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A Systematic Review of the Internet of Things Contribution to Obtain Supply Chain Integration

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Abstract

The integration of Internet of Things (IoT) technology to achieve supply chain integration (SCI) has been considered a hot topic in recent years. Through a systematic literature review in the context of supply chain management, this article aims to review IoT and its role in achieving SCI, as well as to provide new directions for future research. The principal objective of this article is to categorize scholarly articles that examine the utilization of IoT in the supply chain to achieve SCI in different sectors. The selection and refinement process identified a total of 133 articles. After removing duplicates and after the screening stage, the number reached 35 studies. These 35 studies were analyzed by introduction, primary results, and conclusions in the assessment stage. Finally, of those 35 studies, 26 were selected to be thoroughly examined for this review of the literature. The literature underscores the pivotal role of Internet technology in achieving SCI and finds solutions based on different industry sectors with appropriate research questions.

Keywords
Supply Chain Integration (SCI), Supply Chain, Internet of Things (IoT), Digitalization

1. Introduction
The Internet of Things (IoT) has been recognized as a breakthrough advancement in information technology (S. M. Ali et al., 2023) enabling the digital connection of embedded information and communication technology systems and facilitating the networking of objects and devices through the Internet, providing the possibility of data collection and transmission (Ande et al., 2020; T. de Vass et al., 2018; Tavana, 2023). Therefore, such networks and systems become more intelligent as they can be monitored, controlled, and executed remotely (Alabdulatif et al., 2023). IoT, the link of the interconnection of all things, represents an extension of Internet capabilities, fostering innovation and integration within supply chain systems and networks (Ardito et al., 2019). By facilitating the exchange and sharing of information among supply chain participants, IoT is a contributing factor in the modernization of supply chain operations, underscoring its theoretical and practical significance (Colicchia et al., 2019; Yang and Wang, 2021).

Supply chains serve as interconnected networks comprising multiple entities spanning upstream, midstream, and downstream sectors, with manufacturing enterprises at their core (Xia et al., 2023). In today's globalized economy, continuous supply chain integration (SCI) is crucial for businesses to stay competitive, meet customer demands, and improve operational performance (Tiwari, 2021). As a result, integration is bound to become an inevitable and unavoidable requirement for supply chain development (Munir et al., 2020). In addition, SCI aims to link all supply chain participants by optimizing visibility, traceability, interoperability, and collaboration, thereby maximizing supply chain and firm performance (I. Ali et al., 2023; de Vass et al., 2021).

Applying IoT technology in SCI entails leveraging existing infrastructure and application systems to enhance integration, visualization, and intelligence within supply chain systems (de Vass et al., 2021). IoT facilitates increased visibility and real-time tracking of inventory and shipments (Tan and Sidhu, 2022; Tavana, 2023), thereby optimizing operations, improving efficiency, reducing expenses, and increasing customer satisfaction (Jarašūnienė et al., 2023). Moreover, IoT fosters internal and external integration, influencing various aspects of company performance such as financial, social, and environmental (Tharaka de Vass et al., 2018; Fatorachian and Kazemi, 2021).

1.1 Objectives

Boosting the development of the digital supply chain has theoretical research significance and practical application value. As a result, there has been a tremendous amount of research on advanced technologies and their impact on supply chain topics over the past few years, resulting in many valuable insights. A comprehensive literature review by Ben-Daya et al. (2019) addressed the role of IoT in SCM. Rejeb et al. (2020) provided a holistic and structured overview of the current state of IoT research in the realm of SCM and logistics from a holistic perspective and in a structured manner. Khanuja and Jain (2020) provided a comprehensive review of SCI enablers, dimensions, and performance. Tiwari (2021) offered a comprehensive overview of the recent advancements in the implementation of Industry 4.0 technologies and SCI about supply chain operations. Taj et al. (2023) addressed various aspects of IoT-based supply chain management.

According to the mentioned papers, the body of knowledge and literature about SCI should be improved. Furthermore, as the viewpoints of articles may vary according to different industries (Khanuja and Jain, 2020; Tiwari, 2021), a need to provide comprehensive literature on SCI according to different sectors is felt. As a result, it is clear that no extensive article fully and comprehensively examines the role of the IoT in SCI. Therefore, it was deemed necessary to conduct a literature review that offers a comprehensive perspective on the role of the IoT in achieving SCI. Taking a look back at the literature, this article contributes to the SCI literature by addressing the mentioned gap. This article explores the implementation of IoT to achieve SCI and finds solutions based on different industry sectors with proper research questions.

1. What is the status of knowledge and understanding regarding the application of IoT to achieve SCI?
2. What is the focus of previous articles regarding the application of IoT in SCI based on different industry sectors?

