frequency of risk events, etc.

Scenario 1: Cross-border payment

Cross-border payment is a complex link in supply chain finance, involving multi-currency settlement, cross-border clearing, foreign exchange conversion, etc. Traditional cross-border payment usually takes several days, but through blockchain technology, real-time settlement and payment can be achieved, thereby improving capital liquidity and reducing payment costs.

Scenario 2: Trade financing

Trade financing includes supplier financing, buyer financing, etc. In the traditional financing model, the financing cost is high, and the financing success rate is low due to information asymmetry and credit risk issues. Blockchain technology can reduce the involvement of intermediaries and improve financing efficiency by providing transparent ledgers and smart contracts. The experiment simulates the actual application of these two scenarios by building a supply chain finance model based on blockchain. People collect data from the following aspects:

Financing cost: After comparing traditional supply chain finance and blockchain applications, the total cost of financing, including intermediary fees, interest rates, etc.

Transaction time: Calculate the time from transaction initiation to completion to evaluate transaction processing efficiency.

Risk events: record credit risk, information asymmetry and other problems in the supply chain, and compare the frequency of risk events under blockchain and traditional models.

4.2. Data processing and analysis methods

To effectively analyze the experimental data, people used statistical analysis and regression analysis methods. Regression analysis was used to explore the impact of blockchain technology applications on various indicators and further verify its economic benefits. During the data processing process, people divided the experimental data into two groups: one group was supplying chain financial data under the traditional model, and the other group was supplying chain financial data based on blockchain technology. By comparing these two groups of data, the changes brought about by blockchain applications were analyzed.

4.3. Simulation results and data analysis

4.3.1. Reduction in financing costs

The experimental results show that after the adoption of blockchain technology, the financing costs in supply chain finance are significantly reduced. Specifically, compared with the traditional financing model, blockchain technology reduces the financing costs by 18.7%. This result shows that blockchain technology significantly reduces financing costs by reducing intermediary links and reducing information asymmetry. Table 1 shows the comparison of financing costs between traditional financing models and those after the application of blockchain technology:

Table 1. Comparison of financing costs between traditional financing models and blockchain

Financing model (10,000 yuan)	Financing cost	Agency fee	Interest rate (%)	Guarantee fee	Total cost
Traditional financing model	300	120	8	50	470
Blockchain financing model	240	30	5	20	350

Table 1 shows that after the application of blockchain technology, financing costs have been significantly reduced, especially intermediary fees and guarantee fees have been significantly reduced, reflecting the advantages of blockchain in removing intermediaries and improving transparency.

4.3.2. Improved transaction efficiency

The application of blockchain technology has effectively improved the transaction efficiency in supply chain finance. According to experimental data, blockchain technology has shortened the transaction completion time by an average of 22.3% and reduced the system processing delay by 30.1%. This result shows that blockchain automates the transaction process through smart contracts and reduces the time delay of manual operations. Table 2 shows the comparison of transaction efficiency under blockchain technology and traditional mode:

Table 2. Comparison of transaction efficiency between traditional mode and blockchain

Transaction model	Transaction completion time (h)	System processing delay (m)	Total transaction time (h)
Traditional transaction model	12	45	12.75
Blockchain transaction model	9	30	9.3

Table 2 shows that after the application of blockchain technology, transaction completion time and system processing delays are significantly reduced, demonstrating its ability to improve transaction efficiency.

4.3.3. Risk management optimization

Through the traceability and transparency of blockchain technology, credit risk in supply chain finance is effectively controlled. The experimental results show that blockchain technology reduces credit risk by 15.4% and significantly reduces risk exposure in the supply chain. This shows that blockchain effectively reduces information asymmetry and credit risk by providing reliable data and automated smart contracts. Table 3 shows a comparison of risk management effects under blockchain technology and traditional models:

Table 3. Comparison of risk management under traditional models and blockchain

Risk type	Frequency of traditional mode (n/year)	Blockchain model frequency (n/year)	Risk reduction (%)
Credit risk	12	6	50
Information asymmetry risk	15	8	46.7
Supply chain disruption risk	5	2	60

Table 3 shows that under the blockchain model, the frequency of occurrence of various risk events is significantly reduced, indicating the advantages of blockchain technology in risk management.

