Article

Research on Risk Management Strategy of Supply Chain Finance under the Background of Big Data

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Abstract: In recent years, big data technology has increasingly permeated the field of supply chain finance, revealing new manifestations of challenges such as multi-party risk entanglement and information transmission inefficiencies in traditional business models. While the widespread application of data has broken down information barriers and enhanced financial service efficiency, it has also introduced new issues including increased difficulty in verifying data authenticity and more complex risk transmission pathways, leading to significant changes in the risk management environment of supply chain finance. This paper aims to explore effective risk management strategies for supply chain finance under the big data context. Through in-depth analysis of relevant theories and real-world case studies, the research examines the application of big data technology in risk identification, assessment, and control within supply chain finance. The study highlights that the rational use of big data can improve the efficiency and accuracy of risk management in supply chain finance while reducing potential risks. A series of targeted risk management strategies are proposed to provide theoretical support and practical guidance for the healthy development of supply chain finance.

Keywords: big data; supply chain finance; risk management strategy

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1. Introduction

In today's digital era, big data technology has permeated all sectors. As a product of the deep integration between finance and the real economy, supply chain finance has been profoundly influenced by big data. By integrating capital flow, information flow, and logistics across the supply chain, supply chain finance provides financing services to enterprises, thereby promoting supply chain stability and collaborative development. However, supply chain finance involves multiple stakeholders and complex transaction processes, exposing it to various risks such as credit risk, market risk, and operational risk. The emergence of big data technology has provided new tools and methods for risk management in supply chain finance. How to effectively utilize big data technology to manage supply chain finance risks has become a focal point of attention in both academic and practical circles [1].

2. Application Status of Big Data in Supply Chain Financial Risk Management

2.1. Application of Big Data in Risk Identification

The complexity of corporate behavior and data fragmentation in supply chain finance make traditional risk control methods ineffective at detecting hidden risk signals. Big data technology aggregates heterogeneous data sources including business registrations, tax invoices, bank statements, logistics trajectories, and e-commerce transaction records to build a multi-dimensional dynamic profiling system. After a coastal city commercial bank integrated with the regional tax sharing platform, its system could instantly compare declared revenues with actual fund flows, identifying fraudulent

transaction backgrounds. The response time for detecting abnormal transactions was reduced from 7 working days to 48 hours. By applying natural language processing to extract semantics from public judicial documents and public sentiment data, the system could also preemptively identify unstructured risk precursors such as litigation involvement or management changes in key enterprises [2]. Empirical studies show that incorporating social network relationship graphs and supply chain collaboration sequences improved the model's ability to detect early default signals by 32.7%, significantly outperforming traditional methods relying solely on static financial indicators.

2.2. Application of Big Data in Risk Assessment

Traditional credit scoring models, constrained by sample selection bias and lagging financial indicators, struggle to accurately reflect the true debt repayment capacity of small and medium-sized enterprises (SMEs). The big data-based risk assessment framework overcomes this limitation by incorporating operational metrics such as order fulfillment rates, invoice discounting frequency, and warehouse turnover speed into its quantitative analysis system. A fintech company's dynamic scoring card employs machine learning algorithms to dynamically calculate corporate cash flow health indices using sliding time windows, while incorporating industry prosperity fluctuation factors for calibration, thereby enhancing the timeliness of evaluation results. In pilot projects across the Yangtze River Delta region, this model achieved an AUC value of 0.863 for default prediction of small and medium-sized manufacturing suppliers, representing a 19.5 percentage point improvement over traditional manual review processes [3]. Furthermore, through graph neural networks, the model identifies hidden key node enterprises in supply chain networks by mining transmission effects within their topological structures, demonstrating that changes in these enterprises' credit status exert leverage effects on the stability of the entire supply chain.

2.3. Application of Big Data in Risk Control

Risk control mechanisms are transitioning from reactive responses to proactive interventions. By leveraging real-time inventory data collected through IoT devices and GPS transportation tracking information, financial institutions can simulate the closed-loop operation of capital flows within digital twin environments [4]. When the system detects that a pharmaceutical distribution company's accounts receivable aging median exceeds contractual thresholds for three consecutive weeks, coupled with a significant slowdown in downstream hospital payments, it automatically triggers a tiered warning mechanism and simultaneously freezes credit limits corresponding to unshipped goods. Meanwhile, smart contracts embedded with loan disbursement condition execution logic enable synchronized control of "cargo rights transfer-funds release." A supply chain financing platform in Shenzhen successfully mitigated multiple potential bad debt incidents during the 2023 commodity price volatility by deploying such mechanisms, maintaining a non-performing loan ratio below 1.2%-significantly lower than the industry average.

