Application of Artificial Intelligence in Supply Chain Management

MSc Research Project
MSC AI for Business

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MSc Project Submission Sheet

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Application of Artificial Intelligence in Supply Chain Management

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Abstract

AI in SCM has helped in increasing efficiency, reliability, and cost-effectiveness of the supply chain management system. The purpose of this study is to understand the current trends of the AI application in the SCM that could affect the flexibility of supply chains, inventory management, demand forecasting, and the optimization of the supply chain functions. To this end, the study relates to SC resilience to major disruptions including the COVID-19 disruption where AI was instrumental in demand forecasting and inventory replenishment for giants like Walmart and Amazon. AI can be applied in the area of operations through data analysis for decision support, predictive maintenance, and automation cutting down of human error and resource wastage. This will be done using secondary and primary data mix. Another issue that has been pointed out in the study is the quality of available data, as well as the interpretability of the resulting models, which raises the topic of the importance of XAI in the context of stakeholders' trust. Directions for future studies indicate that AI should be implemented alongside other technologies such as IoT and blockchain to improve the operations of supply chains. Finally, based on the research, one can conclude that AI can indeed become a key driver of change in SCM, which will help achieve competitive advantages and better adapt to disruptions.

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1 Chapter 1: Introduction:

1.1 Background

Over the last few years, the application of AI in SCM has received much attention with organizations using AI in planning, demand forecasting, inventory management, supply management, and logistics. All these have not only enhanced the effectiveness of operations but have also reduced cases of wastage and misuse of resources. AI has various functions in SCM; it can provide predictions, real-time decisions, and automated solutions that contribute to the improvement of supply chain functions to greater heights (Pervaiz, 2020). The integration of AI into scm has transformed the logistic chain. AI has improved SCM efficiency, flexibility, and effectiveness, raising the bar for operations. Large corporations like Amazon and Walmart have shown how AI can improve inventories, market demand, and operations. Walmart discovered that machine learning for demand forecasting improved accuracy by 10–12% and reduced inventory expenses by 20%. AI cuts transport costs by 15% in Amazon SCM, proving its value.

Despite these advances, AI in SCM faces issues such hyperparameters, system cold starts, and data quality (Aljohani, 2023). Model interpretability is still important since 'black box' techniques can damage stakeholder trust and decision-making. This article investigates the current seriousness of the difficulties above and assesses AI's evolutionary potential in SCM. This paper will provide a beneficial comparative analysis of AI-based SCM systems and a proper outlook for SCM theoretical framework development.

1.2 Aims of Research

The main objective of this study is to discuss the current state of AI implementation into SCM and to reveal potential development trends. The study aims at offering an understanding of how AI improves the flexibility and agility of the supply chain especially when disrupted. Furthermore, the study seeks to determine the effects of AI on the inventory and demand of products and the contribution of AI automation to the optimization of supply chain processes.

1.3 Research Questions

The research is guided by the following key questions:
- In what ways does the application of AI technology affect the adaptability of supply chains to new and significant disruptions?
- In what way do the dynamics of artificial intelligence impact the possibilities of inventory management and demand estimation in supply chains?
- How does the use of AI in automation and robotics help to deliver supply chain which is more effective, efficient and less costly than conventional supply chain?

1.4 Research Objectives

To address these questions, the research aims to achieve the following objectives:
- Examine the effects of integrating AI into the supply chain with an emphasis on the subject's capacity to handle disruptions.

- Examine the impact that AI has on inventory management and demand and determine the changes in the accuracy of the method.
- Analyze the impact of AI and automation/robotics on the supply chain in terms of optimization, cost, and environmental perspectives.
- Discuss the current trends in the integration of AI in SCM and likely future trends and uses.
- Identify the advantages and disadvantages of integrating AI into SCM and provide suggestions for companies that are planning to implement AI.

1.5   Rationale of the Research

In the present SCM environment, where artificial intelligence is being used more, it's important to assess its effects on organisations. As global supply chain networks become more complicated and risk-sensitive, better technology is needed. This paper showed that AI can evaluate vast volumes of data and provide real-time insights to supply chain management to improve efficiency and reduce risk.

AI can do more than improve SCM procedures. It lowers waste and improves resource use, making it better than sustainability. AI predicts demand and controls inventories, eliminating overstocking and environmental damage. It eliminates labour costs and boosts efficiency with AI. The research also fills a major literature vacuum. Despite many talks about AI in SCM, the literature lacks actual studies of its long-term advantages. This research seeks to solve this gap by offering real-world data and advice on AI and SCM. Thus, it advances academic research and aids enterprises in AI adoption decisions.

AI also improves SCM, according to this study. It also describes how AI may improve, strengthen, efficiently, and sustain supply chains. The research will benefit SCM and organisations who want to employ AI for competitive advantage. As AI technology advances, AI in SCM will become a major performance measure for international operations efficiency and sustainability.

2 Chapter 2: Literature review:

AI is influencing today's business operations through improvements in productivity, improved management decision, and creativity in business activities in different sectors. The purpose of this literature review is to investigate the different angles of how the use of AI can influence SCM with viewpoints on logistics, inventory control, supply chain finance, and sustainability (Pendy, 2024). This review will focus on the opportunities and limitations of AI applied in SCM, along with contributions and advancements foreseen soon to strengthen this article's understanding of the state and future of AI in SCM by including other literature from different sources (Petrin, 2019). This paper aims to consider recent research and developments of AI technology in SCM population starting from theory and advancing towards practice.

2.1 Historical Development and Theoretical Framework

AI technologies were first used in SCM in the late 1970s to improve company decision-making and efficiency. AI was initially used on SCM to automate mundane tasks, capture business trends, and intelligently analyse data to make decisions (Min, 2010). The technical challenges and other limitations of using AI in supply chain management initially limited its adoption.