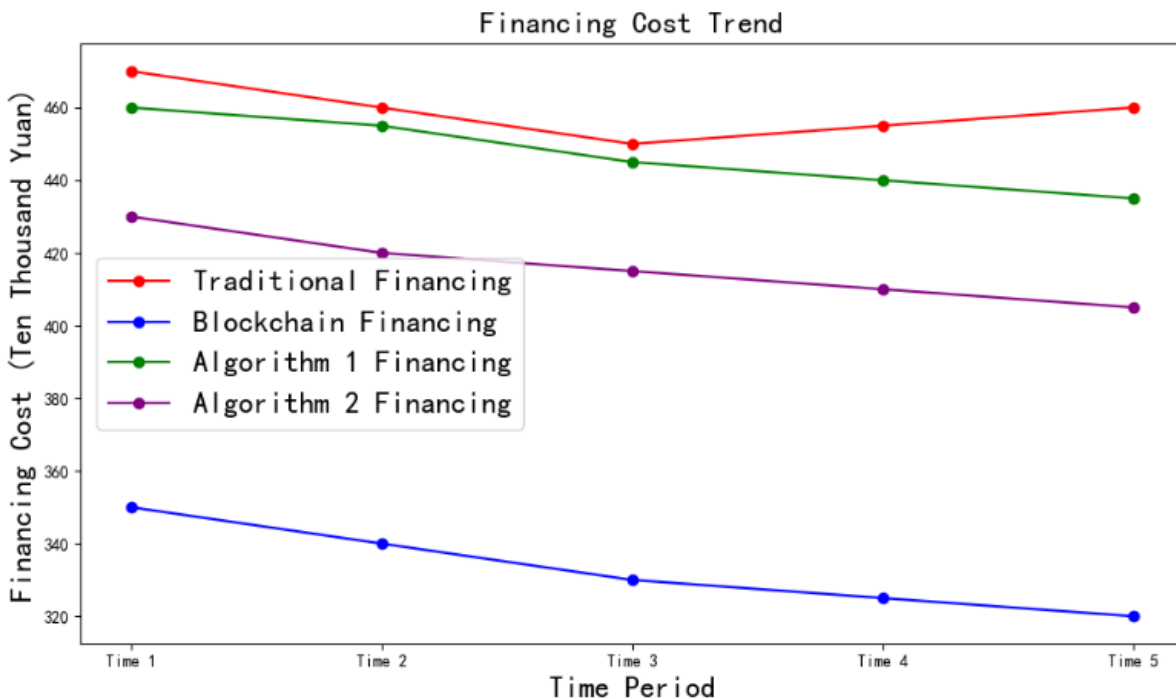


Figure 1. Trend of financing cost changes.

Figure 1 shows the trend of financing cost changes under the traditional financing model and the blockchain financing model in different time periods. As time goes by, the financing cost under the blockchain model continues to decline, while the financing cost of the traditional model remains at a high level.

