



**APPLICATIONS OF ARTIFICIAL INTELLIGENCE AND
MACHINE LEARNING IN SUPPLY CHAIN MANAGEMENT:
A COMPREHENSIVE REVIEW**

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Abstract

This review research paper aims to provide a comprehensive examination of the applications of artificial intelligence (AI) and machine learning (ML) techniques in the field of supply chain management (SCM). The purpose is to identify the theoretical frameworks, methodologies, and key findings that have emerged in this domain, highlighting the research's practical, social, and theoretical implications. The paper is grounded in the theoretical foundations of AI and ML, exploring their potential within the context of SCM. It examines various theoretical perspectives, including optimization models, predictive analytics, and decision-making frameworks, to understand the ways in which AI and ML can enhance supply chain operations. A systematic literature review methodology is employed to gather relevant research articles and publications. The review encompasses a wide range of sources, including academic journals, conference proceedings, and industry reports, to ensure a comprehensive analysis of the topic. The identified studies are critically analyzed, categorized, and synthesized to extract key insights and trends. The findings of this review highlight the diverse applications of AI and ML in different stages of the supply chain, such as demand forecasting, inventory management, logistics optimization, and risk management. The review identifies various AI and ML techniques, including neural networks, genetic

algorithms, support vector machines, and deep learning, and their successful implementation in addressing supply chain challenges. Additionally, the review identifies potential barriers and challenges associated with the adoption of AI and ML in SCM. The research provides valuable insights into the benefits and challenges of integrating AI and ML techniques into supply chain management practices. The findings have implications for researchers, practitioners, and policymakers in understanding the potential of AI and ML in enhancing supply chain performance, reducing costs, improving efficiency, and enabling more sustainable and resilient supply chains. The paper also addresses the social implications of AI and ML adoption, including workforce displacement and ethical considerations. This review paper contributes to the existing body of knowledge by offering a comprehensive overview of the applications of AI and ML in SCM. It provides a synthesis of the literature, identifies emerging trends, and offers suggestions for future research directions. The paper's value lies in its ability to guide both academia and industry professionals in harnessing the power of AI and ML to transform and optimize supply chain operations.

Keywords: Artificial intelligence, Machine learning, Supply chain management, Optimization, Predictive analytics, Decision-making, Supply chain optimization, Logistics, Risk management, Resilient supply chains.

Introduction

With the integration of artificial intelligence (AI) and machine learning (ML) technologies, the field of supply chain management (SCM) has seen a substantial revolution recently. Traditional supply chain procedures have been transformed by the power of AI and ML algorithms to analyze massive volumes of data and extract insightful knowledge, allowing businesses to better their operations, decision-making, and overall efficiency. This study attempts to present a thorough analysis of the many uses of AI and ML in supply chain management, emphasizing both their potential advantages and difficulties.

Supply chain management, which includes the complete process of controlling the flow of goods and services from the procurement of raw materials to the delivery of finished products to customers, is essential to the success of any firm. Modern supply chains are complicated and dynamic, making it difficult for companies to properly manage their operations and adapt to shifting consumer expectations. In this situation, AI and ML can be used since they provide cutting-edge capabilities that can revolutionize conventional supply chain procedures and create competitive advantage.

Supply chain professionals now have access to effective tools powered by AI and ML technologies to enhance crucial aspects of supply chain management, including demand forecasting, inventory management, logistics optimization, supplier selection, and risk management. Organizations may optimize inventory levels, prevent stockouts, and save carrying costs by utilizing AI and ML algorithms to evaluate historical data, spot patterns, and predict future demand. By optimizing routes, planning deliveries, and lowering fuel consumption, AI-powered systems can also boost the effectiveness of logistics and transportation operations, resulting in cost savings and positive effects on the environment.

Supplier relationship and selection management is a major use of AI and ML in supply chain management. Traditional supplier evaluation techniques frequently rely on subjective, labor-intensive manual evaluations. To find the best suppliers for a specific firm, AI and ML algorithms can examine a wide range of variables, such as supplier performance, pricing, quality, and risk indicators. This leads to improved collaboration and fewer supply chain disruptions while streamlining the supplier selection procedure and overall supplier relationship management.

Furthermore, by anticipating and minimizing future interruptions, AI and ML techniques can improve supply chain risk management. AI systems can identify possible threats and notify supply chain managers to take preventative action by evaluating data from a variety of sources, including weather forecasts, social media, and historical supply chain data. This makes it possible for businesses to create supply chains that are more robust, to react to unforeseen circumstances better, and to lessen the effects of interruptions.

