

AI in E-commerce supply chains: Identifying Implementation Challenges.

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ABSTRACT

Purpose – This paper explores the application of Artificial Intelligence (AI) in e-commerce supply chains, addressing the challenges that need to be overcome to successfully implement AI in supply chain systems. The aim is to identify and analyze the technological, organizational, operational, and external barriers that hinder AI adoption and to propose strategies that enable efficient, automated, and customer-centric supply chain management.

Design/methodology/approach – The study reviews literature and real-world examples of e-commerce firms that have adopted AI technologies in their supply chain operations. It focuses on understanding the impact of various barriers such as technological limitations, decision-making issues in real-time, organizational resistance, data handling difficulties, and legal constraints. The research further examines how firms have developed strategies and business models to overcome these barriers through effective data governance, workforce adaptation, and policy support.

Findings – The study identifies several critical challenges in the adoption of AI in e-commerce supply chains. These include technological limitations, inefficiencies in real-time decision-making, resistance to change within organizations, inadequate information management systems, and compliance with regulatory and legal requirements. Despite these challenges, several successful e-commerce firms demonstrate that the strategic application of AI enhances operational efficiency, automation, and customer satisfaction. The findings emphasize that overcoming these barriers requires an integrated approach involving organizational restructuring, regulatory support, and continuous technological innovation.

Originality/value – This research contributes to the growing body of knowledge on AI integration in e-commerce supply chains by summarizing existing challenges, highlighting best practices, and identifying research gaps. It provides insights valuable to industry practitioners and policymakers for designing frameworks that promote sustainable, ethical, and resilient AI-driven supply chains. The study also suggests directions for future research, including empirical validation, sustainability assessment, and ethical considerations in AI implementation.

Keywords: AI in supply chain, e-commerce, AI challenges, logistics, digital transformation

1. INTRODUCTION:

Artificial intelligence (AI) discourse already is one of the fields of transformative nature that can provide supply chain management with modernistic circumstances, especially in the context of dynamism of e-book and the e-commerce offerings (Lee, 2025). As the competitive landscape of the business environment becomes more efficient, speedier and more knowledgeable to deal with clients, AI technologies are added as a crucial component of operational excellence (Tariq, et al., 2021). The significance of AI in supply chains is that it brings forth gigantic measures of information, tendencies, and it helps functioning in the creation of the data-founded decisions that are more effective, precise, and receptive to alterations. Applications of AI technologies providing an option of demand prediction, brokerage operation, automation of warehouses, and customer action shows have redefined in e-commerce businesses in which a

company relies on real-time decision making tools in increasing levels of dependence (Daisy, 2021). The application of AI to the e-commerce supply chains has been shifting at a similar rate as the technology of machine learning, big data analysis, and robotics. Firstly, the automation consisted in a basic inventory management and monitoring (Shah & Badi, 2021). However, with the latest innovations in state-of-the-art predictive algorithms, the supply chain systems have been more proximal and turned into the quickest functioning system. Predictive analytics can assist business in anticipating the market features and accordingly manage inventory efficiently and enable mitigating factors that may be inflicted by order and elastic demand or logistic factors (Nweje & Taiwo, 2025). AI-enhanced smart logistics are now being developed by routing any object using less fuel thus making the process of arriving to customers more efficient and thus enhancing the customer satisfaction and decreasing the cost of operations.

AI has simplified the development of intelligent warehouses, which operate on robots and Internet of Things (IoT) (Buntak, et al., 2019). These technologies will grant the possibility to sort them, select them, and package them automatically to have the fulfillment process quicker and more precise. Their inclusion has become critical in e-commerce where a customer dreams of getting his or her orders within a maximum duration of one day or even after a day which has prompted the adoption of such smart systems in order to keep up with the competition. AI-driven customer-based analytics will help firms to make tailored services, predict purchasing patterns, and simplify a buying experience based on updated information that also encompasses efficiency of supply chain with customer-led practices (Badmus, et al., 2024).

Barriers to the application of AI in Supplies Chains of E-Commerce

Although the introduction of Artificial Intelligence (AI) into the e-commerce supply chain has enormous potential to peak the activity of operational efficiency and decisions, introducing AI into the supply chain practice has its share of challenges. Even though the task of invention management, logistics, and demand prediction with the uses of AI gains popularity, numerous companies find it hard to be able to manage to seamlessly adopt it (Davenport, 2018). The shift, between the old system of supply chain and the new system, based on AI, is accompanied by elaborate technological, financial, and organizational obstacles that usually slump the pace of implementation or even halt its progress. The awareness of these barriers is critical to closing the gap between the potential AI benefits, both theoretically and practically, and their effect within the context of e-commerce (Wang, et al., 2023). Technological limitation is one of the greatest challenges. The introduction of AI has a high cost due to the necessary data infrastructure, such as high quality, permanent datasets and heavy analytics solutions with machinery capable of working with large amounts of data in real-time. Numerous companies in the e-commerce industry, especially the small and medium ones, do not have a high level of digital maturity that allows them to maintain such systems (Gonzalez-Tamayo, et al., 2023). Additional risks that complicate the process are data fragmentation, poor data quality and cybersecurity risks. Moreover, the implementation of AI tools can be a challenge to integrate with the making of the older infrastructure due to the possible unwillingness of the older systems to be compatible with new algorithms and automation tech (Wolniak & Stecula, 2024). Such technology compatibility may result in inefficiencies, downtime and other implementation expenses.

The paper will have the following research objectives which will include:

- Determining critical issues in the implementation of AI in e-commerce supply chains.
- Evaluating the effects of such challenges to supply chains performance.
- Checking the current literature in order to identify research gaps.
- Seeing recommendations to future research and industry practice.

