Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: http://www.science-gate.com/IJAAS.html

The impacts of the internet of things and artificial intelligence on logistics in supply chain management

Wael G. Alheadary *

College of Computer Science and Engineering, Taibah University, Medina, Saudi Arabia

ARTICLE INFO

Article history:
Received 12 August 2023
Received in revised form
23 December 2023
Accepted 9 January 2024

Keywords:
Internet of things
Artificial intelligence
Supply chain management
Design science
Predictive analytics

ABSTRACT

The transportation and management of goods industry, along with the operations of many related companies, could be significantly transformed by two fast-developing technologies: the internet of things (IoT) and artificial intelligence (AI). In more detail, for overseeing the movement and storage of goods in this sector, various strategies and structures have been suggested in academic writings. However, these suggestions often overlook how IoT and AI can be combined. To address this oversight, the present study introduces a new approach named IoT-AI-SCM, created using design science. This approach brings together the mentioned technologies within the management of supply chains. The method applied in this study is known as the design science method. The approach we developed is outlined in five key steps: 1) utilizing sensors and devices enabled by IoT, 2) gathering and connecting data, 3) storing and processing data using cloud technology, 4) applying AI, 5) analyzing and predicting outcomes, and 6) smart planning and improvement. By implementing this proposed approach, a company can reimagine its supply chain and logistics management using the essential features of IoT and AI.

1. Introduction

In today's global context, supply chains are functioning in a more complicated and dynamic market. A reliable supply chain is necessary for such a situation to adapt to sudden changes that may occur to consumers' needs (Modgil et al., 2022). Supply chain management (SCM) could be revolutionized by the integration of the Internet of Things (IoT) and Artificial Intelligence (AI), which would result in a considerable increase in productivity, visibility, and sustainability. To supply items or services to customers, SCM needs to coordinate several activities, including procurement, production, transportation, and distribution (Mitra et al., 2021). Organizations may handle these tasks so effectively, which helps them to forecast demand, cut costs, and improve customer experience using AI and IoT.

These two technologies are two important trends that are becoming prevalent in our society; thus, it is important to understand how the two can work together in order to benefit both experts and the general public (Gill et al., 2019). The pervasiveness of IoT creates a great deal of data that can be collected (big data) and analyzed in a variety of ways. There is no realistic way to track this volume of data by human effort, given the sheer volume of data that needs to be tracked. The use of AI will play an important role in tracking, going through, and distilling this huge quantity of data gathered through IoT and converting them into valuable, actionable insights.

SCM, on the one hand, has grown more complex in today's fast-paced and connected world, and IoT and AI, on the other hand, have combined because of the demand for effective, quick, and data-driven solutions (Zohuri and Behgounia, 2023). Due to getting integrated with AI and IoT, SCM has experienced a transformation; this integration helps operations to get optimized, visibility to increase, and firms to succeed in such an increasingly competitive environment (Helo and Hao, 2022). This article examines the revolutionary impacts of AI and IoT on SCM and the advantages they provide to business organizations. Real-time visibility and precise tracking of items used to be the main issues in SCM; however, the advent of AI and IoT has allowed enterprises to achieve visibility in the supply chain (De Vass et al., 2021). IoT-based

* Corresponding Author.
Email Address: wheadary@taibahu.edu.sa
https://doi.org/10.21833/ijaas.2024.01.019
Corresponding author's ORCID profile:
https://orcid.org/0000-0003-3165-7972

devices such as sensors, RFID tags, and connected devices provide real-time information on location, temperature, humidity, and other crucial characteristics. By analyzing this information using AI algorithms, organizations make more educated decisions, foresee disruptions, and optimize logistical operations. SCM has been revolutionized by AI-driven predictive analytics, as illustrated in a framework developed by Maheshwari et al. (2021). AI algorithms can accurately predict demand by examining historical data, market trends, consumer behavior, etc. As a result, firms can maximize inventory levels, decrease stockouts, and minimize surplus inventory (Wei et al., 2019). Taking a proactive approach to risk management is made possible by predictive analytics, which also assists in identifying patterns, anomalies, and potential dangers within the supply chain. In addition to highlighting their advantages, disadvantages, and possible future effects, this study intends to investigate the functions of AI and IoT in SCM.

Therefore, and to answer the above questions, this study aims to propose a compressive framework using design science research. It combines the IoT and AI elements, which can help organizations redesign the way their supply chain and logistics are managed.

The remainder of the article is organized as follows: Section 2 summarizes the background studies. Then, Section 3 discusses the methodology. Section 4 presents the results and discussion. Finally, Section 5 presents the conclusions and recommendations for future work.

2. Literature review

This section reviews the studies previously conducted on AI, IoT, and SCM. For instance, Kousiouris et al. (2019) proposed an integrated system microservice architecture that consumes data feeds from online systems and semantically annotates them, along with post-processing tasks such as monitoring the supply chain, analyzing the location of goods, and estimating delays. The approach is validated by integrating a set of deployment scenarios with appropriate application code programmed by intuitive workflow-based structures.

