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Research on Credit Risk Management in Supply Chain Finance Based on Blockchain Traceable Ledgers and Smart Contracts—Focusing on Accounts Receivable Financing Scenarios

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Abstract: With the continuous development of core enterprise-led supply chain collaboration, accounts receivable financing has become a major means of solving the liquidity problems of SMEs. However, traditional supply chain finance still suffers from many problems, such as inadequate credit identification, difficulty in determining the authenticity of transactions, insufficient process traceability, and difficulty in tracking risks. This article uses blockchain traceable ledgers and smart contract mechanisms as the main technical framework, and constructs an analytical framework of "data on-chain - credit penetration - process verification - dynamic early warning - collaborative handling" using the logic of supply chain finance risk management. After systematically reviewing English literature from recent years, and based on global trade finance gaps and blockchain supply chain finance market data, this paper analyzes the realistic driving factors, mechanisms, and implementation obstacles of embedding blockchain into credit risk governance. An evaluation model is established based on default probability, expected loss, transparency index, and comprehensive risk value, and a multi-level governance strategy for accounts receivable financing is proposed. Blockchain is not merely a tool for information recording; it is an institutional infrastructure for credit confirmation, transaction verification, risk sharing, and process constraints. Only when used in conjunction with smart contracts, external data interfaces, regulatory rules, and tiered authorization mechanisms can adverse selection and operational risks be reduced, and the goal of credit risk management be achieved while ensuring that risk management can be verified, calculated, and traced.

1 Introduction

In the digital economy, supply chain finance has transformed from the traditional offline credit granting and bill verification model to an online, platform-based, and ecosystem-driven model dominated by transaction data, logistics data, and contract performance data. For many SMEs at the end of the industrial chain, financing difficulties are not simply a matter of funding, but a complex phenomenon caused by hindered credit transmission, high information verification costs, and financial institutions' inability to confirm the true trade background. Regarding accounts receivable financing, while the credit of core enterprises can be transmitted along the chain to upstream and downstream partners, this transmission generally relies on manual review, repeated confirmation, and fragmented record-keeping, resulting in slow financing speeds and delayed risk identification.

In recent years, research on the intersection of blockchain and supply chain finance has clearly gained momentum. Most studies believe that blockchain has characteristics such as distributed notarization, timestamps, tamper-proof and traceability, which can strengthen the identification of the authenticity of transactions, strengthen performance constraints with the help of smart contracts, and thus improve the trust foundation in supply chain finance [1][2]. In terms of credit propagation, game equilibrium, trust mechanism and risk contagion, relevant studies also show that blockchain can improve the situation of information asymmetry and will promote changes in the financing forms and governance scope among supply chain entities [3][4][5].

However, in practice, blockchain technology is still in a stage of "partial effectiveness but incomplete system" in supply chain finance credit risk management. Data on-chain does not equate to data authenticity; on the contrary, on-chain transparency can conflict with commercial privacy protection. Without a unified data interface, trusted external oracles, and layered access control, platforms will find it difficult to transform on-chain evidence into enforceable credit authorization. Therefore, this paper, from the perspective of accounts receivable financing, studies how blockchain technology can be embedded into the entire process of credit risk identification, assessment, early warning, and handling, and proposes feasible governance strategies.

2. Current Status Analysis of the Research Topic

From the perspective of the global supply chain finance environment, the financing gap is widening, making it imperative to strengthen credit governance innovation. The Asian Development Bank's "Trade Finance Gaps, Growth, and Jobs Survey" shows that the global trade finance gap expanded from $1.7 trillion in 2020 to $2.5 trillion in 2022, and remains high in 2023. This indicates that traditional credit review and single-credit-granting methods are no longer sufficient to meet the increasingly complex financing needs across entities, regions, and levels. Supply chain finance credit risk management is no longer just about static evaluation of individual financing companies, but requires the dynamic identification of genuine orders, warehousing, logistics, invoices, payment commitments, and upstream and downstream relationship networks.

Figure 1 shows that the global trade finance gap has not decreased since the COVID-19 pandemic; instead, it has remained at a high level. This indicates that financial institutions still face significant difficulties in verifying the genuine trade background, performance capabilities, and certainty of repayment for SMEs. The larger the financing gap in supply chain finance, the greater the need to leverage blockchain technology to create a verifiable, traceable, and shareable data chain to mitigate adverse selection and double-pledging risks during the credit granting process.