This paper has been developed such that it provides a general overview of the use of AI in electronic Warehouse-chain of command in e-commerce. The introductory part has included the significance of AI and the issue of research since, at that point, it will examine in more depth the applications of AI in relation to machine learning, NLP, computer vision, and blockchain.. The problems in deployment are then examined in the following sections which are then backed by the case study of the top e-commerce companies. The paper concludes by reviewing the essential findings, providing strategic, managerial, and policy implication along with research gaps that can be filled in the future. Lastly, the conclusion manages to paraphrase the contributions and limitations of the study and cite the future directions that the study will be verified to be accomplished, making the flow of the study to have a structured coherent flow.

2. LITERATURE REVIEW

2.1 AI in Supply Chain Management

2.1.1 AI Applications in E-Commerce Supply Chains

One of the transforming elements in e-commerce supply chains involved Artificial Intelligence (AI), as the technology promoted the use of data to make decisions, automation and predictive effectiveness (Dash, et al., 2019). Some of the major AI technologies that define this change would include machine learning, natural language processing (NLP), computer vision, and AI systems with blockchain (Shinde, et al., 2024). All these technologies are critical towards responding to certain challenges encountered in the supply chain as well as improving visibility, accuracy, and responsiveness in the overall operations. In e-commerce supply chain management, the focus has turned to machine learning of predictive analytics and demand forecasting as one of the most crucial applications (Yusof, 2024). Listing and analyzing lots of historical data, trends of demand among customers, and other external conditions (seasonal demand or market changes) can help forecast the changes of demand trends with great precision with the help of machine learning algorithms. This forecasting value enables business to optimise inventory levels, minimise overstock and stock outs and simplify the procurement planning. For example the Ai demand forecasting is used to assist retailers with making sure that the products will be available when required by the customers and save on storage expenses and increase customer satisfaction (Amosu, et al., 2024). Moreover, machine learning algorithms are constantly changing over time and trained on new data to deliver successively better estimates. This elasticity character renders the e-commerce companies to be sustainable in times of a turbulent consumer behavior, global shocks or a series of supply scarcity. The other area that AI is proving to be very efficient is that of Natural Language Processing (NLP) of customer support and automation (Kalusivalingam, et al., 2020). The queries posed by customers are too many that McShop platforms compete with Carvanza of customer queries in contexts of both product queries and order track and product returns. Virtual assistants and NLP chatbots are able to pick and respond to the customer question one by one in real time reducing the work of human support staff and

leading to the 24/7 availability. Based on the profiles of the customers such systems are able to scan the sentiment, differentiate between intent and even customize interactions depending on the profile of the customers. Further, applying NLP allows giving unstructured data, such as email, invoice, and a message to a supplier internal automation and converting it into an insight that can be acted upon (Holloway, 2024). This will boost the cross-departmental reaction, reaction quicker and the overall consumer experience. The higher usually is the stage of NLP modelling, the broader the NLP model can be accordingly allowed to be multilingual and capable to discern context that is extremely crucial to the process of international e-commerce.

2.1.2 Benefits of the AI use in E-Commerce Supply Chains

The application of the AI technologies to the supply chain in the domain of e-commerce implementation is defined by a series of benefits that should not be reduced to the supply chain automation and analytics (Dash, et al., 2019). These include efficiency that is among the most outstanding advantages. The systems that are based on AIs streamline the complex work in the logistic processes that enable faster response to order and orchestrate the efforts of suppliers, distributors and retailers in real-time. Business, in its turn, can allocate the resources more efficiently and focus on such strategic points as market expansion and innovations in the process of repetition work automatization and optimization of workflows. Cost reduction is another inevitable consequence of the integration of AI (Ahmad, et al., 2021). Predictive analytics and business process automation support the efforts of the business to minimize its waste, reduce human error, and reduce inventory hold costs (Ojika, et al., 2022). The use of tools which will allow to optimize the routes with the help of AI possibilities will help the logistics officers know the most efficient delivery routes to save on fuel and costs on transportation. In addition, the businesses would avoid the costly expenditure of recalls and delay in manufacturing products through the application of the predictive maintenance and early detection of defects with the help of computer vision. The AI has also come in with enhanced accuracy of the forecasting that is essential in handling the e-commerce demand volatility (Kaul & Khurana, 2022). The conventional techniques of making predictions do not guarantee that unanticipated fluctuation in the taste of people or market shock will be incorporated in the consumer preference though AI remains receptive to changes with the influx of data into the system. It gives such flexibility that it means that inventory and resources distribution occur in response to current demand trends and which leads to under-shoots of operations and the improving customer satisfaction. Automation effect is even deeper as it is one of the key points of AI (Acemoglu & Restrepo, 2018). The AI reduces dependency in man, and reinvigorates all procedures towards the supply chain, in warehouse robots and in the ancient-fashioned autopilot.

2.2 AI Implementation in E-Commerce Supply Chain

2.2.1 Developing reason of AI in e-Commerce Supply Chain operation

In its endeavor to bring efficiency, accuracy and responsiveness of every step of the value chain Artificial

Intelligence (AI) has developed eminent changes in the domain of execution of e-commerce supply chain (Tamm, et al., 2020). It does not merely influence inventory management and effective logistics, but advances to its final-mile drop-offs and customer service. The AI-driven systems rely on the predictive analytics as well as machine learning models that aid in prediction of demand during inventory management with high level of accuracy (Muthukalyani, 2023). Equipped with a possibility of analyzing large amount of data such as previous sales history, changes in the market environment or even irrelevant factors such as weather or economy indices, AI can also contribute to the maintenance of optimal level of stocks in businesses. This reduces the costs, stock out, and overstocking. Also, the AI-powered warehouse management systems handle storage allocation, picking, and sorting and, therefore, can make the working routine quicker, as well as minimise errors on behalf of human operators (Sodiya, et al., 2024). The AI technologies have introduced a new level of control and visibility paradigm, with regard to the optimization of logistics. The route optimization algorithms consider numerous factors including the state of traffic, quantity of fuel consumed, and time of weather assurances and come up with the best delivery routes. This results in reduced costs of delivery and lessening time of delivery. The other advantage of AI to freight management is neuralgia in the event of potential disruption, such as equipment malfunctioner, traffic jam, weather, or other events, and subsequently, causes companies to reorganize the schedule and associated routes. The level of predictive logistic is also essential to the global e-commerce participants in the maintenance of integrity of international shipment management as well as continuity of the supply chain.