Optimization of logistics was presented together with an intelligent logistics framework along with a structure for managing transportation in order to improve customer experience, optimize logistics, and minimize transportation costs by using two models for IoT and intelligent logistics (Bhargava et al., 2022). The aim of the work is to identify the optimal routes for logistics scheduling, monitor the parameters of logistics vehicles (e.g., fuel consumption, wheel-axel vibrations, and engine vibrations), monitor temperature, design efficiently customized maintenance schedules, and predict maintenance for logistic vehicles to ensure their efficiency. Nahr et al. (2021) stated that the practical implementation of IoT and AI technologies can foster cooperation between supply chain integration and IoT-based SCM. Radanliev et al. (2020) claimed that digital technologies have changed the way supply chain operations are organized. Modern technology has significantly advanced since the introduction of IoT and AI. Since then, IoT and AI have become standards for Internet-connected innovative and intelligent products, enhancing supply chain integration.

An in-depth analysis of the security risks associated with IoT applications, as well as possible countermeasures, is provided in Meneghello et al. (2019), as well as a discussion of IoT technologies in terms of integrity, anonymity, confidentiality, privacy, access control, authentication, authorization, resilience, and self-organization of IoT technologies. Tyagi et al. (2020) covered a wide range of topics, including the internal structure of Intelligent Automation, its evolution, and its future importance (as a result of future work) in many different useful applications. In addition, Intelligent Automation Systems was explained through e-healthcare applications, and a perspective was given on how it could change the healthcare industry and save millions of lives. Abir et al. (2020), tracing back to the beginning of IoT and AI, pointed out that there has been a significant advancement in current technologies. The authors added that IoT and AI had served as bastions for intelligence connected to the internet and as intelligent catalysts for supply chain inclusion. Chishti (2020) maintained that AI and SCM were critical components of the earlier COVID-19, which kept everyone at home in 2020. IoT and AI have improved end-to-end supply chain performance, boosting supply chain availability, clarity, and authenticity during the pandemic (Singh et al., 2021). This improves customer service and makes purchasing much better and more user-friendly. Note that although AI allows devices to learn from their data and experience, IoT deals with how devices interact with the internet (Singh et al., 2021). On the other hand, the authors in Smith (2005) reported that the tracking of systems, vehicle tracking, fleet control, route optimization, and customers' online purchases and tracking delivery are only five frequent areas where the IoT and AI are commonly utilized.

Most businesses occasionally predict that introducing AI would cause SCM activities to spend less time on planning, scheduling, and many other tasks (Pournader et al., 2021; Ben-Daya et al., 2019). The logistics industry has embraced emerging technologies, including blockchain, to satisfy the rising demand and complexity of operations because intelligence and efficiency are the key determining factors in these technologies. Supply chain stakeholders can have real-time visibility into the position, state, and status of items in transit by integrating IoT devices like GPS trackers, RFID tags, and sensors with AI-driven analytics. This increases the openness of the supply chain, lowers theft and loss, increases the accuracy of deliveries, and makes proactive problem-solving possible. When controlling disruption risks in SCs, Ivanov and Dolgui (2021) investigated the circumstances underlying the design and execution of the digital twins. The conceptual architecture for a digital twin the study proposes for SCM disruptions is based on model-based and data-driven methods. This combination makes it possible to identify the relationships between risk data, disruption modeling, and performance evaluation. The study's findings advance the understanding of predictive and reactive decisions among researchers and decision-makers by utilizing the benefits of SC visualization, historical disruption data analysis, and real-time disruption data to guarantee end-to-end visibility and business continuity in multinational corporations.

Gubbi et al. (2013) introduced a free-market economy model that can be utilized to enable fully distributed autonomous control of resources in large-scale heterogeneous wireless sensor networks (WSNs). Future WSNs are anticipated as a component of the global IoT, where various WSNs can collaborate in a sizable network of heterogeneous WSNs to address common issues.

Sharma and Dash (2023) identified the current and potential AI methodologies and Microsoft Dynamics 365 to support SCM research and practice. The survey of the application of AI to smart supply chain management focuses on four primary areas: AI in intelligent delivery management, AI integration with Facebook, AI in smart retailing, and AI in smart manufacturing. They used Supply Chain Managing and Microsoft Energetic Forces 365 to reveal how intelligent supply chains use Microsoft 365.

