Application and Efficiency Enhancement of Large Models in Supply Chain Risk Management

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Abstract: With the deepening of globalization and the continuous extension of supply chain networks, the complexity and vulnerability of supply chains are also increasing. Various risks such as supply interruptions, demand fluctuations, natural disasters, and geopolitical conflicts pose a huge threat to the stability of supply chains. Traditional risk management methods have limited adaptability to complex environments, making it difficult to comprehensively respond to these dynamic changes. In recent years, as an important breakthrough in the field of artificial intelligence, big models have demonstrated unique advantages in supply chain risk management with their powerful data processing, natural language understanding, and intelligent decision-making capabilities. Large models can provide enterprises with more accurate risk identification, comprehensive risk assessment, and efficient emergency response support through multi-source data integration, scenario simulation, and dynamic optimization. This article systematically analyzes the core technologies and application scenarios of large models in supply chain risk management, explores their practical performance in improving risk management efficiency, and proposes path suggestions for technology integration, data governance, and intelligent platform construction. Through theoretical analysis and case studies, this article provides important theoretical basis and practical guidance for enterprises to build a more intelligent supply chain risk management system, helping them enhance their competitiveness and risk resistance in the complex global supply chain environment.

1. Introduction

Supply Chain Risk Management (SCRM) is an important means for enterprises to ensure stable operations in complex global supply chain networks. With the continuous deepening of globalization, the networking and cross regional characteristics of supply chains have become increasingly prominent, and the types and degrees of risks faced by enterprises have also increased. From supplier defaults and demand fluctuations to natural disasters and geopolitical conflicts, uncertainty in the supply chain has gradually become a core challenge in business operations. Traditional risk management methods often rely on static models and empirical decision-making, making it difficult to cope with rapidly changing external environments and highly complex network structures, especially when faced with heterogeneous data from multiple sources, resulting in insufficient information integration capabilities and lagging decision-making.

In recent years, the rapid development of artificial intelligence technology has brought new opportunities for supply chain risk management. Large models, such as the GPT series models, demonstrate unique advantages in data analysis, scenario simulation, and intelligent decision-making due to their large-scale parameter training, context understanding, and multimodal data processing capabilities. Its powerful text comprehension ability enables it to analyze unstructured data in the supply chain, such as news reports, policy documents, and industry reports; And its generative capability can provide optimized risk response strategies for complex scenarios.

This article aims to explore the specific application of big models in supply chain risk management and analyze their mechanism in improving management efficiency. Through systematic literature review, case analysis, and theoretical modeling, this article will reveal the technical advantages and

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application prospects of large models in supply chain risk identification, assessment, and response, providing theoretical support and practical guidance for building a more intelligent and efficient supply chain risk management system.

2. Technical Principles and Characteristics of Large Models

As an important technical tool in the field of artificial intelligence, big models have emerged in many fields with their powerful data processing and intelligent analysis capabilities [1]. Supply chain risk management, as a complex multivariate system problem, has brought disruptive innovation to this field through its technological characteristics and advantages. This section discusses the definition and development of large models, core technologies, and their advantages, exploring their technical principles and unique characteristics.

2.1 Definition and Development of Large Models

Large scale models are large-scale neural network models based on deep learning techniques, typically trained on massive amounts of data to achieve high-level generalization and contextual understanding abilities. Compared with traditional artificial intelligence models, the significant feature of large models lies in their extremely large scale parameters (usually reaching billions or even trillions), which can process multimodal data (including text, images, and time series data) and perform complex tasks. These features enable large models to demonstrate excellent adaptability and predictive ability in cross domain and cross scenario applications [2]. In recent years, big models have made breakthroughs in fields such as natural language processing, image generation, and speech recognition, laying the foundation for their application in supply chain risk management. For example, the ability of large models to handle heterogeneous data from multiple sources and make decisions in complex scenarios can effectively respond to the dynamically changing risk factors in global supply chains.

2.2 Core Technologies of Large Models

The core technology of the big model includes the following three key areas.

Firstly, natural language processing (NLP) is one of the core applications of large models. Big models can analyze and understand unstructured data such as supply chain documents, policy documents, and news reports, helping businesses identify potential risk factors hidden in textual data. For example, by analyzing policy changes or international trade news in the upstream and downstream of the supply chain, large models can provide timely risk warnings for enterprises.

Secondly, generative artificial intelligence technology enables large models to predict and simulate potential supply chain risk events. This ability can not only assist companies in conducting scenario analysis, but also provide decision-makers with more comprehensive response strategies. For example, generative AI can predict the impact of natural disasters on logistics networks and optimize emergency measures in the supply chain.

