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Impact of AI and Machine Learning on Supply Chain Optimization in Developing Economies

Neha Soni

Computer Science Engineering, RIMT University

ruheesoni01@gmail.com (Corresponding Author)

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ABSTRACT

Background: Emerging economies face various unsolved issues that limit supply chain development, such as inefficiency and unhealthy competition, lack of transparency, and an underdeveloped technological infrastructure.

Purpose: This paper describes how Artificial Intelligence and Machine Learning can solve these problems with the help of supply chain management in various areas. In developing economies, Artificial Intelligence and Machine Learning are transforming supply chain management, offering exceptional opportunities for optimization. In this paper, the innovative potential of AI and Ml is explored, as how this technology enhances supply chain efficiency, minimizing operational cost and optimizing decision-making in resource bottleneck environments. There are so many unique challenges in developing economies that impact supply chain performance such as gaps in infrastructures, partial access to data, and irregular market conditions.

Methods: A literature review of recent studies and reports on AI and ML applications. This paper discusses the concept of the supply chain, artificial intelligence, and machine learning, and recent applications of Artificial Intelligence and Machine Learning in the processes of the supply chain, it analyses critical constraints to adoption, skill gaps, investment hurdles as well as technological readiness.

Results: AI and Machine learning-driven technologies are strengthening organizations in various fields to better presume trends in the market such as decreasing the lead time, enhancing the level of inventory, probabilistic analytics, and market forecasting. This paper studies the continuous with a discussion of how supply chain optimization using AI and ML might promote long-term economic growth in developing nations and policy recommendations to encourage wider usage of these technologies.

Conclusion: In the end, Artificial Intelligence and Machine learning are critical instruments for enhancing supply chain competitiveness and resilience in the face of external economic challenges. Even though there are some hurdles such as technological adaptation and infrastructural requirements, the implementation of AI and ML can help improve supply chain efficiency and enable economic growth in emerging economies.

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1. Introduction

The current state of global supply chains is typified by a constant rise in complexity and dynamic nature. Globalization, technology breakthroughs, changing customer needs, and other factors require a paradigm shift in favor of more flexible and agile management techniques. In this regard, artificial intelligence and machine learning have surfaced as game-changing technologies that might completely alter the way companies plan their supply chains. Organizations can improve efficiency, resilience, and customer happiness by implementing proactive tactics for their supply chain ecosystems and gaining a deeper understanding of them by utilizing the power of machine learning and artificial intelligence. This study explores the various ways that artificial intelligence can be used to optimize supply chain management. We concentrate on three crucial areas such as market forecasting, inventory optimization, and probalistic analytics that have enormous room for development. In these fields, traditional methods frequently depend on manual intervention, historical data analysis, and reactive measures. But AI-powered solutions offer a more advanced and data-driven methodology, allowing companies to foresee problems, adjust to shifting market conditions, and maximize resource distribution throughout the whole supply chain network (Dauvergne, 2022). The fundamental goal of this research is to look into and examine the impact of AI on three critical components

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of supply chain management. This paper reviews existing literature and explores real-world case studies to highlight AI's transformative potential for creating a more proactive and intelligent supply chain environmen (Druehl *et al.*, 2018).

