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Research on Supply Chain Finance Risk Management Application Based on Blockchain Technology

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Abstract: *This study aims to explore the application of blockchain technology in supply chain finance risk management. By using the normative analysis method, a theoretical model of supply chain finance risk management based on blockchain technology is established, and its feasibility and effectiveness are analyzed. Through the analysis of the theoretical foundation of supply chain finance, the characteristics and advantages of blockchain technology, and the existing problems, this study proposes corresponding solutions. The research results show that the supply chain finance risk management model based on blockchain technology can effectively improve the efficiency and security of supply chain finance risk management.*

Keywords: *Blockchain technology, supply chain finance, risk management, normative analysis, model establishment.*

1. Introduction

1.1 Research Background

In modern economy, supply chain finance has become an important form of finance. Supply chain finance refers to a financial model in which financial institutions provide funding and financing services based on supply chain trade activities. Through supply chain finance, companies can solve financing problems more flexibly and efficiently, improve supply chain efficiency, accelerate fund turnover, reduce trade risks, and achieve win-win results.

Although the supply chain finance model has many advantages, there are also many risks in trade activities, such as supplier credit risk, transportation risk in logistics, and credit risk of financial institutions. Therefore, supply chain finance risk management has become a very important link. Only effective risk management measures can ensure the safety and reliability of supply chain finance.

Blockchain technology is a decentralized distributed ledger technology with characteristics such as immutability, trustlessness, and decentralization, and has been widely used in the financial industry. In supply chain finance risk management, blockchain technology can realize the sharing of supply chain information and asset management with trustlessness, and provide financial institutions with more secure and efficient financial services. At the same time, blockchain technology can optimize the operation efficiency of the supply chain, reduce trade risks, and achieve the sustainable development of supply chain finance.

This study aims to explore the application of blockchain technology in supply chain finance risk management, in order to improve the safety and reliability of supply chain finance. By using the normative analysis method, establish a corresponding theoretical model, explore the application of blockchain technology in supply chain finance risk management, provide reference and theoretical guidance for the development of supply chain finance business, and have important research significance and practical value.

1.2 Literature Review

Supply chain finance has become increasingly popular in recent years, as it allows suppliers to receive payment faster while providing buyers with extended payment terms. However, traditional supply chain finance is limited by the lack of transparency, trust, and security in the system. Blockchain technology

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offers a potential solution to these issues by providing a decentralized, immutable ledger that can be accessed by all parties involved in the supply chain. This part of the paper aims to provide a literature review on the application of blockchain technology in supply chain finance risk management.

Han, J., & Han, M. (2022) introduced the application of blockchain technology in supply chain finance, emphasizing its advantages in data security and risk control, and proposed suggestions for creating a new ecology of blockchain + supply chain finance[1]. Sun, R., He, D., & Su, H. (2022) analyzed the factors affecting the decision-making of participants in supply chain finance, constructed an evolutionary game model of small and medium-sized enterprises and financial institutions, and studied the role of blockchain technology in reducing risks[2]. Fu, H., Zhang, F., Su, Z., Han, Y., & Wu, Y. (2021) introduced the application of blockchain technology in supply chain finance and emphasized its role in risk management, pointing out the issues to be aware of when applying blockchain technology[3]. He, R. (2020) found that the application of blockchain-based smart contracts is changing the mode and rules of human transactions, but its distributed nature also exacerbates financial risks. Both internal governance and external governance are key to controlling smart contract risks, which is of great significance to the development and industrial transformation of China's blockchain technology[4]. Li, J., & Zhang, Z. (2021) proposed a moral risk prevention strategy for logistics service providers based on blockchain technology. They established a Stackelberg game model for the risk issues caused by third-party logistics service providers' false reporting behavior and verified the change in supply chain profits before and after the application of blockchain technology through numerical analysis. The results showed that the application of blockchain technology can effectively reduce the moral risks of third-party logistics service providers, improve the overall supply chain profit, and promote the effective increase of profits of various nodes in the supply chain, helping the healthy and orderly development of the supply chain[5]. Ma, C., et al. (2020) reviewed the application and innovation of blockchain technology in the financial field, discussed the impact and change of blockchain technology on traditional financial models, and proposed relevant policy suggestions to guide the healthy development of China's blockchain finance. The contribution of this literature is to provide valuable references and guidance for research and practice in the fields of blockchain finance and risk management[6]. Li, X., & Liu, Z. (2017) found that the supply chain intelligent governance mechanism based on blockchain can solve opportunistic risks and trust issues. They proposed a governance system framework, including smart contract mechanism, consensus mechanism, reward mechanism, security transparency mechanism, sharing mechanism, collaboration mechanism, autonomous mechanism, and hierarchical structure mechanism, to achieve effective connection and coordination of supply chain intelligent governance[7].

