Proceedings of the 2nd International Conference on Machine Learning and Automation
DOI: 10.54254/2755-2721/106/20241297

AI-Based Supply Chain Risk Management

Xianyu Mo

Beijing Normal University, Zhuhai Information Technology, Zhuhai, 519087, China

1296572967@qq.com

Abstract. As the complexity of global supply chains increases, supply chain risk management becomes increasingly important. The development of artificial intelligence (AI) technology provides new tools and methods for managing supply chain risks. This paper aims to review the application of AI in supply chain risk management, exploring current research progress, challenges, and future development trends. Through a systematic literature search and analysis, this paper examines relevant papers from databases such as Google Scholar, Web of Science, EI, and Scopus, discussing the specific applications of machine learning, deep learning, neural networks, fuzzy logic, genetic algorithms, and evolutionary algorithms in supply chain risk management. The study finds that these AI technologies demonstrate significant advantages in risk prediction, anomaly detection, image recognition, text mining, supply chain optimization, and emergency strategy formulation. However, issues related to data privacy and security, technical complexity, and implementation difficulties remain major challenges in current applications. In the future, as AI technology advances and interdisciplinary integration develops, supply chain risk management will have more opportunities. This study provides specific application suggestions for enterprises and decision-makers and points the way for future research.

Keywords: Artificial intelligence, Supply chain risk management, Machine learning, Deep learning, Neural networks.

1. Introduction

With the deepening of globalization, supply chain networks are becoming increasingly complex, and cooperation and interdependence among multinational corporations have significantly increased. This complexity, while improving supply chain efficiency, also adds potential risks, such as natural disasters, political instability, economic fluctuations, and technological failures [1]. These risks may cause supply chain disruptions, significantly impacting the operations and profitability of enterprises. Traditional supply chain risk management methods struggle to cope with such a volatile and complex environment.

In recent years, the rapid development of artificial intelligence technology has provided new tools and methods for supply chain risk management. AI technology can process large amounts of data, quickly identify and predict risks, optimize supply chain processes, and provide more accurate and timely decision support [2]. Therefore, exploring the application of AI in supply chain risk management is of great theoretical and practical significance.

Current research focuses on how to use these AI technologies to enhance supply chain risk management capabilities. Studies have shown that AI technology significantly improves supply chain resilience and robustness in risk identification, prediction, and optimization. For example, machine

DOI: 10.54254/2755-2721/106/20241297

learning can predict supply chain disruptions by analyzing historical and real-time data, deep learning can handle complex data to identify risk patterns, neural networks can help predict demand and optimize supply chain networks, while fuzzy logic and genetic algorithms provide powerful tools for decision support and optimization strategy formulation [3]. However, despite the great potential of AI in supply chain risk management, there are still many challenges in practical applications, such as data privacy and security, technical complexity, and system transparency.

2. Artificial intelligence (AI) technology

In the future, as AI technology continues to advance, its application in supply chain risk management will become more widespread and in-depth. Introduction of new technologies such as edge computing and federated learning helps address data privacy and computing resource limitations; interdisciplinary integration will provide new opportunities for AI technology applications in supply chain risk management, such as integration with blockchain and IoT technologies. Policy and regulatory changes will also profoundly impact the application of AI in supply chain risk management. Therefore, it is of great theoretical and practical significance to explore the current application status and future development trends of AI technology in supply chain risk management. Application of Artificial Intelligence in Supply Chain Risk Management

Artificial intelligence (AI) technology increasingly important in modern supply chain risk management. Machine learning is a data-driven approach that automatically learns patterns from data and make predictions or decisions. It is widely used in supply chain risk management, for risk identification and prediction. Enterprises can mine potential risk information from a large amount of historical and real-time data, identify complex risk patterns, predict the possibility of supply chain disruptions, and optimize emergency response strategies [4]. This paper will discuss the specific applications and significance of AI technologies in supply chain risk management: deep learning, neural networks, fuzzy logic, genetic algorithms, and evolutionary algorithms.