1.1. Supply Chain

In academic literature, the term "supply chain" is well documented and typically refers to the arrangement of businesses that offer goods or services to the consumer market. Every one of them puts forth a definition based on the field it originates in and the goals that guide its examination. While some definitions adopt a business or process perspective, others adopt a product perspective. The supply chain is responsible for organizing and directing the entire material flow, which starts at the supplier and ends at the final consumer, passing via the distributor and manufacturer. They define it as the entirety of actions that have an impact on the customer's realization, whether directly or indirectly. In addition to manufacturers and suppliers, the supply chain also consists of transporters, warehouses, retailers, and actual consumers (Chopra & Meindl, 2016). The procedure that begins when a customer puts an order and continues until the good or service is delivered and paid for is generally referred to as the supply chain. Thus, the procurement of raw material, the intermediate transformation of the product, its delivery to the final client, and the planning, execution, and management of all operations about the movement of materials and information are all included in the supply chain. It is a group of interconnected businesses working together to carry out tasks that guarantee the flow of goods and services from the point of creation to the conclusion of their useful lives. Consumer demands are evolving, and they now anticipate a greater range of services, such as specific delivery methods, replenishment schedules, delays, dependability, supply security, data transfer, and post-purchase support. In terms of packaging, replenishment, and forecasting modes, this forces all the stakeholders to further integrate directly through data capture and direct transfer techniques into the ultimate consumer's sales act. Due to globalization, the growth of many sorts of flows, and the evolution of global consumption patterns, supply chains have grown extremely complicated in the modern day. The goals of the supply chain are, in general, to process orders, guarantee the availability and storage of goods and raw materials, plan orders and deliveries, and anticipate and forecast consumer needs. It consists of multiple components such as production planning, inventory management, transportation management, and demand forecasting and planning (Blackhurst *et al.*, 2018). It seeks to reduce the costs associated with these elements of storage, transportation, and product availability by operating along these guiding principles. Good supply chain management can lead to important outcomes like "zero stock," "just in time" delivery, and most importantly, the absence of worldwide stock shortages. As a result, the supply chain can be thought of as a network of businesses dedicated to effectively managing the flow of all services at the most affordable price. Information technologies are used to maximize all of this, as is the sufficiency of information flow against the various networks of businesses dispersed along the product's distribution chain. Businesses will need to handle their supply chains far more skillfully than they do now if they want to survive in the years to come. Companies change for a variety of reasons, chief among them being the following: an increasing number of competitors, an outgoing demand from customers for better service, more options and cheaper pricing, and the ongoing evolution of technologies.

1.2. Artificial Intelligence

A subfield of computer science called artificial intelligence is concerned with building machines that can carry out operations that normally call for human intelligence. These activities include applying prior knowledge, deciphering language, identifying patterns, problem-solving, decision-making, and even emulating creative human behavior (Belhadi & Landry, 2022). AI aims to create machines that can carry out activities on their own either by imitating human brain processes or by coming up with completely new approaches to problem-solving.

In general, AI falls into two categories:

- Narrow AI, also known as weak AI, is created to perform a single task or a small range of tasks, including chess playing, language translation, or facial recognition. That includes the majority of AI systems in use today.
- Strong AI, or general artificial intelligence, is a theoretical type of AI that is capable of all intellectual functions that humans can do, such as learning, thinking, and adapting to a wide range of tasks. This is still only a notion, not an actuality.

A range of algorithms are used by AI to carry out tasks. Here are a few of the most important AI algorithms:

- Search Algorithm: It is used to search for ideal or nearly ideal solutions by navigating a solution area. As an illustration, consider Depth First Search and an algorithm.
- Deep learning algorithm: These methods use multi-layered neural networks, or deep networks, as a subset of machine learning that draws inspiration from the structure of the human brain to interpret complex data. Typical algorithms are as follows:

    - CNN: Convolutional neural networks are mostly used for the recognition of images and videos.
    - RNN: Recurrent neural networks are beneficial for applications requiring sequences, including time series prediction or speech recognition.
- Genetic Algorithm: They produce solutions to optimization and search issues through the process of natural selection. They progress a group of potential solutions in the direction of superior ones.
- Fuzzy logic: Approximate reasoning is handled by this approach as opposed to fixed or exact reasoning. In control systems, when judgments must be taken in the face of uncertainty, it is frequently utilized.

1.3. Machine Learning

A subtype of artificial intelligence known as machine learning enables software, systems, or algorithms to learn and adapt without having to be explicitly designed to do so. Typically, machine learning (ML) employs data or observations to create a computer model that is used to study and improve technology performance by combining various data patterns with real and anticipated outcomes. Algorithm-based machine learning models perform a great job of identifying abnormalities and deriving predictions from large amounts of data. It is the perfect answer to some of the most important problems facing the supply chain sector because of these strong attributes (Mahraz *et al.*, 2022). There are three primary groups of algorithms that we can identify based on the data that each one uses throughout the training or learning pr Berrado Focess.

