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Risk analysis of supply chain finance in the context of blockchain based on comprehensive fuzzy evaluation method

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Abstract: *In view of the problems existing in traditional supply chain finance, such as narrow scope of credit objects, limited information integration and difficult transaction supervision, the application framework of blockchain technology supply chain finance is established by using the characteristics of blockchain, such as openness, decentralization, traceability and smart contract. The comprehensive fuzzy evaluation method will be used to provide blockchain solutions and optimize the current supply chain financial risks from the perspective of blockchain and in combination with supply chain financial risks, establish a supply chain financial risk evaluation index system suitable for blockchain, and put forward a more accurate fuzzy prediction model, which puts forward a new direction for the research of supply chain financial risks. This demonstrates the practicality of blockchain technology in supply chain finance, offering countermeasures to enhance overall efficiency for all participants.*

Keywords: *Supply chain; Blockchain technology; Financial risks; Comprehensive fuzzy evaluation method*

1. Introduction

With the rapid development of e-commerce and network technology, the competition between enterprises in today's society has long been upgraded from product competition to supply chain competition. As early as 2001, the world's authoritative "Fortune" will supply chain management. As one of the four most important strategic resources in the 21st century, by combining upstream and downstream or even combining the upstream and downstream of the upstream and downstream of the downstream of the upstream to group together to form a supply chain, the market has also formed a supply chain competition situation. The node enterprises within the same supply chain are interdependent, and the phenomenon of "both honor and dishonor" has appeared. In the supply chain, credit sale has always been the mainstream transaction mode among enterprises. However, due to the small scale of upstream and downstream enterprises in the supply chain, limited financial capacity of enterprises, and high threshold of obtaining bank financing, insufficient funds will directly affect the subsequent production activities. If financing loans are not timely in place, the capital chain will even be broken, and enterprises will go bankrupt and liquidated, thus affecting the normal operation of the entire supply chain.

Based on such difficulties, we are actively exploring the integration of production and financing docking to provide financial support for entrepreneurs upstream and downstream of the industrial chain. In the future, under the support of national policies, "Internet +" will promote the full cooperation among commercial banks, core enterprises, supply chain collaboration platforms and other parties in the field of supply chain finance. As an emerging technology in computer technology, the rise of bitcoin makes the blockchain technology, as an underlying important concept, well known to people. Its unique distributed ledger technology enables any subject to join it, and establishes a trust relationship between the interaction between the subject through a technical level formed by an encryption algorithm, which is recorded by a distributed shared ledger with a time stamp. Any data can be transferred to the ledger of other entities in real time.

The integrated application of blockchain technology plays an important role in the new technological revolution and industrial change[1], and actively promotes the integration of blockchain and the economy and society, and summarizes the five major roles: promoting data sharing, optimizing business processes, reducing operating costs, enhancing collaboration efficiency and building a credible system, which fully

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demonstrates the determination to develop blockchain technology, and undoubtedly has significant guiding significance for the development of the industry, and will be blockchain development rise to the level of national strategic technology [2].

Blockchain technology, as an emerging computer technology, has significant research value in the field of supply chain finance. This paper combines blockchain and supply chain financial risk, applies fuzzy comprehensive evaluation to carry out innovative evaluation of supply chain financial risk in the context of blockchain, and puts forward blockchain financial risk solution proposals for the new situation in the hope of improving the current blockchain-driven supply chain financial risk [3].

This paper introduces the relevant concepts of blockchain and utilizes the advantageous features and laws of blockchain technology to overcome the risks in traditional supply chain finance in a targeted way. From the perspective of blockchain combined with supply chain financial risks, it provides blockchain solutions and optimizes the current supply chain financial risks, and establishes a supply chain financial risk evaluation index system applicable to blockchain, proposes a more accurate prediction model, and puts forward a new direction for the research of supply chain financial risks.