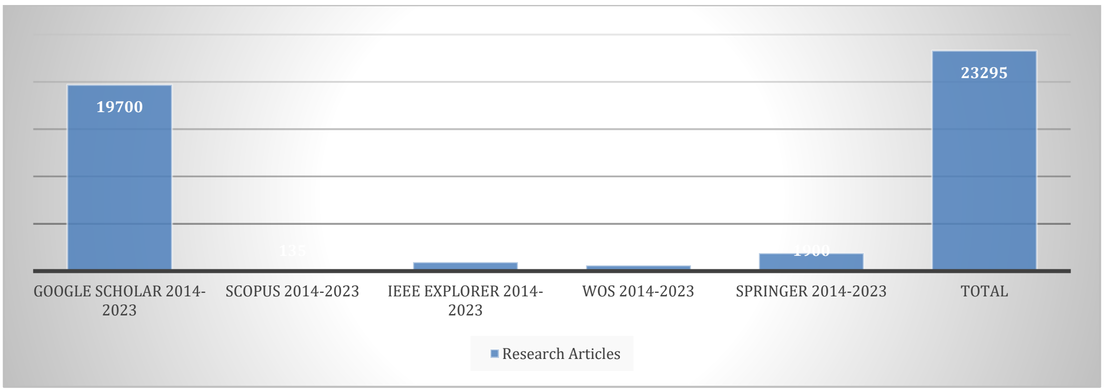
3. Problem statement

Even though a variety of models and frameworks have been proposed in the literature to manage supply chains in the logistics industry, the integration of the IoT and AI has not received adequate attention. In order to maximize the full potential of IoT and AI, organizations need to use these technologies to their full potential in order to transform the logistics industry and unlock their full potential. Increasing visibility, managing inventory better, and performing predictive maintenance are a few examples of the benefits that IoT and AI integration can result in, including greater operational efficiency, cost reductions, and ultimately achieving business success within the rapidly evolving logistics landscape. Thus, this study aims to integrate the two above-mentioned technologies into the supply chain management framework, which is called IoT-AI-SCM.

4. Research methodology

This study uses the design science method to propose an integrated IoT and AI model applicable to SCM (Al-Dhaqm et al., 2016). A design science research approach is a research method that focuses on generating innovations and evaluating them in order to make them more effective. Essentially, it is a method of problem-solving that combines scientific research principles with the practicalities of engineering and design to solve problems in the most effective way. The purpose of this type of research is to develop solutions to real-world problems in the form of artifacts that can be designed, implemented, and evaluated to address the specific problem at hand. The main objective of design science research is to create new knowledge through the design and creation of artifacts, which serve as tools to create new knowledge. A software system, a prototype, a model, a framework, or even a theory are just a few examples of those kinds of artifacts, and they can take a variety of forms. The research process consists of identifying a problem or opportunity, formulating design principles, creating and evaluating the artifact, and reflecting on the results of the process.

The Google Scholar, IEEE Explorer, Science Direct, Scopus, Springer, and Web of Science search engines were used to gather English articles published from 2014 to 2023 about IoT, AI, and SCM. Then, the articles related purely to IoT, AI, and SCM were selected. The following keywords were used during the search process: “internet of things,” “artificial intelligence,” “supply chain,” “sustainability,” “sustainable management,” and “supply chain management.” As Fig. 1 shows, out of the total 23,295 articles, 19,700 articles were extracted from Google Scholar, 135 articles from Scopus, 950 articles from IEEE Explorer, 610 articles from WoS, and 1,900 articles from Springer.



Keywords: "internet of things"; “artificial intelligence”; “supply chain”; “sustainability”; “sustainable management”; “supply chain management”

Fig. 1: Data gathered from the search engines

The inclusion and exclusion criteria displayed in Fig. 2 were followed to filter the articles collected for this study. 12,000 out of 23,295 articles were excluded from the screening process due to duplication. Then, 500 articles were removed for different reasons during the excluding process. In addition, 350 articles were found to be out of scope, 129 articles were just repetitions of the literature, and 22 articles had missing details. Finally, only 338 articles remained to be analyzed in this study. Fig. 3 displays the distribution of articles based on the filtration criteria.