This study is divided into 5 sections. Following the introduction, a comprehensive background is provided in Section 2. In the third step, Section 3 delves into the review approach and also presents a categorization of the chosen articles. Section 4 consolidates the knowledge extracted from selected articles and provides empirical studies based on industries. Finally, the last section concludes the paper.

2. Background

2.1 Internet of Things

Predictions indicate a substantial increase in connected IoT devices and systems worldwide, reaching over 29.42 billion by 2030 (Turksonmez and Ozcanhan, 2023). Incorporating IoT into business practices and collaborating with trade partners allows organizations to transform operational strategies, enhance supply chain integration (SCI), and improve efficiency. IoT applications offer real-time tracking, introducing responsiveness and agility to operational processes while minimizing data latency and analysis delays (Tu et al., 2018). In the context of SCM, IoT is defined as a network comprising digitally connected physical objects with the capability to sense, monitor, and interact within a firm and across its supply chain (Ben-Daya et al., 2019; Rebelo et al., 2022; Rejeb et al., 2020). The adoption of IoT in supply chains offers benefits such as enhanced security, productivity, operational efficiency, and overall customer experience by reconfiguring conventional business models (S. M. Ali et al., 2023). The advent of IoT enables effective communication and data transmission, facilitating informed decision-making within warehouses and during transportation across different entities within the supply chain (Taj et al., 2023).

2.2 Supply Chain Integration

2.2.1 Definition of SCI

Supply Chain Integration (SCI) refers to the level of strategic collaboration between a core company and its supply chain partners, as well as the joint management of processes in inter- and intra-organizations (Ruzo-Sanmartín et al., 2023). The objective is to ensure the smooth and efficient flow of data, money, products and services, with the ultimate goal of delivering the highest value to customers at minimum cost and time (Flynn et al., 2010). The SCI system can visualize and intelligently manage the entire supply chain, improve the level of enterprise management, improve operational efficiency (Xia et al., 2023), and enhance the competitiveness of enterprises by closely linking relevant manufacturers and suppliers (Chhetri et al., 2022). It can be found that although scholars have defined SCI from different perspectives, they have reached consensus on four aspects:

First, participants in SCI involve all enterprises involved in the supply chain, and the achievement of the overall goal is inseparable from the efficient cooperation of all participating entities (Dehgani and Jafari Navimipour, 2019). Second, SCI is a management method in which members of the supply chain conduct higher-level and more efficient cooperation and coordination in order to provide greater value to customers and improve the overall competitive advantage of the enterprise (Chen, 2019). Third, SCI is used to improve the overall performance of the supply chain, effectively reduce the cost of supply chain operation, ensure the complete delivery of services and products, and meet customer needs to the greatest extent (Tang et al., 2021). Ultimately, the enhancement of enterprise competitiveness and the maximization of customer value are realized (Ardito et al., 2019). From this, we can define the purpose of SCI as follows: The purpose of SCI is to provide maximum value to customers with the lowest cost and highest efficiency and to enhance the overall competitiveness and organizational performance of the company through a series of internal and external activities for information sharing and high-level and high-efficiency cooperation between enterprises.

2.2.2 Dimensions of SCI

The diverse dimensions of SCI can be categorized into customer (downstream), supplier (upstream), and internal integration. External integration, which refers to customer and supplier integration, is the degree to which a core firm collaborates with its external partners to develop synchronized, collaborative strategies, practices, and processes (Flynn et al., 2010). In contrast, by using internal integration, departments within a company structure their organizational strategies to work together to meet customer needs in a tight and seamless manner (Jafari et al., 2023; Zhen, 2022).

2.2.3 Need for SCI

Today's competitive business environment requires information sharing to manage supply chain relationships and drive supply chain performance (Kankam et al., 2023). Information management has become a vital market movement in SCI through supplier integration, strengthening the connection and interaction between enterprises and suppliers to exchange information and knowledge in a timely manner and make corresponding adjustments based on feedback (Tiwari, 2021). However, through integration, effective information sharing enhances the understanding of partnership establishment and improves the efficiency and effectiveness of the supply chain (Kankam et al., 2023). Complete, upstream, and downstream supply chain members cannot obtain complete market feedback information (Ben-Daya et al., 2020). Trust-related issues still deteriorate interfirm cooperation and integration. At the same time, there is a lack of effective communication between supply, production, and demand. In addition, the information exchange between the company and the outside environment is not sufficient. (Min et al., 2019). In addition to information flow, the right flow of finances can also positively affect the SC performance (Asgari Sooran et al., 2023). However, integrating supply chains at higher levels increases suppliers' and companies' trust in each other as well as in customers (Shukor et al., 2021). As a result, the level of SCI determines the current competitiveness of enterprises (Tiwari, 2021).