Over the past few decades, processing power and data availability have increased, allowing AI to handle more sophisticated SCM applications. AI research in SCM has shown that supply chain network design, supplier selection, inventory management, and demand forecasting are useful (Sharma, 2022). Such progress has led to AI techniques that improve SCM research and application.

AI in decision-making and SCM is based on machine learning, large data, and computational intelligence. Machine learning algorithms, neural networks, and predictive analytics are the foundation of AI and help stakeholders analyse vast data, find rationales, and make decisions. AI in data processing and analysis helps supply chain management improve functionality and save costs and time (Toorajipour, 2021).

Even with AI, predictive analytics, and real-time tracking, supply chains can achieve transparency, ethical MSCs, and efficient, productive, and sustainable resource use (Pal, 2023). Thus, AI in SCM is a new form of management innovation that allows supply chain managers to apply new conceptual tools to respond to dynamic supply chain problems.

2.2 Integrating Artificial Intelligence in the Fields of Logistics and Supply Chain Management

Data Utilization

AI leverages information from digital logistics applications and IoT technologies in the handling of supply chain. IoT devices generate large volumes of information on different logistics activities such as the location of shipments, storage conditions, and transportation performance. Some of the data collected is as follows and they are in turn analyzed by the AI algorithms to predict the future trends that help in demand forecasting and inventory management. For instance, IoT sensors can be used to measure temperature and humidity during transportation and AI can evaluate this information to maintain the appropriate conditions and avoid food spoilage and deterioration of the product's quality (Kondratenko, 2023).

Decision-Making Enhancements

AI brings a positive impact in decision making in logistics since it reduces the chances of human error since repetitive tasks are automated and provides real-time data. Sophisticated algorithms and machine learning can process big data and real-time data to identify inefficiencies and plan them to avoid problems and suggest solutions. For instance, AI for predictive analytics can predict high or low demand, and thus companies can prepare for the changes in demand. This leads to decreased holding costs and increased customers' satisfaction due to the timely delivery of products (Zeng, 2023). In addition, through analysis of the supply chain, AI can help to establish areas of weakness and propose changes that can improve the efficiency of the supply chain and thus increase productivity and decrease operational expenses (Balfaqih, 2023).

Human-AI Collaboration

AI is used to enhance human functions in managing logistics and supply chain activities. AI systems do not replace human workers but assist them in their tasks whereby most of the routine and time-consuming data processing is done by the AI systems while the human workers are left to handle more challenging matters. For instance, in the planning and scheduling of delivery and transportation, AI tools can help the logistics planners by providing them with information and insights and perform specific planning schedules that are rote in nature so that the planners can focus on planning and solving problems. Also, AI provides recommendations for decision-making since it analyzes data extensively and provides the best solutions to human beings, making their decisions more precise and faster (Boute, 2021). This interaction results in supply chain processes that are faster and can respond to the dynamic market and customers' needs and conditions.

AI utilizes the data gathered from IoT and digital logistics applications to enhance decision-making and extend human capacity in supply chain management. Through such actions as relieving personnel from repetitive work and offering immediate data analysis, AI optimizes organizational performance, minimizes expenses, and improves supply chain adaptability and readiness for change.

2.3   Uses of AI in Various SCM Functions

Inventory Management

AI has greatly impacted inventory by means of the following: demand forecasting, stock optimization, and automated reordering. Sales forecasting entails the use of AI algorithms such as historical sales data, trends in the market and other factors that may influence future sales. This predictive capability enables the business to hold the right amount of stock, and this eliminates overstocking and stock out situations. For example, AI in demand forecasting has made it possible for organizations to plan when to produce goods in line with market demand, hence reducing the costs of holding unnecessary stock (Singh, 2023). AI also helps in stock management through the application of machine learning algorithms in consumption patterns to determine the best stock levels to use. This approach helps in achieving the right stock in the right place at the right time which in turn improves the supply chain management (Tang, 2023). In addition, AI integrated automated reordering systems help in the reordering process by

placing orders by using information on stock levels in real-time and hence minimize the part played by the human side which is usually error-prone (Dash, 2019).

2.4   Supply Chain Finance

AI is critical to supply chain finance as it can improve risk management, fraud detection, and working capital management. Such systems use big data from different sources to assess possible financial risks and recommend measures to address them. For instance, AI can identify which suppliers are likely to go bankrupt, thus enabling firms to prevent nasty shocks (Rajagopal, 2023). In fraud detection, AI models keep tracking the transactions going on and alert the user when something suspicious is detected. The real-time analysis in this case assists firms to minimize their losses and improve security (Olan, 2022). In addition, working capital is also enhanced by AI as it helps in determining the best ways of managing inventory, ordering, and payment. This optimization helps businesses to keep working capital while avoiding the expenses linked to overstocking and overdue payments (Pal, 2023).

2.5   Sustainable Supply Chain Management

AI plays a crucial role in sustainable supply chain management since it enhances the level of transparency, the efficiency of operations, and discourages unethical behaviors. AI technologies improve the level of transparency since the tracking and monitoring of products across the various stages of the supply chain are made possible; this minimizes the chances of unethical conducts. For instance, AI can monitor the carbon emissions of supply chain processes and ensure that the company is environmentally friendly and sustainable (Muthuswamy, 2023). AI also helps in minimising costs and eliminating wastage, hence increasing operational efficiency. AI in supply chain management can help in demand forecasting hence improving the allocation of resources and reducing the negative effect on the environment (Chauhan, 2022). Furthermore, it is for the same reason that AI sustains ethical practices by rating the suppliers according to their sustainability indices, making certain that all the stakeholders in the supply chain are compliant to the environmental and social responsibility benchmarks (Pawlicka, 2022). Therefore, AI applications are widespread in SCM functions that improve inventory management, supply chain finance, and sustainability. With the help of AI in demand forecasting, risk management, and encouraging ethical practices, it is possible to increase the efficiency of supply chain management, decrease costs, and make the supply chain more sustainable.