2. Opportunities and Challenges of Blockchain Application in Supply Chain

2.1 Application of blockchain in supply chain

(1) Blockchain's timestamp mechanism and non-tamperability enhance transparency for the supply chain.

Under the traditional supply chain finance model of the e-commerce industry, although the credit evaluation of e-commerce enterprises relies on the transaction data of the enterprises, the business flow, logistics, capital flow and information flow in the supply chain of the e-commerce industry are in the hands of different market players, resulting in the isolation of the information, so that the authenticity of the information is not recognized effectively, resulting in the lack of transparency of the information in the entire supply chain. The timestamp mechanism of blockchain technology can record all the modifications of information, thus ensuring the transparency of information [4].

(2) The decentralization of blockchain enhances the right to speak on the chain for small and medium-sized e-commerce enterprises.

Under the traditional supply chain finance model of e-commerce industry, small and medium-sized e-commerce enterprises are unable to accurately judge the credit of small and medium-sized e-commerce enterprises due to factors such as insufficient credit and unstable transaction data, thus banks and other funders are only able to provide small and medium-sized e-commerce enterprises with supply chain finance through e-commerce platforms or other intermediary methods. Under the blockchain mode, the blockchain can accurately record the detailed data of SMEs, and banks and other funders can obtain the detailed data of SMEs through the blockchain, so that they can accurately give credit lines without relying on the e-commerce platforms and intermediaries to provide financing services for SMEs, which largely improves the discourse power of SMEs.

(3) The smart contract and consensus mechanism of blockchain can reduce the cost of financing for small and medium-sized e-commerce enterprises.

Table 1: Characteristics of supply chain finance model based on blockchain technology.

Mode	Regulatory Governance	Information Flow	Controllable Funds	Trust Transmission	Enterprise Financing
Blockchain technology model	Real-time tracking and supervision	Distributed bookkeeping in blockchain, tamper-proof	closed and controllable	Realization of full supply chain coverage	Low cost, convenient and quick
Traditional model	Asymmetric information, difficult to regulate	Different information masters, information silos	Uncontrollable	First-level ecommerce platform	High additional costs

Under the traditional e-commerce supply chain finance model, the business is usually carried out in an offline contracting mode, which requires the preparation of a large number of paper contracts and materials and consumes a large amount of manpower and material resources, and these costs will certainly be transferred to the lender's SMEs, thus increasing the financing costs of SMEs. And under the

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blockchain technology mode, for the development of supply chain finance business can be carried out through online operation, using smart contracts and consensus mechanism, reducing the risk in operation, realizing the whole online operation of supply chain finance, thus reducing the cost of financing for small and medium-sized enterprises [5], so as to achieve the purpose of reducing the cost of financing for small and medium-sized e-commerce enterprises (see Table 1).

2.2 Challenges facing dual-chain finance

(1) Challenges brought by blockchain technology. Blockchain technology has been introduced for only more than ten years, and there are still many technical problems of its own, so dual-chain finance based on blockchain technology will also be affected to a certain extent. First, the data storage problem. There is a lot of unstructured data in the supply chain, and with the development of science and technology, credit data will grow explosively, which is a certain challenge to the data storage technology of blockchain. The second is the data security problem. Blockchain technology itself has certain security risks, for example, if the hacker obtains more than 51% of the arithmetic power, he can tamper with the loan data of the enterprises on the chain, or with the development of quantum computers and other technologies, the encryption technology of blockchain has the risk of being cracked[6]. Third, a new information silo has been formed. The traditional supply chain financial system has serious internal information segmentation, and there is a serious problem of information silos, blockchain technology can integrate the supply chain "four streams" of information, and open up the information barrier, but at the same time, due to the blockchain in the cross-chain technology, there are technical barriers, resulting in the formation of new information silos in the dual-chain finance, and different dual-chain finance is easy to form new information silos. Due to the different consensus mechanisms, smart contracts and other technologies based on different consensus mechanisms, it will cause the information between the supply chain to be unable to intercommunicate, so that the business of enterprises is fragmented and the cost of financing increases. Fourth, blockchain increases trust without providing credit. Blockchain technology can facilitate the credit circulation of enterprises at all levels in the supply chain, but it cannot directly provide credit for SMEs, and the credit is still provided by the core enterprises, which can be delivered through the Token technology of blockchain. In addition, blockchain can't guarantee the authenticity of the uplinked data, and can only guarantee that it will not be tampered with in the process of data transmission, so it can't solve the problem of enterprise counterfeiting and fraud from the source. Fifth, logistics information can not be uploaded to the chain in real time. The core of the supply chain is logistics, but dual-chain finance can not be real-time collection of logistics information of movable assets on the chain, resulting in the current form of movable asset financing is relatively single [7], and the diversified forms of financing such as in-transit goods pledges are limited.