2.2.4 Barriers / Challenges in SCI

In practical applications, SCI still faces many challenges and obstacles. At present, the integrated mechanism of benefit and risk sharing has not yet been formed between the upstream and downstream parts of the supply chain, which dramatically affects the flow of products, services, and information (Lu et al., 2022). The most common hurdles in the previous studies were uncertainty and risk, along with barriers related to relationships (Bakhshi Movahed et al., 2023). In addition, the complexity of technological solutions and the cost of acquiring and implementing those solutions are the two main barriers to increasing information sharing within supply chains (Tiwari, 2021).

This is the common need of modern enterprises to adapt and be resilient to the development of the new economic era. However, there is still a lack of intention to establish and maintain long-term cooperative relationships between upstream and downstream enterprises through the supply chain (Meng et al., 2023). Each node enterprise pays more attention to its own business development and does not actively communicate with the upstream and downstream enterprises, making it difficult for them to grasp the market accurately and quickly, customer demand, and loss of market competitiveness. Enterprises may also have different or even conflicting interests and goals. In the process of maximizing their own interests, there will often be vicious competition. By harming the interests of other participants of the supply chain to increase their own profits or reduce costs, it is easy to cause the failure of cooperation has greatly affected the regular operation of the supply chain, making SCI unable to achieve the initial goals (Wang and Feng, 2022).

2.2.5 Benefits of SCI

With the rapid and continuous development of economic globalization, SCI has become a significant aspect of SCM. SCI is considered as a higher-level and more efficient cooperation and coordinated management method to create greater value and improve the competitive advantage of enterprises. The efficient development of SCI has become an essential guarantee for enhancing the core competitiveness of enterprises (Saragih et al., 2020). Given that the level of SCI is one of the critical factors that predicts the future failure or success of an enterprise, establishing a complete and efficient supply chain system that can achieve enterprise development goals has become a new profit growth point for enterprises and a means to improve competitiveness (Tian et al., 2021). Effective SCI shortens the delivery time (Alzoubi et al., 2022), reduces the expense and cost of enterprise inventory (Srinivasan et al., 2017), improves the capital turnover rate (Zhao et al., 2015), and improves services to satisfy the diversified consumption needs of customers (Yang et al., 2023), which has become a powerful way for enterprises to seize market share and achieve good performance. Therefore, it is necessary to work together on the following aspects to reduce and eliminate many obstacles faced by SCI in the actual enterprise operation in order to ensure the sound and efficient development of SCI (Feng and Wang, 2021).

3. Methodology

The review process has undergone noticeable enhancement by "synthesizing research in a systematic, transparent, and reproducible manner with the twin aims of enhancing the knowledge base and informing policymaking and practice" (Tranfield et al., 2003). To conduct a comprehensive and effective systematic literature review, and according to the nature of this study, the technique employed for conducting the literature review is derived from the guidelines proposed by Denver and Tranfield (Denyer and Tranfield, 2009), tailored for the field of management and organizational studies, and Carrera-Rivera et al. (Carrera-Rivera et al., 2022), which is suitable for the field of computer science.

In this article, a systematic literature review and in-depth analysis of scientific journals and conferences articles are planned with the goal of improving knowledge related to the Internet of Things (IoT) and supply chain integration (SCI), as well as providing new directions for future research. The main purpose of the research is to know the role of IoT in achieving SCI. The first step in the planning stage begins with dividing the SLR goals into searchable keywords based on the research questions presented in the Introduction section.

In the second step, and in order to find articles that would address the two study questions listed above, we began the process of exploration on Compendex (Ei Engineering Village), Engineering Collection (ProQuest), and Web of Science as the three main databases. The primary objective is to categorize scholarly articles that examine the utilization of the IoT in supply chain management to achieve integration. To do this, a specific collection of keywords has been thoughtfully selected depending on the desired outcomes. It is important to note that these keyword sets are to be included in the search query. The search primarily utilizes two sets of terminology, "Supply Chain Integration" and "Internet of Things". It should be mentioned that the search was done on 9th January 2024, obtaining total records of English as a language. Table 1 provides detailed search syntax information for this study.

Table 1. Detailed Search Syntax

Database	**Search Syntax**	**Field**
Compendex	((("supply chain integration" OR "integrated supply chain") WN KY) AND (("internet of things" OR "IoT") WN KY))	Subject / Title / Abstract
Engineering Collection (ProQuest)	noft("supply chain integration" OR "integrated supply chain") AND noft("internet of things" OR "IoT")	Anywhere except full text - NOFT
Web of Science	"supply chain integration" OR "Integrated supply chain" (All Fields) and "Internet of things" OR "IoT" (All Fields)	All Fields

For the study selection and refinement, 133 papers were identified in total. The first criterion for exclusion was the publication year. Since 2016 is the primary focus of this review, 29 papers were excluded. Table 2 provides the exact number of papers for each database.