From a technological supply perspective, the commercial prospects of blockchain in supply chain finance are constantly being enhanced. Market research data shows that the blockchain supply chain finance market size was approximately $1.8 billion in 2024, is expected to reach $2.4 billion in 2025, and is projected to reach $34.6 billion by 2034. Platform companies, core enterprises, and financial institutions are continuously increasing their investment in on-chain rights confirmation, smart contract settlement, bill circulation and notarization, and risk penetration management. The focus of technological evolution has shifted from whether or not blockchain technology can be implemented to how it can reduce risk costs and improve credit conversion efficiency.

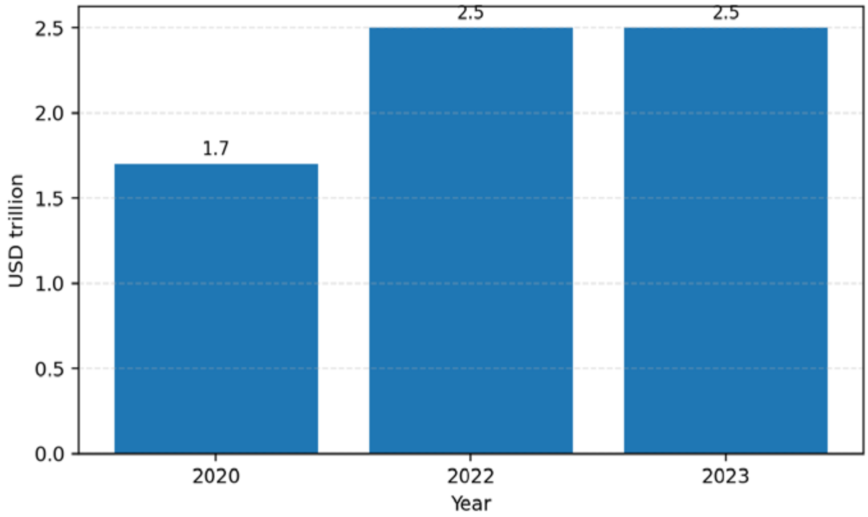

Figure 1. Changes in the global trade finance gap(Source: Compiled from ADB, Trade Finance Gaps, growth and jobs survey, 2023/2025)

In terms of academic research, existing results generally follow three paths. The first category focuses on literature reviews and knowledge graphs, highlighting the overall effects of blockchain such as improving transparency, reducing fraud, and improving process efficiency [1][2]. The second category uses game theory models and operational management models to analyze the impact of blockchain use on financing structures, guarantee mechanisms, governance relationships, and profit distribution [3][6][9]. The third category explores ways to combine blockchain with machine learning, industrial internet, or interpretable models from the perspectives of trust evaluation, credit risk contagion, and intelligent decision support [4][5][8].