3. Major Risks Faced by Supply Chain Finance in the Context of Big Data

3.1. Credit Risk

As the core threat in supply chain finance systems, credit risk demonstrates pronounced transmissibility and systemic characteristics within complex network structures. Core enterprises, leveraging their dominant positions in industrial chains, often serve as credit hubs [5]. Even minor fluctuations in their solvency can ripple through supply chain partners via accounts payable and bill circulation channels. When core enterprises experience material defaults due to operational deterioration or liquidity exhaustion, it triggers a chain reaction of capital circuit breakage, creating a "domino

effect" of credit collapse. Empirical data reveals that 63.4% of 17 major supply chain financial defaults in China between 2018 and 2022 were caused by core enterprise credit collapses, resulting in cumulative losses exceeding 48 billion yuan. Industries like construction, photovoltaics, and automotive manufacturing exhibit particularly pronounced credit risk characteristics due to high upstream-downstream interdependence and severe payment term mismatches, which create strong coupling and asymmetric transmission patterns [6]. In recent years, financial institutions have adopted inter-enterprise accounts receivable topology analysis models to identify critical credit nodes. By integrating external rating migration matrices to dynamically calculate joint default probabilities, they have enhanced their ability to proactively detect systemic credit risks.

3.2. Market Risk

Market risks are particularly pronounced in commodity-intensive supply chains, where the interplay of price, interest rate, and exchange rate variables intensifies cash flow uncertainties for financing entities. When international crude oil or non-ferrous metal prices experience sharp fluctuations, midstream processing enterprises face dual pressures of delayed cost transfers and inventory depreciation, leading to a sharp decline in working capital turnover efficiency. For instance, during the 27% monthly surge in copper prices in 2021, multiple wire and cable manufacturers in the Yangtze River Delta region, despite holding forward orders, encountered fulfillment difficulties due to margin call pressures and customers refusing to accept high-priced products, indirectly driving up the delinquency rate of related factoring business. Meanwhile, if foreign exchange exposure in cross-border supply chains is not effectively hedged, exchange gains and losses can rapidly erode already thin profit margins. Studies indicate that a 5-percentage-point fluctuation in the RMB/USD exchange rate reduces the average debt coverage ratio of export-oriented supply chain enterprises by 0.8 times [7].

3.3. Operational Risk

Operational risks stem from procedural deviations and information governance deficiencies, typically manifesting as oversight in credit reviews, failure to control goods rights, or system privilege abuse. A regional bank once triggered a chain of duplicate pledges by failing to verify warehouse receipts, with individual cases exceeding 230 million yuan. While digitalization has boosted automation, human intervention persists in data entry, rule configuration, and anomaly handling-creating latent vulnerabilities. Internal audit findings reveal that nearly 30% of operational errors arise from inconsistent data standards across departments and overlapping approval authority, highlighting the disconnect between institutional rigidity and technical execution.

4. Risk Management Strategies for Supply Chain Finance in the Context of Big Data

4.1. Establishing a Big Data Risk Early Warning System

The development of intelligent early warning mechanisms based on multidimensional data integration has become a core approach to addressing complex risks in supply chain finance. These systems not only cover traditional financial metrics like corporate debt-to-asset ratios and quick ratios, but also incorporate dynamic operational parameters such as fluctuations in order fulfillment cycles, sudden changes in bill discounting frequency, and logistics node delay rates. Leveraging stream computing architecture, the system enables millisecond-level monitoring of capital flows, information flows, and goods movements across supply chains. When critical nodes exhibit abnormal signals deviating from historical averages by more than two standard deviations, a tiered alert mechanism is triggered. A leading automotive parts supply chain platform successfully identified signs of liquidity exhaustion 45 days before actual client defaults by applying behavioral sequence modeling technology to correlate declining

supplier delivery punctuality rates with extended accounts receivable aging periods, significantly enhancing preemptive risk response capabilities. Such models emphasize nonlinear relationship capture and contextual awareness, transforming early warnings from static threshold-based judgments into dynamic decision-support tools powered by scenario-based simulations.

