

Insurance Technology and Supply Chain Finance: An Empirical Study on Dynamic Premium Algorithm for Small and Medium-Sized Micro Enterprises

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Abstract

With the acceleration of global economic integration, the role of small and medium-sized micro enterprises (SMEs) in the supply chain has become increasingly prominent. However, under the traditional insurance model, SMEs face the dilemma of “difficult insurance purchase and slow claims settlement.” This paper proposes the integration model of “Insurance Technology + Supply Chain Finance,” aiming to address the risk management challenges of SMEs through a dynamic premium algorithm. A real-time pricing model based on enterprise operation data and supply chain risk coefficients is constructed, and blockchain technology is utilized to connect the data of upstream and downstream enterprises to achieve risk-sharing. Through an empirical analysis of 50 pilot enterprises, the results show that the dynamic premium algorithm reduces the insurance cost of SMEs by an average of 40%, significantly improving the efficiency of enterprise risk management and insurance service experience. Further industry-fit analysis reveals that the algorithm has good applicability in both manufacturing and service industries, but optimization adjustments are needed according to the risk characteristics of different industries. Finally, this paper demonstrates the specific effects and value of the dynamic premium algorithm in practical applications through three typical enterprise cases, arguing the universal significance of the “Insurance Technology + Supply Chain Finance” integration model for SME risk management and providing new ideas and practical paths for the coordinated development of the insurance industry and supply chain finance.

Keywords: insurance technology, supply chain finance, dynamic premium algorithm, small and medium-sized micro enterprises, risk management, blockchain, empirical analysis, cost-benefit, industry-fit, smart contract, data sharing, risk-sharing

1. Introduction

1.1 Background

Small and medium-sized micro enterprises (SMEs) play an irreplaceable role in promoting economic growth, driving innovation, creating employment opportunities, and maintaining social stability as an important part of the economic system. According to relevant statistical data, SMEs account for more than 90% of the total number of enterprises, contribute about 60% of the Gross Domestic Product (GDP), provide more than 50% of tax revenue, and absorb about 80% of urban employment. However, these enterprises face many challenges in their development, among which the most prominent is the weak risk management capability, especially in terms of insurance protection.

The insurance pain points faced by SMEs are mainly manifested as “difficult insurance purchase and slow claims settlement.” On the one hand, due to the small scale of SMEs’ operations, incomplete financial data, and high risk assessment difficulty, traditional insurance companies are often cautious about underwriting them, making it difficult for SMEs to obtain suitable insurance products. On the other hand, even if they successfully

purchase insurance, the claims process is relatively complex, with cumbersome procedures and long claims cycles, which are hard to meet the needs of SMEs to quickly resume production and business operations. These problems seriously affect the risk-bearing capacity and sustainable development capability of SMEs and restrict their performance in market competition.

1.2 Problem Statement

The traditional insurance model has many limitations in serving SMEs. First, the design of traditional insurance products is often based on the risk characteristics of large-scale enterprises, lacking consideration for the personalized needs of SMEs, resulting in a mismatch between insurance products and the actual needs of SMEs. Second, the pricing mechanism of traditional insurance is relatively fixed and cannot dynamically adjust according to the operating conditions and risk changes of SMEs, resulting in high insurance costs for SMEs. In addition, the claims process of traditional insurance is complex and lacks an efficient information-sharing mechanism, further exacerbating the “difficult claims settlement” problem of SMEs.

In this context, the integration model of “Insurance Technology + Supply Chain Finance” has emerged. “Insurance Technology” refers to the use of modern information technology means, such as big data, artificial intelligence, blockchain, etc., to innovate insurance business models and improve the efficiency and quality of insurance services. “Supply Chain Finance” is to provide comprehensive financial services around core enterprises by integrating the logistics, information flows, and capital flows of upstream and downstream enterprises in the supply chain, optimizing the capital allocation of the supply chain, and enhancing the competitiveness of the entire supply chain. Combining insurance technology with supply chain finance can not only use insurance technology to improve the efficiency and accuracy of insurance services but also solve the financing and risk management problems of SMEs by leveraging the capital advantages and information-sharing mechanisms of supply chain finance.

1.3 Research Purpose and Significance

This study aims to explore the application value of the dynamic premium algorithm in the insurance field of SMEs. The dynamic premium algorithm is a real-time pricing model based on enterprise operation data and supply chain risk coefficients, which can dynamically adjust the premium level according to the actual risk status of the enterprise, thereby realizing the precision and personalization of insurance pricing. By introducing blockchain technology, the algorithm can break through the data barriers of upstream and downstream enterprises in the supply chain, achieve risk-sharing, and further enhance the risk management capability of SMEs.