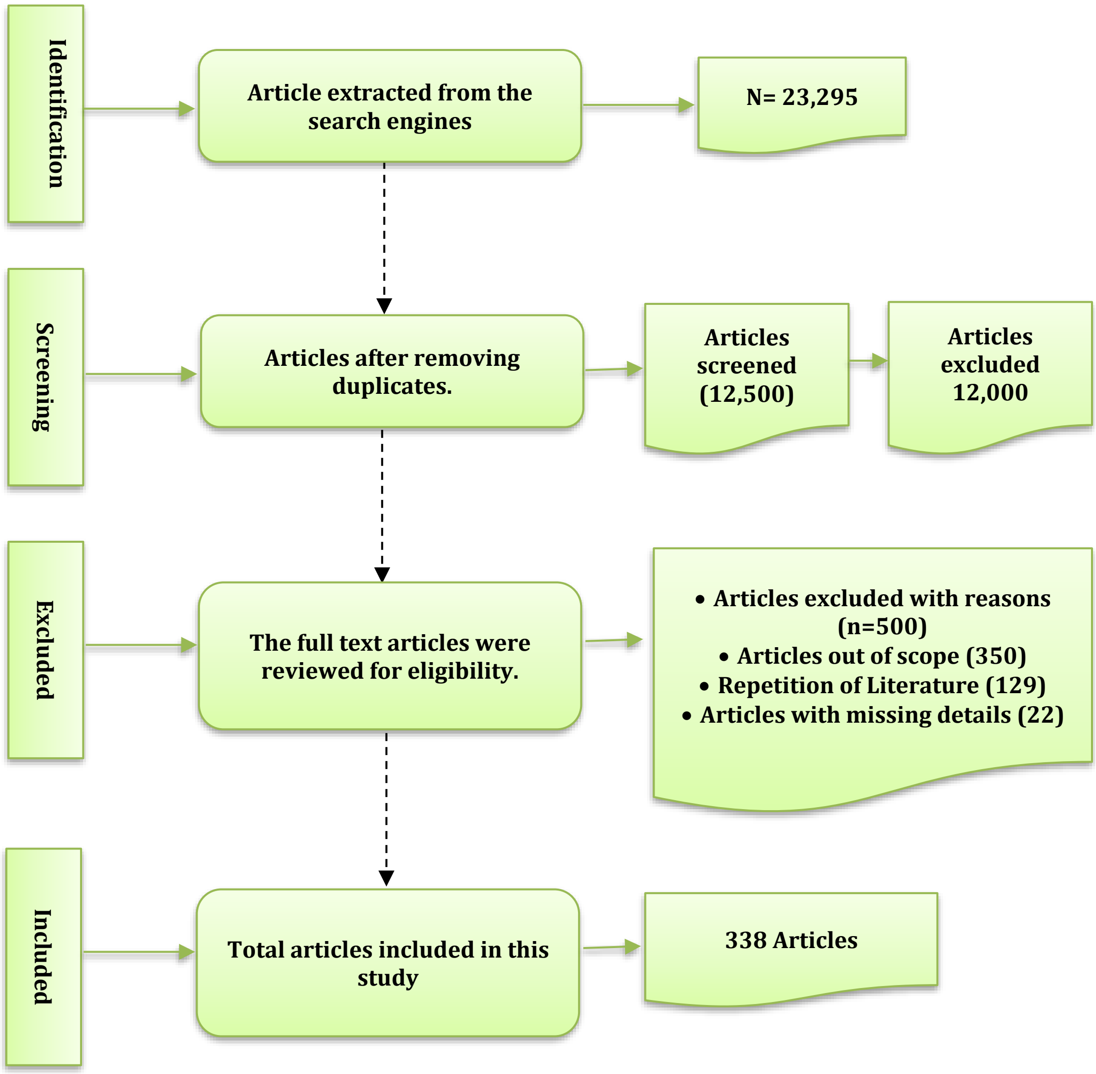


Fig. 2: Filtration process

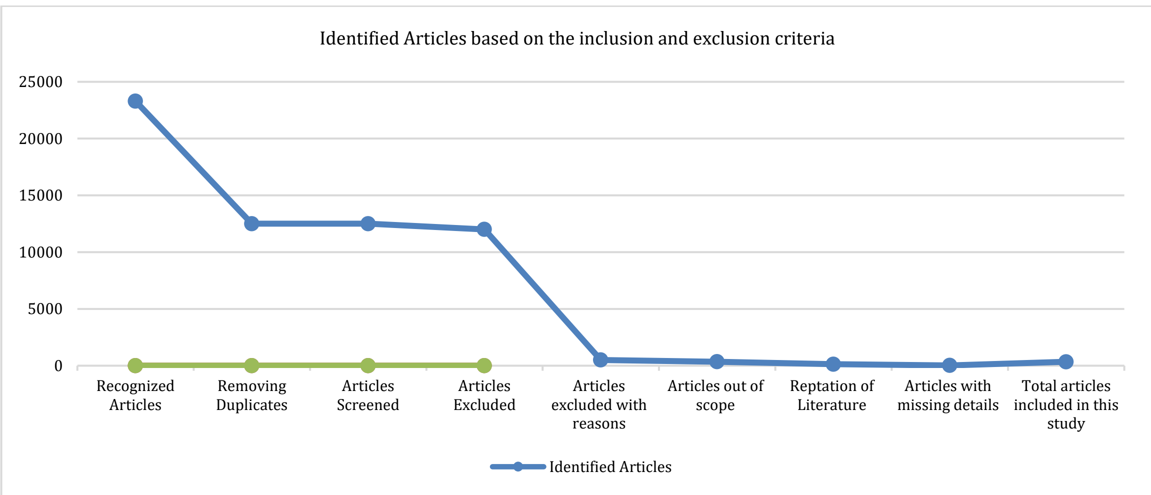


Fig. 3: Identification process based on the inclusion and exclusion criteria

The 338 articles analyzed in this study were distributed into six categories, as shown in Fig. 4. As Fig. 4 illustrates, 26% of the articles were focused on IoT, 20% on AI, 21% o on SCM, 9% on IoT and AI, 7% on IoT and SCM, and, finally, 17% on AI and SCM.