Finally, large-scale dataset training is one of the technical foundations of large models. By training on massive amounts of multi domain data, large models can extract cross domain knowledge structures and form a global understanding of supply chain risks. This ability is particularly important for dealing with complex and multidimensional risk scenarios in the supply chain.

2.3 Advantages of Large Models

The advantages of applying large models in supply chain risk management are mainly reflected in three aspects. Firstly, there is the data-driven analytical capability. Large models can provide in-depth analysis by integrating structured and unstructured data, thereby improving the accuracy and comprehensiveness of risk identification. Secondly, there is the ability to quickly adapt to complex scenarios. Large models, with their contextual understanding and multi task learning characteristics, can cope with the constantly changing dynamic environment in the supply chain [3]. Finally, the ability to efficiently handle large-scale heterogeneous data, whether it is text data, time series data, or other types of data, can be uniformly processed by large models, providing more efficient support for

risk decision-making.

3. Current Status and Challenges of Supply Chain Risk Management

With the deepening of globalization and the complexity of supply chain networks, the importance of supply chain risk management has become increasingly prominent. However, in current practice, supply chain risk management still faces many challenges, including diverse risk sources, limitations of traditional management methods, and an urgent need for intelligent tools. This section explores the current situation and challenges of supply chain risk management from three aspects: risk sources, shortcomings of traditional risk management, and the need for intelligence.

3.1 Risk Sources

The sources of supply chain risk are diverse, including both internal factors and external environmental uncertainty [4]. Firstly, internal and external risks are the most common threats in the supply chain. For example, internal risks such as supplier default, demand fluctuations, and logistics delays can directly affect the normal operation of the supply chain; External risks such as natural disasters, geopolitical conflicts, and epidemics can disrupt the overall operation of the supply chain on a larger scale. Secondly, information asymmetry is an important challenge in supply chain risk management. Due to the involvement of multiple nodes in the supply chain, information transmission may experience delays, loss, or even distortion, resulting in decision-makers being unable to obtain comprehensive and accurate information [5]. This phenomenon of information asymmetry often leads to misjudgment of risks or delayed response, further exacerbating the instability of the supply chain.

3.2 Shortcomings of Traditional Risk Management

Traditional supply chain risk management methods are inadequate in the face of increasingly complex supply chain environments. Firstly, static risk assessment models are difficult to adapt to dynamically changing environments. For example, when there are sudden changes in market demand or supply chain networks, traditional models cannot adjust evaluation results in real time, resulting in decision-making lag [6]. Secondly, traditional risk management has weak integration capabilities for multi-source data. In the supply chain, data sources typically include structured data (such as inventory data, transportation data) and unstructured data (such as market news, policy documents). Traditional tools lack the ability to integrate multi-source data and extract key risk information from it. In addition, the lag in risk prediction and decision-making processes is also a bottleneck for traditional management methods. Traditional tools often rely on historical data for prediction and lack the ability to analyze real-time data and future trends, making it difficult to provide timely and accurate risk warning and decision support for enterprises.

3.3 Intelligent Requirements

In order to cope with the complex and ever-changing supply chain risk environment and improve the resilience and agility of the supply chain, enterprises urgently need to introduce more intelligent and efficient risk management tools. Intelligent tools can extract valuable information from massive amounts of data, analyze potential risks in the supply chain in real-time, and quickly adjust strategies based on dynamically changing environments [7]. Big model technology has become an important breakthrough in the field of supply chain risk management due to its powerful data processing and intelligent analysis capabilities. By utilizing big model technology, enterprises can effectively identify risks, optimize decision-making processes, and build a more flexible and intelligent supply chain risk management system.

4. Application of Large Models in Supply Chain Risk Management

With the dynamic changes and increasing uncertainty in the supply chain environment, the application of large models in supply chain risk management is becoming increasingly widespread, and their powerful data processing and analysis capabilities provide new solutions for enterprises.

This section discusses in detail the specific applications of the large model from three aspects: risk identification and warning, risk assessment and modeling, and risk response and recovery.

4.1 Risk Identification and Warning

Large scale models have shown significant advantages in risk identification and early warning. Firstly, the integration and analysis of multi-source data is a major characteristic of large models. The multi-source data involved in the supply chain comes in various forms, including social media comments, industry news, market reports, policy documents, etc. Large models can quickly integrate structured and unstructured data, extracting potential risk information related to the supply chain. For example, by using large models for sentiment analysis of consumer evaluations on social media, companies can quickly identify potential issues in their product or service chain [8]. Secondly, the natural language processing (NLP) capabilities of large models provide the possibility for analyzing unstructured data. In supply chain risk management, complex policy documents, supplier reports, and industry standards are often involved. Through NLP technology, large models can quickly read and understand these texts, locate possible risk points, and provide early warning for managers.

