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Transforming supply chain management through adoption of artificial intelligence: Indian context

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Abstract
Artificial Intelligence (AI) has the potential to revolutionize various aspects of business operations. AI can be used to analyse data and make predictions about demand, optimize logistics and transportation routes, and identify in-efficiencies in the supply chain. This can lead to improved responsiveness to changes in demand, reduced lead times, and lower costs. With the help of AI, supply chain managers now get a clearer picture of the overall system, leading to smarter decisions and more attentive customer service. This trend took root with the introduction of expert systems and fuzzy logic and reached full maturity sometime after 2010. Since early 2010, AI applications have exploded in popularity, generating both excitement and trepidation about the future of labour and corporate administration. The supply chain literature appears to be playing catch-up with some recent efforts to incorporate modern AI methods within its core studies, even though businesses are embracing AI and investing in AI solutions to improve their end-to-end supply chain operations. Today's state-of-the-art AI was molded by the development of big data, analytics, and various graphics processing unit (GPU) and deep learning (DL) applications.

Keywords: Artificial intelligence, big data, cost reduction, Indian context, supply chain management

Introduction

New machines have arrived on the scene. The first machine age, known as the Industrial Revolution, resulted in the automation of physical labour. The machine age that we have now entered-the Digital Revolution-will further the automation of physical labour and drive the computerization of cognitive tasks through the rise of Artificial Intelligence (Al), i.e., "intelligence" exhibited by machines.

The concept of "intelligent" artificial beings is not new. Since the 19th century, history and literature have provided fantastical approaches to Al. The most striking example is Mary Shelley's creation of Frankenstein's monster two hundred years ago. The idea of this creature, incidentally, came about during the gloom created by the 1815 volcanic eruption of Mount Tambora in Indonesia, which led to around three years of global climate upheaval, disrupting the rhythm of the seasons and disturbing temperatures and rainfall, causing famine, epidemics and social disorder.

In 1950, Alan Turing developed his famous Al test, which aims to measure the ability of a machine to exhibit behaviour that is indistinguishable from that of a human. The Turing test separates a human interrogator from two respondents-a computer and a human. If the interrogator is unable to tell who is responding, the machine is considered to be a successful Al tool.

The field of Al research was developed in the 1950s by pioneers such as Herbert Simon, Allen Newell, John McCarthy, Marvin Minsky and Arthur Samuel. All were optimistic about the future of Al, and had concluded that within twenty years, machines would be capable of accomplishing any human task. Minksy claimed that, "within the next generation, the problem of creating 'artificial intelligence would substantially be solved." in hindsight, they failed to identify significant obstacles that lay on the path to achieving this goal.

In the years that followed, the field of Al went through several cycles, with periods of disappointment, criticism and funding cuts (called Al winters) alternating with brief periods of renewed interest.

As we all bear witness today, the field of Al has made remarkable progress in the last 20 years, driven by a combination of factors:

- exponential growth in computing power and memory capacity;
- the development of cloud computing and distributed and parallel processing;
- the availability of large databases (to "train" algorithms);
- global connectivity of both humans and machines; and
- last but not least, significant improvements in theoretical understanding.

Since the 1950s, the field of Al has evolved to cover an extensive range of concepts, including cognitive computing, natural language processing, robotics, image analytics, sensors and numerous areas of research.

Machine learning, which can be defined as the science and engineering of making machines "learn", is at the heart of Al. These processes have already become ubiquitous in daily life, from search engines to virtual assistants and robo-advisors, and leave many to wonder where this burgeoning field of research could lead.

The Al revolution is a priority topic for decision makers, governments and private industries given the economic, geopolitical, social and business consequences it may have in the years to come.

