(Review Article)

The integration of Artificial Intelligence in demand forecasting and inventory management in the United States

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Abstract

The integration of Artificial Intelligence in demand forecasting and inventory management in the United States has been examined in this paper. Demand forecasting and inventory management are two of critical areas in supply chain management, which is a veritable tool for promoting industrialization, manufacturing capabilities, and customers satisfaction. The use of AI in form of robotics, machine learning, deep learning, and predictive analytics, among others in all aspects of supply chain operations is gaining ground by the day. The integration of AI into the supply chain process can sustain multi-billion dollars trades in the United States, by reducing the cost of production and distribution, reducing human errors causing inaccurate demand forecasts, return shipment and cancellations of orders, etc. The challenges relating to the use of AI in demand forecasting and inventory management such as high cost of installation and maintenance, data privacy violations, requirement of skilled personnel, which are limited in global supply, and employees' resistance to change were also identified. The outlook of relationship between Artificial Intelligence and supply chain management looks hopeful, brighter, and encouraging. This will be made possible by continuous development of AI capabilities and reducing the challenges of its widespread integration.

Keywords: Demand Forecasting; Inventory Management; Artificial Intelligence; Supply Chain Management; Economic Growth; Efficiency.

1. Introduction

Inventory management and demand forecasting are two integral aspects of the supply components in a production process. From the supply of input resources to production plant, the supply of semi-finished within subsections of the plant, and the finished products to the distribution chains, maintaining a stable and consistent level of inventory is a natural process of sustaining efficiency in production and supply chain. While inventory management manages the supply side of raw materials and finished products, demand forecasting anticipates the level of demand that is to be met by the supply side. Unal et al (2022) describes inventory management as concerning the planning and controlling the inventory of a company to ensure sustainability. Inventory management was defined by Singh and Verma (2018) as complex process that encompasses the application of management principles in inventory management for the purpose of minimizing investment inventory and balancing the demand and supply side. Although the system of inventory management and demand forecasting plays critical roles in production and distribution of goods, its scope has been broadened and applied in different business areas such as retails, logistics and supply chain management (Beutel-AL, 2012; Varghese et al, 2012; Acosta et al, 2018; Granillo Macias, 2020; Sridhar et al, 2021; Xie, 2021).

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The importance of supply chain management, especially in the areas of demand forecasting and inventory management, has necessitated the introduction of digital technologies into the process. Meanwhile, the widespread digitization of demand forecasting and inventory management process, especially by blue-chip companies and manufacturing giants across the world further emphasized the efficacy of internet technologies in aiding business operational efficiency. Machine Learning (ML), Internet of Things (IoT), Artificial Intelligence (AI), Blockchain Technology (BT), and Cloud Computing have been variously adopted across business fields. Their impacts have continually been tested both by qualitative and quantitative studies. Notably, there have been more advantages than the disadvantages of adopting internet technologies in boosting business operation performance. Akinbolajo (2024) asserted that by technological optimization of supply chain process can enhance manufacturing operations in the US.

Although there are numerous internet technologies available for adoption in optimizing demand forecasting and inventory management in businesses, the Artificial Intelligence (AI) has become more widely adopted. Numerous definitions and descriptions have been advanced for AI. While there is no consensus on the definitions, all definition and description attempt have a common denominator, that is, the development of a computer-aided robot that performs the task that would ordinarily be carried out by humans. Google (2024) described Artificial Intelligence (AI) as the backbone of innovation in modern computing with its ability to unlock values for businesses and individuals. Google (2024) further defined Artificial Intelligence as "a field of science that is concerned with building computers and machines that can reason, learn, and act in such a that would normally require human intelligence or that involves data whose scale exceeds what humans can analyze." Kanade (2022) also defined Artificial Intelligence as "the intelligence of a machine or a computer that enables it to imitate or mimic human capabilities." While Artificial Intelligence (AI) can perform functions, this objective of this paper is to examine its role in the management of demand forecasting and inventory management in the United States.

2. Literature review

The role of supply chain management in boosting industrial performance has been widely considered in the literature. While some of the studies were empirical, others were qualitative in contributing to knowledge in the area. This section considers different contributions to knowledge on the relation between industrial productivity and the role of supply chain management.