Table 2. Number of Articles for Each Database According to the Year of Publication

Database	**2016-2023**	**Before 2016**	**Total**
Compendex	48	21	69
Engineering Collection (ProQuest)	28	4	32
Web of Science	28	4	32
Total	104	29	133

As the search utilized three primary databases, there may be instances of duplication. After eliminating 47 duplicates, the total number of remaining articles was reduced from 104 to 57. To determine whether the 57 identified articles were suitable for the research questions or not, titles, abstracts, and keywords were carefully and thoroughly analyzed in the screening stage. Based on the analysis, there are 35 articles that can be defined as close to the topic and showing some relationship with it. Therefore, these 35 studies were analyzed in the assessment stage by introduction, primary results, and conclusions. Finally, of those 35 studies, 26 were selected to be examined thoroughly for this systematic literature review. Figure 1 shows the above steps in a visual representation as a flow chart.

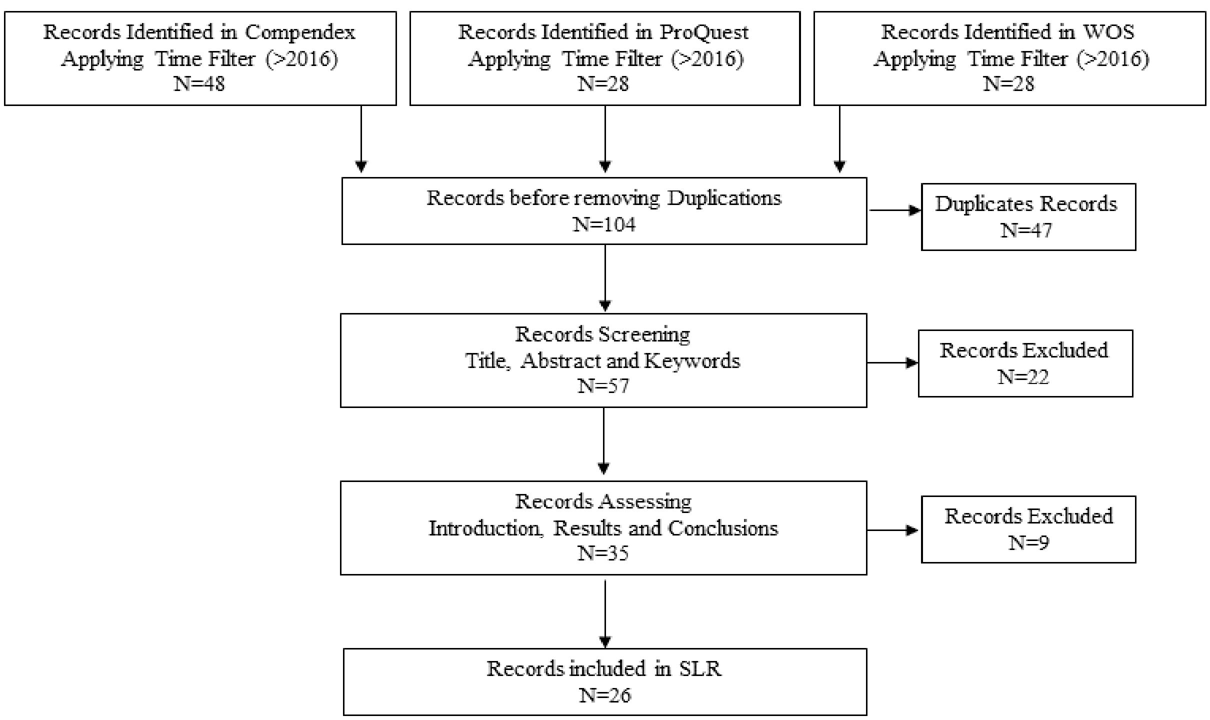

Figure 1. The Article Selection Process for SLR.

According to Figure 2, which shows the frequency of articles in journals and conferences, research in the field of IoT within the SCI database is experiencing an increasing trend. Notably, the writing of articles in this field shows a significant rise from 2021 onward.

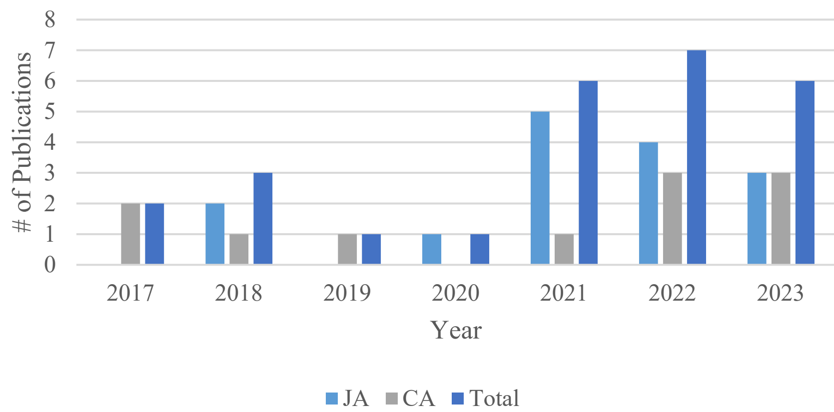

Figure 2. Number of Publications by Year.