Artificial Intelligence: A Game Changer for Business Arena

Since its inception in 2012, Al has seen both development and collapse due to several factors. The last two decades have seen a resurgence in the interest and uses of Al across several industries as a result of the increased flow of data and complexity that has evolved in business scenarios **(**Scholten *et al*. 2014) [19]. The potential of Al in many business functions is being explored in light of current needs and future goals. Al is defined as a network of computers that can simulate human intellect while making decisions on

how to approach a business problem **(**Huang & Rust, 2018) [13]. Al helps with business system design thinking and learns from data to gain insights without human input. With the help of Al, organizations can pinpoint the weak points in their supply chain management and allocate resources accordingly **(**Fosso Wamba & Akter, 2019) [9], By rapidly extracting client expectations, sensing the market, utilizing failure modes, optimizing internal and external supply chains, and encouraging a more creative workforce through the automation of routine tasks, Al has the potential to help businesses build the best possible goods (Jabbour *et al*., 2020). There has been a steady uptake of Al by industries as diverse as manufacturing and e-commerce to solve supply chain problems. Most supply chains experienced a new level of resilience testing during COVID-19 as they were challenged to handle increasingly complicated jobs (Zouari *et al*. 2031).

Customers in the modern corporate world want supply chains to provide both customized solutions and reliability. With the use of Al, a system has been designed to detect client profiles and provide individualized products without compromising security or privacy. In conclusion, the application of Al is expanding at a rapid rate, and supply chains and organizations that don't recognize and capitalize on Al in their operations may soon be unable to achieve the necessary supply chain resilience in the dynamic business market that can emerge because of COVID-19-like scenarios.

"Expert systems", also known as "knowledge-based systems", are a subfield of artificial intelligence that focuses on the development of software that gives computers the ability to perform tasks that have historically been carried out by humans with the assistance of specialized instruction and knowledge in supply chain management (Pournader *et al*., 2021). The components of an expert system that are outlined by Kusiak (2019) [16] are as follows: Knowledge reorientation, which is where knowledge is framed, the interface engine, which describes the control strategy, and knowledge acquisition, which enables the system to collect data and knowledge for the purpose of problem-solving in supply chain management.

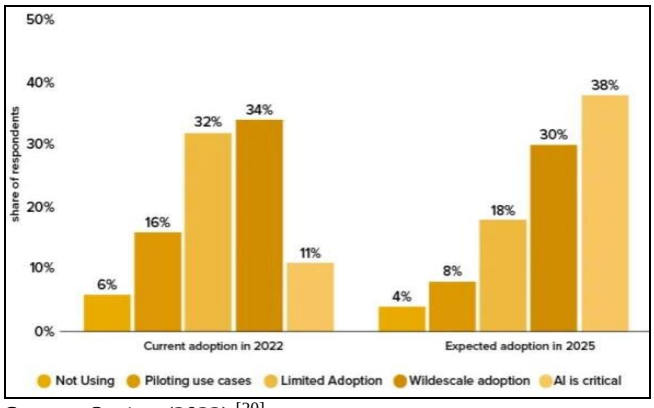
Methods that are rule-based, fuzzy, frame-based, and hybrid are some examples of expert system approaches that can be utilized in conjunction with one another to obtain optimal outcomes of Al in supply chain management (Zarbakhslinia *et al* 2018). According to the research that has been done by Jakupewa *et al* (2014), expert systems perform very well in fields in which hu man intelligence may be formally organized. If not formally captured, the efficiency of expert systema may drastically decrease (Haenlein & Kaplan, 2019) [10], [11]. This difficulty becomes even more obvious when attempting to solve cognitive Impairments with the help of expert systems.

For the past few years, AI has been rolled out with spectacular speed in an increasing number of areas, such as medicine, the auto industry, finance, manufacturing, agriculture and marketing. This expansion lies at the crossroads of three major technological developments the emergence of big data, the normalization of the interconnection between humans and machines, and advances in machine learning (technology that enables machines to learn from experience). Al is progressively transforming the way in which the economy and society operate.