Previous studies have focused on theoretical discussions. The literature mostly concentrates on theoretical exploration, with little discussion of specific issues such as practical application scenarios and implementation steps of blockchain technology in supply chain financial risk management. Empirical analysis: although some literature has analyzed the role and advantages of blockchain technology in supply chain financial risk management, there is a lack of empirical analysis support, such as the lack of real data and case studies. The research perspectives and focuses of the literature are different, and a systematic and comprehensive research framework has not been formed, which lacks a comprehensive and in-depth understanding of research in this field. In summary, further exploration and research are needed for the topic of "Research on the Application of Blockchain Technology in Supply Chain Financial Risk Management". Future research can start from the perspectives of empirical analysis, systematic and comprehensive exploration, and delve into the application of blockchain technology in supply chain financial risk management, in order to provide powerful support and guidance for the development of relevant fields.

2. Relevant Theoretical Analysis

2.1 The Theoretical Basis of Supply Chain Finance

2.1.1 Definition and Development History

Supply chain finance refers to a model of providing financial services to enterprises in the supply chain by utilizing information and resources from various links in the supply chain. This model solves the problem of capital flow in the supply chain through financial means, enhances the liquidity and stability of the supply chain, and also brings new business opportunities to financial institutions. The concept of supply chain finance first appeared in the 1990s. With the rapid development of the Internet, mobile Internet, and financial technology, supply chain finance has become a hot area, attracting the attention and investment of numerous start-ups and financial institutions.

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2.1.2 Theoretical Foundations of Supply Chain Finance

The theoretical foundations of supply chain finance mainly come from the fields of supply chain management, finance, and risk management. Supply chain management refers to the coordination and optimization of various links in the supply chain to improve its efficiency and effectiveness. The core of supply chain management is information sharing and collaboration, which is achieved through information technology and management methods to achieve real-time, accurate, and secure sharing and transmission of information in the supply chain. Finance is the study of monetary and capital markets, including financial markets, financial institutions, and financial instruments. Supply chain finance is a new financial model that uses financial means to solve funding flow problems in the supply chain and provide financing and fund management services to businesses in the supply chain. Risk management is a management tool that involves identifying, assessing, and controlling risks. Supply chain finance involves multiple-party cooperation and fund circulation, with certain risks such as information asymmetry, credit risk, and market risk. Therefore, corresponding risk management measures are needed to ensure the safety and sustainability of supply chain finance.

2.1.3 Problems and Challenges

Supply chain finance faces a series of problems and challenges in practice. First, there is an issue of information asymmetry in supply chain finance. Different links in the supply chain may have different information, leading to information asymmetry, which affects the effectiveness and reliability of supply chain finance. Second, there is credit risk in supply chain finance. Due to different credit situations among companies in the supply chain, there is a certain credit risk.

2.2 Overview and Characteristics of Blockchain Technology

Blockchain technology is a new decentralized and distributed data storage and transaction model, known as the "trust machine." It achieves secure and trustworthy transmission of information through the use of cryptographic technology and consensus mechanisms and has strong application potential. This section will provide a detailed introduction to the concept, characteristics, and principles of blockchain technology and explore its prospects for application in risk management in supply chain finance.

2.2.1 Concept and Development History of Blockchain Technology

Blockchain technology was first proposed in 2008 by Satoshi Nakamoto for the purpose of creating a decentralized transaction system for Bitcoin. It is a distributed ledger technology that links multiple data blocks together to form an immutable chain structure, enabling decentralized and distributed data storage and transactions. With the continuous development of blockchain technology, more and more application scenarios are being explored and applied, such as supply chain management, financial transactions, and the Internet of Things.

The development history of blockchain technology can be divided into three stages: the Bitcoin stage, also known as the Blockchain 1.0 era, which mainly focuses on the issuance and trading of digital currencies; the Ethereum stage, also known as the Blockchain 2.0 era, which mainly focuses on the development of blockchain applications and the implementation of smart contracts; and the Blockchain 3.0 era, which mainly focuses on the integration of blockchain technology with emerging technologies such as artificial intelligence and big data to achieve more extensive and in-depth applications.

During the Bitcoin stage, blockchain technology was mainly used for the issuance and trading of digital currencies. Bitcoin is the representative of blockchain technology, which uses the Proof-of-Work (PoW) consensus mechanism to ensure the security and credibility of data. The success of Bitcoin drew attention and recognition to blockchain technology.

During the Ethereum stage, blockchain technology gradually shifted towards application development and the implementation of smart contracts. Ethereum is the first blockchain platform to support smart contracts, which uses the Proof-of-Stake (PoS) consensus mechanism and introduces the ERC20 token standard, making it easier and more flexible to develop blockchain applications.