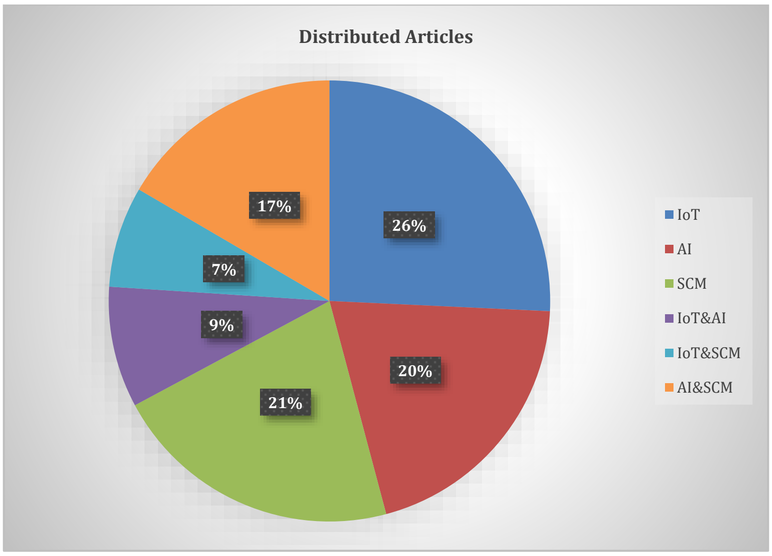


Fig. 4: The distribution of articles based on the six categories

Therefore, the common aspects and concepts of the IoT and AI, which have an effect on SCM, were integrated into a single framework called the IoT-AI-SCM framework. Fig. 5 displays the proposed framework consisting of five main abstract stages:

A) The use of IoT-enabled sensors and devices: The IoT devices connect to a gateway or other edge device through which they can share the sensing data they collect; this data finds its way into the cloud to be analyzed or analyzed locally by the gateway. There are times when these devices can communicate with other related devices and act upon the information they receive from one another. During this stage, three main tasks need to be accomplished: Deployment of IoT sensors, data collection on various parameters, and tracking and identifying goods.
B) Data collection and connectivity: To track the performance of IoT devices, data must be collected from sensors connected to IoT. By collecting and transmitting real-time data, it is possible to monitor and track the status of the IoT network, and this data can be stored and retrieved at any point in time in the future to monitor the network status. It consists of three main activities: Collecting data from IoT devices in real-time, ensuring seamless connectivity, and aggregating data from multiple devices.
C) Cloud-based data storage and processing: A cloud computing service is an internet-based cloud storage and processing service that uses a remote server located off-site to store and process computer data. Today, this is one of the most common and effective methods of storing data. Generally, the responsibility for hosting, managing, and security of data stored on a server lies with a third-party provider. Hosting, managing, and securing the data on a third-party provider's servers is one of the services provided by the company. This stage consists of three main things: Storing the collected IoT data in a secure and scalable cloud infrastructure, utilizing cloud-based platforms to process and analyze the data, and providing the computational power required for advanced AI algorithms and machine learning models.
D) AI analytics and predictive insights: Predictive analytics is a type of analytics that uses data to predict the future outcomes of a given task. A statistical model that utilizes data analysis, machine learning, AI, and statistical models (which also incorporates data analysis) can be used to predict future behaviors using data analysis, machine learning, and AI. It includes the following activities: Implementing AI algorithms and machine learning techniques to analyze the collected data, using predictive analytics to forecast demand, optimizing inventory levels, and identifying potential disruptions. AI can identify patterns, anomalies, and correlations in the data to improve decision-making and operational efficiency.
E) Intelligent routing and optimization: By using an AI-derived algorithm, we can generate routes whose efficiency depends on traffic patterns, weather conditions, and locations of delivery. The reduction in travel time, as well as the improved delivery of goods to customers, is the result of these optimized routes, which also reduces the amount of time businesses spend on travel. Thus, this stage consists of five main activities: Optimizing routing decisions using AI algorithms (which are done based on real-time data, traffic conditions, and delivery constraints), optimizing fleet management, reducing transportation costs, improving delivery times, and minimizing carbon footprint.