Artificial Intelligence in Supply Chain Management

In recent years, there has been a rise in interest in the practice of applying Al techniques to the modelling and simulation of complicated systems in supply chain management (Chen *et al*., 2022). Through the utilization of Al in the form of modeling and simulation, one can obtain a more in-depth grasp of how a system functions, hence enhancing their ability to make better decisions (Bennett & Hauset, 2013) [6]. Agent-based computing techniques could be a valuable tool for describing the interaction of system components and analyzing performance in real-world scenarios in supply chain management (Zamani *et al* 2022).

Al has been increasingly applied in supply chain management to improve performance in an Agile and Lean perspective. Many companies are investing in digital solutions to optimize their supply chain operations. Figure 1 depicts the global Al adoption rate in supply chain and manufacturing businesses. Literature has shown that Al can provide companies with the ability to respond quickly to changes in demand, reduce waste, and improve collaboration and customer satisfaction.



Source: Statista (2022) [20]

Fig 1: Global AI Adoption Rate in Supply Chain and Manufacturing Business (2022 and 2025)

According to Barták *et al*. (2010) [4], the term "artificial intelligence (AI) planning and scheduling in supply chain management" refers to a set of methods for making intelligent system decisions within the context of restrictions (such as the availability of resources in a manufacturing facility). Planning, in contrast to scheduling, which is concerned with the assignment of activities to resources in a specific amount of time, is concerned with making decisions to optimize the sequence in which activities take place (Kreipl & Pinedo, 2004) [15], Recent advancements in artificial intelligence have made it possible for managers to detect and predict disruptions that may impair normal system operations (such as fraud detection, predictive maintenance, and system failures), and they have also assisted with system recovery in a more responsive and data-driven approach. These advancements have made it possible for managers to detect and predict disruptions that may impair normal system operations (Abedinnia *et al*., 2017) [1].

Uses of Artificial Intelligence in Supply Chain Management

Artificial Intelligence has a number of qualities that can help to solve major problems in the supply chain and perform as well as improve its performance. Artificial Intelligence

gives an edge to supply chain management in some areas like demand forecasting, quality inspections, visibility, customer experience, production planning, flexibility, routing, customer service, warehouse and inventory management issues, last mile tracking of the goods, and fraud prevention to reduce fraud risk. So, these are some of advantages Artificial Intelligence provides to supply chain management.

Artificial Intelligence may be used in supply chain management

1. To control the storage time - Reduction in ideal time fast-moving of materials from origin to destination.
2. Tracking the Consignment- To know the position of luggage at every point of contact to update and know the coming time.
3. Stock reduction-Maintain required and order as and when required.
4. Cost reduction by using technology and finding out optimum routes Using small distance routes to deliver the luggage.
5. Analysing before taking any action - Real time data helps to make the right decisions at any time. Artificial Intelligence learning doing fast analysis of data than human and within a fraction of a second move ahead with the next steps.
6. Reduction in manual efforts- It helps to reduce unwanted efforts and in case of unloading any lug-gage, Artificial Intelligence uses automated guided vehicles to load and unload.