In the Blockchain 3.0 era, blockchain technology begins to integrate with emerging technologies such as artificial intelligence and big data to achieve more extensive and in-depth applications. For example, a typical Blockchain 3.0 application is the supply chain finance risk management application based on blockchain technology, which combines blockchain technology with supply chain finance business, improving the efficiency and security of supply chain finance business.

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2.2.2 Characteristics of Blockchain Technology

Blockchain technology has several characteristics:

(1) Decentralization

Blockchain technology achieves decentralized data storage and transactions, meaning there is no centralized institution or node that controls all the data and transaction processes. Instead, a network composed of numerous nodes jointly maintains and verifies the data. This decentralized structure ensures data security and reliability, and avoids the risk of single-point failures and data tampering.

(2) Distributed Ledger

Blockchain technology adopts a distributed ledger to record and store transaction data. Multiple nodes jointly maintain a copy of the same ledger, and the ledger's updating and verification are completed by the consensus mechanism. This distributed ledger structure ensures data consistency and reliability, and reduces the risk of data tampering.

(3) Consensus Mechanism

Blockchain technology adopts a consensus mechanism to maintain data security and trustworthy transmission. All nodes in the network reach consensus to ensure data consistency and integrity. Currently, mainstream consensus mechanisms include Proof of Work (PoW), Proof of Stake (PoS), and Delegated Proof of Stake (DPoS). This consensus mechanism structure ensures data security and trustworthy transmission, and improves data reliability.

(4) Privacy Protection

With the widespread application of blockchain technology, people are increasingly concerned about personal privacy and data protection issues. Blockchain technology performs well in protecting data security and trustworthiness, but there are still some problems in privacy protection. Because the characteristics of blockchain technology are openness and transparency, all participants can view and verify the data, which may lead to the leakage of personal privacy information. Therefore, privacy protection has become an important issue that blockchain technology needs to solve.

To address this issue, researchers have proposed some solutions, such as using Zero-Knowledge Proof (ZKP) technology to protect privacy. ZKP technology is a way of proving that one knows certain information without revealing that information, and it can ensure data privacy and integrity. In addition, there are other privacy protection schemes, such as homomorphic encryption-based schemes and ring signature schemes.

2.3 Advantages of Blockchain Technology in Supply Chain Finance Risk Management

In supply chain finance, credit risk, liquidity risk, and operational risk are the main risk factors. Adopting blockchain technology can effectively reduce these risks, thereby improving the efficiency and stability of supply chain finance. This section will elaborate on the advantages and applications of blockchain technology in supply chain finance risk management from the aspects of information transparency, credit rating, smart contracts, and cross-border payments.

2.3.1 Information Transparency

Information transparency is a key issue in supply chain finance. Due to the involvement of multiple parties in supply chain finance, information flow is affected by various factors, and information asymmetry and opacity often lead to increased credit risk and operational risk. Adopting blockchain technology can effectively solve these problems.

Blockchain technology provides a decentralized data storage and transmission method, and any party can query and share data. Transaction information and goods flow information on the blockchain can be traced in real-time, and participants can clearly understand information such as the location, quantity, and quality of goods, thus achieving information transparency. In addition, blockchain technology provides mechanisms for data security and privacy protection, ensuring the authenticity and security of information.

In recent years, some supply chain finance platforms have adopted blockchain technology to achieve information transparency. For example, Xiaomi Finance and Ant Financial, part of Alibaba Group, have introduced blockchain technology in supply chain finance, achieving supply chain transparency and traceability.

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2.3.2 Credit Rating

Credit rating is another key issue in supply chain finance. Traditional credit rating methods have problems such as information asymmetry and inconsistent rating standards, resulting in inaccurate rating results. Adopting blockchain technology can effectively solve these problems.

Blockchain technology provides a decentralized credit rating mechanism, and any participant can query and verify the rating results. A credit rating mechanism based on the blockchain can make rating results more accurate, fair, and transparent. Credit rating data on the blockchain can be shared and agreed upon, improving the credibility and stability of the rating results.

In recent years, some supply chain finance platforms have adopted blockchain technology to implement credit rating. For example, several domestic supply chain finance platforms, such as ChainRong and Chain Link Finance, have adopted blockchain technology to implement credit rating in supply chain finance.

The advantage of blockchain technology in supply chain finance credit rating lies in its characteristics of tamper-proof and distributed storage, which can improve the accuracy and credibility of credit rating. Due to the decentralized and transparent characteristics of blockchain technology, an open, transparent, and tamper-proof credit rating system can be formed in the supply chain, effectively curbing information asymmetry and fraudulent behavior in supply chain finance.

There are two ways to apply blockchain technology to credit rating in supply chain finance: the first is to write credit rating data into the blockchain to avoid distortion of credit rating due to data tampering; the second is to use smart contracts to implement credit rating, thus automatically executing contract terms related to credit rating. The use of smart contracts to implement credit rating can closely integrate credit rating with trade contracts, thus automatically executing credit rating and risk management operations during the trading process.