Table 3 and Figure 3 present different sectors that selected articles were categorized based on them. According to Figure 3, 68% of articles are in the retail sector, agriculture and food sector, and manufacturing sector.

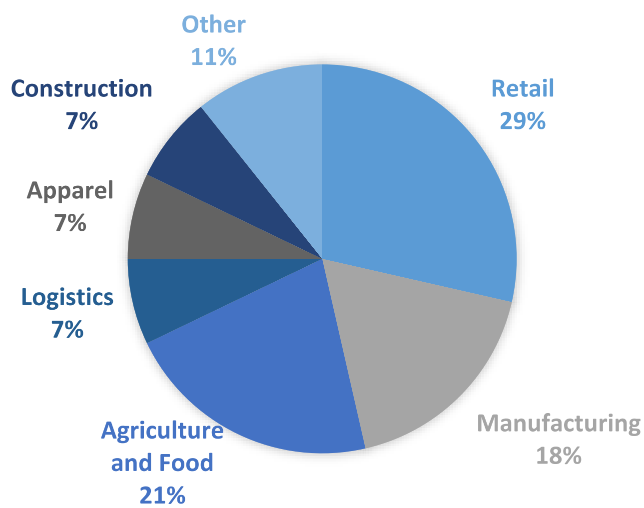

Figure 3. A Pie Chart Illustrating the Percentage Breakdown of Articles in Different Industries.

Table 3. Clustering of Articles Based on Using IoT to Achieve SCI According to the Industry Sector

Industry	Authors
Retail	(Shafique et al., 2018),(Zhen, 2022),(Ernawan et al., 2022), (Singh et al., 2021), (de Vass et al., 2021), (Tharaka de Vass et al., 2018), (T. de Vass et al., 2018), (Argyropoulou et al., 2023)
Manufacturing	(N et al., 2023), (Bellini et al., 2022), (Fernando et al., 2023), (Shen et al., 2023), (Deflorin et al., 2021)
Agriculture and Food	(Mantravadi and Srai, 2022), (Wakenshaw et al., 2017), (Srinivasan et al., 2017), (Saurabh and Dey, 2021), (Yadav et al., 2023), (Leong et al., 2023)
Logistics	(Zhou et al., 2021), (Pundir et al., 2019)
Apparel	(N et al., 2023), (Madushanka et al., 2023)
Construction	(Wakenshaw et al., 2017), (Xia et al., 2023)
Other Industries	(Afrifah et al., 2022), (Hou and Chen, 2022), (Kamble et al., 2023)

4. Results and Discussion
The necessity of applying IoT to achieve SCI in different sectors will be examined in the following sections.

4.1 Retail
Most of the studies (29%) have explored the transformative impact of IoT on SCI in the retail sector. In a comprehensive examination, Shafique et al. (2018) explored the relationship between IoT capabilities, external integration (supplier integration (SI) and customer integration (CI)), and green supply chain performance (GSCP). The findings demonstrated that IoT implementation directly enhances customer and supplier integration, positively influencing GSCP. The limitations acknowledged included a focus on specific industries and the absence of internal SCI considerations. Moreover, it underscores the pivotal role of digital technologies, particularly IoT, in ensuring sustainable competitiveness. Zhen (2022) extended this exploration of the impact of IoT on achieving SCI in the retail sector by scrutinizing 230 retail enterprises in China, revealing a positive influence of both dimensions of SCI on firm performance, with internal integration having a particularly strong influence on external integration. The study underscored the tangible benefits of IoT applications, emphasizing improvements in operational efficiency, loss minimization, and enhanced market competitiveness for retail enterprises. Furthermore, research by Ernawan et al. (2022) highlighted the impact of IoT capabilities on three aspects (dimensions) of SCI and their subsequent consequences on supply chain capabilities and firm performance. An organization's internal supply chain may benefit significantly from the implementation of IoT capabilities, according to the findings. The integration of IoT was found to generate economic value and contribute to overall company performance, enabling the formulation of an omni-channel strategy and business model, thereby driving competitive advantage, and fostering customer loyalty. The study emphasizes the necessity for further research in diverse industries and underscores the crucial role of incorporating digital technologies, particularly IoT, in managing SCI for sustainable competitiveness. Singh et al. (2021) highlighted the positive impact of implementing IoT and AI in SCM within the retail sector. The integration of IoT devices facilitates real-time data access, order tracking, and accurate deliveries, thus enhancing supply chain efficiency, availability, clarity, and authenticity, especially during challenging circumstances such as the pandemic.