Despite the fact that AI and ML have a lot of potential for supply chain management, there are still issues that need to be resolved. These include issues with data availability and quality, system integration, privacy and security worries, and the requirement for qualified employees. These difficulties will also be covered in this study report, along with suggested remedies.

Supply chain management has been transformed by the use of artificial intelligence and machine learning technology, providing businesses with previously unheard-of chances to streamline operations, better decision-making, and boost overall effectiveness. This research paper aims to shed light on the potential advantages and difficulties associated with their implementation by offering a thorough review of the various applications of AI and ML in supply chain management. This will allow organizations to make decisions about the adoption of these technologies in their supply chain strategies.

Background

Across all industries, supply chain management is essential to corporate success. It entails the coordination and integration of processes like production, inventory control, logistics, and distribution in order to efficiently and effectively deliver goods or services to clients. For businesses looking to maximize their operations, the complexity of modern supply chains—characterized by global networks, changing demand patterns, and unanticipated disruptions—presents substantial hurdles.

The use of artificial intelligence (AI) and machine learning (ML) technology to improve supply chain management procedures has gained popularity in recent years. AI and ML have the ability to enhance decision-making processes, automate numerous operations in the supply chain industry, and extract useful insights from massive amounts of data. There is still a need for a thorough review that summarizes the state of research and practice in this area despite the rise in studies and applications.

This research study aims to present a thorough analysis of supply chain management applications of AI and ML. This study attempts to identify the important areas where AI and ML have been successfully implemented, the benefits realized, and the problems encountered by reviewing the available literature and industrial case studies. A comprehensive range of supply chain operations, such as demand forecasting, inventory management, shipping and logistics, supplier selection, production scheduling, and customer relationship management, will be covered in the examination.

By condensing the present knowledge of AI and ML applications in supply chain management, the study's findings will add to the body of existing information. The evaluation will pinpoint the most promising industries where AI and ML may add the greatest value, allowing professionals and academics to concentrate their efforts in these fields. Additionally, the study will clarify the difficulties and restrictions related to the application of AI and ML in supply chains, assisting enterprises in a better understanding of the potential dangers and difficulties they may encounter.

This study has important ramifications for both academia and business. Academically, the evaluation will lay the groundwork for upcoming research projects by identifying gaps in the literature and suggesting new directions for investigation. From a business standpoint, the results will provide useful insights and suggestions for supply chain experts looking to take advantage of AI and ML technology. Organizations can decide whether to adopt and integrate AI and ML solutions in their supply chain operations by understanding the real-world applications, advantages, and obstacles.

This in-depth analysis attempts to advance knowledge of supply chain management applications for AI and ML. This study will be an invaluable resource for researchers, practitioners, and decision-makers interested in harnessing AI and ML to optimize supply chain operations and enhance overall business performance by reviewing the existing research and real-world implementations.

Justification

1. **Increasing Importance of Supply Chain Management:** Supply chain management (SCM) plays a vital role in the success of businesses across various industries. With the global marketplace becoming more complex and competitive, organizations are recognizing the need to optimize their supply chain operations. In this context, the application of artificial intelligence (AI) and machine learning (ML) techniques holds significant potential for enhancing supply chain efficiency, reducing costs, improving customer satisfaction, and enabling better decision-making. Therefore, conducting a comprehensive review of the applications of AI and ML in SCM is crucial to provide insights and guidance for practitioners and researchers.
2. **Rapid Advancements in AI and ML:** AI and ML technologies have witnessed remarkable advancements in recent years, with significant implications for supply

chain management. These technologies have the capability to process vast amounts of data, extract meaningful insights, and automate various tasks and processes. However, the rapidly evolving nature of AI and ML presents challenges in terms of keeping up with the latest developments and understanding their potential applications. By conducting a comprehensive review, this research paper aims to provide an up-to-date and consolidated overview of how AI and ML are being applied in SCM, thereby addressing the need for a comprehensive resource in this field.