2.6   Systematic Reviews and Taxonomies

AI research in supply chain management (SCM) focusses on sensing and interacting, learning, and decision making. Sensing and interacting require AI to sample IoT data and provide real-time supply chain data. Mentorship involves constructing models to recognise data patterns and forecast new outcomes. Decision-making employs AI to analyse data to improve supply chain decisions (Pournader, 2021).

The following AI research in SCM and growth findings were made using bibliometrics: Since IoT and sensor technologies are improving to collect and analyse large volumes of data, sensing and interacting methods are emerging. Big data and the requirement for efficient cognitive

processes are making techniques, especially machine learning, more important. They underpin existing and future SCM AI techniques (Toorajipour, 2021).

AI improves SSCM transparency, efficiency, efficacy, and ethics, according to rigorous reviews. Since they improve supply network visibility and accountability, AI applications in SSCM focus on sustainability and the environment. AI analysis can forecast environmental impact and provide sustainable solutions (Fahimnia, 2015). AI optimises resource utilisation and reduces waste, which is crucial for a sustainable supply chain (Paliwal et al., 2020).

AI integration in SCM can boost operational efficiency and sustainability. Various systematic publications highlight how AI can foster ethical supply chain management by grading suppliers on sustainability, ensuring that all chain members satisfy environmental and social standards (Younis, 2022). Such an approach shows how AI can construct sustainable, efficient, and dependable supply chains (Derwik, 2017).

2.7 Challenges and Opportunities

Data Quality and Integration

The first issue that arises when applying AI to SCM is the quality of the data and their compatibility. AI systems depend on the data that is accurate, complete and timely for the proper working of the system. Some of the problems that arise from poor data quality include inaccuracies in the data, inconsistencies in the data, and incomplete data which all tend to greatly affect the AI models. Also, gathering data from various sources like IoT devices, ERP systems, and third-party logistics providers can be challenging and time-consuming. This integration is further complicated by data being in different formats and standards that may create data silos and disjointed insight (Nozari, 2022). Solving these problems necessitates strong data management policies and sophisticated data processing systems that guarantee the accuracy and compatibility of the available information with the demands of the supply chain (Dogru, 2020).

However, data quality issues and AI model explanation issues are also mentioned in the research. Deep learning's complicated algorithms hide conclusion-making, making it hard for stakeholders to trust AI-generated conclusions. cold start concerns, where an AI model lacks historical data, especially when introducing new items or providers. To improve SCM transparency with artificial intelligence, explainable artificial intelligence (XAI) may be appealing (Nozari, 2022).

Model Interpretability and Transparency

Another major issue with AI applications in SCM is related to the explainability of AI models. Most of the AI models, especially deep learning AI models are 'black box' models in that the decision-making process is not easily explicable. This opacity can be an issue since supply chain managers will likely be hesitant to rely on AI systems whose inner workings they do not comprehend. Besides, legal and ethical issues demand the explainability of AI decisions to increase their credibility (Šilenskytė, 2024). To combat these problems, it is necessary to create XAI techniques that can help to explain the decision-making process of the model. . The adoption of XAI is also advantageous in that it helps enhance the stakeholders' confidence in the AI-driven procedures since such procedures are more explainable (Fosso Wamba, 2022).

Thus, to address these problems, firms should focus on data-driven approaches to improve data quality through data governance and preparation. Explainable AI (XAI) approaches can also

boost design explainability and stakeholder trust. When creating AI models, businesses must consider the cold-start problem, transfer learning, and synthetic data production to ensure they perform even without previous data.

Future Opportunities

However, the following are the opportunities of AI in SCM; AI when integrated with other modern technologies such as IoT and advanced analytics can assist in the transformation of the supply chain. IoT devices can collect data of different supply chain processes in real time and AI can use this data to provide a forecast and optimization of decisions. For instance, AI enhances the ability to predict demand, stock, and delivery which in turn enhances efficiency and reduces costs (Sharma, 2022). Additionally, AI can also be useful in the sustainable supply chain management by utilizing the resources optimally and avoiding wastage and also following the legal provisions regarding the environment. This is especially the reality today, particularly because organisations are now required to be sustainable and promote socially responsible business (Muthuswamy, 2023). The integration of AI with IoT and analytics can create massive advantages in terms of efficiency, sustainability, and supply chain performance. With development and advancement in AI technologies, their significance will be more and more fundamental in defining the advanced future of SCM.

2.8   AI for building Resilient supply chains

Resilience Strategies

There are many approaches that AI can bring to the table concerning supply chain vulnerability, specifically in big data analysis, forecasting, and procedural assistance. Another AI method is the machine learning approach whereby huge data analytics are used to identify possible disruptions and recommend the strategies to be used. For instance, AI can use fuzzy logic programming which assists in arriving at a decision where information is somewhat ambiguous and by coming up with a more accurate solution. Also, WNN and EDAS are applied to explore patterns and improve the supply chain processes to enhance the resilience (Belhadi, 2022).

The literature on AI in SCM is still emerging, demonstrating its growing importance in improving SCM processes. Machine learning and predictive analytics are prominent AI technologies for demand forecasting, inventory control, and operational efficiency (Belhadi, 2022). AI in SCM improves accuracy, speed, and cost, according to research. AI can reduce forecasting mistakes by 10–12% and assist Wal-Mart and Amazon reduce inventory management resources.

It also promotes aspects of supply chain visibility, which form part of supply chain resiliency. Thus, using AI-based predictive analysis and IoT data sources, networks of logistics and supply can get a better understanding of the processes and increase the proactive approach to solve problems as soon as possible. This leads to sustaining the operations of the supply chain as it is not disrupted, especially during unforeseen circumstances such as the COVID-19 pandemic (Modgil, 2022).