In addition to credit rating, blockchain technology can also be applied in supply chain finance to achieve functionalities such as smart contracts and cross-border payments. In supply chain finance, due to the high risks associated with cross-border payments, traditional cross-border payment methods involve many intermediaries and complex processes, resulting in issues such as long payment times, high fees, and complex procedures. However, using blockchain-based cross-border payment methods, due to its characteristics of decentralization, transparency, and security, can achieve peer-to-peer cross-border payments, and have advantages such as short payment times, low fees, and simple processes.

2.4 Issues of Blockchain Technology in Supply Chain Financial Risk Management

The problems and challenges of blockchain technology in supply chain financial risk management mainly include performance bottlenecks, privacy protection, technical standards, and legal regulations. The following will discuss these issues separately.

2.4.1 Performance Bottlenecks

Currently, there are still certain bottlenecks in blockchain technology in terms of transaction processing and response time. Traditional public chain blockchain systems such as Bitcoin and Ethereum are limited in performance by consensus mechanisms and block size, and can only process dozens to hundreds of transactions per second. The performance of private and consortium chain blockchain systems is relatively higher, but there are still certain bottlenecks when handling high-concurrency transactions. This makes it difficult for blockchain technology to meet the requirements of supply chain finance for high efficiency and real-time performance in practical applications.

Researchers have proposed some solutions to the performance bottleneck issue. For example, using sharding technology to divide the blockchain network into multiple sub-networks, each independently processing transactions to improve transaction processing speed. In addition, the performance of the blockchain system can be improved by optimizing consensus mechanisms and improving smart contract programming.

2.4.2 Privacy Protection

The transparency and tamper-proof nature of blockchain technology means that all transaction records can be publicly viewed, which may leak trade secrets and personal privacy related to transactions. In supply chain finance, such privacy breaches may result in loss of business interests and also violate privacy regulations.

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To address privacy protection issues, researchers have proposed some solutions. For example, using zero-knowledge proof technology and encryption algorithms to encrypt and conceal transaction information, and only authorized personnel can view and access relevant information. In addition, obfuscation techniques can be used to mix transaction records together to protect the privacy of transaction information.

2.4.3 Technical Standards

The standardization level of blockchain technology is relatively low, and there are interoperability issues between different blockchain systems. In supply chain finance, such interoperability issues may cause problems such as inconsistent data and incomplete transactions.

To address technical standard issues, researchers and the business community have started to attempt to develop blockchain technology standards. For example, the consortium chain standard develops standards for consortium chain technology to ensure that different consortium chains can be mutually compatible and interoperable. In addition, some international organizations and standardization institutions have also begun to focus on standardizing blockchain technology. For example, the International Organization for Standardization (ISO) has established a special committee to develop standards for blockchain and distributed ledger technology. The development of these standards will help promote the development and application of blockchain technology, improve the security and reliability of the technology, and provide better guarantees for enterprise blockchain applications.

On the other hand, legal and regulatory issues are also important issues for blockchain technology in supply chain financial risk management. The application of blockchain technology often involves the legal and regulatory issues of multiple countries and regions, such as data privacy protection and the legal effectiveness of smart contracts. The differences and uncertainties in these legal and regulatory issues may bring certain risks and challenges to the application of blockchain technology. Therefore, researchers need to conduct in-depth research and analysis of relevant legal and regulatory issues to provide corresponding legal consulting and risk assessment services to enterprises.

3. Research Content

3.1 Theoretical Model for Supply Chain Financial Risk Management Based on Blockchain Technology

This paper proposes a theoretical model for supply chain financial risk management based on blockchain technology, which achieves end-to-end risk management for supply chain finance by leveraging the decentralized, secure, and traceable nature of blockchain. The model is built upon a distributed system for supply chain financial risk management that employs blockchain features such as distributed ledger and smart contracts.

3.1.1 Participant Management Module

The participant management module is one of the core modules of the distributed system for supply chain finance and is responsible for managing the identity information, credit assessment results, and asset information of participants. This module utilizes the distributed ledger functionality of blockchain to achieve decentralized management of participant identity and information sharing. The following three aspects provide a more detailed analysis and discussion of the participant management module.

(1) Identity authentication

In this module, each participant needs to undergo identity authentication to ensure the authenticity and credibility of their identity. Participant identity authentication can be verified using methods such as digital certificates and biometric technology. After verification, a digital identity label will be generated and stored in the distributed ledger of the blockchain for other participants to verify and identify.

(2) Credit assessment

The module also includes functionality for credit assessment of participants to evaluate their credit status and risk level. Credit assessment can be based on data such as historical transaction records, asset information, and repayment records. Assessment results will be recorded in the distributed ledger of the blockchain and available for other participants to access and verify.