(2) Challenges faced by building a dual-chain financial platform. In addition to the challenges brought about by blockchain technology itself, there are also considerable challenges in the process of building a platform for dual-chain finance. First, there is a large talent gap. At present, there is a large gap in the demand for blockchain talents in China's blockchain market. Many blockchain enterprises, in the absence of core technology and professional talents, force the launch of less mature products in order to seize the market and pursue the value of blockchain reputation, leading to confusion in the relevant market. Secondly, small and medium-sized enterprises have difficulties in chaining. Dual-chain finance requires enterprises to integrate the transaction information in the supply chain on the chain, however, most of China's SMEs have a low degree of informatization, information integration is more difficult, the environment and technology of comprehensive informatization is relatively lacking, the cost of informatization is higher, and the threshold of on-chaining is higher, which increases the financing cost of SMEs [8]. In addition, many SMEs are not willing to upload their operational information to the public, they will worry about the technical risks of blockchain, and worry about the leakage of the enterprise's operational data and business secrets. Third, China lacks a standardized and relevant regulatory system. The development of blockchain technology in China is still in the initial stage, and the financial innovation empowered by blockchain technology has problems such as lagging management concepts, high technological thresholds, and a single supervisory body, etc. Moreover, the current dual-chain financial platform in China lacks unified platform standards and sound laws and regulations, which leads to higher legal risks for the main body of transactions in the dual-chain financial transaction chain.

2.3 Opportunities and challenges brought by technological changes

At present, the Internet era is moving from the information Internet to the value Internet, in the supply chain network composed of suppliers, manufacturers, retailers, consumers and recyclers, etc., relying on

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the core enterprise as the main body to coordinate the interactive transmission of capital flow, information flow and logistics, it has been difficult to meet the diversified and rapidly developing market demand. From within the supply chain enterprises, problems such as production data falsification, equipment data silos, and inefficient information transmission are becoming more and more prominent [9]. From the upstream and downstream of the supply chain, although the core enterprise like Walmart exists in the whole supply chain management system, but because of its limited control of the upstream and downstream of the supply chain, it is difficult to obtain the data of the whole network of the supply chain, and there is a risk of information falsification and tampering [10]. These problems on the one hand will increase the difficulty of the core enterprise's supply chain management to the upstream and downstream extension, on the other hand, make it difficult for the core enterprise to ensure the reasonable integration of logistics, information flow and capital flow in the supply chain, resulting in the asymmetry of the management capacity and demand. For this reason, enterprises begin to pay attention to the value guarantee of the whole supply chain in the process of information transmission and build a centralized supply chain resource sharing platform, but the security and completeness of such platforms often depend on the core enterprises. Table 2 demonstrates the opportunities and challenges brought by blockchain technology to supply chain operations, which we elaborate separately from different stages of supply chain operations[11][12].

