Research on Receivables Financing Model in Supply Chain Finance Based on Blockchain Technology

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Abstract. The deep integration of blockchain technology and supply chain finance is a new trend in the current landscape of supply chain financial services. This paper thoroughly explores the business process and characteristics of the blockchain-based receivables financing model in supply chain finance. Drawing on comprehensive risk management theory, the risk focal points of this model are systematically analyzed. Using fuzzy comprehensive evaluation and analytic hierarchy process, risk assessment indicators for the blockchain-based receivables financing model in supply chain finance are constructed, and empirical research is conducted to manage these risks effectively. The study reveals that the risk factors of the blockchain-based receivables financing model in supply chain finance, ranked from high to low, are core enterprise risk, collateral risk, macro-environmental risk, technological risk, and operational risk. Based on these findings, recommendations are proposed, including the establishment of a robust core enterprise supervision system, reinforcement of collateral management, prudent assessment of the macro environment, increased investment in technology, and enhancement of internal corporate management systems and financial literacy of personnel.

Keywords: Blockchain; Supply Chain Finance; Receivables; Smart Contracts; Core Enterprise; Risk Management

1 Introduction

Small and medium-sized enterprises (SMEs) constitute a vital component of the national economy, making significant contributions to economic development. However, due to insufficient credit, these enterprises commonly face challenges in securing financing. Following the outbreak of the COVID-19 pandemic, SMEs have emerged as severely affected areas, experiencing issues such as decreased business revenue and disrupted cash flow, urgently requiring financial support. Supply chain finance, as a financial innovation, centers around the core enterprises in the supply chain. By effectively integrating information flow, fund flow, and logistics among supply chain members, it provides flexible financial services, effectively alleviating information asymmetry and reducing financing risks. It offers a potential solution to the difficulties and high costs of financing for SMEs [1,2]. Therefore, over the past decade, especially since the outbreak of the COVID-19 pandemic, supply chain finance has experienced rapid development in China.

MSIEID 2023, December 08-10, Guangzhou, People's Republic of China

DOI 10.4108/eai.8-12-2023.2344789

However, during the implementation of supply chain finance, problems such as empty collateral pledges and repeated pledges are common. There are high risks of data tampering and leakage, and the operational costs of the business are relatively high. Weak multi-level penetration capabilities of core enterprise credit continue to manifest, hindering the further development of supply chain finance [3,4]. Simultaneously, with the continued popularity of Bitcoin, blockchain technology has gained increasing attention from various sectors of society. It is gradually recognized that as a new generation of information technology, blockchain, with its characteristics of decentralization, good traceability, and tamper resistance, has the potential to profoundly transform traditional financial operations [5,6].

It can perfectly address issues related to the credit self-certification inherent in the centralized accounting method, showing a natural coupling with supply chain finance. Blockchain technology can leverage supply chain finance to realize its inherent value and continuously undergo technological iterations to address various issues in supply chain finance. At the same time, supply chain finance can also leverage blockchain technology to effectively respond to new societal requirements for supply chain finance in the new era, achieving high-quality development. In this process, the two complement each other, achieving mutual benefit and win-win outcomes. The development of blockchain + supply chain finance has become a new trend in the financial industry.

2 Literature Review

Scholars have predominantly focused their research on analyzing the positive effects of applying blockchain technology in supply chain finance. Omran et al. , through an analysis of two supply chain finance operations, namely reverse factoring and dynamic discounting, found that blockchain technology enhances transparency, automation, and trust levels in supply chain finance. This, in turn, addresses the inefficiency issues inherent in traditional supply chain finance to a certain extent [7]. Hofmann suggest that the integration of blockchain technology benefits all participants in the supply chain, improving transaction efficiency in financial operations and reducing corporate financing costs [8]. Rijanto analyzed 30 blockchain-based supply chain finance projects, concluding that blockchain technology facilitates process automation, cost savings, and reduces the risk of illicit activities [9]. Ioannou and Demirel argue that adopting blockchain technology in supply chain finance increases transparency, reduces regulatory costs, lowers fraud risks, and enhances speed and operational efficiency through digitization, smart contracts, and the Internet of Things [10].