Case Studies:

AI Applications for Enhancing Supply Chain Management Students: Homer & Saeed, 2020"AI Applications for Supply Chain Management

Walmart: Inventory and Sales Forecasting

Another component in which Walmart has used AI is forecasting demands and Inventory control, especially during the moment of COVID-19. Despite that, Walmart was able to use algorithms for reaction to the past data and external conditions and, thus, predict properly the amount of demand increase and adjust inventory levels to the customers' interest. This approach made it possible to guarantee that vital assets have been in one way or another provided throughout even as the supply chain experienced serial disruptions; in this context, AI was used to prove supply chain robustness (Belhadi, 2022).

DHL: PM & LO

Following are the current technologies that DHL logistics use: Predictive maintenance which is based on Artificial intelligence. These AI systems provide real-time information about the state of the equipment, its future failures, and timely maintenance with a focus on continuity. Also, DHL has adopted the use of AI for the purpose of dynamic route planning, where traffic information, weather conditions, and delivery volumes are considered in order to achieve timely deliveries and at the same time minimize costs (Alhasawi, 2023).

Amazon: Optimisation of route and last mile delivery

Amazon today uses AI for routing optimization especially about the last-mile delivery services during very busy periods. AI algorithms use aspects like traffic patterns, weather conditions, and delivery schedules and to suggest the best routes for the delivery drivers. This capability was quite essential particularly when the pandemic resulted to an increased rate of e-commerce. To manage organisational supply chain performance when delivery reliability came under pressure, Amazon's AI systems kept on supporting its supply chain activity, which proved its infrastructural role in performing supply chain operations (Singh, 2023).

Portuguese Automotive Supply Chain:

The exercise types which were presented are Simulation and Resilience Strategies. The work on Portuguese automotive supply chain used artificial imitation to analyse different supply chain conditions and important plans of resilience. The analysis was based on a three-echelon supply chain and several risk coping mechanisms including but not limited to emergency stock, contingency capacity at the suppliers' end, and multiple sourcing. Through the application of AI simulations, flow supply chain managers in the automotive industry-got to learn the most efficient ways of enhancing the supply chain and its resistance to any disruption (Carvalho, 2012).

COVID-19 Impact: Improving Supply Chain Fragility

A global study on COVID-19's effect found how adopting firms used AI to improve supply network robustness. AI made work more visible, and manageable risks, which assisted in having flexible procurement approaches amid disruptions. This paper has presented AI themes that fundamentally supported the pandemic's enterprise resilience including transparency, personalized solution, and last-mile delivery (Modgil, 2022).

Automobile Supply Chain: Risks and their Mitigation Strategies

AI's impact on disruption management and competitive sustainability was examined in an automobile supply chain management case study. Emergency stock, capacity backup, and

different sourcing were investigated. AI was used to create a strong supply chain topology for speedy reintegration, market share maintenance, and consistent client prices (Rezapour, 2017). The preceding examples show how AI may enhance supply chain vulnerability across sectors. Demand forecasting, predictive maintenance, route optimisation, and risk management keep supply chain operations healthy throughout disruptions.

Future research directions

These strains in SCM and AI include blockchain for transparency, AI for analytical insight, and AI for environmentally sustainable SCM. Small and medium firms affected by AI are understudied, and the supply chain vulnerability effects of AI integration are unknown. The SCM AI implementation guidelines are: Future studies should focus on: Thus, AI's strategic application to SCM requires data management, explainable AI, and SCM-AI specialist collaboration (Wang, 2020).

This study discussed AI's many SCM applications in logistics, inventory management, supply chain finance, and sustainability. Big data and machine learning, forecasting, and IoT integration in decision-making boost operational efficiency and provide a backup in case of disruption. AI-based demand forecasting and stock optimisation have been effective, especially in Walmart, DHL, and Amazon's automatic reordering systems. Supply chain managers and practitioners can use AI for demand forecasting, risk management, real-time decision-making, and more. By integrating AI into operations, transparency, cost savings, and sustainability improve. To maximise AI's potential, data quality, model interpretability, and the need to discuss AI and big data governance must be addressed. If used, AI might transform SCM by boosting efficiency, robustness, and sustainability. The continual progress of AI technology suggests that managing its use will be crucial for firms that want to respond to market complexity and variety. Implementing AI in SCM is not a suggestion; it will define the future of enterprises and industries.

3 Chapter 3: Methodology

3.1 Research Design

Therefore, this research employs a qualitative and quantitative research approach to investigate the use of Artificial Intelligence (AI) in supply chain management (SCM). Due to the nature of the research, secondary data sources are used to build the understanding of the current state of AI technologies in SCM and the possible future applications. Supported by the primary quantitative data collected from questionnaire. The rationale for selecting the mix approach is in the ability of the method to study multifaceted phenomena and gain an in-depth understanding of the topics.

3.2 Literature Review

This research relies solely on literature reviews to obtain and analyse data. It evaluates industry and other relevant papers, books, and reports. The goal is to review SCM AI literature and analyse trends and pros and cons. The literature review will be extensive and use the following database. Google Scholar, JSTOR, ScienceDirect, IEEE Xplore. We'll utilise keywords like AI in SCM, AI with inventory management, and AI-based supply chain automation. Thus, the

literature study will incorporate works from the recent decade to reflect AI's current use in SCM. Data from the identified literature will be critiqued and classified in this phase. AI in demand, inventory, supply chain, and logistics planning will be covered. Literature reviews will include theories and concepts used by prior academics to explain AI integration and influence in SCM. Thus, the review will provide a solid theoretical foundation for assessing AI's impact on supply chain performance.