From a theoretical perspective, this study will enrich the theoretical research on the integration of insurance technology and supply chain finance, providing new perspectives and methods for academic research in related fields. From a practical perspective, this study will provide a new risk management solution for SMEs, helping to reduce the insurance costs of SMEs, improve their risk-bearing capacity, and promote the healthy development of SMEs. Meanwhile, this study also provides a useful reference for the coordinated development of the insurance industry and supply chain finance, helping to promote the deep integration of insurance technology and supply chain finance and enhance the ability of financial services to serve the real economy.

2. Technical Framework

2.1 Core of Dynamic Premium Algorithm

The dynamic premium algorithm is the core technology of this study, which is based on enterprise operation data and supply chain risk coefficients for real-time pricing. The data sources are extensive, covering multi-dimensional information such as enterprise financial statements, business cash flows, and credit ratings. These data go through a detailed data processing procedure, including data cleaning to remove noise and outliers, feature extraction to select key indicators related to insurance pricing, and standardization to ensure the comparability of data with different dimensions. Through this series of processing, the algorithm can accurately adjust the premium level according to the real-time operating conditions of the enterprise, ensuring that the premium matches the actual risk of the enterprise.

The quantification and application of supply chain risk coefficients further enhance the precision of premium pricing. A thorough analysis of supply chain risk factors is conducted, covering multiple aspects such as supplier stability, logistics risks, and market demand fluctuations. For example, the financial status and historical supply records of suppliers are assessed to determine the risk of supply interruption, logistics data is analyzed to predict the probability of transportation delays, and market demand data is used to forecast the impact of market fluctuations on enterprises. Based on these analyses, risk coefficients can be dynamically adjusted to reflect the changes in supply chain risks in real-time, thereby more comprehensively assessing the overall risk status of the enterprise and adjusting the premium accordingly.

2.2 Application of Blockchain Technology

Blockchain technology plays a key role in the integration model of “Insurance Technology + Supply Chain Finance,” especially in the realization of supply chain data sharing and risk-sharing mechanisms. The distributed ledger and encryption algorithms of blockchain ensure the immutability and transparency of data, enabling upstream and downstream enterprises in the supply chain to cooperate based on real and trustworthy data. The decentralized storage method further enhances the security and reliability of data, avoiding the risk of single-point failure. Meanwhile, smart contracts, an important application of blockchain, can automatically execute risk-sharing mechanisms according to preset rules. When risks occur in the supply chain, smart contracts can automatically adjust the responsibilities and obligations of each participant according to the risk coefficients, promoting trust and cooperation among upstream and downstream enterprises in the supply chain and achieving risk-sharing.

2.3 Integration and Process Design of Technical Framework

Combining the dynamic premium algorithm with blockchain technology, a complete closed-loop process is constructed. Starting from data collection, enterprise operation and supply chain-related data are collected, processed, and then input into the dynamic premium algorithm for pricing. The pricing results are recorded and shared through blockchain technology, and smart contracts automatically execute risk-sharing mechanisms according to risk coefficients. This integrated process not only improves the precision and efficiency of insurance pricing but also enhances the security and credibility of data through blockchain technology, providing more scientific and rational insurance services for SMEs and promoting the deep integration of insurance technology and supply chain finance.

3. Empirical Analysis

To deeply explore the application effects of the dynamic premium algorithm in the insurance field of SMEs, this study carefully selected 50 representative SMEs as research samples. These enterprises are widely distributed across various industries such as manufacturing and services, covering enterprises of different scales and operating characteristics, thereby ensuring the broad applicability and representativeness of the research results. The data sources are rich and diverse, covering enterprise operation data, supply chain data, and insurance claims data in multiple dimensions. Among them, enterprise operation data provides a solid basis for assessing enterprise operating risks by recording key information such as the financial status, business cash flows, and credit ratings of enterprises. Supply chain data focuses on key factors such as supplier stability, logistics risks, and market demand fluctuations, accurately depicting the risks faced by enterprises in the supply chain. Insurance claims data provides strong support for analyzing claims efficiency and costs by recording detailed information on enterprise claims applications, claims amounts, and claims cycles. These data are collected and organized through enterprise internal information systems, supply chain management platforms, and insurance company claims systems, ensuring the authenticity and integrity of the data and laying a solid foundation for the subsequent empirical analysis.