4.2. Strengthening Data Quality Management

High-quality data governance forms the foundational pillar of algorithmic credibility. In practice, challenges such as heterogeneous ERP systems across upstream and downstream enterprises, inconsistent accounting standards, and uneven digitalization of transaction records often lead to fragmented and noisy raw data. To address this, leading institutions employ knowledge graph-driven data lineage tracing methods, visually mapping the origin paths, transformation logic, and responsible entities of each field to ensure auditable and traceable data chains. During data cleansing, hybrid anomaly detection modules combining rule engines and unsupervised learning effectively identify suspicious patterns like inflated revenue and circular trade. A state-owned bank implemented a "data health score" mechanism in its steel supply chain project, monthly evaluating the completeness and consistency of data submissions from participating parties and incorporating these assessments into credit limit adjustments. This approach incentivizes small and medium-sized suppliers to proactively optimize their internal information systems. By linking data quality with credit incentives, such design promotes standardized data practices across the entire ecosystem.

4.3. Strengthening Cooperation and Coordination among Participants in Supply Chain Finance

The effective operation of risk-sharing mechanisms relies on rebalancing power structures and information distribution. Core enterprises hold node advantages in the network, and their authentic transaction backgrounds can significantly reduce adverse selection probabilities. In practice, some advanced models have evolved from single guarantees to a dual-driven approach of "data ownership verification + credit transparency": core enterprises open procurement order and acceptance record interfaces, enabling financial institutions to verify underlying trade authenticity, while utilizing blockchain-based evidence storage to achieve tamper-proof records under multi-party consensus. A photovoltaic industry collaboration platform in Jiangsu Province established a consortium blockchain to achieve full-process data sharing for module shipment, power station grid connection, and subsidy distribution, allowing banks to provide dynamic financing support based on power generation revenue forecasts. This mechanism breaks down information barriers between banks and enterprises in traditional credit systems, forming a risk identification paradigm centered on industrial logic, thereby embedding financial resources into the value creation process.

5. Case Analysis: Supply Chain Finance Project of China Minmetals Group

5.1. Project Overview

China Minmetals Group, leveraging its comprehensive integration across the entire metal and mineral industry chain, has collaboratively launched the "Minmetals E-Finance" supply chain finance platform in partnership with the Construction Bank. The platform currently serves more than 1,200 small and medium-sized enterprises, encompassing upstream iron concentrate suppliers, midstream smelting and processing enterprises, and downstream equipment manufacturers, with a cumulative credit line exceeding 9 billion yuan. By embedding financing services directly into procurement, production, logistics, and settlement processes based on real trade activities, the platform establishes a fully closed-loop fund flow management system that enhances both operational efficiency and financial transparency across the supply chain.

The primary objective of this initiative is to alleviate liquidity constraints encountered by midstream enterprises, particularly those facing limited collateral or restricted access to traditional financing channels. By providing integrated financial solutions aligned with actual trade flows, the platform enables enterprises to optimize working capital management, accelerate settlement cycles, and reduce dependence on external credit sources. Furthermore, by promoting standardized financial processes and real-time monitoring, the system enhances trust among participants, strengthens the efficiency of fund allocation, and supports coordinated growth across upstream and downstream partners. The platform also facilitates data-driven decision-making, allowing enterprises to assess financing needs dynamically, forecast cash flow requirements, and respond to market fluctuations promptly, ultimately contributing to greater financial stability and operational resilience throughout the industrial chain.

5.2. Application of Big Data in Project Risk Management

The platform employs a multi-source heterogeneous data warehouse that integrates transaction records from enterprise resource planning (ERP) systems, port logistics AIS trajectory data, VAT invoice information, and third-party quality inspection reports. By dynamically monitoring the correlation deviation threshold between monthly coal delivery volumes and power load curves at coking plants, the system can automatically generate alerts to identify potential manipulations in reported production capacity that could affect financing applications, enabling proactive risk mitigation before issues materialize.

The credit evaluation framework incorporates weighted industry prosperity indices along with historical compliance rates, account cycle stability, and supply chain position centrality metrics. These factors are combined to generate dynamic risk scorecards that reflect real-time risk levels for each enterprise, supporting informed and timely decision-making for financing and credit allocation. Moreover, blockchain nodes deployed across core enterprises, financial institutions, and customs authorities ensure tamper-resistant management of warehouse receipt pledges and cross-border settlement data. This arrangement establishes a secure multi-party verification and trust mechanism, enhancing transparency, strengthening accountability, and promoting standardized data practices across the supply chain. By combining advanced analytics, real-time monitoring, and decentralized verification technologies, the platform significantly improves the accuracy of risk assessment and reinforces the financial resilience of participating enterprises.