3.3 Case Studies

Besides the literature component, the research study will also use case studies to demonstrate the applicability of AI in SCM. Real-life examples are useful from the case studies because it is easier to understand how some companies adopted AI technologies to address particular supply chain needs. This approach will help in matching the theoretical aspect of the findings with the practical aspect of the application of AI in SCM (Sundarakani, 2021). The cases to be used in this research will be selected in relation to the questions that will be posed and the objective of the study. The industry sectors will be the criteria for selection based on the extent of AI usage, problems solved, and results obtained.

3.4 Questionnaire:

The approach used included developing a structured questionnaire that targeted the use of artificial intelligence in supply chain management. The questionnaire consisted of 15 questions related to AI adoption, technologies being used, advantages and disadvantages. The survey was conducted with 15 participants who are professionals and work in medium and large enterprises with 51 and more employees in different industries. The data was collected using an online survey which was posted on the LinkedIn platform to ensure that the participants were diverse and relevant.

3.5 Data Analysis

The information that will be obtained from the literature review as well as the case studies and Questionnaires as a first hand data will be subjected to mix content analysis. Categorization of the collected data is done in a structured manner to arrive at the major themes and patterns. The purpose is to identify how AI technologies are used in SCM and their impact on the different aspects of the field including demand forecasting, inventory management, and logistics optimization.

The first technique in the analysis process will be the where I will look at the data and identify the main themes and literature and after that I will collect primary data for questionnaire. Subsequently, these will be merged into categories that are pertinent to the research questions and objectives. In this case, it will be possible to come up with themes that will define AI in relation to SCM by repeating the process of analyzing the data.

3.6 Ensuring Validity and Reliability

To minimize the threat to internal validity and increase the reliability of the study, proper care will be taken in the conduct of the research. The choice of the literature and cases will be based on specific criteria for inclusion and exclusion to enhance the relevance and quality of the study. Besides, the use of triangulation will be applied by comparing the findings from different sources to ensure that the insights and conclusions are consistent. The mixed analysis will be systematic and the reasons for classification of data will be documented. For primary data privacy and confidentiality will not be compromised and this will increase the credibility of the research since other authors will be able to replicate the research work (Noble, 2015).

3.7 Ethical Considerations

Since this study employs secondary data, the main ethical issues include the appropriate citation of sources and data accuracy (Sivarajah, 2017) and for primary data privacy and confidentuality of the respondants. All the literature and case studies and questionnaire used in the research will be properly acknowledged, thus crediting the original authors of those works in case of qualitative and the biased will be avoided in case of quantitative. The study will follow the ethical practices as expected in academic research, which means that the results obtained will not be manipulated or twisted in any way. To sum up, this work uses a sound mixed research approach, including the literature analysis, questionnaire analysis and the case study, to examine the role of AI in SCM.

4 Chapter 4: Results and Discussions:

4.1 Use of AI Technology and the Resilience of Supply Chains in Emergence of New and Significant Disruptions

AI technology prolongs the overall flexibility of supply chains to new and material disruptions by offering better, efficient, and timely data analysis and insights. Predictive analysis and machine learning are some of the AI features that can analyze large and real time data to help determine any disruptions that could occur. For example, the COVID-19 outbreak saw Walmart and Amazon implement the use of AI in demand prediction and subsequently the management of their stocks. This was a preventive measure, which helped to maintain the supply of necessary products when most supply chains were being affected. The efficiency of the AI model in demand forecast and the constant update of the inventory management system enhances business sustainability and stability during organizations' unanticipated disruptions (Belhadi, 2022; Singh, 2023).

Figure 1: AI in logistics and supply chain: Use cases, applications, solution and implementation

Also, it improves the supply chain transparency and visibility of the products and services that circulate within the supply chain. This increase in transparency helps the supply chain managers to easily see areas that are constrained or require improvement through adoption of suitable strategies promptly. For instance, smart IoT can track shipment's location, storage conditions and transportation performance and yield indispensable information that can be used to refine logistics and avoid possible disruptions (Kondratenko, 2023). Also, the possibility of big data analysis leads to supply chains taking a predictive approach to risk management, assessing the concerned risks and coming up with measures to prevent them from developing into major disruptions (Modgil, 2022).

The investigation indicated that AI in SCM improves efficiency, cost, and flexibility. Retailers like Walmart, DHL, siemens and Amazon use AI to estimate demand, increase supply, and save costs. AI has helped these companies respond to recognised disturbances, like as the global COVID-19 pandemic, and improve supply chain response times (Kondratenko, 2023).

4.2 The dynamics of artificial intelligence and the possibilities of inventory management and the demand estimation in the supply chains.

Artificial intelligence constantly influences inventory control and demand forecasting in supply chains since it entails sophisticated algorithms and data analysis to enhance the precision and speed of supply systems. The artificial intelligence demand forecasting incorporates historical sales data, market trends, and other external factors to estimate the future demand with much accuracy. It further assists in predicting the amount of stock that is needed to be available in the stores, which helps avoid cases of overstocking or running out of stock. For instance, AI among consumers and market trends to calculate the right stock quantity and

holding time (Singh, 2023). This approach not only keeps holding costs to the barest minimum but also helps to meet the customers' needs as products are restocked as they are sold.

Figure 2: AI in inventory management: Redefining inventory control for the digital age

Besides, AI speeds up the reordering process through setting up automated reordering systems that are based on real-time data. Such systems reduce the chances of human interferences and help keep the inventories at the most appropriate levels. For example, automated reordering systems involving AI can put orders depending on the current stock status and demand estimations; this eliminates the need for human input and the probabilities of errors (Dash, 2019). In addition, they found that AI's capacity to analyse big data and offer insights to supply chain managers assists with decision-making on the management of inventory. Thus, managing the demand fluctuations and bringing the optimal stock levels, AI minimizes the excess inventory, cuts the storage costs, and enhances the efficiency of the supply chain. In this regard, AI dynamics affect inventory management and demand estimation by advancing the accuracy, efficiency, and cost optimization in supply chain (Tang, 2023).