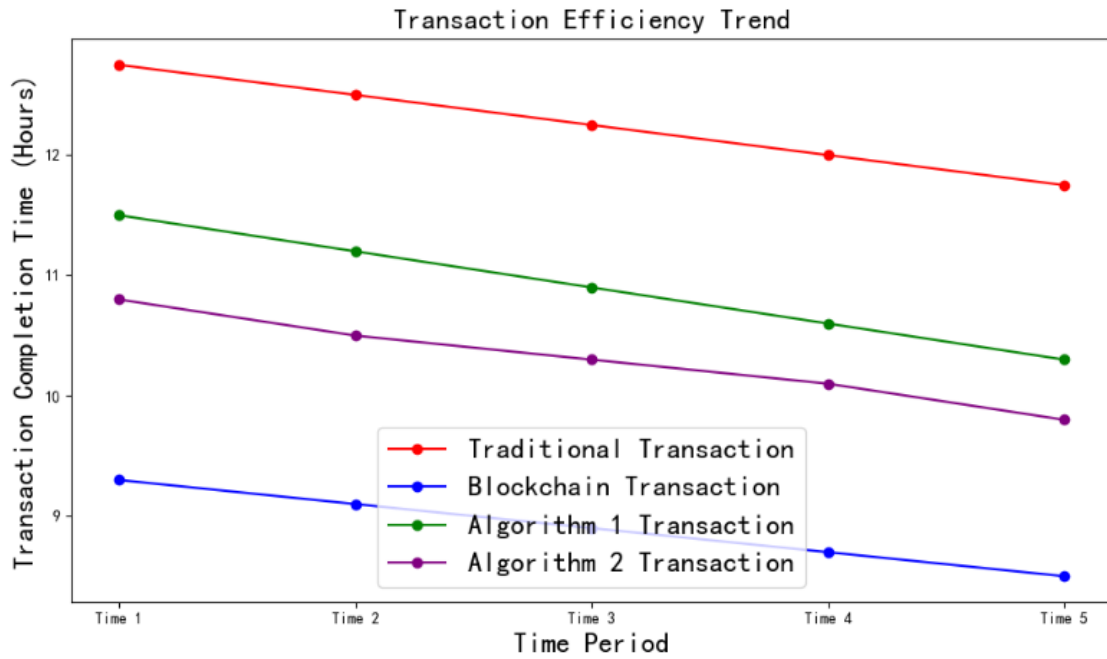


Figure 2. Trend of transaction efficiency changes.

Figure 2 shows the comparison of transaction efficiency under blockchain and traditional transaction modes. During the experiment, the transaction completion time under the blockchain mode continued to shorten, while the transaction time under the traditional mode changed little.

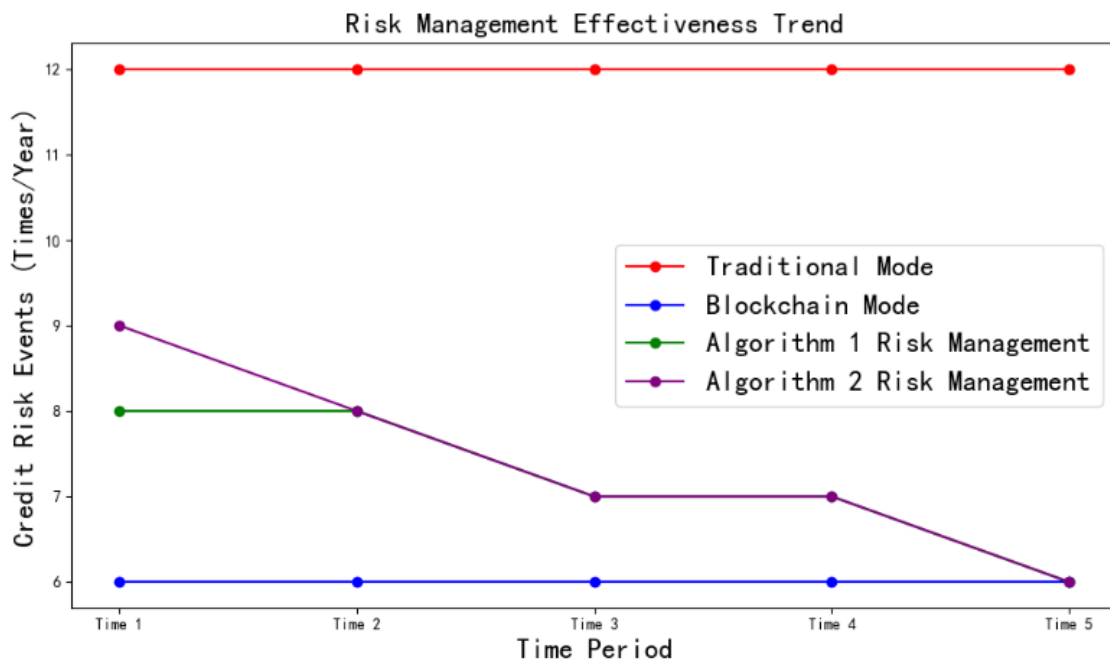


Figure 3. Trend of risk management effect changes.

Figure 3 shows the gradual optimization of blockchain technology in risk management. During the experiment, the frequency of risk events under the blockchain model decreased significantly.