4.2 Risk Assessment and Modeling

In the risk assessment and modeling phase, large models demonstrate strong technological potential through scenario simulation and dynamic decision support. On the one hand, large models can conduct high-precision risk simulations based on historical data and current scenarios. For example, by simulating the impact of natural disasters on the supply chain, large models can predict their scope of influence and potential economic losses, providing reference for enterprises to develop response plans. On the other hand, generative AI technology for large models can provide dynamic decision support for managers [9]. In the supply chain, there may be multiple solutions in different scenarios. Large models can generate multiple optimization decision solutions based on real-time data, such as providing feasibility analysis for different path planning in logistics, helping enterprises quickly make optimal choices.

4.3 Risk Response and Recovery

In the risk response and supply chain recovery stages after emergencies, large models also have important application value. Firstly, in terms of path optimization and resource allocation, large models can provide specific action recommendations for enterprises. For example, when the supply chain is interrupted, large models can quickly analyze bottlenecks in the logistics network, provide guidance for resource allocation and transportation path optimization, thereby reducing losses and improving efficiency. Secondly, the large model can also combine historical cases with real-time data to quickly generate emergency plans. For example, in the face of sudden risks such as epidemics or natural disasters, large models can analyze past response measures and their effects, tailor quick response plans for enterprises based on the current environment, and help enterprises resume normal operations and reduce long-term risks [10].

5. Path and Practice of Efficiency Improvement

In order to fully utilize the potential of large-scale models in supply chain risk management, it is necessary to explore ways to improve efficiency from the aspects of technology integration, decision efficiency optimization, and continuous model optimization. These practical measures not only enhance the application capability of large models, but also lay the foundation for enterprises to build a more intelligent supply chain management system.

5.1 Technology Integration and Data Governance

5.1.1 Improvement of data quality

The effective application of large models relies on high-quality data, which is particularly important for supply chain management. Establishing a unified data governance framework to enhance data integrity, accuracy, and consistency can provide a solid foundation for the training and

application of large models. For example, enterprises can reduce redundant data and information silos by integrating supplier information, order records, and logistics data, thereby improving the accuracy of risk analysis. In addition, a comprehensive data cleaning and annotation process helps improve data quality, enabling large models to learn and predict from more accurate data.

5.1.2 Construction of technology integration platform

Embedding big model technology into an enterprise's existing supply chain management system is an important step towards achieving intelligence. By building an integrated technology platform, enterprises can fully integrate the capabilities of large models into various aspects such as procurement, production, logistics, and sales. For example, some leading enterprises have developed cloud based large model platforms that embed risk prediction modules into supply chain management software, enabling risk identification, assessment, and response to be completed within a unified interface. This integration method not only improves the intelligence level of the system, but also helps enterprises achieve synchronous optimization of information flow, logistics, and capital flow.

5.2 Optimization of Decision Efficiency

5.2.1 Real-time decision support

Risk management in the supply chain often requires making accurate decisions in a short period of time. The powerful computing power of large models enables real-time analysis of multi-source data, significantly reducing the time from risk identification to decision implementation. For example, in the event of a sudden supply chain interruption, the large model can analyze the bottleneck points of the logistics network in real time and quickly generate the optimal resource allocation plan. This ability is of great significance for dealing with complex supply chain scenarios, as it can help businesses reduce losses and improve operational efficiency.

5.2.2 Multi-party collaborative decision-making

Supply chain management involves collaboration between multiple nodes, and the intelligent analysis results provided by large models can effectively promote multi-party collaborative decision-making. For example, in a globalized supply chain, suppliers, manufacturers, and distributors from different regions may need to participate in risk assessment and response simultaneously. By sharing analysis reports generated by large models, all parties can quickly understand the nature and scope of risks, coordinate actions, and avoid decision-making delays caused by information asymmetry. In addition, the large model can provide targeted suggestions for all parties, such as adjusting supplier delivery time or optimizing inventory strategies, further enhancing collaborative efficiency.