Table 2: Opportunities and Challenges of Blockchain Technology for Supply Chain Operations

Supply chain operations	Opportunities presented by blockchain technology	Challenges presented by blockchain technology
Transparency in supply	Multi-level visibility of the supply chain Ability of participants to traceability projects	Blockchain traceability platforms are not interoperable Participants' participation in traceability programs or not Intelligence in manufacturing
Intelligence in manufacturing	Self-organized production Matching demand and supply	Performance constraints Lack of regulation
Securitization in logistics	Reduction of paper checking work Provide information on the entire shipping process	Provide information on the entire shipping process Digital labeling of commodities requires IoT tools
Platformization of sales	Automation of transactions Redistribution of profits	Challenging the position of maximizing corporate profits
Ecologization of governance	Collaborative governance	Trust issues of the technology itself

3. Supply chain financial risk analysis in the context of blockchain based on comprehensive fuzzy evaluation method

3.1 Financial risk evaluation index system construction

(1) Indicator system construction

According to the different possibilities of risk occurrence in the process, the supply chain financial risk evaluation indexes can be broadly speaking summarized into four first-level indicators and a number of second-level indicators, and the construction of the specific indicator system is shown in Table 3-2.

(2) Determination of indicator weights

This paper adopts the hierarchical analysis method and cites 12 experts and scholars to judge and analyze the online supply chain financial risk evaluation indexes according to the judgment rules of the scalar method, and through the expert scores, a comprehensive judgment evaluation table is calculated as shown in Table 3.

Using the sum method to calculate the maximum eigenvalue λmax, and the corresponding standardized eigenvector $\omega(k)$, the judgment matrix meets: $CRk = 0.023 \leq 0.1$, so the comparison matrix has satisfactory consistency, and the calculated eigenvectors are also recognized. Therefore, the weights of the first-level indicators and the weight coefficients of the second-level indicators can be obtained, and the specific values are shown in Table 4.

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Table 3: Comprehensive expert judgment evaluation form

Level 1 Indicator	External Environment Risk	Internal Control Risk	Day-to-day Operation Risk	Transaction Settlement and Fund Supervision Risk
External Environmental Risks	1	0.190	0.343	0.414
Internal Control Risks	5.250	1	3.833	4.167
Daily Operation Risk	2.917	0.261	1	1.25
Transaction Settlement and Fund Supervision Risk	2.417	0.24	0.8	1

Table 4: Table of weight coefficients of supply chain finance risk evaluation indicators

	First indicators	weights	Secondary Indicators	weights
Supply Chain Finance Evaluation Indicator System	External environment risk W1	0.79	Industry policy risk	0.455
			Industry market environment change risk	0.545
	Internal Control Risk W2	0.574	Organizational structure and management team risk	0.257
			Credit Risk of Financing Enterprises	0.283
			Financial Risk	0.135
			Business Assessment and Audit Risk	0.325
	Daily Operation Risk W3	0.189	Operator Management Risk	0.315
			Financing Enterprise Credit Rating Risk	0.273
			Supervision System Risk	0.412
	Transaction Settlement and Fund Supervision Risk W4	0.158	Account Funding Risk	0.167
			Realization Risk of Goods Sales	0.521
			Bad Debt Provision Risk	0.312

3.2 Supply chain financial risk evaluation model establishment in the context of blockchain

(1) Supply chain financial risk evaluation model in the context of blockchain based on fuzzy comprehensive evaluation method.

From the established supply chain financial risk evaluation index system in the context of blockchain, it can be seen that the supply chain financial risk evaluation index contains a large number of qualitative indicators, and certain qualitative indicators can only be evaluated through a relatively fuzzy concept, and it is impossible to score them with a precise score. Therefore, based on this phenomenon, this paper introduces the method of fuzzy comprehensive evaluation to construct the supply chain financial risk evaluation model, and the relative quantification of supply chain financial risk evaluation indexes to determine the level of supply chain financial risk.

The specific steps of the fuzzy comprehensive evaluation method are as follows:

1) Determine the factor field of the evaluation object: U={u1,um,⋯un}, that is to say, there are n evaluation indexes, indicating from which aspects we describe the evaluated object in terms of judgment.