In summary, the majority of scholars have analyzed the processes and positive effects of blockchain + supply chain finance from a macro perspective, lacking specific research on business models. Existing studies are mostly qualitative, with a dearth of quantitative research. This paper aims to contribute by focusing on the research object, exploring the operational models of blockchain + supply chain finance, analyzing the positive effects, and, based on qualitative risk identification, constructing a quantitative risk assessment system for the blockchain + supply chain finance accounts receivable financing model, achieving a unified approach between qualitative and quantitative research.

3 Overview of Blockchain + Supply Chain Finance Receivables Financing Model

3.1 Meaning and Features of Blockchain

Blockchain is a novel technology originating from Bitcoin, involving three key concepts: transactions, blocks, and chains. Transactions refer to operations on the ledger, causing a change in the ledger's state with each operation. Blocks are designed to record all transactions and the resulting state within a specified time frame, representing a consensus on the current ledger state. A block consists of a block header and block body, with transaction information contained in the block body and all information from the previous block in the block header. The chain is formed by linking blocks in chronological order, serving as a log of the entire ledger's state changes. Technically, blockchain is underpinned by cryptography and distributed computing. Cryptography addresses privacy and information verification concerns, ensuring the authenticity and tamper resistance of information. Distributed computing, or consensus protocols, incentivizes participants to collectively maintain a consistent ledger, solving the double-spending problem.

3.2 Business Process of Blockchain + Supply Chain Finance Receivables Financing Model

The Blockchain + Supply Chain Finance Receivables Financing Model is an integrated application process utilizing consortium chains and the concept of Tokens. It comprises five steps:

Opening Bank Accounts: Core enterprises and suppliers at all levels open bank accounts with commercial banks.

Contract Signing and Supply: Contracts are signed between first-tier suppliers and core enterprises, as well as among suppliers at different levels. Suppliers deliver goods, generating accounts receivable.

Upload and Confirmation: All participants (core enterprises and interested suppliers) upload scanned contracts, invoices, and relevant documents to the blockchain system, confirming their respective debts.

Verification and Loan Disbursement: Commercial banks verify the documents, issue loans, and the blockchain supply chain finance system automatically splits debts, intelligently issuing relevant loans to suppliers at different levels using Tokens as a measurement tool.

Payment and Collection: Core enterprises make payments upon maturity. In case of delay, banks initiate collection processes, taking necessary measures to recover loans from core enterprises.

The specific business process is illustrated in Figure 1. Assuming a core enterprise A with N-tier suppliers, the blockchain + supply chain finance model ensures credit-based lending based on confirmed debts. For instance, if the core enterprise owes 1st-tier supplier B $2 million, the bank issues a loan of $500,000 using Tokens. This process repeats down the supply chain until N-tier suppliers receive loans totaling the core enterprise's accounts payable of $2 million. The model maintains the self-financing characteristics of supply chain finance while leveraging

blockchain technology for technical enhancements and value-added services such as business traceability.