2.2.2 Success Stories of the Successful of AI usage in E-Commerce

A number of the pioneering firms in e-commerce have integrated AI into their supply chain operations and have been a leader in terms of innovativeness and efficiency in their operations (Bezditnyi, 2024). The example of Amazon relates to a widespread brand of using AI in the logistics and fulfillment systems globally. Its AI engine handles millions of SKUs by indicating customer demand, managing inventory to the fulfilment centres, and facilitating quick processing of orders. The robotics-enabled warehouses (equipped with autonomous mobile robots that aid in sorting and transfers of the packages by the robots) have greatly reduced human labor and enhanced rate of fulfillment at Amazon (Nuckel, 2023). Moreover, the AI-based forecasting and pricing systems of the company bring dynamism into inventory and product prices according to the real-time market facts. The other case of successful implementation of AI to manage supply chain is Alibaba, an e-commerce giant. The system called ET Brain developed by the company applies machine learning and data analysis to model the process of urban movement and logistics optimization that helps to predict any traffic jams and get good delivery recommendations that can be used to prevent traffic jams. Alibaba AI On big shopping occasions like the Singles' Day, the logistics platform of the Alibaba group caters to billions of orders and delivers them on time in its vast network (Zhao, 2020).

2.2.3 Challenges to the implementation of AI

Despite all these positive aspects, the process of AI implementation into the supply chain designed to support e-commerce is fraught with problems particularly when it comes to scalability and real-time decision making. The issue of scalability also emerges as the companies strive to scale AI solutions to new markets or whenever the companies have to work under different conditions. The reason is that robots require high quality and volumes of data, which can be utilized in the process of prediction, but most companies are plagued with data silos, lack of uniformity, and low levels of agency integration. Dispersing business makes data integrity difficult in the long run because the businesses dispersed. Moreover, the AI solutions are consuming massive workforce to the computer, and infrastructure is costly to small and medium-sized enterprise (SMEs) (Pasham, 2017). The other issue is the issue of real-time decision-making. The AI models should be capable of working with large amounts of data in real-time and respond instantly to the changes in the market. An example is the fact that where a demand charity or a supply dislocation is the case, the AI systems should be built in a way to correct their predictions and offerings on the spot to avoid wastage (Spirito, 2024).

2.3 Review of Existing Studies

According to Shrivastav (2021), there are various obstacles to the application of AI in supply chain management (SCM), with issues in multi-actor collaboration dependence, relying on different data types, adopting AI adoption, managing change, and the absence of a formal AI governance approach among some of the possible constraints. The researchers point out that SCM is a concept that incorporates many parties, and their unwillingness or the inability to cooperate effectively would eventually affect the implementation of AI. Lack of standardization of supply chain will complicate attempts to create unified AI solutions. The opposition to the AI implementation relates to fear of change, the lack of knowledge about AI and hesitations regarding the AI-oriented decision-making process. AI adoption is in need of changes in organizations, which is typically subject to operational issues, further slumping the implementation process. Lack of a clear system of governance leads to lack of uniformity and may cause risks in regards to AI application. To overcome these barriers, Shrivastav argues that practitioners, policymakers, researchers, and governments should join forces to come up with the best strategies of successful implementation of AI in SCM.

In their article “*AI-Driven Optimization Models to E-commerce Supply Chain Operations: Demand Prediction, Inventory Management, and Reduction in Delivery Time with consideration of cost*”, Kaul and Khurana (2022) point to the importance of AI in improving the numerous areas of the supply chain management within the context of the e-commerce industry. Based on the results of their studies, demand prediction models, which are AI-based, apply neural networks and machine learning algorithms, and improve the predictability of demand significantly, which explains why they are more effective in minimizing resources and decreasing wastage. AI-based inventory management tools improve inventory optimization that includes

regulating overstocking, stock each, and eventually improving operational efficiency. The latter research also highlights how deep reinforcement learning can be used to enhance logistics and the process of delivery, therefore, accounting for shorter degrees of transit time and higher degrees of customer satisfaction. The authors conclude that despite the efficacies of the adoption of AI into the e-commerce supply chains in enhancing efficiency and cost-efficiency of the supply chains, implementing it demands the investment in effective AI infrastructure and training of the workforce by the business enterprises to be the most advantageous.

Lari, Vaishnava, and Manu (2022) discuss the course of the AI in transforming the environment of the e-commerce in their study entitled *Artificial Intelligence in E-commerce: Applications, Implications, and Challenges*. Their work cites the AI applications as custom suggestions systems, chatbots, fraud detection, and automated decision-making as necessary to the customer experience and operations enhancement. These findings indicate that AI-based predictive analytics can assist a company to gain a better insight into consumer behaviour that results in more effective marketing decisions and product positioning. There are also severe problems that the authors raise, and they are the questions of the privacy of the data, the ethical issues of the application of algorithms as a decision maker and the potential unemployment of the individuals with AI robotization. The article shows that it is necessary to justify such concerns using regulatory policies and the ethical nature of AI implementation, but it is based on the opportunities of AI to contribute to the evolution of the space of e-commerce.

Ndlovu et al. (2022) focus on the opportunities, challenges, and strategies that should be pursued in their article *Leveraging Artificial Intelligence to Improve the Security, Efficiency and Resilience in E-commerce Supply Chain Management* and discuss ways that AI might be utilized to enhance the security and resilience of the supply chain. AI-driven security systems comprising of threat detection algorithms and fraud prevention mechanisms make the digital transactions and customer data more secure. The study also indicates that automation of supply chain activities through the use of AI is efficient in that it minimizes the number of errors in manual processes, efficiency in routing and optimizing supply chain demand. Nevertheless, the paper also notes that the issue of cyber security risks linked to AI-based systems, complications of implementing AI into the current supply chains, and that strategic policies should be introduced in order to enable a successful introduction of AI can also be seen as a challenge. The authors note that an organization should have a moderated strategy, implementing AI in a responsible way, and deal with potential risks associated with the technology via constant observation and the observance of regulation.