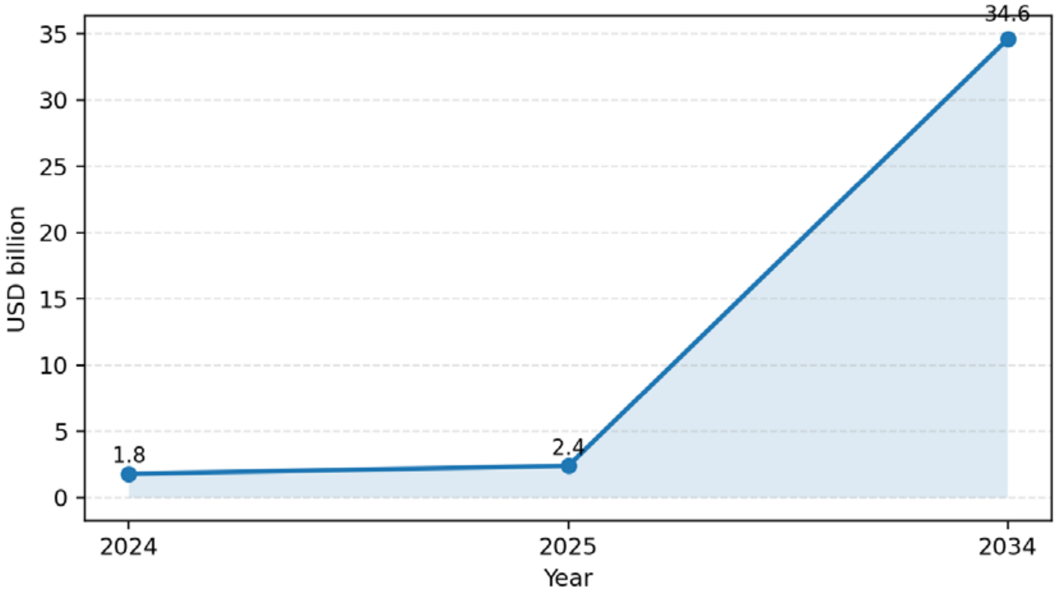

Figure 2 Blockchain in Supply Chain Finance Market Size(From：from 2024/2025 market brief produced by Globmal Market Insdtas)

Figure 2 illustrates the rapid development phase of the blockchain supply chain finance market. Although future forecasts are uncertain, the actual growth from 2024 to 2025 reflects the market's demand for on-chain rights confirmation, automatic reconciliation, and collaborative risk governance. As financing transactions have shifted from single-node review to multi-party collaborative verification, the value of blockchain has expanded from simply storing information to enhancing credit and governing processes.

Table 1 Traditional SCF and Blockchain-enabled SCF Risk Comparison

Dimension	Traditional SCF	Blockchain-enabled SCF	Risk Impact
Data source	Fragmented forms	Shared ledger	Lower asymmetry
Verification	Manual review	Multi-party validation	Lower fraud risk
Collateral status	Repeated checking	Time-stamped proof	Lower double-pledge risk
Monitoring	Periodic audit	Real-time tracking	Earlier warning
Contract execution	Offline enforcement	Smart contract trigger	Lower moral hazard

Table 1 illustrates that blockchain is not a simple replacement for paper certificates, but rather a reshaping of the risk identification approach in supply chain finance. In the traditional model, risks are primarily caused by data fragmentation and slow verification; while the blockchain model uses a shared ledger and timestamps to transform the transaction process into a continuous and verifiable event, shifting credit assessment from post-event verification to in-process monitoring and pre-event constraints.

Currently, blockchain application research is moving from proof of concept to mechanism optimization, and there are still many problems such as cross-chain collaboration, privacy computing, regulatory access, and scenario standardization[7][10]. Therefore, it is necessary to define the scope of blockchain in the risk management system and determine its conditional limitations.

From a credit quantification perspective, the basic probability of default for financing companies can be expressed as a logistic function.

$$PD_i = 1 / (1 + e^{-z_i}),\ z_i = \beta_0 + \Sigma_{k=1}^{n} \beta_k x_{ik} \quad (1)$$

In equation (1), PD_i represents the probability of default for the i-th financing company, and x_{ik} refers to the indicators composed of five aspects: debt repayment ability, order stability, payment cycle, historical overdue payments, and transaction authenticity. This equation shows that blockchain does not replace the credit model itself, but improves the estimation quality of default probability while ensuring the authenticity and timeliness of input data.

3. Raise questions

Although blockchain can significantly improve the information asymmetry problem in supply chain finance, four problems still exist in credit risk management.

First, the issue of the authenticity of on-chain information has not been completely resolved. Blockchain can only guarantee that information will not be tampered with after it is uploaded, but it cannot inherently guarantee that it was authentic and error-free before being uploaded. If the data uploaded by core enterprises, logistics companies, or warehousing nodes is itself distorted, financial institutions will still conduct credit activities based on erroneous data, thus creating the problem of "an untrustworthy source within a trustworthy record."

Second, there is a structural break in credit transmission. Supply chain finance emphasizes the credit spillover of core enterprises, but in a multi-tiered supply chain environment, the transaction chains between second- and third-tier suppliers and core enterprises are longer, involve more transactions, and carry higher performance risks. If on-chain identity governance is insufficient, credit is only transmitted at the first level and cannot form deep-level supplier financing coverage.