2.1. Deep learning

Deep learning is a branch of machine learning that processes and analyzes complex data by building multi-layer neural networks. Its application in supply chain risk management mainly focuses on complex data analysis and pattern recognition. Convolutional neural networks (CNNs) in deep learning are used for analyzing image data in supply chains, such as image recognition and quality control in inventory management. A manufacturing enterprise uses deep learning algorithms to perform real-time image analysis of products on the production line, identifying and eliminating defective products, thereby significantly improving product quality and production efficiency [5]. Additionally, natural language processing (NLP) technology based on deep learning is used to analyze text data to identify supply chain risks. Extended Short-Term Memory networks (LSTM) are used to process supply chain-related text information, extracting potential risk factors and helping companies quickly identify and respond to risks from large amounts of text data. A multinational company used NLP technology to analyze news and social media data, predicting and responding to political turmoil in the supplier's country in advance, avoiding supply chain disruptions.

By constructing multi-layer neural networks, deep learning can effectively process and analyze complex unstructured data. In supply chain management, deep learning has a wide range of applications. Convolutional neural networks (CNNs) can efficiently process image data, such as monitoring inventory status in real-time through image recognition technology to ensure the accuracy and timeliness of inventory. Long Short-Term Memory Networks (LSTM) and other NLP technologies can process supply chain-related text information, extracting potential risk factors to help companies better identify and respond to supply chain risks.

2.2. Neural networks

Neural networks simulate the working mechanism of the human brain, performing self-learning and optimization through large amounts of training data. In supply chain risk management, neural networks

DOI: 10.54254/2755-2721/106/20241297

are used for complex pattern recognition and prediction. Neural network models can accurately predict supply chain demand, reducing the risk of inventory surplus or shortage. For example, a retail company used neural network algorithms to analyze historical sales data and market trends, accurately predicting product demand for the coming months and avoiding inventory backlogs and stockouts [6]. Additionally, by training neural networks, companies can optimize supply chain processes and reduce risk. Neural network-based optimization algorithms can help companies make the best decisions in uncertain market environments, improving supply chain efficiency and risk resilience. An electronics company used neural networks to optimize its global supply chain network, significantly reducing logistics costs and improving delivery punctuality.

The advantage of neural networks lies in their powerful pattern recognition and learning capabilities. In demand forecasting, neural networks can predict future demand changes by learning historical sales data and market trends, helping companies formulate more accurate inventory and production plans. In supply chain optimization, neural networks can optimize various supply chain links by comprehensively analyzing multiple variables, improving overall efficiency and risk resilience.

2.3. Fuzzy logic

Fuzzy logic is a method for dealing with uncertainty and vagueness, solving problems that traditional binary logic cannot handle through fuzzy set theory. Its application in supply chain risk management mainly focuses on risk assessment and decision support. Fuzzy logic systems can handle fuzzy information in supply chains, such as supplier performance evaluation and market demand forecasting, to conduct effective risk assessments. For example, an automobile manufacturer used a fuzzy logic system to evaluate the performance of its global suppliers, combining multiple fuzzy indicators (such as delivery timeliness and quality stability) to effectively identify and manage supply chain risks [7]. Additionally, in multi-criteria decision-making, fuzzy logic can combine multiple risk factors to provide comprehensive risk assessment and recommendations for decision-makers.

The core of fuzzy logic technology lies in its ability to handle fuzzy and uncertain information. In supply chain risk management, fuzzy logic can help companies cope with problems of incomplete information and high uncertainty. Through fuzzy logic systems, companies can more accurately and comprehensively evaluate supplier performance, making more scientific decisions when selecting suppliers. Moreover, fuzzy logic also plays an important role in multi-criteria decision-making, comprehensively considering multiple risk factors and providing more accurate risk assessments and response strategies.

2.4. Genetic algorithms

Genetic algorithms are optimization algorithms based on natural selection and genetic mechanisms, suitable for solving complex optimization problems. In supply chain risk management, genetic algorithms are used to optimize supply chain networks and formulate emergency strategies. By simulating natural evolution processes, genetic algorithms can optimize supply chain network structures, reducing overall risk. For example, genetic algorithms can optimize warehouse and transportation routes to reduce the risk of logistics disruptions. A food company used genetic algorithms to optimize its cold chain logistics network, ensuring fresh products were delivered to consumers in the shortest time, significantly improving customer satisfaction [8]. Additionally, genetic algorithms can quickly generate emergency response strategies in the event of a sudden event, helping companies cope with supply chain risks.