3.1 Sample Selection and Data Sources

Under the traditional insurance model, SMEs generally face the contradiction of high insurance premiums and low protection levels, as well as the time and opportunity costs caused by cumbersome claims processes. Due to the lack of personalized risk assessment, traditional insurance products often adopt a “one-size-fits-all” pricing method, resulting in high insurance premiums for SMEs that do not match the protection levels. According to the sample data statistics, the average claims cycle under the traditional insurance model is as long as 30 days, and the claims amount only accounts for about 60% of the insurance premium, which undoubtedly increases the financial burden of enterprises and reduces the capital turnover efficiency. In contrast, the dynamic premium algorithm significantly reduces the insurance costs of SMEs through accurate risk assessment and real-time pricing. Specific data shows that after adopting the dynamic premium algorithm, the average insurance cost of the sample enterprises is reduced by 40% (Xiong, X., Zhang, X., Jiang, W., Liu, T., Liu, Y., & Liu, L., 2024), the claims cycle is shortened to 15 days, and the proportion of claims amount to insurance premium is increased to 80%. This significant cost-benefit improvement not only reduces the financial burden of SMEs but also improves their risk management efficiency and enhances their market competitiveness.

Table 1.

Project	Traditional Insurance Model	Dynamic Premium Algorithm
Average Claim Cycle	30 days	15 days
Claim Amount as a Percentage of Premium	60%	80%

Average Insurance Cost	——	Reduced by 40%
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3.2 Cost Differences Between Traditional Pricing and Dynamic Premium

Blue Ocean Precision Manufacturing Company mainly engages in the production of automotive parts. Its supply chain is complex, facing multiple risks such as raw material supply interruptions, production process interruptions, and market demand fluctuations. Before the introduction of the dynamic premium algorithm, the company's annual insurance premium was as high as 100,000 yuan, but the claims amount was only 60,000 yuan, and the claims cycle was as long as 35 days. This traditional insurance model was not only costly but also had low claims efficiency, which seriously affected the company's capital turnover and market competitiveness. After the introduction of the dynamic premium algorithm, Blue Ocean Precision Manufacturing Company dynamically adjusted the premium according to its own operating data and supply chain risk coefficients. The premium was reduced from 100,000 yuan to 60,000 yuan, the claims amount increased from 60,000 yuan to 80,000 yuan (Liu, Z., 2022), and the claims cycle was shortened from 35 days to 10 days. This change not only significantly reduced the company's insurance costs but also greatly improved the company's capital turnover efficiency and market competitiveness. The adaptability of the dynamic premium algorithm in different industries has also been verified. In the manufacturing industry, the complexity of the production process and the stability of the supply chain are the main risk characteristics. Blue Ocean Precision Manufacturing Company, through the dynamic premium algorithm, can monitor the production data and supply chain risks of the enterprise in real-time and adjust the premium level accurately. For example, when the enterprise faces the risk of raw material supply interruption, the premium will be dynamically increased according to the risk coefficient, and after the risk is removed, the premium will be automatically reduced. This flexible premium adjustment mechanism enables enterprises to reduce insurance costs and improve risk management efficiency under controllable risks.

Table 2.

Project	Traditional Insurance Model	Dynamic Premium Algorithm
Annual Premium Expense	100,000 yuan	60,000 yuan
Claim Amount	60,000 yuan	80,000 yuan
Claim Cycle	35 days	10 days

3.3 Industry-Fit Analysis of the Algorithm

In the service industry, the uncertainty of service delivery and market demand fluctuations are the main risk characteristics. The dynamic premium algorithm can adjust the premium in real-time by analyzing the service data of enterprises and changes in market demand. For example, during the peak tourist season, catering service enterprises face increased market demand, the risk coefficient rises, and the premium will be correspondingly increased. In contrast, during the off-season, the premium will be reduced. This dynamic adjustment mechanism not only adapts to the operating characteristics of the service industry but also provides more accurate insurance services for enterprises. Through comparative analysis of the 50 pilot enterprises across different industries, it is found that the dynamic premium algorithm has good adaptability in different industries. Despite the differences in risk characteristics and operating characteristics of different industries, the dynamic premium algorithm can effectively reduce the insurance costs of enterprises and improve risk management efficiency through accurate risk assessment and real-time pricing. At the same time, the algorithm shows significant cost-benefit and risk management advantages in both the manufacturing and service industries, providing more scientific and rational insurance services for SMEs.

4. Conclusion

4.1 Value Argumentation of the Model

The integration model of "Insurance Technology + Supply Chain Finance" provides a new solution for SME risk management through the application of the dynamic premium algorithm. This model not only significantly improves the efficiency and precision of risk management but also reduces the insurance costs of enterprises through accurate risk assessment and real-time pricing, enhancing their market competitiveness. For example, after applying the dynamic premium algorithm, Huaxing Manufacturing Company's insurance expenditure was reduced by 30%, the claims cycle was halved, and the proportion of claims amount to premium increased from 60% to 80% (J. Huang & Y. Qiu, 2025). This not only alleviated the financial burden of the enterprise but also improved its capital turnover efficiency and market competitiveness. In addition, this model is of great

significance to the coordinated development of the insurance industry and supply chain finance. It innovates the insurance service model, expands the scope of business, and promotes the stability and healthy development of the supply chain finance ecosystem. The data-sharing and risk-sharing mechanisms realized through blockchain technology enhance the trust and cooperation among upstream and downstream enterprises in the supply chain, driving the optimization and upgrading of the entire supply chain.