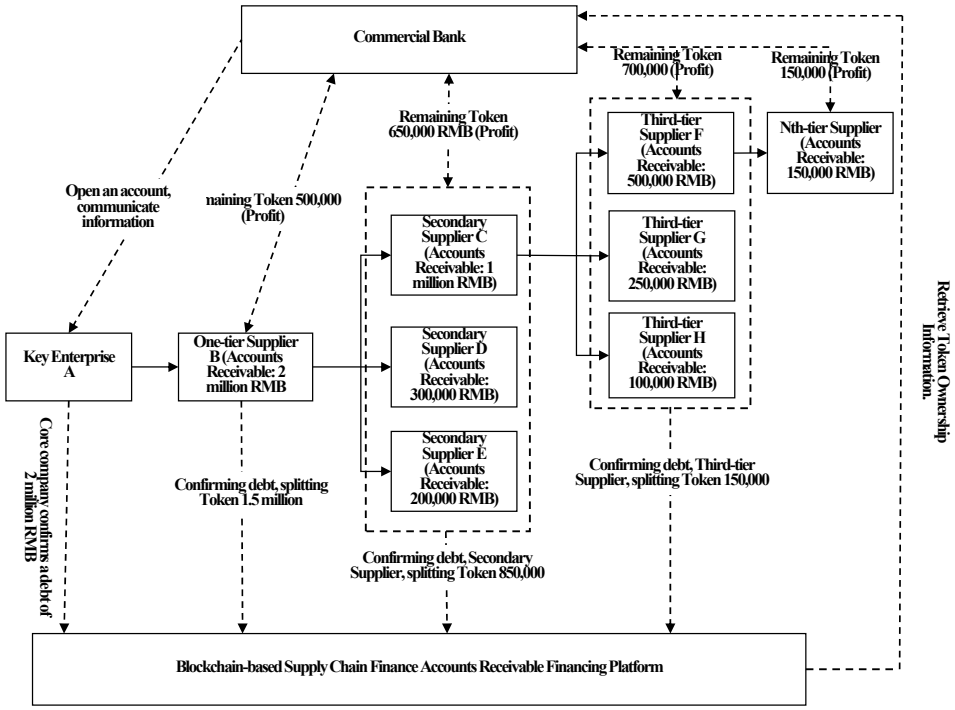

Fig. 1. Business Process of Accounts Receivable Financing in Supply Chain Finance Based on Blockchain Technology

4 Construction of Risk Assessment System for Blockchain + Supply Chain Finance Receivables Financing Model

In this study, a risk assessment system for the Blockchain + Supply Chain Finance Receivables Financing Model has been established, considering five dimensions: macro-environmental risk, core enterprise risk, operational risk, technological risk, and collateral risk (as shown in Table 1). Six experts in the field of finance were invited to utilize the Analytic Hierarchy Process (AHP) and Delphi method① to determine the weights of each indicator.

Table 1. Risk Assessment Indicators for Blockchain + Supply Chain Finance Receivables Financing Model

On the Level of Principles	Indicator Level	Criteria for Measurement
Macro Environmental Risk B1	Market Risk B11	Scoring based on factors such as GDP growth rate and the severity of international trade frictions with the trading partner countries.

	Legal Risk B12	Balancing is based on factors such as the occurrence rate of contract disputes, with lower scores assigned to higher occurrence rates.
	Industry Risk B13	Comparing the industry in which the business operates with the list of enterprises eliminated for outdated capacity published by the Ministry of Industry and Information Technology (MIIT), a lower score is assigned as the business industry aligns more closely with the industries of the listed eliminated enterprises.
	Policy Risk B14	Judgment is based on experts' analysis of the relevant policies of the local government where the business operates.
Core Enterprise Risk B2	Credit RiskB21	Determination is made through searches on platforms such as 'Tianyancha' and 'China Judgments Online' to gather performance information, along with assessment results from third-party rating agencies.
	Profitability Risk B22	Determined through indicators such as the sales profit margin.
	Liability Risk B23	Determined through indicators such as the debt-to-assets ratio.
Operational Risk B3	Leadership Quality B31	Measurement is based on the comprehensive assessment of the leader's educational background, years of leadership experience, and the company's longevity.
	Employee Quality B32	Measurement is based on the comprehensive assessment of employee education level, technical proficiency, and other relevant factors.
	Degree of Management System Perfection B33	Determined based on experts' review of the company's articles of association, management system, and other relevant texts.
Technical Risk B4	Security B41	Based on technical experts, the evaluation of the platform's technical level is judged.
	Reliability B42	Based on technical experts, the evaluation of the platform's technical level is judged.
	Cost B43	Based on technical experts, the evaluation of the platform's technical level is judged.
	Information sharing situation B44	Based on the docking of websites such as the platform and the unified registration of real estate financing and the unified registration of real estate financing.
Collateral Risk B5	Real Risk B51	Determine according to the completeness and authenticity of the registered certification of account receivables, basic contracts and other materials.
	Effective Risk B52	Judgment based on compliance review of financing contracts.
	Liquidity risk B53	Based on the development of the country's financial market and the comparison of developed countries, and the situation of the previous year, it was measured.