1.3.1. Supervised Learning

Supervised learning has predictive analytics to predict a consumer with market-based analysis, and segmentation using k means clustering which is needed for demand fulfillment, marketing, and other logistics functions that can change the world we live in today into a more of data-driven society. These algorithms help the marketing machine learn and predict customer lifetime values, churn rates, and responses to marketing campaigns.

1.3.2. Unsupervised Learning

Unsupervised learning is highly effective when shoehorning unlabeled data into predefined categories, market segmentation, and consumer preference. Consumers are grouped by clustering algorithms in similar behaviors of taste. Visualizing high-dimensional marketing data to reveal hidden patterns and relationships using dimensional reduction techniques. With these algorithms, marketers can find specific customer characters and make plans for their own.

1.3.3. Reinforcement Learning

Reinforcement learning has a high impact on real-time decision-making, such as through dynamic pricing and personalized recommendations. Machine learning algorithms are trained by interacting with the environment and receiving feedback from its decisions as a response to it, therefore improving market outcomes based on past experiences (Zhao *et al.*, 2022). To optimize campaign reinforcement, learning can be used to dynamically manage bids within programmatic advertising.

2. Applications

Computer-based forecasting and demand planning are not new. It is built on a set of algorithms that use numerous data sets, such as shipment data, product lifecycle data, ordering patterns, manufacturing data, and so on, to forecast over time. In contrast, the AI-enabled system understands the best feasible algorithm and data set combinations to evaluate for an accurate forecast. More crucially, AI is helping firms to:

- Acquire almost 100% accurate projections and forecasts of client demand.
- Optimize their R&D, resulting in increased manufacturing with cheaper cost and improved quality.
- Assist with promotion by identifying target customers, demographics, pricing, and messaging.
- Enhancing customer experience.

To obtain competitive edge, these four value-generating domains are crucial.

2.1. Forecast Demand and Optimization

Artificial intelligence has proven to be useful in forecasting and projection. Businesses are constantly trying to strike a balance between supply and demand. Consequently, improved forecasting is required for its manufacturing and supply chain. Artificial intelligence provides accurate and dependable demand forecasting, enabling businesses to optimize their sourcing in terms of purchases and order processing and thereby reduce costs associated with transportation, warehousing, supply chain administration, and other related expenses. This is because artificial intelligence can process, analyze (automatically), and most importantly, predict data. Furthermore, because it recognizes patterns and trends, better production and retailing strategies can be created. Businesses can use this technology, for instance, to minimize waste and stock only the precise quantities (as exact as each individual unit/product) of the things they want to sell. In addition to past sales data and supply chain configuration, machine learning

techniques often rely on near-real-time data about variables like prices, local weather forecasts, and advertising efforts (Ghiani *et al*., 2023). Artificial intelligence is also utilized in R&D departments to determine rapidly whether a prototype has a high chance of succeeding in the market and, if not, why. More significantly, it reduces waste in the design to produce designs that are more efficient. As a result, artificial intelligence has significantly contributed to smart manufacturing.

2.2. Production

Production has benefited greatly from artificial intelligence because of its potential to:

- Better optimize resources and processes.
- Create the best teams possible. that is, teams made up of both humans and robots.
- Enhance quality and reliability that is, create error-free products.
- Minimize maintenance downtime.

Artificial intelligence and machine learning technology have greatly advanced automation processes. One of the more sophisticated areas of artificial intelligence robotics is crucial to the manufacturing of robot behavior and has changed as a result of advances in semantic segmentation and object recognition technologies, especially when it comes to how the robots perceive the characteristics of the materials and objects they interact with. The new camera-equipped, artificial intelligence-enhanced robots are taught to identify empty shelf space (Bughin *et al*., 2017). This results in a significant speed advantage over traditional techniques for selecting items. Because of this, things can be handled by robots without needing to be in fixed, predetermined positions. In its retailer's warehouse, Ocado, a UK supermarket, uses one of the artificial platforms. There, robots navigate thousands of product-filled bins across a complex network of conveyor belts and deliver them to human packers in time for them to fill shopping bags (Dale, 2018). Similarly, additional robots whisk the bags to delivery vehicles, whose drivers find the optimal path to their customers' homes based on the weather and traffic.