3. THEORETICAL FRAMEWORK

3.1 Diffusion of Innovation (DOI)

Everett Rogers created the Diffusion of Innovation (DOI) theory to explain how technology spreads across businesses, together with social domains. The e-commerce supply chain management AI adoption

benefits from DOI because this theory explains how various AI solutions, such as machine learning, natural language processing (NLP), computer vision, and blockchain-integrated AI solutions, align within supply chain systems. Businesses evaluate both the benefits and the ease of implementation of AI solutions through factors such as relative advantage and compatibility before considering complexity, trialability, and observability for their decision. Businesses tend to adopt AI technologies when they view them as useful and simple to integrate, and measurable in their benefits.

DIFFUSION OF INNOVATION MODEL

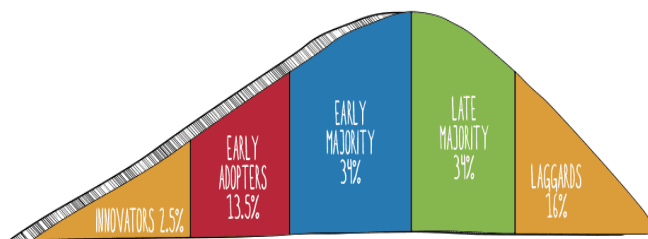


Fig. 1. Diffusion of Innovation (DOI)

Source: Hanlon (2013)

The diffusion process divides market adopters into five groups, starting with innovators, followed by early adopters and early majority, and finishing with late majority and laggards. E-commerce supply chains depend on all five groups to achieve full integration of AI, as each plays an essential role in the spreading process. Innovators act as the first adopters of AI systems, while most large corporations make up this group due to their extensive resources. The companies Amazon and Alibaba maintain leadership in AI adoption through their implementation of AI demand forecasting with robotics automation and autonomous delivery networks. These organizations drive industrial innovation because they choose to invest in cutting-edge AI technology that helps establish new industry standards (Azeta, 2016). The early adopters use select AI systems after watching innovators derive value from their implementation. AI facilitates predictive analytics together with real-time tracking and automation of customer services in businesses categorized as mid-sized e-commerce entities and logistics companies. The successful implementation of AI by early adopters leads both the industry and subsequent adopters to embrace AI-driven solutions. Companies from the early majority segment begin adopting AI after its benefits become commonly acknowledged, together with the reduction of associated risks. Logistics optimization using AI-driven strategies and NLP-based customer service, together with automated quality control, has started to show effectiveness, thus attracting more e-commerce businesses to integrate them for better supply chain efficiency and market competitiveness. A technology standard in the industry drives the majority of companies to implement AI. Most businesses evaluate AI implementations with great caution due to their selective approach toward evidence-based proof of cost-effectiveness and reliability (Folorunso et al., 2010). AI

adoption becomes more common among businesses as they witness numerous experiences of success and encounter cost savings alongside regulatory support. The level of resistance to AI adoption reaches its peak for organizations identified as Laggard companies. Three main challenges stand in the way of these companies, which include outdated computer systems, insufficient technical resources, and funding limitations. Organizations must transform their business only when external market competition or industrial standards demand the implementation of AI.

3.2 Resource-Based View (RBV)

As a strategic management theory, the Resource-Based View (RBV) places a premium value on internal resources and capabilities when businesses work toward sustainable competitive advantage. The Resource-Based View identifies companies that possess robust technical infrastructure and skilled personnel, together with controlled data systems, as those most able to implement successful AI supply chain management solutions in e-commerce. Market-based theories do not recognize the importance that RBV does of internal firm resources to increase market efficiency and competitive edge and drive innovation. Implementation of AI technology in e-commerce supply chains needs multiple essential capabilities within the organization. The first is technological infrastructure. The successful deployment of AI systems, including machine learning demands for forecasting natural language processing for customer service and computer vision for inventory, needs appropriate technological infrastructure (Arbab Kash et al., 2014). Organizations with cutting-edge information technology infrastructure and cloud computing features, together with secure data storage, position themselves well to manage AI applications requiring large data volumes. Amazon, along with other companies, invested substantial funds into constructing AI-powered logistics and automated warehouse infrastructure that forms a key element of their efficient supply chain. The core internal capability needed for success involves effective management and analysis of organizational data. The operation of AI technologies demands enormous datasets for model training through machine learning, as well as predictive analytics and automated decision functions.

Both technology frameworks and skilled workforce members are vital organizational resources necessary for AI implementation. To accomplish their AI deployment, companies require staff with knowledge in data science alongside expertise in AI development, along with supply chain management capabilities. An organization that supports innovation and continuous learning can help prevent workers from resisting changes while working to implement AI successfully. The strategic development and technical training of employees for e-commerce companies lead to better results when implementing AI systems (Szymaniec-Mlicka, 2014). The deployment of artificial intelligence technology requires sufficient funding as its primary driving factor. Companies need to allocate a considerable budget for AI solution implementation since they need to purchase technology design blocks, together with system update implementation and staff training programs. Small companies find it difficult to finance AI investments due

to limited financial backing. Adequate funding lets businesses execute their AI investment plans. Working with technology providers alongside obtaining outside financial support helps businesses handle these barriers so they can extend their AI implementation more efficiently. Although companies benefit greatly from the use of internal resources for AI adoption, they may still encounter obstacles such as technical data complexities, along with expensive implementation requirements and worker reluctance.