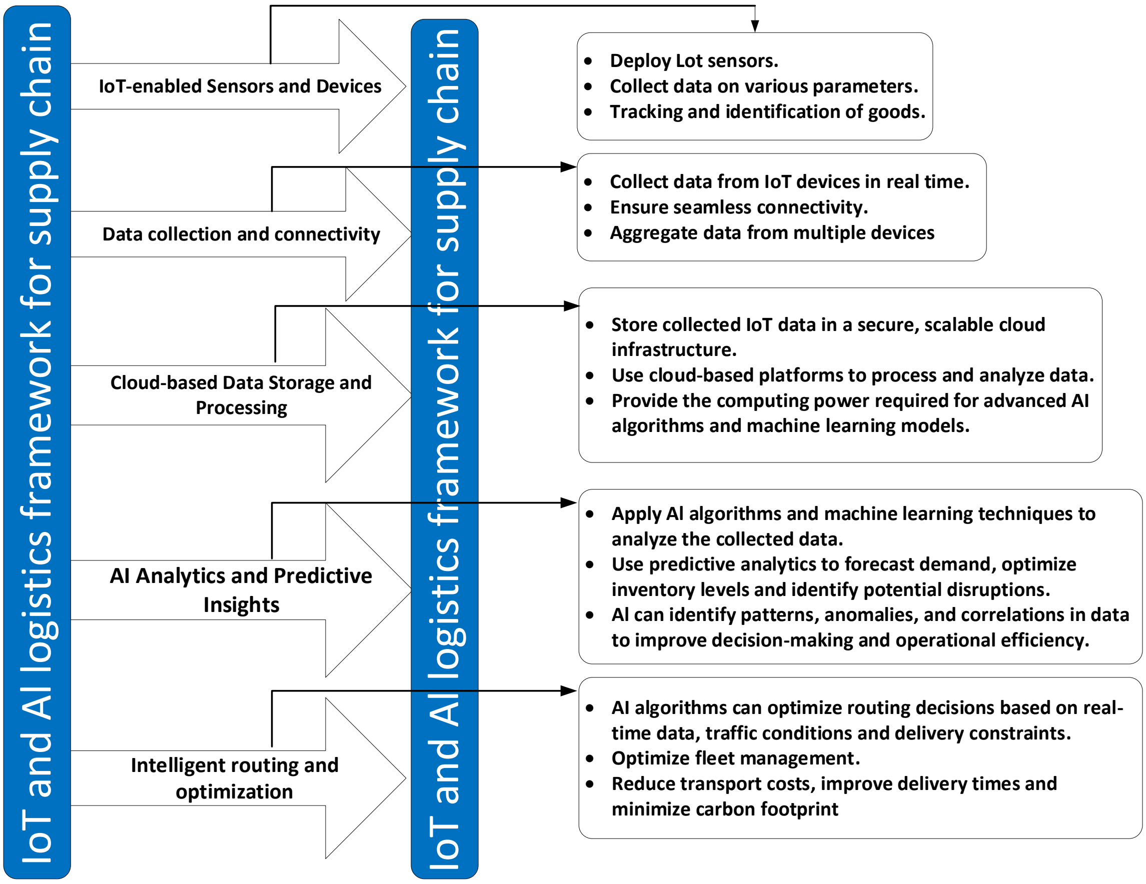


Fig. 5: Integration of AI and IoT with Supply Chain Management framework

5. Results and discussion

AI could play a significant role in improving business operations by using IoT sensors to monitor production and product movements. As a result of the merging of AI and IoT, they can manage inventory and logistics and help suppliers gain greater awareness and accuracy. A major benefit of streamlining the supply chain is that it has an immediate impact on profitability, as well as customer satisfaction. The aim of this paper is to provide a compressive framework for SCM from the IoT and AI perspectives. Several key trends have been emerging in our societies in recent years, such as AI and IoT, and it is important to understand how these two trends work together to provide both the public and specialists with benefits. Thus, we combined the common aspects and concepts of IoT and AI, which may affect the SCM domain. The proposed framework consists of five main stages, which are: i) the use of IoT-enabled sensors and devices, ii) data collection and connectivity, iii) cloud-based data storage and processing, iv) AI, v) analytics and predictive insights, and vi) intelligent routing and optimization.