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(3) Asset information

The module also manages the asset information of participants, including asset types, asset values, and asset owners. Sharing this information will help with risk assessment and control, ensuring the authenticity and credibility of participants in supply chain finance transactions.

(4) Data sharing

The participant management module enables data sharing among participants by implementing decentralized management of participant identity and information sharing. Data sharing among participants will help with risk assessment and control, ensuring the authenticity and credibility of supply chain finance transactions.

In summary, the participant management module is one of the core components of the distributed system for supply chain financial risk management based on blockchain technology. By implementing decentralized management of participant identity and information sharing, the module provides reliable data support for risk assessment and control. The functionality of the participant management module includes identity authentication, credit assessment, asset information management, and data sharing.

3.1.2 Risk Assessment Module

Credit risk among supply chain finance participants is a major challenge in supply chain finance. In order to effectively control the risk of supply chain finance, it is necessary to assess the risk of supply chain finance participants. Traditional risk assessment methods often use a combination of qualitative and quantitative methods, but due to the large number of supply chain finance participants, information asymmetry, and difficulty in evaluation, traditional risk assessment methods have many shortcomings. Therefore, this model uses blockchain technology to build an intelligent contract-based supply chain finance risk assessment model to achieve risk assessment among supply chain finance participants.

This risk assessment module consists of three main components: credit assessment, asset assessment, and risk coefficient calculation. The specific process is as follows:

(1) Credit Assessment

Credit assessment refers to the assessment of the credit status of supply chain finance participants to determine their credit rating and credit score. The credit assessment method used in this model is mainly based on historical transaction records, credit reports, financial statements, and other data of supply chain finance participants, combined with other external information, and analyzed and processed using artificial intelligence algorithms. The evaluation result will be used to calculate the risk coefficient of the supply chain finance participant.

(2) Asset Assessment

Asset assessment refers to the assessment of the asset status of supply chain finance participants to determine their asset rating and asset value. The asset assessment method used in this model is mainly based on asset proof documents, financial statements, and other data of supply chain finance participants, and analyzed and processed using artificial intelligence algorithms. The evaluation result will be used to calculate the risk coefficient of the supply chain finance participant.

(3) Risk Coefficient Calculation

The risk coefficient refers to the degree of risk of the supply chain finance participant based on the results of the credit assessment and asset assessment. The risk coefficient calculation method used in this model is based on artificial intelligence algorithms and statistical models. The results of the credit assessment and asset assessment are weighted and averaged to obtain the risk coefficient of the supply chain finance participant. The higher the risk coefficient, the worse the credit and asset status of the participant, and the greater the risk.

This model uses an intelligent contract-based approach to embed the risk assessment module into the blockchain platform. Specifically, after each supply chain finance participant registers an account on the blockchain platform, they need to upload corresponding transaction records, asset proof documents, financial statements, and other data. These data will be stored and managed through intelligent contracts, and based on the supply chain finance participant's transaction behavior, credit assessment results, asset assessment results, etc., the risk coefficient will be automatically calculated. At the same time, intelligent contracts can automatically execute corresponding risk management measures, such as adjusting credit limits and adjusting margin requirements, to ensure the security and stability of supply chain finance transactions.

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It is worth noting that the intelligent contract-based supply chain finance risk assessment model has the following advantages compared to traditional risk assessment methods: (1) improved information sharing and transparency: all transaction data on the blockchain platform will be stored on the blockchain, and supply chain finance participants can share this data to better understand the credit and asset status of other participants. (2) More accurate risk assessment: the intelligent contract-based risk assessment model can calculate more accurate risk coefficients based on the actual transaction behavior of supply chain finance participants, combined with artificial intelligence algorithms and statistical models.

3.1.3 Risk Control Module

The Risk Control Module is an essential part of supply chain finance risk management and plays a crucial role in preventing and mitigating risks. This module uses smart contract functionality in blockchain technology to control risks among supply chain finance participants. Based on the data provided by the Risk Assessment Module, this module takes measures to control risks, including risk diversification, credit guarantees, and asset pledges.

(1) Risk Diversification

Risk diversification is a commonly used risk control measure that reduces the risk of individual projects or participants by distributing funds to multiple projects or participants. In supply chain finance, risk diversification can be achieved by financing multiple supply chain participants. Because supply chain finance participants have close relationships and high mutual trust, risk diversification can effectively reduce the risk of supply chain finance.

In blockchain technology, smart contracts can automate risk diversification through code. Smart contracts define the rules and conditions for risk diversification, and when these rules and conditions are met, funds are automatically distributed to multiple participants for financing. For example, a smart contract can define a threshold for risk diversification, and when the financing amount of a single supply chain participant exceeds that threshold, the remaining funds are automatically diversified to other participants for financing, thereby reducing the risk of individual participants.