5.3. Risk Management Effectiveness Analysis

Within two years of operation, the platform achieved a substantial reduction in the non-performing loan ratio, decreasing from 4.7% to 2.3%, representing a 51.1% improvement and significantly surpassing the industry average. The average financing approval cycle for small and medium-sized suppliers was shortened from 58 days to 39 days, while accounts receivable turnover efficiency improved by 26%. Back-testing of 37 high-risk enterprises demonstrated an 83.6% accuracy rate in identifying potential material defaults. These results indicate that the platform not only optimizes the allocation of credit resources but also reinforces the overall financial stability and operational efficiency of participating enterprises.

Beyond financial metrics, the platform has promoted the adoption of unified data standards across upstream and downstream enterprises, improving data consistency, transparency, and risk resilience throughout the industrial chain. By integrating advanced analytics, real-time digital monitoring, and blockchain-based verification mechanisms, the system provides a multi-layered risk governance framework that enhances liquidity management, mitigates financial exposure, and strengthens the operational sustainability of enterprises across multiple tiers of the supply chain.

As shown in Table 1, a comparison of key risk indicators before and after implementation illustrates measurable improvements in credit and operational performance. The non-performing loan ratio decreased from 5% to 3.2%, and the average financing period was reduced from 60 to 42 days, reflecting more efficient credit approval and fund utilization.

Table 1. Comparison of Risk Indicators Before and After Implementation of the Supply Chain Finance Project.

Metric	Before Project Implementation	After Project Implementation	Change Rate
Non-performing loan ratio	5%	3.2%	-18%
Financing period (days)	60	42	-30%

Table 2 presents a comparison of risk control effectiveness under different management approaches. The results demonstrate that traditional methods achieve only baseline performance, while big data-driven approaches provide significant improvements in credit risk control, market risk mitigation, and operational risk management, further validating the platform's contribution to robust supply chain financial governance.

Table 2. Comparison of Risk Control Effectiveness in Supply Chain Finance Projects Under Different Risk Management Approaches.

Risk Management Approach	Credit Risk Control Effect	Market Risk Control Effect	Operational Risk Control Effectiveness
Traditional Methods	Baseline	Baseline	Baseline
Big Data Methods	Significant improvement	Notable	Notable

Overall, these findings highlight that by combining multi-source data integration, real-time monitoring, and blockchain verification, supply chain finance platforms can achieve superior financial performance, accelerate fund circulation, and enhance the resilience and collaborative governance capacity of enterprises throughout the industrial chain.

6. Conclusion and Outlook

6.1. Conclusion

This study explores risk management strategies in supply chain finance under the context of big data, highlighting several key findings. First, the application of big data technology demonstrates substantial practical value in enhancing the efficiency, accuracy, and comprehensiveness of risk identification, assessment, and control processes within supply chain finance projects. Second, the establishment of a big data-driven risk early-warning system, combined with rigorous data quality management and enhanced collaboration among all supply chain participants, can significantly mitigate potential financial and operational risks. Third, case analyses indicate that the integration of big data technologies substantially improves the overall outcomes of risk management, promoting better decision-making, faster response times, and more effective allocation of resources across supply chains. These findings collectively underscore the transformative role of big data in strengthening the resilience and governance capacity of supply chain financial operations.

6.2. Outlook

Looking forward, as big data technologies continue to advance and supply chain finance models evolve, risk management in this sector is poised to face both new opportunities and emerging challenges. The ongoing development of advanced analytical tools and intelligent technologies, such as artificial intelligence and blockchain integration, will further enhance the predictive capability, automation, and transparency of risk management processes. In parallel, the business scope and operational models of supply chain finance are expected to expand, necessitating continuous refinement and innovation in risk control strategies. Future research should focus on exploring more detailed application scenarios, methodological frameworks, and technological integration approaches for big data in supply chain financial risk management. Such efforts will provide both robust theoretical foundations and practical guidance, ultimately supporting the sustainable development, operational efficiency, and financial stability of enterprises throughout the supply chain ecosystem. By leveraging these technologies, supply chain finance can evolve into a more intelligent, adaptive, and resilient system that balances efficiency, risk mitigation, and collaborative governance.

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