3.3 Institutional Theory

Institutional theory creates a powerful framework to study how institutional factors affect regulations that guide artificial intelligence adoption in supply chain management practices of e-commerce. The organizational framework includes external elements consisting of legal requirements and business standards alongside public opinions that influence AI implementation opportunities yet generate implementation limitations (Eitrem, 2024). E-commerce supply chains require businesses to understand different regulations combined with data protection laws and ethical requirements, and industry standards before implementing AI-driven technology. Organizations face a primary regulatory challenge because they need to maintain compliance with the European General Data Protection Regulation (GDPR) and also with the United States California Consumer Privacy Act (CCPA) (Forster et al., 2025). The e-commerce supply chains use extensive consumer and transactional data through AI systems to advance operations and predict demands while boosting customer satisfaction. Realistic data governance standards mandate organizations implement secure protection systems along with ethical AI operation protocols and transparent algorithmic decision systems. The failure to comply with these regulatory requirements leads organizations to legal trouble and damage to their reputation while facing monetary penalties, thus making it difficult for them to adopt AI solutions.

Both legal regulations and industry standards and trade associations alongside public social expectations affect the implementation process of AI technology (Oware et al., 2022). The expectation for many online retailers includes maintaining proper ethical AI methods through bias-free algorithms while managing sustainable supply chain management and fair work conditions. AI adoption receives important organizational direction from competitive pressure generated by market leaders since businesses want to conform to industry benchmark standards in order to build better market positions (Barros et al., 2023).

3.4 Technology Acceptance Model (TAM)

Technology Acceptance Model (TAM) is a popular model that can be applied to explain the behavior of both individuals and organizations regarding the use of new technologies proposed by Davis (1989). It postulates that the adoption of the technology is affected by two major factors, which are Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). The degree, to which a technology improves performance, is called PU, and the degree to which it is easy to use is called PEOU. Regarding the example of AI application to the e-commerce supply chains, TAM serves to elucidate

obstacles that companies experience in their attempts to acquire the AI-driven solutions such as automated inventory system, demand forecasting, and robotic process automation. Employee resistance is one of the primary problems of AI implementation, as it is often caused by the fear of losing a job and mistrust in robot decisions. Workers might be willing to oppose AI implementation, in case the employees understand it to be too sophisticated or fear that it is going to make them jobless. Besides, organizational preparedness is an important method in AI adoption (Davis, 1989). The integration process may also pose difficulties to the companies that do not have proper IT infrastructure or the trained staff qualified in AI which would translate to inefficiencies and increased costs. What is more, privacy of data and regulatory issues may slow the adoption of AI, as companies should consider the strict regulations linked to the use of artificial intelligence in supply chain analytics. In order to defeat these difficulties, companies in the region will have to concentrate on the education of the users and prove that AI can contribute to the profession instead of setting it ablaze. Further, the companies ought to focus on the design of AI-friendly interfaces and other requisite training associated that perceive ease of use, which enable successful adoption of AI in e-commerce supply chains.

4. CHALLENGES IN AI IMPLEMENTATION IN E-COMMERCE SUPPLY CHAINS

4.1 Technological Challenges

4.1.1 Technical and Infrastructural Challenges

Modern day enterprises continue keeping the use of the outdated enterprise resource planning (ERP) systems and manual methods and databases that were not imported to be artificially intelligence-based automation. The implementation of artificial intelligence faces challenges because such legacy systems lack live data processing, adaptable features, and communication between systems, leading to expensive and complicated integration procedures. Organizations need to allocate substantial funds to cloud adoption along with purchasing middleware solutions and performing modernization work on their current IT infrastructure (Lari et al., 2022). AI optimization of inventory management, along with logistics and demand forecasting, remains hindered when there is no complete integration of systems. The high computational expenses present a primary technical obstacle during AI implementation (Zulfiqar et al., 2024). AI models function best with high-performance GPUs together with cloud computing services and large-scale data storage. The process of using AI algorithms for analysis, along with their deployment, results in ongoing data processing operations that increase electricity usage while raising operational costs. E-commerce businesses working with low profit margins need to be strongly concerned about these expenses. Businesses should use optimized AI algorithms and cloud-based AI services, and edge computing solutions to strike a balance between cost efficiency and performance.

4.1.2 Data and Trust Issues

Data quality alongside excellent data management determines the level of success achieved by AI applications in supply chain operations. Online

businesses accumulate extensive datasets through transactions with their customers, as well as records from suppliers and information from their logistics operations. The decision-making processes can be negatively influenced by inaccurate predictions from AI systems because of inconsistent or biased, and incorrect data inputs. The quality of data has a negative impact on inventory management as well as forecasting demands and the optimization of supply chain operations. Companies need to uphold strict data protection regulations, including GDPR and CCPA, by following their regulations on both data privacy protection as well as security (Rane et al., 2024). Organizations need to establish comprehensive data governance systems together with self-improving data-cleaning systems to sustain accurate AI functionality. The interpretability of AI models remains a primary challenge because it leads prospective users to call them black boxes. Many AI algorithms produce predictions using deep learning models, which fail to show their methods for reaching those predictions (Qin et al., 2024). The absence of AI system transparency creates concern for decision-making trust among supply chain managers and their regulators, as well as key stakeholders who require assurances for AI systems' operational decisions. AI advancements in e-commerce affect the essential operational elements of pricing decisions, as well as demand forecasting operations and supply chain logistics management systems. Organizations need complete explanations from AI models to feel comfortable adopting their recommendations. Through explainable AI (XAI) methodology, organizations can achieve better transparency to demonstrate AI decision processes while ensuring their systems stay in compliance with business needs and regulations.