2) Determine the rubric hierarchy, the rubric set is the evaluator of the evaluated object may make a variety of total evaluation results composed of a collection, expressed in V: V = {v1,vm,⋯vn}, in fact, is the evaluated object of the change interval of a division. Where Vi represents the ith evaluation result, n is the total number of evaluation results.

3) Conduct single-factor evaluation and establish a fuzzy relationship matrix R. Evaluation from a single factor to determine the degree of affiliation of the evaluation object to the evaluation set V is called

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single-factor fuzzy evaluation. After constructing the hierarchical fuzzy subset, it is necessary to quantify the evaluated object from each factor u,(i=1,2,.....,m) one by one, that is to say, to determine the degree of affiliation of the evaluated object to each hierarchical fuzzy subset from a single-factor point of view, and then get the fuzzy relationship matrix.

4) Determine the weighting coefficient of each factor. The construction of the risk evaluation model should fully take into account the different weights of the indicators, this paper has determined the weight coefficients of the indicators through the hierarchical analysis method in the foregoing.

5) Calculate the comprehensive evaluation vector and comprehensive evaluation value.

(2) Application of fuzzy evaluation system in supply chain financial risk analysis in the context of blockchain

1) Determine the judgment matrix T. In this paper, combining with the bank's credit evaluation method for enterprises (refer to the bank's credit evaluation rubric set), the evaluation level is divided into seven levels, and the median value of each interval is selected as the level parameter, and the corresponding parameter vector is M = (9.5, 8.5,7.5,6.5,5.5,4.5,2), as shown in Table 5.

2) Construct fuzzy judgment matrix. This paper cites the evaluation of five experts on various risk indicators of supply chain financing in the context of blockchain, and the results are shown in Table 6.

Table 5: Judging Levels and Meaning

Level	Score	Meaning
AAA	9-10	Excellent, very little risk
AA	8-9	Very good, low risk
A	7-8	Good, low risk
BBB	6-7	Average
BB	5-6	A little poor
B	4-5	Poor
F	≤4	Very poor

Table 6: Results of Supply Chain Finance Risk Evaluation in the Context of Blockchain

W11	AAA	AA	AA	AA	AAA
W12	AA	AAA	A	AA	AA
W21	AAA	AA	AAA	AAA	AA
W22	AA	AA	AAA	AA	AA
W23	AAA	AA	A	A	AA
W24	AA	AAA	AA	A	AA
W31	AA	AAA	AAA	AA	AA
W32	AAA	AAA	AA	AAA	AA
W33	AA	AA	AA	AA	A
W41	AAA	AA	AAA	AAA	AAA
W42	AA	A	A	AA	AA
W43	AAA	AA	AA	AAA	A

Based on the above evaluation results, the affiliation degree of each evaluation indicator belonging to each evaluation level is derived and the fuzzy relationship matrix T is constructed:

$$\begin{bmatrix} 0.4 & 0.6 & 0 & 0 & 0 & 0 & 0 \\ 0.2 & 0.6 & 0.2 & 0 & 0 & 0 & 0 \\ 0.6 & 0.4 & 0 & 0 & 0 & 0 & 0 \\ 0.2 & 0.8 & 0 & 0 & 0 & 0 & 0 \\ 0.2 & 0.4 & 0.4 & 0 & 0 & 0 & 0 \\ 0.2 & 0.6 & 0.4 & 0 & 0 & 0 & 0 \\ 0.4 & 0.6 & 0 & 0 & 0 & 0 & 0 \\ 0.6 & 0.4 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.8 & 0.2 & 0 & 0 & 0 & 0 \\ 0.8 & 0.2 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0.6 & 0.4 & 0 & 0 & 0 & 0 \\ 0.4 & 0.4 & 0.2 & 0 & 0 & 0 & 0 \end{bmatrix}$$

(3) Calculate the composite rating vector and composite rating value:

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$$Q = W * T = (q_1, q_2, \cdots\cdots, q_n) \text{ , included among these: } q_i = \sum_{i=1}^{n} W_i * t_{ij}$$

After calculating Q = (0.292, 0.573, 0.135, 0, 0, 0, 0, 0), and finally through the formula A = Q * M = (0.292, 0.573, 0.135, 0, 0, 0, 0, 0) * (9.5, 8.5, 7.5, 6.5, 5.5, 4.5, 2) to get the final value of its comprehensive evaluation as A = 8.657.