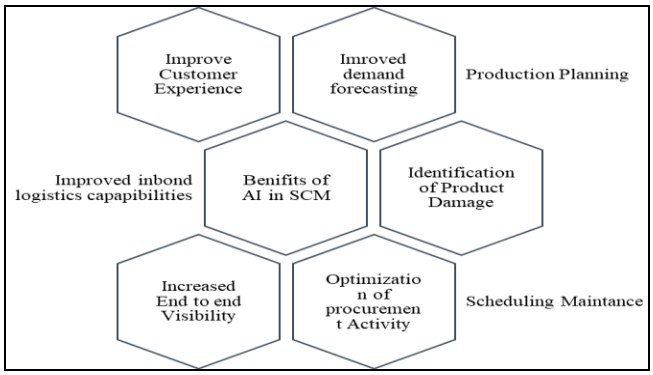


Fig 2: Benefits of Artificial Intelligence in Supply Chain Management

Impact of Al on SCM Performance

Measuring performance is important because it helps businesses learn how to serve their customers better and achieve their long-term objectives. In reaching the desired level of customer satisfaction, it is crucial to evaluate the extent to which needs are satisfied, and resources are used effectively. Rather than focusing on a single firm's performance in the supply chain, a supply chain review considers the interdependencies between all the businesses involved. It gives contest for understanding the whole system, shapes how people act, and reveals how efficient stakeholders and supply chain actors are. Management relies heav ily on the creation and use of performance measures. Transparency and extensive familiarity with the supply chain are aided by using performance measurement tools. Inside-the-company supply chain effectiveness may be measured by keeping tabs on key indicators, including lead time, fill rate, and on-time performance (Yu *et al*., 2017) [23]. These standards are created in-house; thus, they do not consider the full scope of the supply chain.

Figure 3 depicts a framework for the digitalization of supply chain management. Al is one of the technologies that can be utilized in supply chain management as indicated in the reviewed literature. Al-powered solutions have the potential to revolutionize stock management due to their capacity to handle massive amounts of data. These intelligent systems can rapidly analyze and interpret huge datasets, delivering real-time actionable insights for demand and supply planning (Ben-Daya *et al*., 2019) [5]. These Als provide accurate forecasts of future trends in consumer behaviour and seasonality thanks to their complex algorithms.

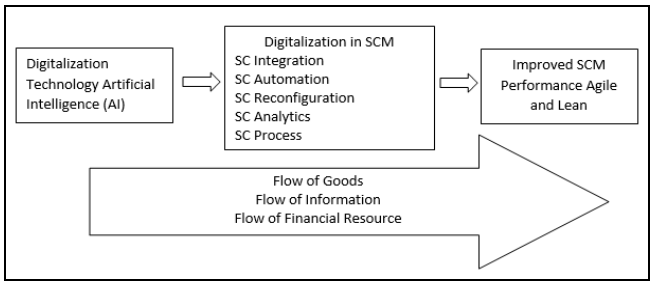


Fig 3: Digitalization of Supply Chain Management

An artificial intelligence program may assist reduce wasteful inventory expenses by anticipating your customers' needs. Automation can greatly improve ware- house efficiency, which is essential to effectively running the supply chain. It would allow for the quick recovery of commodities from warehouses and their delivery to customers with little effort. Using Al in warehouses may increase productivity in several ways, including the rate at which issues are handled, the ease with which routine jobs can be completed, and the number of times workers can focus on more important daily activities planning (Ben-Daya *et al*., 2019) [5], Automating warehouse processes using Al might save time and money by reducing the need for human workers.

The components of supply chain management digitalization include integration of information, resources, and networks, automation using robotics technology, process automation, and intelligent processes, reconfiguration of supply chain networks, an adjustment in the structure of the organization, and supply chains to improve performance, supply chain analytics that assure real-time execution, decisions, process optimization, and advanced forecasting, supply chain process with repetition of a plan, source, make, deliver, and return. It was reported by Xie *et al* (2020) that digitalization and industry 4.0 central objective is the transformation of the supply chain into an intelligent supply chain, which will lead to the elimination of asymmetric information in supply chain. The performance of intelligent supply chain management can be analyzed from visibility, personalization, information governance, warning, sustainability, innovation and learning, agile and lean (leagility) perspectives. Leagility is the combination of lean, which operates with minimal waste, loss, and total cost optimization, and agility which focuses on flexibility and receptiveness. It was stated by Xie *et al*. (2020) that lean and agile are not mutually exclusive in the intelligent supply chain. In addition, he concluded that AI can effectively improve the performance of supply chain management. It was reported by Mohsen (2023) digital supply chain utilizes

AI, Big Data, Blockchains, Cloud, and IoT. Blockchain technology improves supply chain management by facilitating improved process monitoring, simplified regulatory compliance, and more reliable reporting. The cloud enables activities to be carried out rapidly, flexibly, at scale, and fully view all parties involved. IoT helps supply chain professionals like inventory planners, production managers, and procurement managers have more accurate information and forecasts to make strategic decisions regarding the buying, creating, and selling of goods. Mohsen (2022) [18] demonstrated that Big Data plays an important role in various areas of supply chain management, such as procurement planning, logistics, inventory, innovation and product design, operations efficiency and maintenance, product and market strategy development, and network design.