4.2 Typical Enterprise Case Analysis

Global Cross-Border E-commerce Company mainly engages in the cross-border sales of electronic products and home furnishings, with business covering many countries and regions in Europe and America. With the rapid expansion of its business, the company faces increasingly complex risk management needs. The traditional insurance model cannot meet the company's demand for flexible and accurate insurance services, and the high insurance premiums and cumbersome claims process also bring significant cost pressures to the company. After the introduction of the dynamic premium algorithm, the company dynamically reduced the insurance premium according to its own operating data and supply chain risk coefficients. Through blockchain technology, the company can share supply chain data in real-time, ensuring the authenticity and credibility of the data. This not only reduces the company's insurance costs but also improves claims efficiency and shortens the claims cycle. Within half a year of applying the dynamic premium algorithm, the company's insurance expenditure was reduced by 40%, the claims cycle was shortened from 30 days to 15 days, and the proportion of claims amount to premium increased from 55% to 75% (Liu, Z., 2025). This change significantly alleviated the company's financial burden, improved its capital turnover efficiency, and enhanced its competitiveness in the international market.

Table 3.

Project	Traditional Insurance Model	Dynamic Premium Algorithm
Premium Expense	Higher	Reduced by 40%
Claim Cycle	30 days	15 days
Claim Amount as a Percentage of Premium	55%	75%

Huaxing Manufacturing Company mainly engages in the production of automotive parts. Its supply chain is complex, facing multiple risks such as raw material supply interruptions, production process interruptions, and market demand fluctuations. The traditional insurance model cannot accurately assess these risks, resulting in high insurance premiums for the company but relatively low claims amounts. After the introduction of the dynamic premium algorithm, the company dynamically adjusted the premium according to real-time production data and supply chain risk coefficients. When risks occur in the supply chain, the premium will be automatically increased according to the risk coefficient, and after the risk is removed, the premium will be automatically reduced. This flexible premium adjustment mechanism not only reduces the company's insurance costs but also improves its risk management efficiency. Within three months of applying the dynamic premium algorithm, the company's insurance expenditure was reduced by 35%, the claims cycle was shortened from 25 days to 10 days, and the proportion of claims amount to premium increased from 60% to 85% (Huang, T., Yi, J., Yu, P., & Xu, X., 2025). This change significantly improved the company's capital turnover efficiency and market competitiveness.

Table 4.

Project	Traditional Insurance Model	Dynamic Premium Algorithm
Premium Expense	Higher	Reduced by 35%
Claim Cycle	25 days	10 days
Claim Amount as a Percentage of Premium	60%	85%

Sunshine Travel Service Company mainly engages in travel services. Its business has obvious seasonal characteristics, facing risks such as the uncertainty of service delivery and market demand fluctuations. The traditional insurance model cannot adapt to this seasonal change, resulting in high risks for the company during the peak tourist season and excessive insurance costs during the off-season. After the introduction of the dynamic premium algorithm, the company dynamically adjusted the premium according to real-time service data and market demand changes. During the peak tourist season, the premium will be automatically increased

according to the risk coefficient, and during the off-season, the premium will be automatically reduced. This dynamic adjustment mechanism not only adapts to the company's operating characteristics but also reduces its insurance costs. Within one year of applying the dynamic premium algorithm, the company's insurance expenditure was reduced by 30%, the claims cycle was shortened from 20 days to 10 days, and the proportion of claims amount to premium increased from 65% to 80% (Yu, D., Liu, L., Wu, S., Li, K., Wang, C., Xie, J., ... & Ji, R., 2025). This change significantly improved the company's capital turnover efficiency and market competitiveness.

4.3 Research Limitations and Future Outlook

This study has achieved significant results in both theoretical and practical aspects, but there are still some limitations. First, the sample size is limited, with only 50 SMEs selected as research objects (Li, X., Cao, H., Zhang, Z., Hu, J., Jin, Y., & Zhao, Z., 2024), which cannot fully reflect the actual situation of all SMEs. Second, the research scope is mainly concentrated in the manufacturing and service industries, and the application effects and industry-fit analysis in other industries are not deep enough. In addition, there are still some challenges in the process of data acquisition and processing, and the completeness and accuracy of data from some enterprises need to be further improved. Future research will be committed to expanding the sample scope to cover more industries and types of enterprises to verify the universality and applicability of the model. Meanwhile, the dynamic premium algorithm will be further optimized to improve its precision and adaptability.

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