2.1. Conceptual Reviews

There are certain concepts that are important in examining the relationship between Artificial Intelligence (AI) and supply chain management. The concepts aid the understanding of the relation between the variables, especially in application, the benefits and the challenges. Related concepts in this paper are examined thus:

2.1.1. Integration

Integration, as a term, has been variously and contextually defined in the literature. Gulledge (2006) describes integration as the process of making separate applications work together, which were not originally designed to do so, by sharing information through some form of interface. Iintegrations in business may be related to aligning different separate operations to interact across levels to produce a common output. Firms have often adopted either vertical or horizontal integration, or both in their operations to enhance business performance, efficiency and profits. In the context of this paper, the infusion of Artificial Intelligence (AI) in the operations of demand forecasting and inventory management is both innovative and necessary for the enhancement of business operations. This integration may be done at the level of individual firms, and it may be done cooperatively by several aligning firms in the same industry.

2.1.2. Artificial Intelligence (AI)

Artificial Intelligence (AI) is a composite name for several high-level computer systems of machines that performs supersonic functions typical of humans but more efficiently without failing. These systems cover machine learning (ML), deep learning (DL), large language machine (LLM), robotics, natural language processing, predictive analytics, and more. According to Adenekan et al (2024, pp 1610), "AI can analyze large datasets to identify patterns, predict trends, and provide insights that human operators might miss." The advent of AI has revolutionized business models with lots of socioeconomic benefits. The capabilities of AI position are suitable in aiding the smooth operation of supply chain, which is mostly organized through demand forecasting and management, and inventory management. Despite the ongoing process of adopting AI in specific areas of supply chain operations, its potentials are enormous.

2.1.3. Demand Forecasting

Demand is a household name in the field of economics. It is one of the foundational concepts in the free-market system and economics. Demand may be generally defined as the quantity of goods or service that a consumer is willing and able to buy at a prevailing price per unit of time. The concept of demand forecasting speaks to a foreseeable succession of time-variant specific needs in a process, production or distribution. According to Nguyen (2023) and as corroborated by Perera et al (2019) and Abolghasemi (2020), information relating to future demand is critical to the success of business decisions for producers, traders, customers, and policy makers. Gerasymov (2024) described demand forecasting as a process in supply chain that uses past records alongside modern trends to predict future changes in demand. The author further asserted that an effective supply chain process will resolve problems relating to customer demand, inventory management, pricing, returns and cancellations, transportation, labor force and manufacturing demand.

2.1.4. Inventory Management

Lakshmi et al (2023) defined inventory management as "the process of ordering, storing, using, and selling a company's inventory (i.e., raw materials, components, and final good)." Inventory refers to a list of all items that are used in a particular enterprise. In the context of supply chain management, inventory covers all items of raw materials, semi-finished goods, finished products, byproducts, wastes, and other directly or indirectly useful components in business. Many studies have identified the benefits of engaging in inventory management, which includes enhancing operational efficiency, elimination of financial losses and loss of time in processing orders. Inventory management also provides adequate planning of resources and their deployment during business operations.

2.1.5. Supply Chain Practice: The United States and the World

Supply chain practice in the United States covers both local processes and the international supply chain operations. The United States' economy is the one that is highly globalized. The influence of this globalization has generated both positive impacts and negative consequences, respectively. For instance, a virus like COVID-19 could easily originate in China and spread to the United States, potentially via interactions within global supply chains. While efforts are often focused on sustaining positive outcomes through policy formulation, the negative impacts on the local economy are mitigated through stakeholder engagement, policy directives, and technological innovations. These impacts and the consequences, noticeably, have direct bearing on supply chain practice in the United States. Interestingly, politicians have campaigned over the years on the need to emphasize America's greatness on trade and political influence by improving or slowing down continental integration. The influence of the US in different areas of the global economy includes bilateral or multilateral trade partnerships, security pacts, foreign direct investments, and the likes, which at one level or the other requires supply operations.

To sustain the business relations, managing local and cross-border supply chain processes is a *sine qua non.* America's flagship companies like Amazon, Zara, Nike, and Coca-Cola, rely on seamless supply chain operation to meet up with global customers' demands. To enhance production and distribution efficiency, the role of demand forecasting and inventory management cannot be overstated. Raw materials, semi-processed products, and finished products are distributed across the largest networks on the globe. Without proper analysis of expected demand and the current level of inventory to power supply, unnecessary delay may have severe consequences for cross-border trade. Mostly, some local manufacturing industries rely on certain importation of resources for effective production. These realities shape the supply chain operations between the United States and the rest of the world. Coordinating international and local supply chain operations and movement of products in hundreds of millions locally and internationally require a failproof demand forecasting and inventory management system.