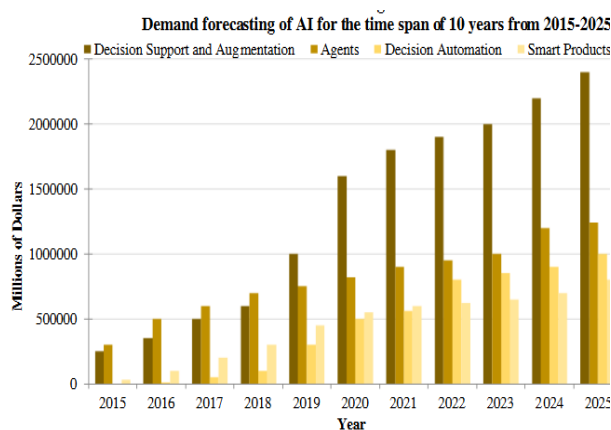


Fig. 2. Demand forecasting of AI
Source: Goswami et al. (2025)

4.1.3 Organizational Challenges

4.1.3.1 Workforce Challenges and Financial Constraints in AI Implementation

Staff members throughout the workforce demonstrate hesitancy towards AI implementation because they predict their positions might be taken over by the technology. Staff members who worked with traditional supply chain management strategies for many years face difficulties in adjusting to AI-based operations. The resistance to change has negative impacts on both the

implementation duration and the total commitment of AI tools in e-commerce supply chains. The market lacks enough experts who have deep knowledge of artificial intelligence and machine learning alongside analytical data expertise (Sakka et al., 2022). Lack of experienced personnel influences both the recruitment and the training of new technical skills in the employee, which introduces time loss in the process of AI implementation, hindering the potential benefits of AI. Companies should come up with employee training systems with reskilling plans and change management strategies whereby one or the other can prove to be the tool used by AI to enhance the efficiency in operations rather than displacing labor. The implementation of AI is expensive due to its intensive amounts of investments. The deployment of AI-enabled supply chain systems implies huge financial costs on both hardware and software buy and professional human resources recruitment (Nagarajan et al., 2023). It costs organizations to allocate funds to acquire high-performance Computer systems on top of cloud storage space and AI analytics software in order to run their operations. The total expenses increase because of system upgrades that require implementation alongside maintenance procedures and the need for cybersecurity protection. Businesses, especially those in the small or medium-sized enterprise category, often struggle to adopt AI technology because they face significant financial obstacles (Leesakul et al., 2022). Larger enterprises face decisions about AI investment hindered by doubts regarding how well they will generate returns on their investment in the long term. Businesses seeking to solve these financial issues should research flexible AI implementations and cloud computing AI platforms, together with step-by-step AI system implementation approaches to achieve financial stability and the maximum return on investment.

4.1.4 Ethical and Regulatory Concerns

AI algorithms obtain instructions through historical data because this data can include unconscious biases that generate discriminatory results. The selection method of biased AI models selects established suppliers from previous performance records instead of evaluating new suppliers who potentially provide better efficiency. AI decisions need to operate with absolute fairness and transparency in order to preserve ethical operations within supply chain networks. Every organization needs to conduct frequent AI model examinations while creating bias-detection tools alongside employing diverse information sets to minimize biased results. The adoption of AI faces major difficulties because of regulatory requirements. National governments across the globe implemented mandatory data protection laws, which include both GDPR in Europe and CCPA in the United States. AI-driven supply chain solutions for e-commerce businesses must demonstrate full regulatory compliance to defend the security of customer data along with supplier data (Bhargava et al., 2021). Non-compliance with laws leads businesses to suffer from high costs through severe legal consequences and serious damage to their reputation, along with decreasing consumer trust. Businesses should dedicate funds to build data protection protocols and secure database-managed systems, together with explainable AI technology frameworks.

Implementation of AI supply chain management in e-commerce requires successful handling of practical concerns involving resistance to change, along with financial hurdles and compliance regulations. The complete utilization of AI benefits through risk minimization depends on investing in employee training as well as implementing cost-effective AI solutions and following ethical and legal frameworks.

4.1.5 Supply Chain-Specific Challenges

4.1.5.1 Operational and Security Challenges in AI-Driven Supply Chains

Predictable market variations together with alterations in customer market trends and outside factors, which include economic disturbances and worldwide pandemics, can produce incorrect forecasting results (Rangaraju, 2023). The ability of AI models to adapt and learn is limited by unpredictable market fluctuations, which produce stock shortages or overstocking as a result. The prevention of these security issues demands that businesses unite AI systems with current data feeds and utilize forecasting algorithms that merge artificial intelligence technology with standard approaches, as well as create backup strategies when demand changes. AI-powered supply chains face two crucial risks stemming from cyber dangers as well as problems regarding data confidentiality (Fosso Wamba et al., 2022). AI processing systems handle large volumes of confidential details such as customer records, together with supplier agreements, along with logistical documents. AI technologies experience high attractiveness to cyber attackers who attempt data breaches and ransomware attacks, and unauthorized access. Security flaws within any part of the supply chain network will compromise the entire system because AI systems operate through cloud computing platforms, which connect multiple networks (Eyo-Udo et al., 2024). Businesses operating within the supply chain need to develop robust cybersecurity systems that combine encrypted data protection with multi-factor verification and perpetual AI system protection to defend their operational network. The protection of consumer data alongside the avoidance of legal problems depends on following data privacy law requirements, which include GDPR and CCPA.

4.1.6 Scalability and Standardization in AI Implementation

Wide-scale AI deployment becomes complex because global markets show differences in available data, together with their connectivity networks and AI assimilation achievements. The AI scalability faces problems because different regions hold advanced digital infrastructure, which contrasts with traditional supply chain use in other areas (Elufioye et al., 2024). Companies need to develop adaptable AI systems that handle varying market situations and deploy AI solutions through the cloud, and build partnerships with local entities to achieve smooth system integration. Standardization of AI frameworks remains a problem alongside compatibility challenges that exist between different platforms. Supply chain management depends on the utilization of multiple AI models and different data formats and machine learning methods, which operate without established industry-wide standards (Modgil et al., 2022). The lack of uniformity between AI systems

produces integration problems that decrease interoperability between networked AI systems and complicate AI implementation processes. Standardization in the business sector can improve through universal AI frameworks adoption, together with regulatory body collaboration and support from technology providers, and platform compatibility when selecting AI solutions. For AI to deliver its supply chain efficiency advantages, it is essential to resolve demand forecasting, cybersecurity, scalability, and standardization challenges for better implementation outcomes.