(2) Credit Guarantees

Credit guarantees are a common risk control measure that assesses the credit status of participants and provides guarantees for those with good credit, thereby reducing the probability and impact of risks. In this model, credit guarantees are based on the smart contract functionality of blockchain technology, which enables credit assessment and guarantees for participants through smart contracts. For example, in supply chain finance, banks can assess the credit of enterprises through smart contracts and provide guarantees for enterprises with good credit, thereby reducing the probability and impact of risks.

When suppliers or borrowers are unable to repay their debts on time, credit guarantee agencies will repay the debts on their behalf, thereby reducing losses. In the traditional finance industry, credit guarantees typically require a tedious approval process, consuming a significant amount of time and labor costs. However, in supply chain finance, using smart contracts to implement credit guarantees can achieve automation and efficiency, thereby reducing costs and risks.

(3) Asset Pledges

Asset pledges are a common risk control measure that pledges the assets of participants to increase the borrower's willingness and ability to repay debts, thereby reducing the probability and impact of risks. In this model, the implementation of asset pledges is based on the smart contract functionality of blockchain technology. Participants can pledge their assets to obtain loans and financing. For example, in a supply chain finance platform, suppliers can pledge their inventory, accounts receivable, and other assets to obtain financial support, while financing parties can pledge their fixed assets such as inventory and machinery to obtain loans. In this process, the smart contract will automatically register and confirm the asset pledge, and automatically release the pledge when the contract conditions are met. This process reduces the complexity of asset pledge and improves efficiency in supply chain finance.

3.1.4 Transaction Management Module

The transaction management module is one of the core modules of the supply chain finance distributed system. It utilizes the distributed ledger and smart contract functions of blockchain technology to manage transactions between participants in supply chain finance. Blockchain technology is a decentralized distributed ledger technology that can record transaction information on different nodes, avoiding the risk of single-point failures in centralized exchanges, while also ensuring the security and reliability of data. Smart contracts are another important application of blockchain technology, enabling

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automated management of transactions to ensure fairness, transparency, and reliability.

(1) Functionality of the Transaction Management Module

The transaction management module can record traceable information about supply chain finance transactions and automatically execute smart contracts during the transaction process to ensure fairness, transparency, and reliability of the transaction. Specifically, the transaction management module includes the following functionalities:

Transaction recording: The transaction management module can record basic information about supply chain finance transactions, including the parties involved, transaction amount, transaction time, transaction status, etc. This information is recorded on the blockchain distributed ledger, ensuring the immutability and traceability of transaction information.

Transaction validation: The transaction management module can validate the validity of transactions, including verifying the identities of the parties involved, whether the transaction amount is sufficient, and whether the transaction time meets the requirements. Transaction validation is an important step in ensuring the fairness and reliability of transactions.

Smart contract execution: The transaction management module can execute smart contracts to automate the various processes involved in the transaction process. Smart contracts are programmable automation contracts that can automatically execute various processes in the transaction process based on set rules, such as fund payments, logistics distribution, quality inspection, etc. The execution of smart contracts can ensure fairness, transparency, and reliability of transactions.

(2) Advantages of the Transaction Management Module

The advantages of the transaction management module are mainly reflected in the following aspects:

Security: The transaction management module adopts the distributed ledger and smart contract functions of blockchain technology, avoiding the risk of single-point failures in centralized exchanges and ensuring the security and reliability of transaction information.

Traceability: The transaction management module can record transaction information on the blockchain distributed ledger, ensuring the traceability of transaction information. Due to the decentralization and immutability of the blockchain distributed ledger, participants can access and view transaction information at any time and from anywhere to ensure transparency and fairness of transactions. In addition, the transaction information recorded in the distributed ledger can also help participants analyze problems and risk factors in the transaction process and take timely measures for adjustment and optimization. In supply chain finance, traceability of transaction information is crucial for risk management. For example, in enterprise financing, if the financing funds of the enterprise are not used for the specified purposes or the business situation of the enterprise changes, the funding provider can discover and adjust the problem in a timely manner by viewing transaction records, effectively reducing and controlling risks. Similarly, other transactions in supply chain finance, such as accounts receivable financing and warehouse receipt pledge financing, also require traceability of transaction information to ensure the safety and fairness of transactions. In addition to the traceability of transaction information, the transaction management module can also use smart contracts to achieve automated execution in the transaction process, further improving the reliability and security of transactions.

Automated execution: The transaction management module utilizes the smart contract function of blockchain technology to automate supply chain finance transactions. Smart contracts can automatically execute various processes involved in the transaction process, improving the efficiency and reliability of transactions.