2.2. Demand forecasting and inventory management techniques

Demand forecasting and inventory management are undertaken using many techniques. In many literatures, demand forecasting is treated as one of the tools used for managing the inventory level in a firm. Although, demand forecasting can serve the purpose of inventory management as emphasized in some literature, it is also capable of playing a role independent of inventory operations. This literature has identified two methods used in supply chain forecasting, the quantitative method, which deals with the use of historical data to predict the future trend or a repetitive pattern, and the qualitative method, which relies on primary data generated as a forecast of the expected demand. However, the adoption of the demand forecasting and inventory management techniques depends on the available data, the specific field of use, among others. Simple moving average (SMA), Autoregressive integrated moving average (ARIMA), Multiple aggregation algorithm (MAPA), Life cycle modelling (LCM), and Adaptive smoothing (AS) are common techniques used for quantitative demand forecasting. In the alternative, market research, panel consensus, historical method, and the Delphi method are the common techniques used for qualitative demand forecasting.

Inventory management is a highly beneficial method of balancing supply with demand as oversupply of goods may necessitate returns or cancellations. These tasks are undertaken at costs, the cumulative effect of such avoidable costs in business may have serious loss consequences on the firm. Managing a firm's inventory may be undertaken using different techniques. Meanwhile, prior to implementing any inventory management technique, firms often identify their supply sources and the demand channel. Many techniques have been advanced in the academic circle for inventory management. Just-in-time (JIT), Just-in-case stock control, First In, First Out (FIFO), Last In, First Out (LIFO), Weighted average cost (WAC), Economic Order Quantity (EOQ), Cross docking (CD), and Drop shipping are some of them. Each technique has individual costs and benefits, and firms have often adopted them as each aligns with their objectives, type of business partners, and other intrinsic factors.

3. Artificial intelligence, demand forecasting, and inventory management

3.1. Artificial Intelligence and Demand Forecasting

The importance of demand forecasting in supply chain processes is such that cannot be quantified in economic terms. The opportunities are boundless, firms strategize in many ways to enhance their demand forecasting capability. This is to reduce supply chain problems that often lead to over or under-supply of products and the probable return-shipping with extra costs. In this regard, there has been increasing level of integration between Artificial Intelligence (AI) and demand forecasting aspect of supply chain operations. The widespread adoption of AI in demand forecasting speaks to the numerous advantages of the integration. The accuracy and the reliability of demand forecast has popularized its use in different fields of endeavors. Manufacturing giants and their trade partners such as Boeing, General Electric, Apple, General Motors, HP, Tesla, Nike, Microsoft Corporation, Procter & Gamble, Coca-Cola, Walmart, and Amazon have engaged in widespread use of AI in their demand forecasting operations.

The AI interacts with historical data and trend of demands over time. This pattern is simulated and subjected to dynamism tests such as sensitive analyses, economic outlook, and global economic projections before the likely demand expectations are captured. With the high rate of precision and versatility, AI can harness data over a wide range of sources, sort them, and deduce information that represents the expectations of individuals, groups, and the economy at large. These pieces of data are analyzed on multi-level basis before a workable conclusion is drawn on their suitability for prolonged or short-term use. The beauty of AI is in its diversity of components and units, this makes it more manipulative for any specific function or task.

The integration of AI in demand forecasting has remained a veritable tool for supply chain operations, enhancing operational performance and the improvement of firms' profitability.

3.2. Artificial Intelligence and Inventory Management

While demand forecasting has been identified as a subset of inventory management by some studies, they are both veritable tools in supply chain operations. If the conclusion drawn by some studies that demand forecasting is a tool for inventory management is valid, then, it would be concluded that the role of artificial intelligence in inventory management is more superior. This means that the level of accuracy that AI can generate will be more beneficial to inventory management processes. Therefore, the need to enhance inventory management processes is at the heart of supply chain management, which has become an indispensable tool in modern business. Oliver Munro, an inventory management specialist, identified six best practices for inventory management:

- Proper categorization of inventory
- Adopting a sustainable inventory management software
- Benchmarking a safe level for stock
- Performing regular stock taking
- Benchmarking the optimal lower and upper bounds for stock level
- Optimizing inventory control level.