4.3 Automation and Robotics with the help of AI in Supply Chain Help to Deliver

Hence, AI in automation and robotics greatly improves supply chain functions, performance, and productivity than conventional strategies. Automated systems with the help of A1 tackle monotonous and tedious processes that take a lot of time and can have human errors. For example, robotic process automation assisted by AI performs repetitive data manipulation and clerical work, allowing people to work more creatively and innovatively (Boute, 2021). This automation also results in high productivity while at the same time cutting the costs of hiring employees and greatly reducing the chances of making errors that are usually common with manual operations.

Figure 3: The Best Uses of Robotics in Logistics and Shipping 2023

AI also helps in improving supply chain activities through data analysis and decision making necessary for the organization. For instance, AI algorithms that firms such as Amazon employ in their operations to enhance route optimization incorporate factors such as traffic congestion, weather and delivery time to recommend the best way that delivery persons should take. This capability is very important during the high demand periods, for instance during the COVID-19 period that saw a rush to e- commerce where first- mile delivery is very important. In terms of efficiency, AI enhances the delivery routes, and thus, decreases the fuel usage, delivery time, and overall expenses required to operate (Singh, 2023). Also, with the ability of AI in carrying out predictive maintenance, the durability of supply chain equipment is increased. Condition monitoring that utilizes AI to alert organizations and companies on the state of their machinery and equipment, and when the equipment is likely to fail, schedules maintenance to be done without any formal notice that the equipment is about to fail. This kind of approach reduces the time that equipment takes in the workshop, the duration that is taken before equipment is repaired and the costs of maintenance in the long run (Alhasawi, 2023).
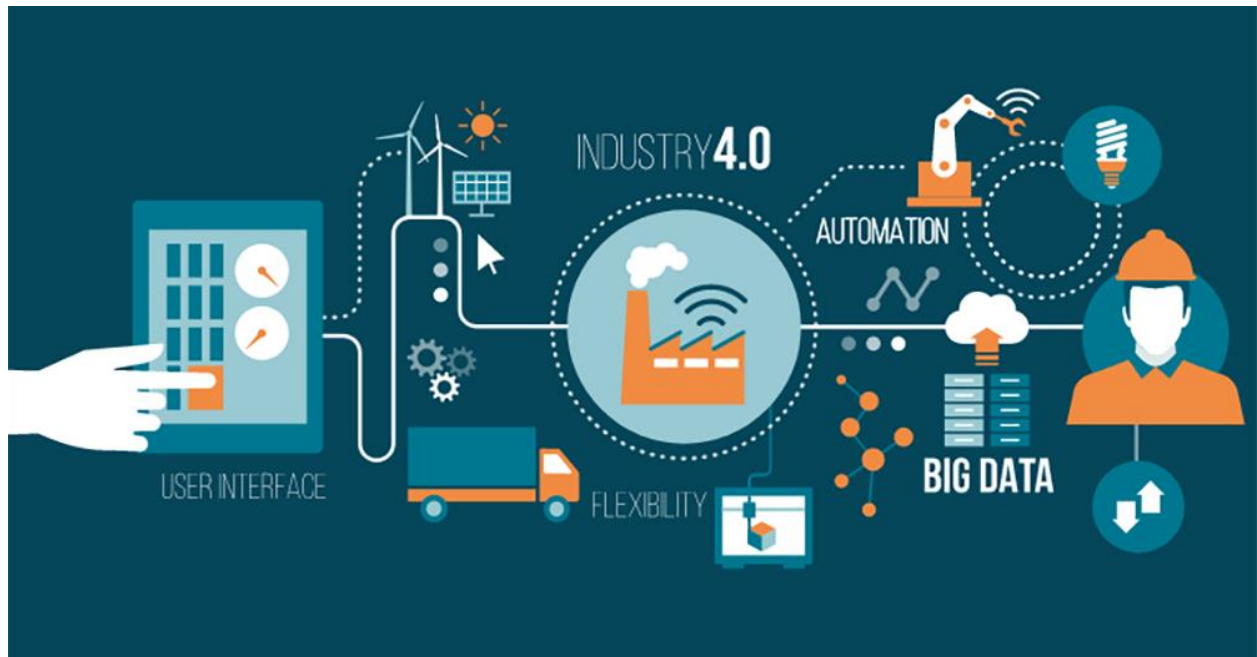
Figure 4: Supply chain automation: key stages in supply chain that can benefit

AI, IoT, and advanced analytics make the supply chain more sensitive and dynamic. AI analyses real-time supply chain data from IoT devices to make recommendations for improvement and decision-making. Since it enhances supply chain monitoring and tracking, it improves supply chain flow. Thus, firms may maximise resource utilisation, save expenses, and improve supply chain performance by using AI's analytical function. Thus, AI in automation and robotics creates a more efficient, cost-effective, and effective supply chain, supporting operational excellence and competitive advantage.

Supply chain management with AI enhances flexibility, inventory control, demand forecasting, and organisational flow. AI-based predictive analysis and real-time data analysis improve supply chain performance and help organisations respond to disruptions. Advanced artificial intelligence and data analysis improve inventory control, saving money and satisfying customers. AI and robotics improve supply chain efficiency, minimise human errors, and lower costs. Future research should address data quality, model explanation, and AI regulation to improve supply chain management using AI. Understanding and using AI's strengths can help firms improve supply chain performance, assure stability and sustainability, and plan future development in the competitive modern market.

4.4   Quantitative primary data Analysis:

AI Implementation and Company Size

Due to firm size and operation needs, AI integration in SCM varies. SMEs, especially those with 1–50 people, adopt AI last. They are limited to demand forecasting and supplier connections when they do. They invest less than $50,000 in AI, and implementations are rarely successful. Instead, mid-size enterprises with 51-250 employees have mostly used AI for inventory and process automation. Such companies invest $50,000–$500,000 in AI. AI adoption is highest in large organisations with 251 or more employees and enterprises with

1000 or more people and budgets over \$1 million. AI is used in logistics, predictive maintenance, and real-time decision-making by these companies.