3.2 Risk Management Measures and Implementation Methods in the Model

The supply chain finance risk management model based on blockchain technology needs to specify risk management measures and implementation methods to ensure the feasibility and effectiveness of the model. This section will describe the risk management measures and implementation methods in the model, including the following aspects:

3.2.1 Risk Management Measures

(1) Supply Chain Information Sharing

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Blockchain technology has the characteristics of decentralization, immutability, and information sharing, which can be applied to information sharing in supply chain finance risk management. In the model, supply chain parties can share information about suppliers, logistics companies, financing parties, etc. through the blockchain platform, forming a complete and traceable supply chain information chain. This way, if there are any abnormal situations in the supply chain, such as cargo losses, supplier credit problems, etc., they can be timely discovered and resolved through blockchain technology, reducing risk.

(2) Smart Contracts

Blockchain technology can use smart contracts to manage contracts in supply chain finance risk management. Smart contracts are automated contracts that can be automatically executed based on predetermined conditions to ensure the interests of all parties are protected. In the model, a trust mechanism can be established between the financing party and the supplier through smart contracts, reducing unnecessary risks. For example, a margin account can be set up between the financing party and the supplier, and the margin can be automatically deducted through smart contracts, protecting the rights of the financing party.

(3) Risk Premium Management

The risks in supply chain finance may lead to an increase in financing costs, so it is necessary to manage risks through risk premiums. In the model, a supply chain finance risk premium management model can be established using blockchain technology, setting different risk premium levels based on different types of supply chain risks. For example, when there are risks such as fund flow risks, market demand risks, credit risks, etc. in the supply chain, dynamic adjustments of risk premiums can be achieved through blockchain technology, reducing financing costs and risks.

3.2.2 Implementation Methods of Blockchain Technology

The supply chain finance risk management model based on blockchain technology can adopt different blockchain implementation methods, including public chains, consortium chains, or private chains, etc. The specific implementation method can be selected based on application scenarios, security, controllability, and other factors.

(1) Public Chain

A public chain refers to a completely open blockchain network in which anyone can participate in node verification, transactions, and other operations. Public chains have the characteristics of decentralization, transparency, fairness, etc., which can ensure the data is immutable and transparent. In supply chain finance risk management, public chains can achieve information sharing and transactions among supply chain parties, improving the transparency and trust of the supply chain. However, public chains also have issues with security and privacy protection, so careful selection is required.

(2) Consortium Chain

A consortium chain refers to a blockchain network composed of several institutions that can jointly manage the nodes, data, and other resources in the network. Consortium chains have higher security, controllability, and privacy protection capabilities and can achieve functions such as shared management and data sharing. In supply chain finance risk management, consortium chains can realize data sharing between supply chain parties and the establishment of a trust mechanism while protecting the privacy and data security of all parties.

(3) Private Chain

A private chain refers to a blockchain network controlled by one or more organizations, which can authorize and manage nodes, data, and other resources in the network. Private chains have higher controllability and security, ensuring the privacy and security of data. In supply chain finance risk management, private chains can achieve secure data sharing among various parties in the supply chain and establish trust mechanisms.

In summary, different blockchain implementation methods have their own characteristics and applicable scenarios, and selection and deployment should be based on actual situations. At the same time, attention should be paid to issues such as data privacy protection, security, and controllability during the implementation process.

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3.3 Feasibility and Effectiveness Analysis of the Model

3.3.1 Technical Feasibility Analysis

(1) Feasibility of Blockchain Technology in Supply Chain Finance

As a decentralized and tamper-proof distributed ledger technology, blockchain technology can achieve open and transparent management of supply chain finance business information with high security and reliability. Its feasibility is reflected in several aspects:

Improve the transparency and credibility of supply chain finance transactions, reduce transaction costs and risks, and increase transaction efficiency;

Realize the sharing of supply chain finance information, improve the collaboration and operability of business processes;

Protect the security of supply chain finance information, prevent data leakage and tampering.

(2) Development and Application Trends of Blockchain Technology

With the continuous development and maturity of blockchain technology, its application in the field of supply chain finance is also expanding and deepening. In the future, with the further improvement of technology and the continuous expansion of application scenarios, the application of blockchain technology in the field of supply chain finance will become more extensive.

3.3.2 Economic Feasibility Analysis

(1) Economic Benefits of Adopting A Blockchain-Based Supply Chain Finance Risk Management Model

Adopting a blockchain-based supply chain finance risk management model can bring the following economic benefits:

Reduce transaction costs: Blockchain technology can realize the sharing and transparency of supply chain finance business information, reduce information asymmetry and redundant verification, and thus lower transaction costs; Increase transaction efficiency: Blockchain technology can achieve automatic execution and smart contracts, improving the efficiency and speed of supply chain finance transactions;Reduce transaction risks: Blockchain technology can ensure the immutability and transparency of transaction information, reducing transaction risks and credit risks.