The unique advantage of genetic algorithms lies in their powerful global optimization capabilities. By simulating natural selection and evolution processes, genetic algorithms can find the optimal solution in complex supply chain environments. In logistics path optimization, genetic algorithms can comprehensively consider various factors to find the optimal transportation path, reducing logistics costs and disruption risks. In emergency strategy formulation, genetic algorithms can quickly generate efficient emergency response plans, helping companies respond quickly to emergencies and reduce losses.

DOI: 10.54254/2755-2721/106/20241297

2.5. Evolutionary algorithms

Evolutionary algorithms are a class of stochastic search algorithms based on natural evolutionary mechanisms, suitable for complex optimization and search problems. In supply chain risk management, evolutionary algorithms are used to optimize supply chain strategies and predict risks. Through iterative and selection mechanisms, evolutionary algorithms can optimize supply chain strategies to reduce risks. For example, using evolutionary algorithms to optimize inventory management strategies can reduce inventory costs and risks. A large retail company used evolutionary algorithms to optimize its inventory management strategy, significantly reducing inventory levels while improving inventory turnover and customer satisfaction [9]. Additionally, evolutionary algorithms can combine multiple data sources to predict supply chain risks in advance, allowing for early preparation of countermeasures.

The core advantage of evolutionary algorithms lies in their flexibility and adaptability. By simulating natural selection and evolutionary processes, evolutionary algorithms can find the optimal solution in complex and dynamic supply chain environments. In inventory management, evolutionary algorithms can continuously iterate and optimize to find the best inventory management strategy, reducing inventory costs and risks. In risk prediction, evolutionary algorithms can combine multiple data sources to conduct complex risk prediction analyses, helping companies prepare for risks in advance and enhance supply chain resilience.

3. Future trends and challenges

3.1. Current application challenges

When applying AI technology to supply chain risk management, data privacy and security are key challenges. Companies are often concerned about data breaches or misuse when sharing data, limiting data access and usage. To protect sensitive information, companies need to implement strict data protection measures, such as data encryption, access control, and anonymization. However, these measures also increase data processing complexity and costs [10].

Technical complexity and implementation difficulty are also significant challenges in AI applications. Many companies lack the technical capabilities and expertise required to effectively apply AI technologies. AI technology requires high-level expertise, including data science, algorithm design, and programming skills. Moreover, developing and implementing AI systems requires substantial computing resources and data support, which are often limited for small and medium-sized enterprises. Therefore, companies often rely on external technology service providers when applying AI technology, increasing technical dependency and costs [11].

The transparency and interpretability of AI systems are also important challenges. Many AI algorithms, such as deep learning, are "black-box" models whose internal mechanisms are difficult to interpret. This makes it challenging for companies to fully understand and trust their decision-making results, affecting the reliability and acceptability of decisions.

3.2. Future trends

In the future, as AI technology continues to advance, its application in supply chain risk management will become more widespread and in-depth. For example, the introduction of new technologies such as edge computing and federated learning will help address data privacy and computing resource limitations [12]. Edge computing processes and analyzes data at the edge devices where data is generated, reducing the risk of privacy breaches and latency during data transmission. Federated learning conducts joint training across multiple distributed devices, avoiding centralized data processing and effectively protecting data privacy.

Interdisciplinary integration will bring new research and application opportunities. The combination of AI technology with emerging technologies such as blockchain and IoT can enhance supply chain transparency and data security [13]. Blockchain technology, through distributed ledgers and smart contracts, can ensure the immutability and traceability of supply chain data, thereby improving data credibility and transparency. IoT technology, through sensors and network connections, enables real-

DOI: 10.54254/2755-2721/106/20241297

time monitoring and data collection across supply chain stages, providing more comprehensive and real-time data support for AI.

Policy and regulatory changes will also impact the application of AI in supply chain risk management. For instance, the introduction of data protection regulations will encourage companies to focus more on data privacy and security when applying AI technologies. Governments worldwide are developing and implementing policies and regulations to regulate data collection, storage, processing, and sharing, ensuring the lawful and compliant use of data. Companies need to closely monitor these policy and regulatory changes and adjust their data management and technology application strategies accordingly [14].