Third, there is a conflict between privacy protection and risk transparency. Financial institutions will try to obtain as much data as possible for credit assessment, but companies are afraid of exposing information such as purchase prices, customer structure, order frequency, and cash flow. Without layered encryption, zero-knowledge proofs, or access control, companies will worry about the leakage of trade secrets and thus reduce their willingness to participate.

Fourth, there is still a gap between smart contract execution and real-world legal constraints. Issues such as late deliveries, quality disputes, order changes, and delayed payments in the supply chain cannot be immediately resolved using deterministic principles. If all complex transaction scenarios are solidified in the code, it can actually lead to rigid contract execution and increase the cost of handling exceptions.

Table 2 Credit Risk Indicator System in Accounts Receivable Financing

Indicator	Meaning	Typical data	Blockchain value
Invoice authenticity	Whether receivable is valid	Invoice, PO, contract	Immutable proof
Fulfillment stability	Order execution consistency	Logistics, delivery, receipt	Process traceability
Repayment certainty	Expected cash inflow quality	Payment promise, history	Shared visibility
Relationship strength	Core buyer dependence	Transaction frequency	Network evidence
Operational anomaly	Fraud or moral hazard signal	Duplicate pledge, delay, dispute	Real-time alert

Table 2 presents the core risk indicators in accounts receivable financing scenarios. This system differs from traditional credit granting, which primarily relies on financial statements, by placing greater emphasis on the transaction process, performance, and the certainty of repayment. The value of blockchain lies in providing these indicators with traceable data sources, thereby transforming credit assessment from a "report center" to a "transaction center."

To measure how well on-chain information improves risk identification, a transparency index can be defined.

$$TI = \Sigma\_\{j = 1\}\textasciicircum\{m\}\, w\_j\, q\_j, \;\; \Sigma\_\{j = 1\}\textasciicircum\{m\}\, w\_j = 1 \tag{2}$$

In Equation (2), the transaction transparency index is TI, the on-chain data quality scores such as invoices, contracts, logistics, receipts, and payment commitments are represented by q_j, and the weights are represented by w_j. The higher the transparency index, the more fully financial institutions can judge the authenticity of trade, and the smaller the uncertainty in credit assessment.

Alternatively, the expected loss framework can be used to measure the credit losses incurred in credit granting activities.

$$EL = PD \times LGD \times EAD \tag{3}$$

In equation (3), EL is expected loss, PD is probability of default, LGD is loss due to default, and EAD is exposure to default. Because blockchain improves the accuracy of PD estimation, reduces fictitious accounts receivable and double pledging, it helps to reduce LGD and EAD, thereby reducing the level of credit loss.

4. Problem Solving/Strategies

Blockchain in supply chain finance credit risk management should not be understood as a single-point technology embedding. Instead, a systematic architecture should be established that includes data collection, on-chain governance, contract execution, risk warning, and regulatory collaboration.

First, establish a system of "multi-source verification and trusted on-chain data." Important data such as purchase orders, electronic contracts, invoices, logistics receipts, warehouse receipts, and payment commitments should be integrated into the platform through a unified interface. External data from various sources, including taxation, customs, credit reporting, judiciary, and IoT devices, should also be used for cross-referencing. Only data that has undergone multi-source consistency verification becomes the official basis for authorization, thus improving the credibility of on-chain data from the source.

Secondly, it is necessary to establish a tiered credit penetration model. For Tier 1 suppliers, a credit granting approach combining core enterprise confirmation and trade flow verification can be adopted; for Tier 2 and lower suppliers, it is necessary to combine information such as transaction continuity, order dependency, historical payment records, and network location to create a multi-level credit profile. The traceability of blockchain enables financial institutions to find the connections between the flow of funds, goods, and information, thereby solving the problem of not being able to see or properly evaluate deeper-level suppliers.

In terms of platform reliability, the joint availability of available nodes is used to measure the degree of operational assurance of the consensus network.

$$R = 1 - \prod_{i=1}^{n}(1 - p_i) \tag{4}$$

(4) R represents the reliability of all consortium blockchains, and p_i represents the probability that the i-th important node provides normal service within a certain period. This formula shows that on a consortium blockchain, the more stable the participating nodes are, the stronger the network's guarantee for transaction notarization and contract execution, and the more continuous the management of credit risk.