2.3. Promotion and Pricing

Because of this, things can be handled by robots without needing to be in fixed, predetermined positions. In its retailer's warehouse, Ocado, a UK supermarket, uses one of the artificial platforms. There, robots navigate thousands of product-filled bins across a complex network of conveyor belts and deliver them to human packers in time for them to fill shopping bags. Similarly, additional robots whisk the bags to delivery vehicles, whose drivers find the optimal path to their customers' homes based on the weather and traffic. Millions of pieces of data about customer behavior, such as the optimum frequency, what grabs their attention the most, and the best days and times of the week to contact the user, are analyzed by machine learning software (Dash *et al*., 2019). The artificial platform determines and forecasts the ideal audience for the brand by analyzing data, including interests, demographics, and other factors. Adext is an artificial platform that can handle and optimize ads on several platforms, such as Facebook and Google Adwords, automatically. More significantly, it identifies the most likely purchasers and facilitates the intended action or conversion. Artificial intelligence has completely changed search engine optimization and online searches. Customers can easily conduct searches using AI-powered gadgets like Microsoft's Cortana, Apple Siri, Google Home, Amazon's Echo, and Apple's Home by just pressing a button or speaking a voice command. (Deb *et al*., 2018). Google's Rankbrain system can understand the speech of users and return the most relevant results according to the user's language and context. That well-known long-tail term will therefore become obsolete. To replace dull keywords with more conversational ones, astute marketers will employ inventive wording that can boost their website's traffic and clientele. The best thing is that an AI platform like Grid can customize a website for each consumer and alter its content according to their preferences, which has completely changed the web design industry. Numerous companies currently use AI-powered chatbots on their websites. More significantly, because they are quick, they can address customer's issues more quickly and provide 24/7 customer service.

2.4. Delivery

The user experience, or making things richer, more personalized, and more convenient for the user, has received increased attention lately. Making every consumer feel special and welcome is the main focus of modern business, although this is a difficult task. In the past, this was challenging and costly, and it was frequently only available to the wealthiest customers. It has radically transformed as a result of AI technologies like machine learning and computer vision. When a typical grocery consumer places several bananas in his cart, for instance, cameras or other sensors may transmit the information to an AI program, which would then have a decent notion of the shopper's preferences based on past purchases. In Seattle, Amazon has constructed a retail outlet that enables customers to grab food from the shelf and leave the store without using a checkout machine to pay. Amazon Go is a store that uses computer vision to track customers once they swipe in and match them with things that have been taken off of shelves. Amazon provides customers a receipt

and charges their accounts for the things in their bags as they depart (Bughin *et al.*, 2017). Drone delivery is becoming a reality. There has been an increase in this field after Amazon completed a successful pilot delivery in rural England in 2016. Google and Chipotle collaborated to bring burritos to Virginia Tech, and Domino's Pizza and Flirty successfully finished a commercial pizza delivery in New Zealand. Drone data is now regularly collected by Amazon during house delivery in order to target future orders. AI is delivering the perfect tools for operation management in every industry, including healthcare, education, and transportation (Druehl *et al.*, 2018).