The Analytic Hierarchy Process (AHP), proposed by Saaty in 1980, is a method of analysis. Its mathematical logic involves comparing the importance of interconnected factors on a scale of 1 to 9, using standard criteria (see Table 2) to assess the relative importance between each pair of factors. This process generates a judgment matrix, denoted as A. Subsequently, by applying the formula $Aw = \lambda max0$, eigenvalues and eigenvectors are obtained. The judgment

matrix A undergoes a consistency check, resulting in a consistency index (CI). The consistency ratio (CR) is calculated using CR = (CI/RI), where RI is the average random consistency index (refer to Table 3). If CR is less than 0.10, the judgment matrix demonstrates satisfactory consistency, and the weights of each factor can be determined. Conversely, if CR exceeds 0.10, adjustments to the judgment matrix are necessary.

Table 2. AHP Comparison Scale

Number	Meaning
1	The i -i factor is the same as the jj factor.
3	The i -i factor is slightly stronger than the jj factor.
5	The i -i factor is stronger than the jj factors
7	The impact of the i -i factor is significantly stronger than the jj factor
9	The i -i factor is absolutely stronger than the jj factors
2,4，6，8	The Impact I affect the level of the level of the I.

Table 3. RI Coefficient Table

Order of a Judgement Matrix	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Six financial experts in the field, utilizing a scale from 1 to 9, conducted a balanced assessment of the impact levels of various indicators. After five iterative rounds, consensus was reached among the six expert scholars, leading to the formation of the judgment matrix for Criterion Layer Indicator A.

$$A = \begin{vmatrix} 1 & 1/3 & 4 & 3 & 1/3 \\ 3 & 1 & 5 & 4 & 1 \\ 1/4 & 1/5 & 1 & 1/2 & 1/4 \\ 1/3 & 1/4 & 2 & 1 & 1/3 \\ 3 & 1 & 4 & 3 & 1 \end{vmatrix} \quad (1)$$

The results obtained through MATLAB software calculations indicate that, for the construction of the Criterion Layer Matrix A, the maximum eigenvalue (λmax) is 5.1867, the consistency index (CI) is 0.0467, and the consistency ratio (CR) is 0.017, which is less than 0.10. This signifies that the judgment matrix exhibits satisfactory consistency.

Simultaneously, the weights for Macro-environmental Risk (B_1) were determined to be 0.1754, Core Enterprise Risk (B_2) with a weight of 0.3516, Operational Risk (B_3) with a weight of 0.0593, Technological Risk (B_4) with a weight of 0.0920, and Collateral Risk (B_5) with a weight of 0.3217.

Similarly, the judgment matrices for Criterion Layer B_1, B_2, B_3, B_4, and B_5 are derived as follows.

$$B_1 = \begin{vmatrix} 1 & 1 & 1 & 1/2 \\ 1 & 1 & 1 & 1/2 \\ 1 & 1 & 1 & 1/2 \\ 2 & 2 & 2 & 1 \end{vmatrix} \tag{2}$$

$$B_2 = \begin{vmatrix} 1 & 1/2 & 1 \\ 2 & 1 & 2 \\ 1 & 1/2 & 1 \end{vmatrix} \tag{3}$$

$$B_3 = \begin{vmatrix} 1 & 3 & 3 \\ 1/3 & 1 & 1 \\ 1/3 & 1 & 1 \end{vmatrix} \tag{4}$$

$$B_4 = \begin{vmatrix} 1 & 1 & 1 & 1/3 \\ 1 & 1 & 1 & 1/3 \\ 1 & 1 & 1 & 1/3 \\ 3 & 3 & 3 & 1 \end{vmatrix} \tag{5}$$

$$B_5 = \begin{vmatrix} 1 & 4 & 3 \\ 1/4 & 1 & 1/3 \\ 1/3 & 3 & 1 \end{vmatrix} \tag{6}$$

Furthermore, the results of the consistency index (CI) and consistency ratio (CR) calculations for each indicator's judgment matrix at the Indicator Layer are obtained. As shown in Table 4, the CI and CR values for each indicator's judgment matrix are all less than 0.1. Through the consistency check, it is evident that the weight values for constructing the judgment matrices for each indicator are effective.