(2) Establishing the Relationship between Costs and Benefits Required to Build the Model

Building a supply chain financial risk management model based on blockchain technology requires investment in technology and human resources. At the same time, the economic benefits brought by the model also need to be reasonably evaluated and measured. Therefore, a thorough analysis and research on the relationship between the costs and benefits required to establish the model is needed. To address this issue, a cost-benefit analysis model can be established to comprehensively analyze and evaluate the costs and benefits of the model.

The cost-benefit analysis model is an economic tool used to evaluate the relationship between the costs and benefits of a project. In this model, costs usually refer to all the costs required for the development and implementation of the model, such as hardware equipment, software development, training, and maintenance, while benefits can be considered from both economic and social perspectives.

In this study, we mainly focus on the economic benefits, which include:

Risk management benefits: Adopting a supply chain financial risk management model based on blockchain technology can help companies better manage supply chain financial risks, reduce financial risk losses, and thereby increase their profitability.

Resource utilization benefits: Adopting the model can reduce the resources invested by companies in supply chain financial risk management, thereby improving resource utilization efficiency.

Market competitiveness benefits: Adopting the model can enhance a company's competitiveness in the market, thereby improving its market position and brand image.

In terms of costs, we need to consider the following costs:

Technology development costs: Including the costs of developing software, hardware equipment, servers, etc.

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Implementation costs: Including the costs of training employees, installing equipment, etc.

Maintenance costs: Including hardware and software maintenance, technical support, etc.

Operating costs: Including the costs of managing and operating the model, as well as other operating expenses.

When conducting cost-benefit analysis, we need to quantify the costs and benefits and compare them in the cost-benefit model. In this study, we can further evaluate the economic feasibility of the supply chain financial risk management model based on blockchain technology by establishing a cost-benefit model.

When evaluating cost-benefit, it is important to consider uncertainty and risk factors. Therefore, in cost-benefit analysis, we also need to evaluate and analyze uncertainty and risk to ensure the accuracy and reliability of the evaluation results.

4. Discussion and Conclusion

4.1 Discussion of the Significance and Contribution of Research Results

This study aims to explore the application of blockchain technology in supply chain finance risk management and propose a standardized analytical theoretical model. The results show that blockchain technology has significant advantages in supply chain finance risk management, which can improve the efficiency and transparency of supply chain finance, reduce risk and cost, and promote the stability and sustainable development of the supply chain.

The main contributions of this study include: (1) providing a theoretical model for supply chain finance risk management based on blockchain technology, providing guidance and reference for risk management in practice; (2) conducting in-depth discussions and analyses of the application of blockchain technology in supply chain finance, revealing its advantages and limitations, and providing references and inspiration for future research and practice.

4.2 Analysis of Shortcomings in the Research and Directions for Future Improvement

During the research process, we also found some shortcomings. First, since this study used a normative analysis method, it is impossible to analyze and verify actual data. Second, we failed to consider some special situations and complexities, such as the challenges and limitations of applying blockchain technology in different supply chain environments.

To address the above shortcomings, we can make improvements in the following areas in the future: (1) combine actual data and cases to further verify and improve the proposed theoretical model; (2) strengthen the discussion of the application scenarios and challenges of blockchain technology in different supply chain environments; (3) conduct in-depth research on the relationship between blockchain technology and supply chain finance, explore more innovative points and application scenarios.

4.3 Summary of Research Conclusions and Recommendations

Through the normative analysis method of this study, we established a theoretical model for supply chain finance risk management based on blockchain technology and discussed and analyzed it. The results show that blockchain technology has great advantages and application prospects in supply chain finance risk management, but there are still some challenges and limitations. Therefore, we recommend focusing on the following directions in future practice:

Improving the scalability and security of blockchain technology: The application of blockchain technology in supply chain finance requires high concurrency, high throughput, and high security. Therefore, future research and optimization of blockchain technology should be strengthened to improve its scalability and security.

Promoting the application and standardization of blockchain technology in the financial industry: The financial industry has higher requirements for security and reliability, so promoting the application and standardization of blockchain technology in the financial industry is an important direction. Future cooperation across institutions and industries should be strengthened, and a standardized blockchain

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technology system should be established.

Promoting smart contract technology: Smart contracts are one of the important applications of blockchain technology, which can improve the efficiency and transparency of supply chain finance. Therefore, future research and promotion of smart contract technology should be strengthened, and smart contract standards should be established to promote its application in supply chain finance.

Strengthening legal and regulatory research on blockchain technology: With the development and application of blockchain technology, its legal and regulatory issues are gradually emerging. Therefore, future research should focus on exploring the legal and regulatory issues related to blockchain technology in supply chain finance, providing a basis for regulatory policies and legal frameworks.

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