Company Size	Number of Responses Adopting AI
Small (1-50 employees)	3
Medium (51-250 employees)	3
Large (251+ employees)	4
Very Large (501+ employees)	2
Enterprise (1000+ employees)	3

Number of Responses Adopting AI

- Small (1-50 employees)
- Medium (51-250 employees)
- Large (251+ employees)
- Very Large (501+ employees)
- Enterprise (1000+ employees)
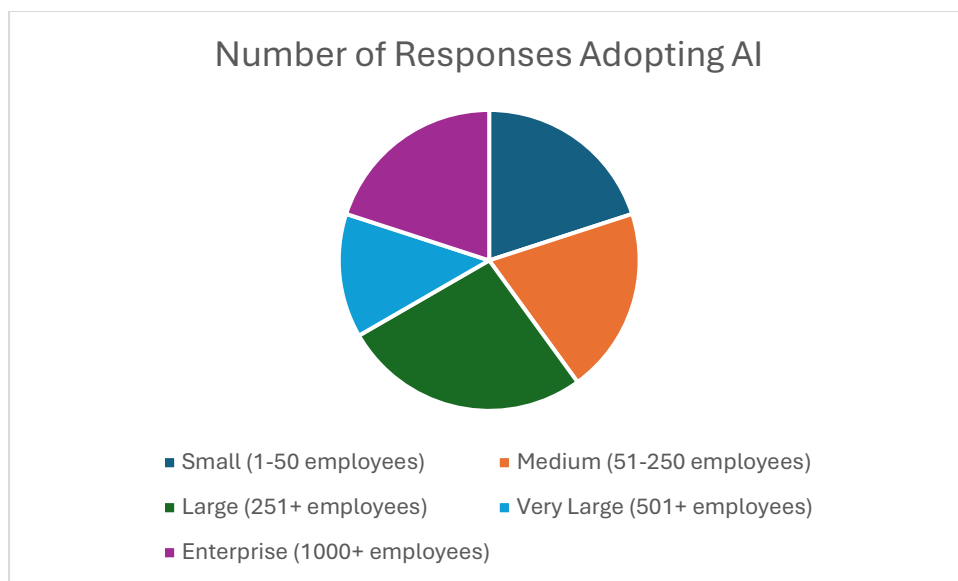
Applications of AI

SMBs utilise AI for demand forecasting, a popular application. AI demand forecasting helps these organisations manage stock levels and reduce stockouts, which are crucial to their operations. However, larger organisations employ AI for supply chain, stock control, and purchasing. Large companies worry about predictive maintenance because it can forecast when equipment may fail and avert costly losses. AI and IoT help organisations organise information in real time and increase supply chain dynamism in complicated processes.

Using Technologies

ML is the most widely utilised AI technology for demand forecasting and inventory optimisation. Predictive analytics helps mid-sized and large companies make better decisions. Mid-sized businesses also use RPA for procurement and inventories. Large organisations are implementing cutting-edge technology like deep learning algorithms, IoT-integrated AI systems, and supply chain control towers. More advanced tools assist automation and real-time control of complex supply chain activities.

AI Adoption, Success, Issues

Most firms, especially mid- and big ones, consider AI moderately to very useful in decision-making, customer satisfaction, and cost reduction. Global corporations and big firms have also rated AI as effective in supply chain flexibility and availability during disturbances like the COVID 19 epidemic. The following hurdles, especially poor data quality, contribute to low small business performance. Implementing AI in existing frameworks is difficult for larger businesses due to opinion changes and a lack of qualified AI system operators.

Impact of AI Investment on Competitiveness

Company size strongly influences AI adoption. Small enterprises pay less than $50,000 to apply AI and choose demand forecasting. Medium-sized companies invest $50000 to $500000, whereas major corporations spend over $1000000 to integrate AI into their supply chain. Some organisations invest more than others, but most believe AI is necessary to succeed in the global business environment. Different sizes and types of businesses know AI is vital for logistics, decision-making, and supply chain agility.
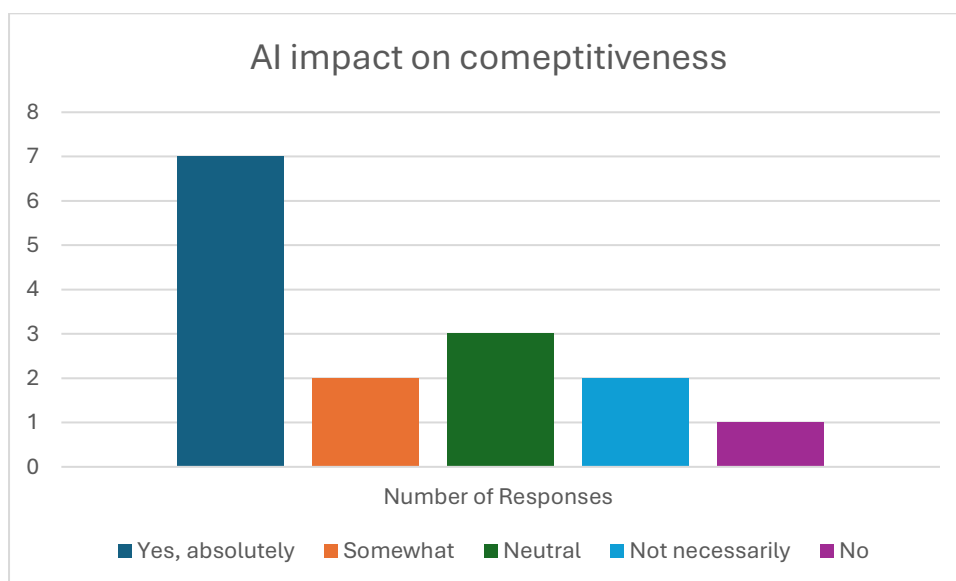
AI in SCM is growing, especially among major companies. Mid- and large-sized enterprises are benefiting from AI in demand forecasting, logistics management, and predictive maintenance. However, data quality, system integration, and staff training remain challenges. However, AI is becoming a key enabler for competitive advantage in the ever-changing global supply chain environment.