In the end, the weights for all indicators are determined, establishing a comprehensive risk assessment system for the Blockchain + Supply Chain Finance Receivables Financing Model, as depicted in Table 5.

Table 4. Consistency Index Values for Second-Level Indicator Matrices

Decision Matrix	λmax	CI	CR	test result
B1	4.0000	0	0	pass
B2	3.0000	0	0	pass
B3	3.0000	0	0	pass
B4	4.0000	0	0	pass
B5	3.0741	0.0371	0.0639	pass

Table 5. Weight Table for Risk Assessment Indicators of Blockchain + Supply Chain Finance Receivables Financing Model

On the Level of Principles	Weight	Indicator Level	Weight
Macro Environmental Risk B1	0.1754	Market Risk B11	0.2000
		Legal Risk B12	0.2000
		Industry Risk B13	0.2000
		Policy Risk B14	0.4000
Core Enterprise Risk B2	0.3516	Credit RiskB21	0.2500
		Profitability Risk B22	0.5000
		Liability Risk B23	0.2500
Operational Risk B3	0.0593	Leadership Quality B31	0.6000
		Employee Quality B32	0.2000
		Degree of Management System Perfection B33	0.2000
Technical Risk B4	0.0920	Security B41	0.1667
		Reliability B42	0.1667
		Cost B43	0.1667
		Information sharing situation B44	0.5000
Collateral Risk B5	0.3217	Real Risk B51	0.6080
		Effective Risk B52	0.1199
		Liquidity risk B53	0.2721

5 Conclusion

5.1 Prudent Selection of Core Enterprises, Strengthening Core Enterprise Supervision System

As seen in Table 5, at the criterion level, the risk weight of core enterprises is the highest, indicating that the quality of core enterprises is the primary focus. Therefore, it is advisable to enhance the core enterprise admission mechanism by integrating platforms such as the Legal Judgment Network to ensure transparency of the historical credit of core enterprises. Establish a whitelist for core enterprises, selecting those with high profitability, reasonable debt levels, and good credit conditions. Incorporate quantitative prediction models for core enterprise financial data, such as asset-liability ratios and sales profit margins, into the platform to provide reference for financing transactions. Establish a core enterprise exit mechanism, implementing dynamic and continuous assessments based on important indicators like asset-liability ratios, sales profit margins, and third-party credit ratings to determine entry and exit.

5.2 Strengthen Management of Pledged Assets to Ensure Authenticity, Validity, and Liquidity

Enhance the authenticity of pledged assets. Encourage integrity and cooperation among participants through initiatives and communication events. Require debtors to provide additional documentation beyond the registration in the Chattel Financing Unified Registration and Publicity System, such as foundational contracts for accounts receivable and evidence of contract fulfillment. Establish a reporting and reward mechanism for false contracts and reinforce external supervision. Improve the effectiveness of pledged assets. Promote the use of standardized contracts to reduce disputes. Implement an alert system for

approaching maturity dates. Increase the liquidity of pledged assets. Facilitate the development of the accounts receivable transfer market and asset securitization to ease the transfer of accounts receivable.

5.3 Strengthen Macro-environment Analysis and Conduct Financing Business Based on Macro-environment Conditions

Blockchain + supply chain finance accounts receivable financing is significantly influenced by the macro-environment. It is essential to assess the macroeconomic environment to determine whether to engage in this business and the scale of operations. Financial institutions should enhance their analysis of the economic environment and interpret local government policies. Governments should further establish and improve relevant legal systems to safeguard the legitimate rights and interests of all parties. Considering the characteristics of blockchain + supply chain finance accounts receivable financing, such as digital signatures and smart contracts, it is recommended that the Supreme People's Court promptly issue relevant regulations to provide a basis for the reliability review of electronic signatures and the determination of neutral third-party identity for platforms recording and saving electronic signature data.

Acknowledgments. This article presents the findings of the research project titled Research on Financial Models and Strategies in the Wine Supply Chain (JZW2023005), a part of the 2023 national higher education and vocational college logistics education reform and research program.

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