4.1.7 External and Market-Driven Challenges

AI regulations, along with policies, show significant differences from one nation to another, which determines the possible implementation of AI-powered supply chain solutions by businesses. Businesses must follow data protection regulations under EU GDPR in areas where these laws apply because they need to comply with requirements for consumer and supplier data handling (Cheng et al., 2021). AI governance standards between different countries create gaps that affect how companies share their data, as well as their ethical guidelines for AI use and their automated process protocols. Mutual inconsistencies between countries make it impractical for e-commerce businesses with international operations to create standardized AI-powered supply chain management systems. The solution to this issue entails three solutions: businesses need specific compliance methods for each region and dedicated legal support, and they should maintain relationships with regulatory authorities for both rule compliance and operational efficiency. The problems created by worldwide supply chain breakdowns make AI implementation more difficult (Mennella et al., 2024). AI models find it difficult to generate accurate supply chain predictions because of events that include geopolitical conflicts together with economic recessions, and pandemics. Global supply chains showed their weaknesses because COVID-19 lockdowns, together with workforce shortages, created problems with delivery timelines and distribution systems.

4.1.8 Market Readiness and Competitive Pressures

Regimental adoption of AI-driven logistics methods and inventory management tools becomes essential because non-adopters will experience diminished competitive potential compared to their AI-using rivals. Market leaders use AI technology to track operations in real-time and forecast demand and automate their warehouses, which makes their operations more efficient while decreasing operational expenses. Small companies together with developing markets face barriers to AI implementation because they have scarce funding and inadequate support teams, and insufficient infrastructure (De Almeida et al., 2021). Advanced AI capabilities separate business performers from others because they maintain leadership positions in the marketplace. Competitive businesses succeed through AI adoption by dedicating investments to AI solutions that scale efficiently without high costs. Smaller firms benefit from working with AI vendors combined with government subsidies for AI implementation and cooperative agreements across different industries to overcome adoption challenges. Employee and business leader

training about AI establishes market readiness and speeds up the process of transforming supply chains with AI-based systems (Neumann et al., 2024). For AI to transform supply chain operations, it is necessary to resolve regulatory obstacles as well as geopolitical conflicts while handling competitive market pressures. Successful businesses will maintain leadership by creating flexible AI approaches and fulfilling regulatory requirements while adopting AI solutions driven by market demands in upcoming e-commerce environments.

4.1.9 AI Bias and Fairness

4.1.9.1 Ethical Considerations in AI-Driven Supply Chain Management

Supply chain management decisions become a matter of ethical concern because of the increasing AI system integration. AI systems aimed at delivering efficiency together with reduced costs and better operational precision might unintentionally generate new ethical problems. The use of AI-driven warehouse automation produces labor-related job losses, which primarily impact entry-level workers (Ijiga et al., 2024). Supply chain AI decision systems operate with limited transparency that hinders businesses from justifying the selection of suppliers and approaches to delivery routes and inventory strategies (Mäenpää et al., 2024). AI model "black-box" operations generate challenges for accountability because decision-making processes are not straightforward to understand, thus creating difficulties when supply chain operation errors happen. Companies need to develop transparent AI models and establish ethical rules for AI decision-making, along with implementing explainable AI techniques for ethical AI adoption.

4.1.9.2 Ensuring Fairness and Eliminating Bias in AI Supply Chains

The main requirement for AI-supplied supply chain management includes unintentional discrimination because biased algorithms generate discriminatory practices between suppliers. AI models use historical data during training because if their training data contains biases such as geographic supplier selection or gender hiring imbalances and market favoritism, AI decisions will support these discriminatory practices. An AI-based supplier selection tool shows a preference for big suppliers compared to small minority businesses because it mirrors historical procurement choices, thereby producing unjust competition (Eyo-Udo et al., 2024). To overcome these biases, companies ought to have an evaluation of AI training data and implement fairness measurement systems to have datasets, which reflect diverse information. The influence of bias in artificial intelligence algorithms pollutes the prediction of demand as well as inventory system allocation (Muldoon et al., 2023). The inaccurate AI predictions take place in cases when the incomplete or biased data sources result in the unfavorable results in relation to some groups of consumers or geographical areas. The shortages of stocks are observed in the markets less attended, whereas some demographic regions experience the overstock issue constantly due to insufficient demand levels compared to the forecast. As a way of addressing the risks of this kind, businesses must implement bias detection mechanisms and humanize AI decisions besides engaging in constant algorithm reviews to revise their algorithms.

Table 1. AI Implementation Challenges in E-commerce Supply Chains

Category	Challenges
Technological	- Legacy system integration issues
	- High computational expenses and power consumption
	- Data quality issues and inconsistencies
	- Lack of AI model transparency (black-box issue)
Organizational	- Workforce resistance to AI adoption
	- Shortage of AI-skilled professionals
	- High implementation and maintenance costs
	- Ethical concerns regarding fairness in AI decision-making
Supply Chain-Specific	- Demand forecasting inaccuracies due to market volatility
	- Cybersecurity threats and data confidentiality risks
	- Scalability issues due to regional differences in AI infrastructure
	- Lack of AI standardization across platforms
External & Market-Driven	- Regulatory compliance challenges (GDPR, CCPA, etc.)
	- Global supply chain disruptions due to geopolitical events
	- Market competition pressures for AI adoption
	- AI bias in supplier selection and resource allocation

5. DISCUSSION AND FUTURE RESEARCH DIRECTIONS

The synthesis of the literature analysis and the analysis of challenges show that, despite the incredible potential of changing the process of the e-commerce supply chain management, the productive use of this sphere of evolution is restrained by many-sided challenges. These barriers include technological barriers, financial barriers, regulatory-driven barriers, and organizational barriers; they can affect the rate and the level of AI adoption in the international e-commerce. The particular predictive demand and simplified operations give AI a chance to be a fundamental part of digital transformation since it could be implemented in an economical way to improve the customer experience and full automation of the logistics (Trushkina, et al., 2020). Any form of advanced AI implementations is bound to perform pathetically unless it is implemented in a well-structured and supported adoption plan. The strategic value of the implementation benefits is in the transformational value of AI potential performance supply chain. The cases of the data fragmentation, the absence of interoperability, and skill gap are the issues that can be addressed in a manner that would introduce the new spheres of efficiencies and responsiveness within e-commerce companies. These

integration systems and high-order technologies could be invested in to ensure that the seamless flow of communication among the suppliers, the manufacturers and other logistics partners so that the AI systems would be running on reliable and well-prepared datasets. The willingness of the organization such as the assistance of the management and training of the staff is also significant and may be key in facilitating the acceptance and reduction of resistance to change. The fact that companies have already taken the step of investing in these areas is more privileged, as it is already using AI in predictive analytics, automated intelligence, and customer-centric logistics.