Focusing on the Australian retail landscape, the investigation by De Vass et al. (2018) focused on how IoT enhances the integration of customers, suppliers, and internal participants in the retail supply chain, which leads to improvements in supply chain performance and, ultimately, organizational performance. The study established that IoT-enabled integration positively influences the delivery, quality, cost, and flexibility of the entire supply chain. Australian retailers benefit from improved visibility, reduced labor requirements, value extraction from data, and enhanced communication between supply chain partners (Tharaka de Vass et al., 2018). Furthermore, they highlighted ways in which IoT improves SCI, providing real-time data and visibility across the entire supply chain. IoT facilitates communication and collaboration between different entities, aids in fulfilling retailers' inventory stock requirements, and enhances operational and information management for suppliers and retailers (de Vass et al., 2021).

Argyropoulou et al. (2023) explored the implications of IoT on SCI, supply chain capability, and firm performance within the UK retail industry, revealing improved firm performance through IoT-enabled supply chain coordination. The findings emphasized that integrating IoT capability into supply chain processes improves firm performance, with a stronger relationship observed in internal integration. By establishing an IoT-based platform facilitating real-time information exchange among all stakeholders in the supply chain, retailers can foster seamless integration. This internal integration sets the stage for external collaboration with customers and suppliers, thereby enhancing supply chain efficiency and effectiveness. The ultimate result was an improvement in overall supply chain performance. The study concludes that IoT can provide a competitive advantage for retailers in the UK, enhancing overall productivity, sales, and profit. The study emphasized the need for efficient standard processes within IoT-enabled supply chains, positioning IoT capability as a potential source of competitive advantage for UK retailers.

4.2 Manufacturing

In the era of Industry 4.0, the manufacturing and production sector is closely interconnected with ICT systems, resulting in increased scalability and competitiveness (Javaid et al., 2022). The adoption of IoT technology to achieve SCI in manufacturing is a subject explored in various studies. Jayashri et al. (2023) focused on the application of IoT sensors in the apparel manufacturing industry, specifically addressing SCM, inventory control, transportation, and logistics. However, the susceptibility of IoT sensors to errors and malicious attacks poses challenges, leading to the proposed integration of blockchain technology through TrustChain. The drive towards IoT in Industry 4.0 has compelled diverse sectors to concentrate on establishing cohesive and interoperable networks within their internal operations and throughout supply chains. This often involves integrating manufacturing processes with those of other industries in the chain, fostering collaboration with suppliers and customers. This necessity has led to the capability to provide data and flow access, facilitating the creation of unified dashboards for customers, and enabling synchronization and supervision. Additionally, it may involve setting up integrated control rooms, synoptics, and dashboards, enabling the collection of data for purposes such as big data analytics, machine learning, and business intelligence applied to production processes (Bellini et al., 2022).

In a complex global context, creating a reliable and secure platform is crucial for successful SCI. Despite its potential, Indonesian SMEs in manufacturing encounter challenges in embracing Industry 4.0 technologies, including unclear policies, elevated investment risks, insecure information sharing, a shortage of expertise, and inadequate incentives (Fernando et al., 2023). When it comes to mass customization (MC) products, the implementation of IoT significantly impacts production time, consumer satisfaction, and supply chain connectivity. Streamlining MC product production time and enhancing consumer self-design experiences can be achieved through effective manufacturer-customizer integration. However, retailer-customizer integration does not yield the same benefits due to potential profitability issues for manufacturers not directly involved in the integration (Shen et al., 2023). Deflorin et al. (2021) contributed to understanding the relationship between the Industrial Internet of Things (IIoT) and production network coordination. The potential of IIoT is highlighted in providing partners with more accurate information related to operational processes, fostering more effective decision-making within manufacturing networks. From addressing vulnerabilities in sensor technology to exploring the potential of Industry 4.0 adoption and investigating the coordination benefits of IIoT, these findings contribute valuable insights to the broader understanding of leveraging IoT for effective manufacturing SCI.

4.3 Agriculture and Food

The integration of IoT into the food and agriculture industry emerges as a pivotal strategy to enhance SCI. Across various studies, common themes emphasized the multifaceted benefits that IoT can bring to this sector. One of the central advantages of integrating IoT in the food supply chain lies in its ability to improve efficiency and transparency. Mantravadi and Srai (2022) highlighted the role of IoT-enabled technologies in connecting producers and consumers, fostering more efficient communication and coordination. This connectivity not only reduces waste but also improves access to healthier food options.