The last point is the most critical aspect of infusing AI technologies into the inventory management processes. Optimization is a way of enhancing the efficiency of the process by reducing the likelihood of human errors in the process and relying more on the efficacy of AI robotics and Machine Learning models for accuracy and efficiency. The use of AI in reading barcodes is a deciding factor between the manual spreadsheets process and full automation. With the ability of AI to seamlessly perform supplier management, inventory analytics and reporting, batch tracking and barcode scanning, as well as multichannel order management among others, it can be concluded that with time, business

operations will require less humans and more robots. Whilst this outcome will provide for smooth inventory management at the levels of retail, warehouse, ecommerce, and manufacturing, the consequences of such on unemployment and low household incomes may attract the attention of policy makers.

Despite numerous benefits adduced to explain the role of Artificial Intelligence (AI) in demand forecasting and inventory management, the integration harbors some inherent challenges, which may undermine its widespread adoption and complete installation. While the list of challenges is seemingly inexhaustive, the following challenges have been identified.

3.3. Exorbitant Cost of AI Technologies

AI technology offers excellent accuracy in demand forecasting, inventory management, and supply chain management in general. However, the cost of its acquisition, installation, and maintenance is high; hence, it is outside the reach of many startup companies that provide services in the supply value chain processes. For safety of business data, it is required that such database is domiciled in the cloud, which also costs so much to set up and maintain. It is hoped that the advancement of AI technologies will provide pocket-friendly integration costs for many prospective subscribers in the nearest future.

3.4. Data Privacy Problem

Data privacy is a common problem that has not been adequately resolved by the surging internet opportunities. Therefore, it costs so much to keep a safe and secure private database, one of the ways of maneuvering the problem is to save on the cloud. Available information reveals that setting up a privately operating cloud platform requires so much in setting up and maintenance in terms of cost. However, the market provides a shared platform like Amazon Web Services (AWS) Cloud, Google Cloud, Microsoft Azure Cloud, Oracle Cloud, IBM Cloud, and others. While these platforms offer accurate storage and retrieval of data, operating such database require strong internet access, which depends on several factors as well.

3.5. Skilled Personnel Requirements

The AI technologies come with high skill requirement for its operations. The demand for highly skilled personnel is a far cry from the current supply. Although, there has been a massive shift of career into tech lately to shore up these shortages, the demand end of the market keeps outgrowing the available supplies. This calls for concern in AI integration across different industries. The vivid consequence of the personnel skilled shortage is the increase in experts' mobility, requiring that a firm that pays more gets the service.

3.6. Workers' Resistance to Change

The advent of AI technologies will put workers on their toes to learn a needed skill to retain their current jobs. Such changes that are imposed by shift in technology may not be welcomed by workers. Therefore, their resistance may subtly frustrate the integration process.

Future trends in AI technology and supply chain operations

With the continuous development of the AI technologies and its increasing possibilities in the field of engineering, industrial production, and commerce, the future of demand forecasting, inventory management and the overall supply chain management looks bright and hopeful. In the nearest future, more firms will have the capability to be onboard on the train of AI integration in all aspects of their operations. The manual forecasting and inventory management by spreadsheets will be faced out. This promises more efficiency in the field of production, distribution and consumption of goods and services.

4. Conclusion

The integration of Artificial Intelligence (AI) in supply chain management, especially in demand forecasting and inventory management in the United States has been examined in this paper. Without demand forecasting, inventory management will encounter difficulties. This is because planning will be difficult, and issues of uncertainties will arise, which may have severe consequences on a firm's survival in a highly competitive market. The integration of the AI technologies in supply chain management, especially in demand forecasting and inventory management can reduce production and distribution costs, thereby leading to enhanced profitability for firms and customer satisfaction for the consumers. Although the full or partial integration of AI into supply chain activities may face challenges such as high installation and maintenance costs, potential data privacy violations, the need for skilled technical personnel, and

resistance to change, the potential benefits of such integration can create positive ripple effects that will benefit all stakeholders, partners, and policymakers. This paper concludes that AI integration into demand forecasting and inventory management can promote production, distribution, trade, and economic growth.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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