Based on a thorough comparison of the proposed framework with existing Supply Chain Management (SCM) models and frameworks, it becomes evident that the proposed framework possesses a distinct advantage. This advantage lies in its ability to effectively combine the IoT and AI aspects, thereby facilitating an easier and more efficient management and structuring of work for domain practitioners. The integration of IoT and AI elements within the proposed framework offers several benefits. Firstly, it enhances the real-time monitoring and tracking capabilities of supply chain processes. By leveraging IoT technologies, such as sensors and connected devices, practitioners can gather and analyze data from various stages of the supply chain in real time. This enables them to make quicker and more informed decisions, leading to improved efficiency and reduced operational costs. Secondly, the inclusion of AI components within the framework enables intelligent decision-making and predictive analytics. Through machine learning algorithms and advanced analytics, the framework can identify patterns and trends in the vast amount of data generated by IoT devices. This empowers practitioners to anticipate potential disruptions, optimize inventory levels, and improve demand forecasting accuracy. Furthermore, the combination of IoT and AI aspects in the proposed framework promotes automation and optimization of supply chain processes. By integrating IoT devices with AI algorithms, practitioners can automate routine tasks, such as inventory management and order fulfillment, leading to increased operational efficiency and reduced human error. Additionally, AI-powered optimization algorithms can help practitioners identify the most cost-effective routes, suppliers, and transportation modes, thereby improving overall supply chain performance. By offering these unique capabilities, the proposed framework addresses the limitations of existing SCM models and frameworks that primarily focus on traditional approaches. The integration of IoT and AI elements empowers domain practitioners to leverage emerging technologies and harness their potential to transform supply chain operations. This not only enhances their ability to manage and structure their work effectively but also enables them to stay competitive in an increasingly digital and interconnected business landscape.

In conclusion, the proposed framework stands out from existing SCM models and frameworks due to its distinctive advantage of combining IoT and AI aspects. This integration enables domain practitioners to leverage real-time data, intelligent decision-making, and process automation, resulting in improved efficiency, reduced costs, and optimized supply chain performance. By embracing this framework, practitioners can effectively navigate the challenges of modern supply chain management and drive sustainable growth in their organizations.

As a result of the development of the IoT-AI-SCM framework, we are able to make significant advancements in the research relating to IoT, AI, and supply chain management. This framework leverages IoT technologies, AI algorithms, and supply chain principles to enhance connectivity, facilitate intelligent decision-making, facilitate predictive maintenance, optimize supply chain processes, and promote collaborative decision-making through the use of these technologies. There is no doubt that the integration of these three fields has the potential to revolutionize supply chain operations, improving overall efficiency, reliability, and performance in a business world that is increasingly complex and interconnected.

6. Conclusion

This study contributes to existing knowledge by examining how an integrated version of AI and IoT for logistics affects SCM efficiency. AI and IoT are being used more and more in the SCM domain. Demand forecasting, distribution and transportation, logistics hub management, sales, marketing, planning, production, and inventory are some of the areas of SCM that benefit from AI and IoT. Additionally, the use of IoT today goes beyond simply tracking goods; it also makes intelligent predictions and aids in loss prevention. Real-time information on the location, state, and status of cargo in transit is available via IoT devices. AI can improve SCM performance by promoting collaboration and customer happiness, eliminating waste, and increasing responsiveness and flexibility. Despite the potential advantages, it is crucial to remember that applying AI and IoT to SCM calls for a substantial investment in time and resources and presents serious ethical issues regarding data protection and security. By promoting flexibility, adaptation, innovation, and sustainable practices, this synergy promotes operational excellence and adds value to all supply chain ecosystem stakeholders. Businesses implementing these technologies will be more capable of taking advantage of new opportunities, increasing their competitiveness, and thriving in today's hectic business environment. Therefore, firms should consider the viability and risks before incorporating AI and IoT into their SCM. Further research in this field would be of great help to businesses and firms of all sorts.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

Abir SAA, Islam SN, Anwar A, Mahmood AN, and Oo AMT (2020). Building resilience against COVID-19 pandemic using artificial intelligence, machine learning, and IoT: A survey of recent progress. IoT, 1(2): 506-528. https://doi.org/10.3390/iot1020028

Al-Dhaqm A, Razak SA, Othman SH, Nagdi A, and Ali A (2016). A generic database forensic investigation process model. Jurnal Teknologi, 78(6-11): 45-57. https://doi.org/10.11113/jt.v78.9190

Ben-Daya M, Hassini E, and Bahroun Z (2019). Internet of things and supply chain management: A literature review. International Journal of Production Research, 57(15-16): 4719-4742. https://doi.org/10.1080/00207543.2017.1402140

Bhargava A, Bhargava D, Kumar PN, Sajja GS, and Ray S (2022). Industrial IoT and AI implementation in vehicular logistics and supply chain management for vehicle mediated transportation systems. International Journal of System Assurance Engineering and Management, 13(Suppl 1): 673-680. https://doi.org/10.1007/s13198-021-01581-2

Chishti S (2020). The legaltech book: The legal technology handbook for investors, entrepreneurs and fintech visionaries. John Wiley and Sons, Hoboken, USA.