Wakenshaw et al. (2017) explored the integration of IoT within the collaborative planning, forecasting, and replenishment (CPFR) reference model, emphasizing its potential to significantly enhance SCI. Through real-time data provided by the IoT, the CPFR model can improve traceability and demonstrate product authenticity, thus building trust and confidence in the food supply chain. Srinivasan et al. (2017) presented a conceptual framework for integrating IoT into the management of agricultural produce inventory and inbound logistics, aiming to enhance transparency and accuracy in the supply chain. Saurabh and Dey (2021) proposed a blockchain-enabled architecture that integrates supply chain nodes using a peer-to-peer system, IoT, and a cloud-based system. This architecture not only improves connectivity and coordination among supply chain nodes, but also enhances trade-compliance mechanisms through the use of smart contracts, contributing to the overall trustworthiness of the system. Yadav et al. (2023) stressed the benefits of digital technologies, including IoT, in improving supply chain visibility and collaboration in the agri-food sector. Real-time monitoring, traceability, and improved efficiency are highlighted as key advantages. However, challenges such as implementation costs, the need for specialized skills, and concerns regarding data privacy and security are acknowledged.

The significance of Artificial Intelligence of Things (AIoT) applications in smart agriculture lies in their potential to transform farming practices through the integration of artificial intelligence and IoT. This integration facilitates the real-time collection of data from agricultural environments, leading to smarter decision-making, resource optimization, and the promotion of sustainable farming practices. Noteworthy trends in this domain include precision farming, predictive analytics, autonomous farming, resource optimization, and enhanced supply chain efficiency. These trends highlight the increasing adoption of AIoT technologies to boost agricultural productivity, reduce dependence on labor, and improve overall operational efficiency. Moreover, AIoT applications in smart agriculture present opportunities for developing decision support systems that can further refine and optimize farming processes (Leong et al., 2023).

4.4 Logistics
The pivotal role of IoT in achieving SCI within the logistics sector is underscored by studies conducted by Zhou et al. (2021) and Pundir et al. (2019). Both research endeavors highlighted the crucial importance of information sharing and coordination among various partners in the supply chain. Zhou et al. (2021) argued that the utilization of Field-Programmable Gate Array (FPGA) and IoT can significantly enhance logistics supply chain collaboration. The integration of these technologies is shown to improve information sharing and coordination, leading to a reduction in costs and the enhancement of services provided to end customers. FPGA, in this context, is posited as a tool to attain marketing objectives, enhance service provision, and establish an effective organizational structure. Simultaneously, IoT contributes to the reduction of delays in decision-making processes and information sharing. The combined effect of these technologies is proposed to enable companies to expand their catering services globally, meeting the diverse needs of a worldwide customer base. In a complementary vein, Pundir et al. (2019) advocated for the integration of IoT with Blockchain technology to achieve a fully digitized supply chain. Their research underscored the progressive nature of digital SCI as a competitive differentiator for enterprises. Organizations adopting this approach demonstrate rapid improvements in asset utilization and the facilitation of new data-based services.

4.5 Apparel
In the context of the apparel manufacturing industry, several studies underscore the pivotal role of IoT in achieving SCI. Jayashri et al. (2023) delved into the multifaceted applications of IoT in supply chain management, inventory control, and transportation within the apparel sector. The authors acknowledge the susceptibility of IoT sensors to errors and security threats, prompting a consideration of potential vulnerabilities in the current IoT-centric architecture. One notable concern raised by Jayashri et al. (2023) is the security and privacy issues associated with independent IoT software. To address this, the authors propose the incorporation of blockchain technology. Their proposed system, TrustChain, employs a consortium blockchain to monitor interactions among supply chain entities. TrustChain dynamically assigns confidence and reputation scores to enhance the security of IoT-based information management, mitigating concerns related to data quality and the entities responsible for recording information on the blockchain.

Another study emphasizing the positive impact of IoT on SCI in the apparel sector is presented by a separate group of researchers. This study acknowledges IoT's positive influence but notes that cloud computing demonstrates a more robust positive impact. The authors highlighted IoT's potential to facilitate real-time data exchange, thereby enhancing the overall performance of the apparel supply chain. Recognizing IoT as a significant technological catalyst, the study positions it as a key player with the capacity to positively impact SCI in the apparel sector, particularly in the context of Sri Lanka (Madushanka et al., 2023). While challenges such as security vulnerabilities are acknowledged, proposed solutions, including the integration of blockchain technology, underscore the ongoing efforts to harness the full potential of IoT in optimizing supply chain processes in this specific sector.

4.6 Construction
The integration of IoT in the construction industry's supply chain is a pivotal aspect, particularly within the context of Industry 4.0. Wakenshaw et al. (2017) emphasized the importance of SCI, focusing on its relationship with the collaborative planning, forecasting, and replenishment (CPFR) reference model. CPFR is designed to harness the collective intelligence of trading partners for efficient planning and fulfillment of customer demand, involving collaborative activities such as strategy and planning, demand and supply management. Wakenshaw et al.'s exploration of IoT's role reveals its potential to significantly enhance SCI. Their case studies highlight the positive

impact of IoT data, although they acknowledge the limitations associated with potential researcher bias and challenges in generalizing findings across diverse contexts.