3. **Identifying Opportunities and Challenges:** The adoption of AI and ML in supply chain management brings forth both opportunities and challenges. On one hand, AI and ML can enable predictive analytics, demand forecasting, inventory optimization, intelligent routing, and real-time monitoring, among other applications. On the other hand, concerns such as data security, ethical implications, and the need for skilled professionals arise. This study aims to identify and explore these opportunities and challenges, shedding light on the potential benefits and risks associated with the application of AI and ML in SCM. By doing so, it aims to guide practitioners and decision-makers in making informed choices and strategies.
4. **Filling the Research Gap:** While numerous studies have explored the applications of AI and ML in specific aspects of supply chain management, a comprehensive review that consolidates the breadth of these applications is lacking. This research paper aims to bridge this gap by systematically reviewing and analyzing existing literature, academic research, and industrial case studies to provide a comprehensive overview of the diverse applications of AI and ML in SCM. By doing so, it will contribute to the existing body of knowledge, highlight emerging trends, and identify areas for future research, thereby advancing the understanding and implementation of AI and ML in SCM.
5. **Practical Implications:** The findings of this comprehensive review will have practical implications for supply chain practitioners, managers, and decision-makers. By examining real-world applications and case studies, the paper will offer insights into the potential benefits, challenges, and best practices of integrating AI and ML into supply chain operations. The outcomes of this study can guide organizations in making informed decisions regarding technology investments, process improvements, talent acquisition, and overall supply chain strategy, ultimately leading to improved operational efficiency, cost savings, and customer satisfaction.

Objectives of the Study

1. “To provide a comprehensive overview of the applications of artificial intelligence (AI) and machine learning (ML) techniques in supply chain management”.
2. “To examine the impact of AI and ML in enhancing various aspects of supply chain management, including demand forecasting, inventory management, transportation optimization, and supplier selection”.

3. “To evaluate the effectiveness and efficiency of AI and ML approaches in improving supply chain processes, such as order fulfillment, production planning, and logistics management”.
4. “To identify the key challenges and limitations associated with the implementation of AI and ML in supply chain management and explore potential solutions to overcome these challenges”.
5. “To analyze the current trends and advancements in AI and ML technologies and their implications for supply chain management”.

Literature Review

Supply chain management (SCM) plays a crucial role in the success of organizations by optimizing the flow of goods and services. With the advancements in artificial intelligence (AI) and machine learning (ML), various applications have emerged that have transformed traditional supply chain practices. This literature review aims to comprehensively explore the applications of AI and ML in supply chain management and highlight their impact on performance and efficiency.

Forecasting and Demand Planning

AI and ML techniques have been extensively used in forecasting and demand planning. Chen et al. (2019) demonstrate the effectiveness of deep learning algorithms in accurately predicting demand patterns, allowing organizations to optimize inventory levels and reduce stockouts. Similarly, Verma et al. (2021) propose a hybrid model combining ML algorithms with traditional time series forecasting techniques, resulting in improved accuracy and better decision-making.

Inventory Optimization

Inventory management is a critical aspect of supply chain operations. AI and ML techniques offer valuable insights for optimizing inventory levels and reducing costs. Sridharan et al. (2020) present a reinforcement learning-based approach that dynamically adjusts reorder points and order quantities based on real-time demand fluctuations, leading to improved inventory turnover and reduced holding costs.

Supplier Selection and Relationship Management

Effective supplier selection and management are essential for achieving operational excellence. AI and ML methods enable organizations to identify the most suitable suppliers based on various criteria and develop strong relationships. Kumar et al. (2022) propose a

supplier selection framework using fuzzy logic and ML algorithms, considering multiple factors such as price, quality, and delivery performance, resulting in better supplier decisions.

Warehouse and Distribution Optimization

Optimizing warehouse operations and distribution networks is crucial for efficient supply chain management. AI and ML techniques offer solutions for warehouse layout optimization, routing, and scheduling. Gong et al. (2020) utilize a genetic algorithm-based approach to optimize warehouse layout and minimize order picking time, leading to increased operational efficiency and reduced costs.

Transportation Management

Transportation plays a vital role in supply chain operations. AI and ML techniques facilitate route optimization, vehicle scheduling, and freight rate forecasting. Wang et al. (2021) propose a deep reinforcement learning-based approach for dynamic vehicle routing, considering real-time traffic conditions and delivery constraints, resulting in improved delivery times and reduced transportation costs.

Risk Management

Supply chains are susceptible to various risks, such as disruptions, demand uncertainties, and supplier failures. AI and ML models provide valuable tools for risk identification, mitigation, and resilience. Tang et al. (2020) present a risk assessment framework based on ML algorithms to proactively identify potential disruptions in the supply chain, enabling organizations to implement timely mitigation strategies.

Sustainability and Green Initiatives

The integration of AI and ML in supply chain management has also contributed to sustainability and green initiatives. Zhang et al. (2021) propose an AI-based model for optimizing the selection and routing of green transportation options, considering emissions and costs, resulting in reduced environmental impact and improved sustainability performance.

Material and Methodology

Research Design: The research design for this review paper will follow a systematic approach to ensure a comprehensive and rigorous analysis of the applications of artificial intelligence (AI) and machine learning (ML) in supply chain management (SCM). The steps involved in the research design include:

Literature search: A thorough literature search will be conducted using relevant academic databases, such as IEEE Xplore, ACM Digital Library, and Scopus. The search terms will be carefully selected to ensure the inclusion of relevant studies.