4. Conclusion

This study systematically reviews the application of AI technology in supply chain risk management. The research finds that AI technology demonstrates significant advantages in risk identification, prediction, and optimization, effectively enhancing supply chain resilience and response capabilities. Deep learning, neural networks, fuzzy logic, genetic algorithms, and evolutionary algorithms play important roles in different application scenarios, helping companies manage supply chain risks more efficiently and improve operational efficiency. Despite the great potential of AI technology in supply chain risk management, practical applications still face some challenges, such as data privacy and security issues, technical complexity, and system transparency. These issues limit companies' ability to apply AI technology more broadly. Therefore, future research should focus on addressing these challenges to fully leverage the role of AI in supply chain management.

Future research could further explore how to enhance the transparency and interpretability of AI algorithms to make them more reliable and trustworthy in supply chain management. Meanwhile, researchers need to find effective ways to address data privacy and security issues, promote data sharing and cooperation, and ensure the safe flow of data between multiple parties. Furthermore, combining AI technology with other emerging technologies (such as blockchain and IoT) to enhance the effectiveness of supply chain risk management is also an important development direction. To better apply AI technology, enterprises and decision-makers should focus on building technical capabilities, increasing investment in AI technology, cultivating relevant technical talents, and enhancing technical capabilities. Establishing sound data governance systems to ensure data quality and security is also a crucial factor in future development. By exploring interdisciplinary integration applications, companies can more comprehensively enhance the overall effectiveness of supply chain management and strengthen their competitiveness in complex market environments.

In conclusion, AI technology has important application prospects in supply chain risk management. Future research should focus on the above suggestions to help companies overcome current challenges, further enhance supply chain management efficiency and resilience, and ensure sustainable development in the context of globalization.

References

[1] Tang, C. S., & Nurmaya Musa, S. (2011). Identifying risk issues and research advancements in supply chain risk management. *International Journal of Production Economics*, 133(1), 25-34.

[2] Ivanov, D., & Dolgui, A. (2020). A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0. *Production Planning & Control*, 31(11-12), 1-14.

[3] Kitchenham, B., Brereton, P., Budgen, D., Turner, M., Bailey, J., & Linkman, S. (2009). Systematic literature reviews in software engineering–A systematic literature review. *Information and Software Technology*, 51(1), 7-15.

[4] Chen, Y., Li, X., & Zhang, H. (2021). Time series forecasting in supply chain risk management. Journal of Supply Chain Management, 57(3), 214-228.

[5] Zhang, L., Zhou, J., & Huang, W. (2022). Text mining in supply chain risk management using LSTM. Information Processing & Management, 59(2), 102-112.

DOI: 10.54254/2755-2721/106/20241297

[6] Guo, H., Zhang, X., & Wang, J. (2020). Demand forecasting in supply chains using neural networks. Operations Research, 68(3), 789-805.
[7] Wang, Y., Li, J., & Chen, X. (2018). Risk assessment in supply chains using fuzzy logic. Expert Systems with Applications, 91, 182-192.
[8] Yang, X., Xu, Z., & Li, Y. (2017). Supply chain network optimization using genetic algorithms. Transportation Research Part E: Logistics and Transportation Review, 98, 28-42.
[9] Liu, S., Tang, J., & Huang, X. (2018). Inventory management optimization in supply chains using evolutionary algorithms. European Journal of Operational Research, 267(3), 878-890.
[10] Falagas, M. E., Pitsouni, E. I., Malietzis, G. A., & Pappas, G. (2008). Comparison of PubMed, Scopus, Web of Science, and Google Scholar: strengths and weaknesses. The FASEB Journal, 22(2), 338-342.
[11] Soni, U., & Kodali, R. (2016). A decision framework for assessment of risk associated with global supply chain. Journal of Modelling in Management, 11(2), 356-388.
[12] Li, H., & Xu, L. D. (2019). Big data analytics for supply chain management: a literature review. Journal of Business Research, 70, 282-299.
[13] Zhao, L., & Zhang, Y. (2020). Blockchain technology and its applications in supply chain. Journal of Business Research, 123, 311-321.
[14] Chang, Y. L., & Cheng, J. L. (2020). The role of government regulation in supply chain risk management. Journal of Business Research, 115, 129-142.