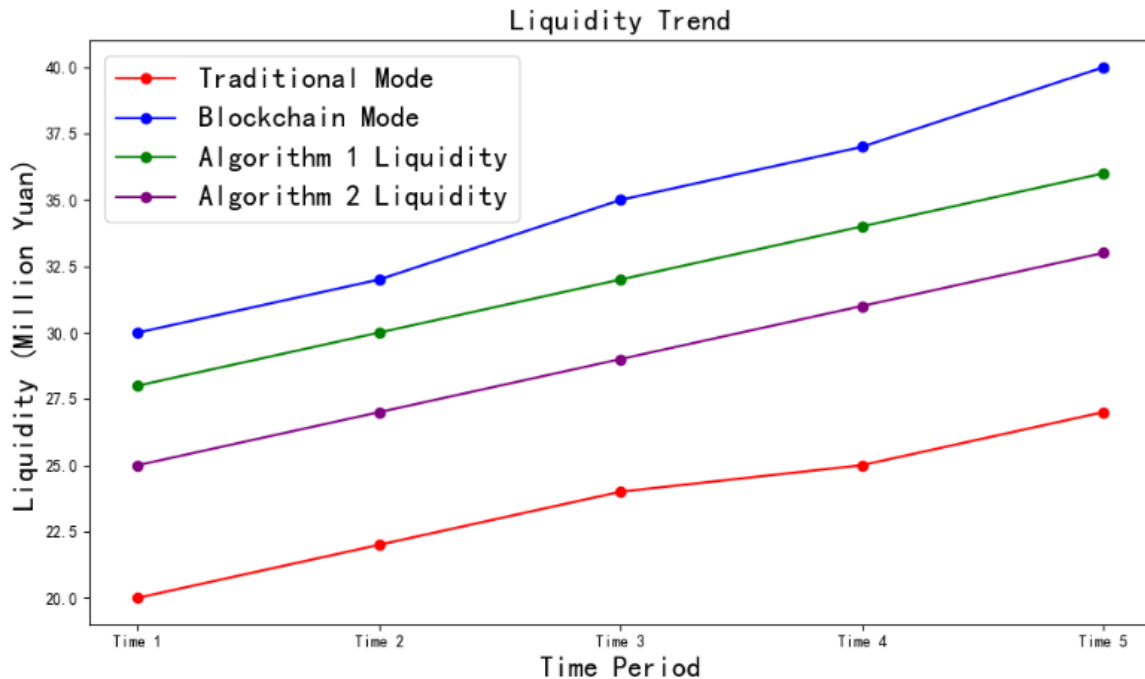


Figure 4. Trend of fund liquidity changes.

Figure 4 illustrates how the blockchain technique affects the liquidity of the funds in the supply chain. Using the blockchain technique, the liquidity of the fund has been improved remarkably.

The experimental results show that blockchain technology has significant advantages in financing costs, transaction efficiency, risk management, etc.: the financing cost is significantly reduced, especially in the reduction of intermediary fees and guarantee fees, which shows the advantages of blockchain decentralization. Transaction efficiency is significantly improved, and the transaction completion time and system processing delay are greatly reduced, showing the automation and efficiency of blockchain. Risk management optimization, blockchain reduces credit risk and information asymmetry by providing transparent and traceable transaction records.

5. Conclusion

This paper makes a deep study on the application of blockchain technology and its economic influence evaluation model. Because of its decentralized, non-changeable and transparent nature, the blockchain technology can enhance the whole financial efficiency of the supply chain, especially in the cost of financing, the efficiency of trade and the risk management. Through the establishment of the economic impact evaluation model, people find that the blockchain technique not only improves the financing process, but also makes the transaction transparent and trustworthy, reduces the credit risk, and enhances the cooperation efficiency. Firstly, the blockchain technique can reduce the cost of financing effectively. By means of intelligent contract and distributed payment and settlement, the blockchain can reduce the complex process and the high agent charge. Secondly, the efficiency of blockchain is reflected in improving transaction efficiency. Its distributed ledger technology can quickly verify and process transaction information, reduce friction and delays in transactions, ensure that all parties in the supply chain can share key information in real time, and improve overall operational efficiency. In addition, blockchain also plays an important role in risk management. Due to the tamper-proof nature of its data, all parties can grasp the dynamic changes in the supply chain in real time, effectively identify potential risks, and take corresponding measures in a timely manner to prevent the spread of risks.

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