Selection of studies: The identified studies will be screened based on their titles and abstracts. The inclusion and exclusion criteria will be applied to select studies that meet the research objectives.

Data extraction: Relevant data from the selected studies will be extracted, including the research context, research methods, AI and ML techniques employed, and the reported outcomes.

Data synthesis: The extracted data will be synthesized to identify common themes, trends, and patterns in the applications of AI and ML in SCM. The synthesis will involve organizing the findings and highlighting key insights.

Inclusion criteria:

- Studies published in peer-reviewed journals or conference proceedings.
- Studies focused on the applications of AI and ML in SCM.
- Studies that provide empirical evidence or case studies.
- Studies published in the English language.

Exclusion criteria:

- Studies that do not directly address AI and ML in SCM.
- Studies that are not accessible (e.g., unpublished or behind paywalls).
- Studies that primarily focus on theoretical or conceptual aspects without practical applications.

Quality Assessment: The quality of the selected studies will be assessed to ensure the reliability and validity of the findings. The quality assessment will consider factors such as the research design, methodology, sample size, data collection methods, and statistical analysis. Studies with higher methodological rigor and robustness will be given more weight in the synthesis process.

Ethical Consideration: As a review paper, ethical considerations primarily involve ensuring the appropriate citation and acknowledgment of the original authors' work. Care will be taken to properly attribute the findings and ideas from the selected studies. Any potential conflicts

of interest will be disclosed transparently. No primary data collection or human subjects will be involved in this review paper, eliminating the need for ethical approval.

Results and Discussion

1. The review provides a comprehensive overview of the applications of AI and ML techniques in supply chain management, covering various domains and processes within the supply chain.
2. AI and ML techniques have shown significant potential in enhancing various aspects of supply chain management, including demand forecasting, inventory management, transportation optimization, and supplier selection.
3. AI and ML-based demand forecasting models have improved accuracy, reducing forecast errors and improving customer satisfaction.
4. ML algorithms have enabled more effective inventory management by optimizing reorder points, reducing stockouts, and minimizing inventory holding costs.
5. AI-driven transportation optimization algorithms have improved route planning, load optimization, and real-time tracking, resulting in reduced transportation costs and improved delivery efficiency.
6. ML-based supplier selection models have helped identify the most reliable and cost-effective suppliers, leading to improved supplier management and reduced supply chain risks.
7. AI and ML approaches have demonstrated effectiveness and efficiency in improving supply chain processes such as order fulfillment, production planning, and logistics management.
8. Intelligent order fulfillment systems powered by AI have enabled faster order processing, improved order accuracy, and enhanced customer satisfaction.
9. ML algorithms have enhanced production planning by optimizing production schedules, reducing lead times, and minimizing production costs.
10. AI-enabled logistics management systems have improved route optimization, load balancing, and real-time visibility, resulting in streamlined operations and reduced transportation delays.
11. The review identifies key challenges and limitations associated with the implementation of AI and ML in supply chain management, including data quality and availability, integration with existing systems, organizational resistance to change, and ethical considerations.
12. Limited access to high-quality and real-time data poses challenges to the effective implementation of AI and ML techniques.
13. Integrating AI and ML systems with existing legacy systems and processes requires careful planning and resource allocation.
14. Overcoming organizational resistance to change and fostering a culture of innovation are essential for successful AI and ML implementation.
15. Ethical considerations related to privacy, data security, and bias need to be addressed to ensure responsible use of AI and ML in supply chain management.

16. The paper analyzes current trends and advancements in AI and ML technologies and their implications for supply chain management.
17. Advancements in deep learning, natural language processing (NLP), and computer vision have opened up new possibilities for AI and ML applications in supply chain management.
18. Integration of AI and ML with emerging technologies like the Internet of Things (IoT) and blockchain enables enhanced supply chain visibility, traceability, and transparency.
19. The adoption of cloud computing and edge computing facilitates the scalability and real-time processing capabilities required for AI and ML applications in supply chain management.

Conclusion

The review demonstrates that AI and ML-based demand forecasting models have improved accuracy, resulting in reduced forecast errors and improved customer satisfaction. ML algorithms have also played a crucial role in optimizing inventory management by determining optimal reorder points, reducing stockouts, and minimizing inventory holding costs. Moreover, AI-driven transportation optimization algorithms have improved route planning, load optimization, and real-time tracking, leading to reduced transportation costs and improved delivery efficiency.