In tandem, Xia et al. (2023) echo the transformative influence of IoT strategies on the construction sector. The endorsement of IoT strategies has given rise to resource sharing as a prevalent practice among enterprises, establishing it as the prevailing norm. Cooperative innovation among enterprises is acknowledged as a pivotal avenue for collaborative green innovation. Furthermore, the sustained promotion of IoT strategies has resulted in resource sharing among enterprises becoming more commonplace, emphasizing its status as the new standard. Cooperative innovation is now recognized as a crucial method for facilitating collaborative green innovation.

4.7 Other Industries

Hou and Chen (2022) focused specifically on the pharmaceutical sector, illustrating how IoT optimizes processes within the drug supply chain. Their work emphasizes the implementation of an integrated supply chain management system, incorporating intelligent supply chain management facilitated by IoT. Through constructing and simulating a comprehensive medical supply chain system based on IoT, the authors developed models for inventory management, transfer operations, storage operations, and performance operations. Leveraging advanced tools such as AI, cloud computing, and smart logistics and architectural algorithms, their research demonstrates a 12.8% cost reduction in comparison to traditional distribution logistics systems. These findings not only highlighted the tangible benefits of IoT in the pharmaceutical supply chain but also provided theoretical insights and technical data for the broader application of IoT logic systems.

Afrifah et al. (2022) broadened the scope by exploring the contributions of new technologies such as Federated Learning, Blockchain, and AI to mitigate supply chain security risks. Their research identifies these technologies as crucial elements in reducing inefficiencies in data management and offering improvements in sustainability, decentralization, optimization, and transparency. Although not directly focused on IoT, their insights contribute to the broader understanding of how cutting-edge technologies collectively enhance supply chain processes. Additionally, Kamble et al. (2023) highlighted the synergistic relationship between Blockchain technology and IoT in the context of supply chain benefits. They underscore that Blockchain provides a secure and decentralized platform for sharing data generated by IoT devices among supply chain partners, ensuring data integrity and confidentiality. Although their emphasis is on the interaction between Blockchain and IoT, their findings further reinforce the transformative potential of IoT technology in optimizing supply chain operations.

5. Conclusion

In this article, the analysis of the literature related to the Internet of Things (IoT) in Supply Chain Integration (SCI) was conducted. Following review guidelines, 26 relevant articles were selected and analyzed, shedding light on the benefits and challenges associated with implementing IoT in supply chain operations to achieve SCI. The findings indicate that the application of the disruptive technology of the IoT to achieve SCI has become one of the popular research areas over the past decade, and the writing of articles in this area has increased significantly since 2021. The integration of IoT into SCM is crucial for achieving efficiency and transparency across diverse and different industry sectors. The application of IoT enhances real-time monitoring, collaboration, and information flow, transforming raw data into valuable insights (Manavalan and Jayakrishna, 2019). The retail sector benefits from IoT capabilities, improving operational efficiency and sustainability (Ernawan et al., 2022; Shafique et al., 2018; Zhen, 2022). In manufacturing, IoT adoption improves decision-making and coordination within supply chains (Bellini et al., 2022; N et al., 2023). The food and agriculture industry sees gains in efficiency, transparency, and collaboration (Mantravadi and Srai, 2022; Wakenshaw et al., 2017). Logistics and apparel sectors emphasize IoT's role in information sharing and supply chain optimization (N et al., 2023; Pundir et al., 2019; Zhou et al., 2021). In construction, IoT enhances collaboration and efficiency (Wakenshaw et al., 2017; Xia et al., 2023). Research in other industries, such as pharmaceuticals and supply chain security, underscores the broader impact of IoT on optimizing processes (Afrifah et al., 2022; Hou and Chen, 2022).

The role of IoT technology in obtaining SCI has shown promising results across various industries. However, it is essential to highlight some shortcomings in this research. The sample selected from the databases is comprehensive but not exhaustive, and due to the selection criteria, we chose, there is the possibility that the sample might exhibit some bias. Despite challenges, the transformative potential of IoT in reshaping and optimizing supply chain processes is evident across industries, emphasizing the need for further research to address specific challenges and explore emerging trends. Within the domain of SCI, the utilization of IoT has demonstrated transformative potential across industries, prompting the need for ongoing research to address specific challenges and explore emerging trends. Security remains a central concern, prompting future investigations to concentrate on developing robust measures, including advanced encryption, blockchain integration, and AI-driven threat detection. Ethical considerations, such as data privacy and responsible use, also warrant exploration. Collaboration between industries is crucial for sharing best practices and technological solutions, fostering innovation in IoT adoption. Research should prioritize scalable and customizable IoT frameworks that are adaptable to diverse supply chain environments. Addressing the environmental impact is imperative, with research focusing on how IoT can contribute to sustainable practices, transitioning from Industry 4.0 to Industry 5.0. In summary, future research should navigate these aspects to unlock the potential benefits of IoT in reshaping and optimizing supply chain processes.

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