5 Chapter:5 Conclusion and Recommendations:

AI technology has improved Supply Chain Management (SCM) efficiency, dependability, and cost. AI gives supply chains a competitive edge in disruption response because it can process

massive amounts of data in real time. Walmart and Amazon, among others, used AI in demand prediction and inventory replenishment to keep popular products in stock during COVID-19. This feature highlights how AI can increase real-time supply chain visibility and prevent dangers. Inventory management and demand forecasting take an exciting turn with AI. Recent advances in artificial intelligence and machine learning reduce overstocking and stockouts by predicting demand. Since automated reordering systems restock stocks without human intervention, they increase efficiency. These optimise resource use and lower company costs. AI in automation and robotics optimises time-consuming procedures with fewer personnel errors. Amazon's AI-based route planning improves delivery time and cost. Maintenance functionality boosts supply chain equipment durability, reducing usage time and costs. These applications demonstrate that AI can boost profitability and productivity.

However, issues remain. AI systems need high-quality data to analyse and learn quickly, making data quality and integration the biggest issues. Unreliable data yields mediocre results compared to field bests. Most AI, especially Deep Learning models, are black boxes, which makes supply chain management difficult because managers must understand AI-based decisions. These difficulties must be resolved to establish explainable AI (XAI) methodologies and earn stakeholder trust. Further research should examine how AI might be combined with blockchain and advanced analytics to improve supply chain performance and visibility. The effects of AI on SMEs and the future effects of AI on supply chain vulnerabilities must also be examined.

However, SCM AI use has several concerns. The cold-start problem, which makes it hard to analyse a new data set or program, data quality, which greatly impacts AI model outcomes, and the difficulty in interpreting and communicating AI model conclusions are still issues. AI models depend heavily on data quality; therefore, any flaw can affect performance. The "black box" aspect of many AI models, especially deep learning, hinders interpretation and transparency, undermining stakeholder trust.

Companies must develop operational solutions for AI integration, such as data management, explainable AI systems, and AI specialists in supply chain teams, to maximise AI's potential in SCM. The ethical application of AI technology should be set by state and federal governments and other companies, including user data protection. Overall, AI in SCM offers great potential to increase supply chains' flexibility, efficacy, and affordability. These challenges can be overcome with strategic planning, data management, and teamwork. As technology improves, AI will play a larger role in supply chain management and boost the global economy. This is why any company that adopts AI and integrates it into its business will be well-positioned to survive in the modern market.

Thus, future research might examine how AI interacts with other developing technologies like IoT and blockchain to improve SCM performance. These technologies improve AI by improving data readability, protection, and decision-making. As research gaps remain, more articles on AI's implications on SMEs and developing nations' supply networks are needed.

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7 Appendices:

7.1 Questionnaire:

Question	A	B	C	D	E
What is the size of your company's supply chain operations?	Small (1–50 employees)	Medium (51–250 employees)	Large (251+ employees)	Very Large (501+ employees)	Enterprise Level (1000+ employees)
How long has your company been using AI technologies in supply chain management?	Less than 1 year	1–3 years	More than 3 years	We are not using AI yet	No plans to implement AI
Which areas of your supply chain currently use AI?	Demand forecasting	Inventory management	Transportation/ logistics optimization	Supplier selection and procurement	Predictive maintenance
Which AI technologies or tools do you use in your supply chain management?	Machine learning models	Robotics Process Automation (RPA)	Predictive analytics	IoT-integrated AI systems	Deep learning algorithms
On a scale of 1 to 5, how effective has AI been in improving your supply chain performance?	Not effective at all	Slightly effective	Moderately effective	Very effective	Extremely effective
What are the main benefits your company has observed from using AI in your supply chain?	Cost reduction	Improved demand forecasting accuracy	Faster decision-making	Increased supply chain flexibility	Improved customer satisfaction
What challenges has your company faced in implementing AI in the supply chain?	Lack of high-quality data	Integration with existing systems	High implementation costs	Lack of skilled personnel	Stakeholder resistance
How much has your company invested in AI technology for supply chain management in 3 years?	Less than $50,000	$50,000–$500,000	$500,000–$1 million	Over $1 million	No dedicated investment yet
To what extent has AI improved supply chain resilience (e.g., during COVID-19 disruptions)?	Not at all	Slightly	Moderately	Significantly	Don't know/not applicable

How has AI impacted your company's demand forecasting accuracy?	No improvement	Minor improvement (1–5% increase)	Moderate improvement (6–15% increase)	Significant improvement (16%+ increase)	Major improvement (20%+ increase)
Have you integrated AI with other technologies in your supply chain?	IoT (Internet of Things)	Blockchain	Advanced analytics	Cloud computing	None
What is your company's primary goal in using AI in the supply chain?	Reducing operational costs	Increasing efficiency and speed	Improving customer satisfaction	Enhancing sustainability	Risk mitigation and supply chain resilience
On a scale of 1 to 5, how confident are you in the accuracy and transparency of AI decisions?	Not confident at all	Slightly confident	Moderately confident	Very confident	Extremely confident
In your opinion, which emerging AI technology will have the most impact on supply chain?	Machine learning and predictive analytics	AI-driven robotics and automation	AI with blockchain for transparency	AI-powered IoT for real-time data analysis	AI-powered supply chain control towers
Do you believe AI in supply chain management will be essential for staying competitive?	Yes, absolutely	Somewhat	Neutral	Not necessarily	No