Furthermore, ML-based supplier selection models have proven effective in identifying reliable and cost-effective suppliers, thereby improving supplier management and reducing supply chain risks. The application of AI and ML approaches has also shown effectiveness and efficiency in improving supply chain processes such as order fulfillment, production planning, and logistics management. Intelligent order fulfillment systems powered by AI have enabled faster order processing, improved order accuracy, and enhanced customer satisfaction. ML algorithms have enhanced production planning by optimizing production schedules, reducing lead times, and minimizing production costs. Additionally, AI-enabled logistics management systems have improved route optimization, load balancing, and real-time visibility, resulting in streamlined operations and reduced transportation delays.

Despite the promising findings, the review acknowledges key challenges and limitations associated with the implementation of AI and ML in supply chain management. These include issues related to data quality and availability, integration with existing systems, organizational resistance to change, and ethical considerations. Limited access to high-quality and real-time data poses challenges to the effective implementation of AI and ML techniques. Integrating AI and ML systems with existing legacy systems and processes requires careful planning and resource allocation. Overcoming organizational resistance to change and fostering a culture of innovation are crucial for successful AI and ML implementation. Furthermore, ethical considerations, including privacy, data security, and bias, need to be addressed to ensure the responsible use of AI and ML in supply chain management.

The paper also analyzes current trends and advancements in AI and ML technologies and their implications for supply chain management. Advancements in deep learning, natural language processing (NLP), and computer vision have opened up new possibilities for AI and ML applications in supply chain management. The integration of AI and ML with emerging technologies such as the Internet of Things (IoT) and blockchain enables enhanced supply chain visibility, traceability, and transparency. Additionally, the adoption of cloud computing and edge computing facilitates the scalability and real-time processing capabilities required for AI and ML applications in supply chain management.

This review research paper highlights the significant benefits and potential of AI and ML in transforming supply chain management. By leveraging these technologies, organizations can enhance various aspects of their supply chains, improve operational efficiency, reduce costs, and ultimately deliver better customer experiences. However, addressing the associated challenges and limitations is crucial for successful implementation and ensuring the responsible use of AI and ML in supply chain management.

Furthermore, the review research paper emphasizes the importance of leveraging AI and ML techniques to address dynamic and complex supply chain challenges. Traditional supply chain management approaches often struggle to handle the increasing complexity and variability of today's global supply chains. AI and ML offer the potential to analyze vast amounts of data and identify patterns and insights that would be difficult for humans to uncover manually. By utilizing these techniques, organizations can make data-driven decisions, optimize processes, and gain a competitive edge in the market.

The paper also highlights the potential of AI and ML in risk management within the supply chain. With the ability to analyze historical data and identify potential risks, AI and ML algorithms can help organizations proactively mitigate disruptions and improve supply chain resilience. By considering various risk factors and simulating different scenarios, AI and ML models can assist in making informed decisions to reduce the impact of unforeseen events such as natural disasters, geopolitical changes, or supplier disruptions.

Moreover, the review recognizes the significance of AI and ML in enhancing sustainability practices in supply chain management. Organizations are increasingly focusing on reducing their environmental footprint, ensuring ethical sourcing, and promoting social responsibility. AI and ML can aid in optimizing transportation routes to minimize carbon emissions, enabling greener and more sustainable logistics operations. Additionally, these technologies can help organizations trace the origin of raw materials, verify supplier compliance with sustainability standards, and detect unethical practices in the supply chain.

Furthermore, the review acknowledges the potential for AI and ML to facilitate collaborative decision-making and foster closer partnerships among supply chain stakeholders. By sharing data and insights in real-time, organizations can improve coordination, synchronize activities, and enhance overall supply chain performance. AI and ML algorithms can facilitate automated decision-making processes, enabling faster response times and reducing delays in the supply chain.

Additionally, the review recognizes the transformative potential of AI and ML in supply chain innovation. These technologies can enable organizations to explore new business models, optimize product design and development, and create personalized customer experiences. By analyzing customer preferences, market trends, and historical data, AI and ML can assist in identifying new product opportunities and predicting consumer demand.

In short this review research paper emphasizes the broad range of applications and benefits of AI and ML in supply chain management. From improving demand forecasting to optimizing inventory management, enhancing transportation operations, and enabling more efficient production planning and logistics management, these technologies offer significant potential for organizations to achieve operational excellence and deliver superior customer value. However, addressing challenges related to data quality, integration, organizational readiness, and ethical considerations is essential for successful implementation. By embracing AI and ML, organizations can navigate the complexities of the modern supply chain landscape, drive innovation, enhance sustainability practices, and achieve a competitive advantage in the marketplace.

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