Stoyanov (2021) [21] presented a general overview of the integration of AI in supply chain management. He reported that AI provides companies with an autonomous supply chain that can transform into a self-aware, self-managed, and self-defining system. Toorajipour *et al*. (2021) reported several subfields of supply chain management that have been improved by using AI. These include distribution and transportation, logistics hub management, sales, marketing, planning, production, and forecasting of supply chain demand.

McKinsey & Company (2021) [17] study found that AI-enabled real-time monitoring and control of production and logistics processes can lead to increased responsiveness and flexibility in supply chain management. This can help companies to quickly adapt to changes in demand and other disruptions, leading to improved performance.

Gülen (2023) found that AI can enhance transparency in supply chain management by providing real-time visibility into logistics and production processes. This can help companies to identify and respond to problems more quickly, reducing waste and increasing efficiency.

Research has also shown that AI can improve collaboration between different stakeholders in the supply chain, such as suppliers, manufacturers, and retailers. By facilitating communication and sharing of information, AI can help companies to work together more effectively, leading to improved performance.

AI-powered chatbots and virtual assistants have been found to improve customer service by providing instant and accurate responses to customer inquiries, leading to higher levels of customer satisfaction. This can help companies to retain customers, increase sales, and improve their performance.

The impact of digital technology, AI, and IoT on supply chain efficiency in the manufacturing industry was addressed by Wang *et al*. (2022). They indicated that several AI technologies have been used in supply chain management including Artificial Neural Networks (ANN), Genetic Algorithms (GA), Virtual Reality (VR), and Artificial Immune Systems (AIS). It was reported that AI has a positive impact on making predictions and planning in supply chain management, it results in minimization of the resources waste and business risk.

Summing-up

Artificial Intelligence (AI) has the potential to significantly improve the performance of supply chain management in several ways: AI can be used to analyze large amounts of data from various sources, such as sensor data, weather forecasts, and social media, to predict future demand and optimize inventory levels. It can be used to optimize logistics, such as transport routes, and scheduling of production and delivery, reducing costs and improving efficiency. AI can be used to predict when equipment will fail and schedule maintenance, accordingly, reducing downtime and costs. It can be used to identify and mitigate potential risks in the supply chain, such as natural disasters, supply shortages, and political instability. AI can be used to monitor and inspect products during production and transportation, ensuring quality and reducing the risk of defects or damage. It can be used to automate repetitive tasks, such as data entry, freeing up employees to focus on higher-value work, and it can be used to improve communication and collaboration between different stakeholders in the supply chain, such as suppliers, manufacturers, and retailers. Overall, AI can help companies to improve their supply chain performance by increasing efficiency, reducing costs, and improving the quality of products and services.

The future of AI in supply chain management is likely to see several trends. AI is expected to become more widely adopted in supply chain management as organizations recognize its potential to improve efficiency and reduce costs. AI systems are expected to become more seamlessly integrated with existing supply chain management systems, allowing for more accurate data analysis and decision-making. As AI becomes more widely used in supply chain management, there will be a growing emphasis on ethical and privacy concerns, such as ensuring that AI systems are free from bias and protecting sensitive data. There will be a shift towards a human-centered approach in AI-driven supply chain management, with a greater focus on training and development for the workforce, as well as considering the human impact of automation and AI-driven processes. AI will play an increasingly important role in predictive analytics, enabling organizations to anticipate and respond to supply chain disruptions and manage risk more effectively. AI and blockchain technology are expected to become increasingly integrated, providing a more secure and transparent supply chain management solution.

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