According to the evaluation grade A = 8.657 within the interval of AA, then it is concluded that the financial risk evaluation result of supply chain in the context of blockchain is AA (see Table 5 for the risk level), and the business risk is relatively small, and according to the size of the business risk to provide different differentiated services for the supply chain to set up different standards in the pledge rate, the service fee rate, the financing period and the amount of financing [13] [14].

4. Suggestions for the Application of Blockchain Technology in Supply Chain Finance Risk Prevention and Control

4.1 Improve the blockchain model

(1) It is necessary to accelerate the docking of enterprise data with the alliance blockchain. It is possible to standardize the data standards of upstream and downstream enterprises in the form of industry standards, and ensure that various types of transaction data of enterprises can be uploaded to the blockchain in a timely manner through the docking of the interface between the accounting computerization system and the enterprise management system. Each enterprise, in accordance with the different supply chain segments in which it is located, uploads data to the corresponding block.

(2) Accelerate the integration of artificial intelligence technology and blockchain technology. In coping with the market risk in the industry supply chain financial risk, the most important link is to intelligently capture market information and store all kinds of information captured into the blockchain, and use big data analysis technology to analyze the market information, so as to obtain detailed market risk information. Increase the application of big data analysis technology in the credit evaluation of financial institutions to improve the accuracy of credit evaluation models.

(3) Accelerate the connection between the "third-party credit evaluation" system and the blockchain. The People's Bank of China should open up the application of personal credit data to a certain extent, allow a certain range of financial institutions and enterprises to access personal credit, and do a good job of connecting the data structure with the blockchain. The platform should establish more perfect evaluation standards for enterprise credit rating, allow consumers to evaluate the sales behavior and services of enterprises, and transform the evaluation into data to dock with the blockchain.

4.2 Increase the standardization and control of supply chain finance risks for the industry

(1) The industry should formulate detailed industry norms, and the supply chain should introduce specific punitive measures for malicious transactions between upstream and downstream enterprises. Regarding malicious brushing and false transactions, appropriate actions are taken based on the severity of the situation. Mild cases receive red risk warnings and store weight warnings; In the case of more serious circumstances, the shop shall be closed and transferred to the judicial organs in accordance with the relevant provisions of the law.

(2) To further improve China's supply chain supervision laws, and clarify the responsibility of core enterprises. The industry supply chain financial supervision into the financial supervision, the use of "double random one random inspection" way, do a good job for the supply chain financial supervision and innovation, and will supervise the results of the enterprise credit, the main person in charge of credit linked to achieve the risk of strict control.

5. Conclusion

Many risk evaluation indicators of supply chain finance in the context of blockchain are difficult to be analyzed directly by quantitative methods, and it is necessary to transform qualitative evaluation into quantitative evaluation with the help of certain qualitative analysis. In this paper, we first analyze the risk indicators of supply chain finance business, construct the indicator evaluation system, calculate the weight coefficients of the risk indicators by combining the hierarchical analysis method, and then make

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an overall evaluation of the supply chain finance risk constrained by a variety of factors by the fuzzy comprehensive analysis method based on the experts' evaluation of the supply chain finance-related risk indicators. The fuzzy comprehensive evaluation method has clear results and strong systematic features in the assessment and metrics of supply chain financial risks under blockchain, which can better solve the evaluation of fuzzy and difficult-to-quantify risk indicators, and has strong practical significance.

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