2.5. Smart Retailing

Artificial intelligence helps industrial and retail companies make better decisions by enhancing supply management, creating memorable theme promotions, and forecasting more accurately and in real time. Artificial intelligence is also improving operational efficiency through robotics and process optimization, which raises output and lowers the cost of manual labor. It is common knowledge that interactive robots are used in stores and warehouses. Large training data sets, new mathematical models, and more powerful computers are what enable the improvement in improved vision. In the field of computer vision, the performance of object identification and semantic segmentation. The capacity to classify them by item type, such as differentiating a tool from a component, has lately improved dramatically. When extending their physical footprints, merchants can forecast future shop performance with the use of artificial technologies. Retailers now use artificial intelligence to improve their location and storage capacity. Merchandising is a crucial component of the retail industry. Artificial intelligence is assisting in merchandising and offering chances to increase assortment efficiency. By employing statistical and geographic modeling, they forecast and reduce their stock. Artificial intelligence is integrated into Amazon's key business processes. Machine learning algorithms navigate thousands of products over a network of conveyor belts in the retailer's warehouse in Seattle, delivering them to workers in time to fill shopping bags. Other robots move cars to delivery vehicles, whose drivers are directed by an artificial intelligence program that determines the optimal path based on traffic and weather conditions (Burgess, 2018).

2.6. Smart Manufacturing

Artificial intelligence has revolutionized the manufacturing industry. From advanced robotics to virtual assistants, manufacturing organizations can now manufacture more goods with fewer errors to meet demand. By automating risky tasks, they can shorten development cycles, increase engineering efficiency, prevent errors, increase safety, lower inventory costs through improved supply and demand planning, and increase revenue through improved sales lead identification and price optimization. All of these benefits contributed to their paid growth (De Jesus, 2019). The novel idea of intelligent manufacturing is a clever method of production in which humans and machines collaborate side by side with little supervision. The Siemens manufacturing division is the best illustration of intelligent manufacturing. Manufacturers are optimizing key performance metrics and reviewing them in real-time with the help of. For instance, customizing a model with virtual programs can save energy consumption and better anticipate, detect, and mitigate staffing and material bottlenecks. More significantly, it notifies the engineers in advance of issues and suggests fixes. AI enables manufacturers to improve time to market, minimize waste, and cut costs while improving assembly line operations. In agriculture, AI is likewise not far behind. The idea of e-plants in a box is a reality that is fantastic for transportable, small-scale, low-capital expenditure plants that can generate a constrained variety of goods at a reasonable price. Huxley uses machine learning, computer vision, and an augmented reality interface to essentially allow anyone to be a master farmer. More significantly, these e-plants can be shipped to distant markets where local, inexpensive production is required and to areas where demand is very high. (Bughin *et al.*, 2017).

3. Conclusion

Artificial intelligence is being used in more commercial sectors thanks to technological advancements in mobile computing, artificial neural networks, robotics, cloud-based machine learning, robotics storage, and information processing algorithms. Due to AI's considerable competitive advantages, many companies are utilizing it in key aspects of their value chains. Most significantly, supply chain, assortments, and marketing are only a few of the manual tasks that have been eliminated thanks to AI technologies. AI is being used by the e-commerce industry to establish prices, customize promotions, manage warehousing and logistics, and forecast trends. Some even go so far as to ship goods and anticipate orders before they have received confirmation of the transaction. In a similar vein, smart manufacturing has arrived. Additionally, businesses must adapt their operations to accommodate the shift from human operators to AI-enabled robots and machines. It is encouraging to see that the trend in AI-driven global industrial operations is rapidly growing, indicating that AI is either currently a concern for many businesses globally or is quickly becoming one. Enhancing the effectiveness of the supply chain is essential for many enterprises. Process improvements of any kind can

make a big difference for organizations that operate with profit margins. Accurate demand forecasting and managing the issues of volatility in global supply chains are made easier by innovative technologies like machine learning. According to studies, in the upcoming days at least 50% of international businesses engaged in supply chain operations will be utilizing transformational AI and ML technology. This illustrates how machine learning is becoming more and more common in the supply chain sector. However, in order to fully benefit from machine learning, businesses must make future plans and start investing in associated technologies and machine learning today in order to enjoy higher profitability and efficiency.

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Authorship Contribution

Neha Soni: Conceptualization of the research idea, writing the manuscript, and manuscript proofreading.

Conflicts of Interest

Author declare that they have no conflicts of interest that could have influenced the work reported in this paper.

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Chitkara University, Saraswati Kendra, SCO 160-161, Sector 9-C, Chandigarh, 160009, India

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