Third, the governance principles are "on-chain transparency, hierarchical permissions, and minimal privacy exposure." For sensitive fields that financial institutions need to verify but companies are unwilling to disclose, hash mapping, layered encryption, trusted execution environments, or zero-knowledge proof schemes can be used to prove the authenticity of transactions without revealing complete business information. This increases platform participation while reducing operational risks caused by information leaks.

Fourthly, it is necessary to improve the collaboration mechanism between smart contracts and human intervention. The standardized and less contentious processes (delivery confirmation, payment confirmation, automatic interest calculation, and triggering of installment payments) should be handled by smart contracts; for situations involving quality disputes, breaches of contract, or changes to special orders, human review and adjudication functions should be added to prevent code from becoming the sole rule and thus causing management rigidity.

Table 3. Governance path of blockchain-credit risk management.

Layer	Key action	Core actor	Expected effect
Data layer	Cross-source verification	Platform + core buyer	Higher data credibility
Ledger layer	Time-stamped evidence	Consortium nodes	Traceable records
Model layer	Dynamic risk scoring	Bank + fintech	Better PD estimation
Contract layer	Rule-based execution	Smart contract engine	Lower operational loss
Supervision layer	RegTech interface	Regulator + auditor	Better compliance

Table 3 outlines a tiered approach to risk governance in blockchain-based supply chain finance. Only by integrating data governance, ledger governance, model governance, contract governance, and regulatory governance can blockchain become an infrastructure capable of addressing credit risk. The absence of any one of these supporting layers will limit the effectiveness of risk management.

At the comprehensive evaluation level, credit risk value can be defined as:

$$CR = \alpha PD + \beta LGD + \gamma OP - \delta TI, \ \alpha + \beta + \gamma + \delta = 1 \tag{5}$$

The overall credit risk value (CR) is obtained by weighting the operational risk level (OP) and the transparency index (TI). The overall credit risk value CR = α × operational risk level + β × transparency index + γ × weight + δ. The transparency index appears as a negative term in the formula, meaning that increased on-chain transparency can offset some of the credit and operational risks. This formula can be used to evaluate whether the platform's mechanism for implementing tiered access, dynamic limits, and early warnings for financing projects is scientifically sound and reasonable.

Fifth, it promotes the integration of blockchain with machine learning risk models. Blockchain serves as a traceable, tamper-proof, and highly efficient underlying data architecture, while machine learning models identify default patterns, anomalies, and risk propagation paths in a large amount of transaction data. After the two are combined, financial institutions have changed from static credit approval to dynamic risk monitoring, thereby greatly improving the advance warning and the accuracy of credit approval [8][9].

Sixthly, it is necessary to strengthen the construction of systems and standards. Current blockchain supply chain finance platforms are created by multiple parties, including core enterprises, banks, technology companies, and local governments, and there are still differences in data standards, scope of responsibility, evidentiary validity, and accountability for anomalies. The construction of unified rules for electronic certificates, on-chain rights confirmation, smart contract auditing, on-chain data interfaces, and cross-chain interoperability should be promoted to provide a reusable and scalable institutional foundation for risk governance.

5. Conclusion

This paper takes accounts receivable financing as its research object, and discusses the application of blockchain technology to supply chain finance credit risk management, analyzing the existing problems and corresponding solutions. Research shows that blockchain can change the credit formation model by leveraging shared ledgers, timestamps, smart contracts, and traceability, shifting from relying on static entity credit and manual verification to relying on dynamic transaction credit and automated verification.

However, blockchain is not a panacea for risk governance. The authenticity of on-chain information, privacy protection, institutional coordination, in-depth supplier coverage, and handling of abnormal scenarios all affect its governance effectiveness. Only when conditions such as trusted data sources, tiered authorization, contract auditing, model fusion, and regulatory coordination are simultaneously met can blockchain significantly impact information asymmetry, default losses, and operational friction.

In the future, real platform samples can be used to conduct empirical comparisons of indicators such as credit approval rate, financing cost, delinquency rate, repayment cycle, and bad debt rate before and after blockchain. Alternatively, the marginal effect and scope of application of blockchain supply chain finance credit risk management can be studied through privacy computing, graph neural networks, and cross-chain governance mechanisms.

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