5.3 Continuous optimization of the model

5.3.1 Model training and updating

The supply chain environment is highly dynamic, which requires large models to constantly adapt to new environments. By regularly updating the training data of large models, enterprises can ensure the accuracy of their predictive capabilities. For example, in the context of frequent outbreaks of epidemics, natural disasters, or geopolitical risks, the risk patterns in the supply chain may rapidly change. Therefore, enterprises should continuously collect the latest data and use it for retraining large models to maintain their sensitivity and accuracy in risk prediction.

5.3.2 Establishment of Feedback Mechanism

User feedback is an important way to optimize the performance of large models. By establishing an efficient feedback mechanism, enterprises can continuously improve the functionality and practicality of large models. For example, in the process of using large models, supply chain managers can provide improvement suggestions for the risk predictions or response plans they generate. These feedback information can serve as a basis for adjusting model parameters or optimizing algorithms, making the large model closer to actual needs, thereby improving its reliability and user satisfaction.

6. Conclusion

6.1 Development Trends

The continuous advancement of big model technology will open up more possibilities for supply chain risk management. For example, the combination of large models and blockchain technology will enhance the transparency and trustworthiness of the supply chain. By using blockchain technology to record real-time data from various links in the supply chain, large models can further enhance the accuracy of risk analysis. In addition, the further development of multimodal AI technology will also promote the application of large models in more complex supply chain scenarios, such as simultaneously analyzing text, image, and voice data, in order to achieve more comprehensive risk prediction and response.

6.2 Challenges and Countermeasures

Although big models have significant advantages in supply chain risk management, they still face challenges such as data privacy and security, and technical implementation difficulties. Firstly, data privacy and security issues are particularly prominent. Large models require a large amount of data for training and application, which may involve the exposure of sensitive information. Enterprises need to protect data security through measures such as data encryption and distributed storage to ensure compliance with privacy protection regulations. Secondly, the difficulty of technology implementation is an important obstacle for enterprises to widely apply large models. To address this issue, it is necessary to strengthen technical training, talent introduction, and cooperation with technology providers in order to reduce the cost and complexity of technology implementation.

In summary, the big model provides a new technological means and way of thinking for supply chain risk management, and its application in risk identification, assessment, and response significantly improves the efficiency of the supply chain. By continuously optimizing the functionality of the large model and combining it with other cutting-edge technologies, the level of intelligence, agility, and resilience in supply chain management will be further improved. This not only provides strong guarantees for enterprises to enhance their competitiveness, but also offers practical solutions to cope with the increasingly complex global supply chain environment.

References

[1] Senna P, Reis A, Santos I L, et al. A systematic literature review on supply chain risk management: is healthcare management a forsaken research field?[J]. Benchmarking: an international journal, 2021, 28(3): 926-956.

[2] Kosasih E E, Margaroli F, Gelli S, et al. Towards knowledge graph reasoning for supply chain risk management using graph neural networks[J]. International Journal of Production Research, 2024, 62(15): 5596-5612.

[3] Hohenstein N O. Supply chain risk management in the COVID-19 pandemic: strategies and empirical lessons for improving global logistics service providers' performance[J]. The International Journal of Logistics Management, 2022, 33(4): 1336-1365.

[4] El Baz J, Ruel S. Can supply chain risk management practices mitigate the disruption impacts on supply chains' resilience and robustness? Evidence from an empirical survey in a COVID-19 outbreak era[J]. International journal of production economics, 2021, 233: 107972.

[5] Yang J, Xie H, Yu G, et al. Antecedents and consequences of supply chain risk management capabilities: An investigation in the post-coronavirus crisis[J]. International Journal of Production Research, 2021, 59(5): 1573-1585.

[6] Yazdani M, Gonzalez E D R S, Chatterjee P. A multi-criteria decision-making framework for agriculture supply chain risk management under a circular economy context[J]. Management Decision, 2021, 59(8): 1801-1826.

[7] Shahed K S, Azeem A, Ali S M, et al. A supply chain disruption risk mitigation model to manage COVID-19 pandemic risk[J]. Environmental Science and Pollution Research, 2021: 1-16.

[8] Um J, Han N. Understanding the relationships between global supply chain risk and supply chain resilience: the role of mitigating strategies[J]. Supply Chain Management: An International Journal, 2021, 26(2): 240-255.

[9] Olson D L, Wu D. Enterprise risk management in supply chains[M]//Enterprise Risk Management Models: Focus on Sustainability. Berlin, Heidelberg: Springer Berlin Heidelberg, 2023: 1-14.

[10] Rauniyar K, Wu X, Gupta S, et al. Risk management of supply chains in the digital transformation era: contribution and challenges of blockchain technology[J]. Industrial Management & Data Systems, 2023, 123(1): 253-277.