Nevertheless, the advantages of the adoption of AI over a successful adoption are more. Guidelines would be to make operations and strategies more dynamic in the more dynamic e-commerce space in the long-run. The wider AI-related implication of supply chain risk management and resiliency is larger. The COVID-19 pandemic has shown that the conventional supply chains were vulnerable to bad fortunes because of unexpected changes (Sheffi, 2020). Remembering that AI-crated systems have the capacity to observe the equipment, as well as the procedures that the equipment can perform, they make a company more sensitive to the possible disruption and capable of reacting to the emergency. The AI investment is not merely the modernization of the technology, but an investment in the functionality of supply chains, which is becoming a more popular topic as one of the determinants of competitive advantage in the e-commerce market (Qi, et al., 2023).

5.1 Performance of AI adoption recommendation Policies and Managerial Recommendations

The policy level interventions and managerial activities are required in order to implement AI in e-commerce supply chain. Another way that can be played at the policy level by policymakers and even the regulatory bodies of the industry would be to build an enabling ecosystem to the integration of AI. This implies development of standardised data governance models, data security, and the wise application of AI in making supply chain decisions. The tax benefits, research grants, and innovation hubs are the incentives that can be employed to come up in order to promote the use of AI technologies by small and medium-sized enterprises (SMEs) (Kalpaka, et al., 2020). In addition, bridging the knowledge gap may be achieved by the participation of the world of academia in collaboration with technology developers and industry practice through a partnership that is led by the government. This would render AI research projects to be aligned with the practical needs of the e-commerce processes, but have been published in a transparent, accountable and without losing the consumer confidence. In terms of management perspective, AI application must be introduced in an integrated way of thinking of e-commerce firms. This begins by building an efficient strategic vision to incorporate the adoption of AI with business expectations. In case of investing in an extensive AI initiative, the managers should conduct opinion preparedness regarding the existing infrastructure, information capacity, and labor capacities (Sey & Mudongo, 2021). Sanctification of the risks associated with financial constraints and integration constraints can

also be resolved through generating scaleable and modular AI solutions. Pilot projects, in which companies test AI applications in one specific area (size e.g. predicting the demand in warehouses or automating warehouses) should be the first messages that companies focus on and then go broad in the organization.

The future scenario of scientific research is also characterized by great prospects of ethical aspects of developing AI-controlled decisions in supply chains. As AI systems gain more importance in strategical business decision making, beginning with the selection of suppliers and pricing policies, there is a need to develop ethical governance. Researchers should delve into any type of bias, discrimination, and lack of transparency of AI algorithms with regards to its effects in supply chain morality and diversity. Development of the ethical guidelines alongside the principles of how the AI is to be implemented in international e-commerce-related activities could become a means of preventing such unpredictable results and responsible innovation. The fact that it has been observed that the aspect of scalability and decision-making in the real-time was a challenging issue in the previous analyses is a testament to the fact that additional empirical research is needed. The question of future research can contain the development of cortative AI systems that have the ability to process high-rate streams of flowing data and stay accurate and clear. Academia ought to be alongside industry whereby such concepts would be experimented and tested in the real world context to develop something that would have value. The potential of longitudinal studies regarding the consequences of adopting AI in companies, job creation and/or vacancy elimination, as well as client satisfaction, is high. Most of the existing research provides short-term analysis or cross-sectional studies in such a way that no information exists of the long-term effect of AI.

6. CONCLUSION

This paper has discussed the business but transformational side of the Artificial Intelligence (AI) in e-commerce supply chains and the opportunities it provides and the difficulties that may hinder its successful implementation. The key pieces of information that have been learned consist of the concepts that AI technologies, such as machine learning, natural language processing, computer vision, and blockchain integration, can provide support in the process of enhancing the efficiency of the operations, predicting the performance, and the satisfaction of the customers; such factors can be enhanced, but it is extremely reliant on overcoming significant challenges in their implementation. Such risks which encompass technological, financial, organization and regulatory issues must be well addressed with the perceptions of transforming the implementation of AI to be an experience of sustainable competitive advantage. The article attests to the fact that AI is more than a technological device and it is a strategic facilitator that has the capability to alter the dynamics of a supply chain and generate resilience and lead data-intensive decision-making processes through e-commerce ecosystems. The research can benefit the practitioner and the academia. Theoretically, it is a summary of the existing studies that are carried out regarding the adoption of AI, which,

though, continues further by identifying the major impediments and ways in which they can be resolved. It points to the necessity of ensuring that AI projects are integrated with more strategic supply chain objectives and thereby enables more technological innovation-percentage disconnect seem to be permitted between the management implementation of the technology innovation. The research, as a practitioner, offers one such useful ingredient on how e-commerce organisation can be successful in terms of integrating AI technologies within it - with the role of organisational preparation, data management, human development, and functions integration. The paper gives the strategic implications related to the implementation of AI that ought to be deployed by the decision-makers as the guideline regarding whether they are prepared, effectively make use of resources, and have the capacity to design policies that facilitate innovative methodologies and manage risks. To effectively embrace AI, key to the successful integration, the vision needs to bridge technology and business strategy. The most critical investment was in data infrastructure of supply chain managers to maintain a certain level of data consistency, access and security, which are the pillars of effective AI performance. Second, the government, academic, and industry should cooperate to provide conducive policies, ethics and knowledge

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