De Vass T, Shee H, and Miah SJ (2021). IoT in supply chain management: Opportunities and challenges for businesses in early industry 4.0 context. Operations and Supply Chain Management: An International Journal, 14(2): 148-161. https://doi.org/10.31387/oscm0450293

Gill SS, Tuli S, Xu M, Singh I, Singh KV, Lindsay D, and Garraghan P (2019). Transformative effects of IoT, Blockchain and Artificial Intelligence on cloud computing: Evolution, vision, trends and open challenges. Internet of Things, 8: 100118. https://doi.org/10.1016/j.iot.2019.100118

Gubbi J, Buyya R, Marusic S, and Palaniswami M (2013). Internet of things (IoT): A vision, architectural elements, and future directions. Future Generation Computer Systems, 29(7): 1645-1660. https://doi.org/10.1016/j.future.2013.01.010

Helo P and Hao Y (2022). Artificial intelligence in operations management and supply chain management: An exploratory case study. Production Planning and Control, 33(16): 1573-1590. https://doi.org/10.1080/09537287.2021.1882690

Ivanov D and Dolgui A (2021). A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0. Production Planning and Control, 32(9): 775-788. https://doi.org/10.1080/09537287.2020.1768450

Kousiouris G, Tsarsitalidis S, Psomakelis E, Koloniaris S, Bardaki C, Tserpes K, and Anagnostopoulos D (2019). A microservice-based framework for integrating IoT management platforms, semantic and AI services for supply chain management. ICT Express, 5(2): 141-145. https://doi.org/10.1016/j.icte.2019.04.002

Maheshwari S, Gautam P, and Jaggi CK (2021). Role of big data analytics in supply chain management: Current trends and future perspectives. International Journal of Production Research, 59(6): 1875-1900. https://doi.org/10.1080/00207543.2020.1793011

Meneghello F, Calore M, Zucchetto D, Polese M, and Zanella A (2019). IoT: Internet of threats? A survey of practical security vulnerabilities in real IoT devices. IEEE Internet of Things Journal, 6(5): 8182-8201. https://doi.org/10.1109/JIOT.2019.2935189

Mitra S, Chanda B, and Bhattacharya P (2021). Supply chain management with application of lean Six Sigma and artificial intelligence: An integrated empirical investigation. Journal of Supply Chain Management Systems, 10(1/2): 12-20.

Modgil S, Singh RK, and Hannibal C (2022). Artificial intelligence for supply chain resilience: Learning from COVID-19. The International Journal of Logistics Management, 33(4): 1246-1268. https://doi.org/10.1108/IJLM-02-2021-0094

Nahr JG, Nozari H, and Sadeghi ME (2021). Green supply chain based on artificial intelligence of things (AIoT). International Journal of Innovation in Management, Economics and Social Sciences, 1(2): 56-63. https://doi.org/10.52547/ijimes.1.2.56

Pournader M, Ghaderi H, Hassanzadegan A, and Fahimnia B (2021). Artificial intelligence applications in supply chain management. International Journal of Production Economics, 241: 108250. https://doi.org/10.1016/j.ijpe.2021.108250

Radanliev P, De Roure D, Page K, Nurse JR, Mantilla Montalvo R, Santos O, and Burnap P (2020). Cyber risk at the edge: Current and future trends on cyber risk analytics and artificial intelligence in the industrial internet of things and industry 4.0 supply chains. Cybersecurity, 3: 13. https://doi.org/10.1186/s42400-020-00052-8

Sharma P and Dash B (2023). Smart SCM using AI and Microsoft 365. International Journal of Advanced Research in Computer and Communication Engineering, 12(1): 44-54. https://doi.org/10.17148/IJARCCE.2023.12106

Singh S, Gupta A, and Shukla AP (2021). Optimizing supply chain through internet of things (IoT) and artificial intelligence (AI). In the International Conference on Technological Advancements and Innovations, IEEE, Tashkent, Uzbekistan: 257-263. https://doi.org/10.1109/ICTAI53825.2021.9673265

Smith AD (2005). Exploring radio frequency identification technology and its impact on business systems. Information Management and Computer Security, 13(1): 16-28. https://doi.org/10.1108/09685220510582647

Tyagi AK, Fernandez TF, Mishra S, and Kumari S (2020). Intelligent automation systems at the core of Industry 4.0. In: Abraham A, Piuri V, Gandhi N, Siarry P, Kaklauskas A, and Madureira A (Eds.), Intelligent systems design and applications: Advances in intelligent systems and computing: 1-18. Volume 1351, Springer, Cham, Switzerland. https://doi.org/10.1007/978-3-030-71187-0_1

Wei N, Li C, Li C, Xie H, Du Z, Zhang Q, and Zeng F (2019). Short-term forecasting of natural gas consumption using factor selection algorithm and optimized support vector regression. Journal of Energy Resources Technology, 141(3): 032701. https://doi.org/10.1115/1.4041413

Zohuri B and Behgounia F (2023). Application of artificial intelligence driving nano-based drug delivery system. In: Philip AK, Shahiwala A, Rashid M, and Faiyazuddin M (Eds.), A handbook of artificial intelligence in drug delivery: 145-212. Academic Press, Cambridge, USA. https://doi.org/10.1016/B978-0-323-89925-3.00007-1