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RESEARCH PAPER

Challenges and Drivers of the Internet of Things in the Supply Chain: A Systematic Review

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ABSTRACT

In today's world, supply chains must adopt new and intelligent technologies to achieve objectives such as enhancing productivity and performance, competitiveness, and overcoming challenges. The Internet of Things (IoT), as an emerging and transformative technology, is considered one of the most significant technology areas today and has garnered considerable attention across various industries. However, the implementation of IoT at the supply chain (SC) level faces numerous challenges and obstacles, and its acceptance at this level requires specific drivers. To date, no specific classification has been provided for drivers at the SC level, and existing classifications for challenges also need to be reviewed and updated. Given the importance of IoT in SC management, a systematic review at this level is necessary. This article provides a systematic literature review to identify and classify the challenges and drivers of IoT at the SC level. The study reviewed articles published from 2004 to 2023, ultimately identifying and categorizing 92 challenges into 16 categories: financial, standards and government regulations, privacy and security, energy consumption, health issues, hardware and software issues, culture in the SC, lack of knowledge and awareness, poor IT management, coordination in the SC, perception, the Challenge of uncertainty, lack of Plan and Strategy, incompatibility with existing technology, supply Problems, and user acceptance and trust in technology. Additionally, the study identified 4 antecedent drivers (pressures, understanding the benefits, government regulations, government incentives) and 10 consequent drivers (production benefits, improving competitive advantage, inventory management, cost management, improving transparency, efficiency of information flow, development of responsiveness and agility, sustainable development, facilitation of management, and development of cooperation and coordination). Finally, a model for implementing IoT technology in the SC is presented. This model synthesizes the findings from the literature review and offers a practical roadmap for organizations seeking to leverage IoT in their supply chains. By addressing the identified challenges and utilizing the drivers, organizations can effectively integrate IoT technology, thereby enhancing the efficiency, transparency, and overall performance of their SC operations.

KEYWORDS: Internet of things; Supply chain; Challenge; Driver.

1. Introduction

Over the past few years, supply chains have undergone considerable changes and transformations [1]. Supply chains (SC) are becoming more challenging and complex over time. In the face of the proliferating changes and challenges driven by globalization and emerging technologies, the utilization of information and communication technology has become indispensable [2]. Accordingly, there is a growing need to integrate Industry 4.0 technologies, such as the Internet of Things (IoT), into SC management. [3]. IoT has emerged as a highly disruptive technology in the 21st century, capturing the attention of the academy and the industry [4]. IoT is the most significant emerging trend in technology, and it has sparked an unprecedented information revolution, solidifying its position as one of the key technologies in today's landscape [4, 5]. This technology is

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experiencing continuous growth, profoundly impacting various domains. Technology is not only driving the Industry 4.0 revolution on a global scale, but it is also expanding its reach to consumers, enriching their work efficiency and overall quality of life [6]. IoT technology aims to fill the gaps between the human, cyber, and physical worlds by creating a global network that connects people, things, data, and processes [7]. Driven by the rise of IoT, many companies have endeavored to incorporate this transformative technology into their smart infrastructure. [8]. The concept of IoT allows for the interconnection of different technologies, which has the potential to revolutionize various fields, particularly supply chain management [9]. As supply chains have become more intelligent and technology-driven, research on IoT and its innovative applications in the supply chain has seen rapid growth [1]. The diverse applications and capabilities enabled by IoT technology can provide significant advantages for the SC. Its impact on the future of SC is expected to be substantial and far-reaching [10]. Key IoT technologies, such as radio frequency identification (RFID), cloud computing, and wireless sensor networks (WSN) can be widely utilized in the SC [11]. Among the applications of IoT technology in the SC, we can mention the effective tracking of activities through sensor-based systems [2], creating a unique view along the SC [12], as well as the appropriate as well as timely sharing of information or data between stakeholders [11, 13].

After reviewing the articles and considering the opinions expressed, adopters of IoT view this technology as crucial for business success in the upcoming years. With the increasing intensity of competition in the business world, they anticipate that companies failing to embrace IoT will lag behind their competitors [12, 14]. Although IoT holds great importance and is used in numerous applications, incorporating this technology into the SC encounters significant challenges [15]. Some of these challenges include financial challenges [16], complex architecture [17], lack of knowledge [18], lack of security and interoperability [19]. Therefore, the identification and investigation of these challenges hold significant importance. In addition, to create motivation for adopting IoT devices in the SC, we must identify and examine the drivers of this technology.

The challenges and drivers of IoT have been studied separately by various researchers, as shown in Table 1. However, reviewing and integrating these findings can provide a more comprehensive understanding and open up multiple research opportunities. For instance, Ahmetoglu (2022) has examined the challenges and benefits at the organizational level, while other studies, such as Rejeb (2021) and Amer (2021), have focused on the acceptance of IoT in a specific sector and limited their findings to that particular industry. Furthermore, some studies, like the research conducted by Birkle and Hartmann (2019) and Amer (2021), have solely focused on the challenges and have yet to address the drivers.

Previous studies have primarily focused on the challenges of IoT, neglecting to discuss its drivers. However, it is important to pay special attention to IoT drivers because they can motivate and significantly impact the adoption and implementation of IoT. This study aims to address this gap by conducting a systematic review (SR) of the existing literature on the challenges and drivers of IoT at the supply chain level, building upon previous studies. The current study offers a unique perspective on the definition of "driver" and provides a comprehensive review of the challenges. This study defines challenges as factors that create problems and limitations in achieving the goal. On the other hand, the term "driver" refers to the factors that generate motivation or cause the occurrence or spread of a particular phenomenon. All of the above points highlight the significance of this topic and the need for further research in this area. Therefore, this study was conducted to identify, investigate, and classify the challenges and drivers of IoT at the SC level, ultimately proposing a technology implementation model.

Tab. 1. Summary of review articles on IoT in the SC

Sourses	Year	Organization Type	Time span
[20]	2022	Warehousing and logistics operations	2011-2021
[12]	2022	General	2016-2021
[21]	2021	Supply Chain Management	2000-2020
[22]	2021	Halal food supply chain	2008-2020

[23]	2021	Food Supply Chain	2010-2020
[24]	2019	Supply Chain Management	2008-2018
[25]	2018	Supply Chain Management	2000-2017
This Study	2023	Supply Chain	2004-2023

2. Research Methodology

The current study used the systematic literature review to identify the challenges and drivers of IoT in the SC. A systematic review is a meticulous and thorough type of literature review, carried out in an organized, transparent, and replicable manner. It aims to comprehensively gather and synthesize all available evidence to answer research questions. [26]. Figure 1 presents the steps of SR [27].

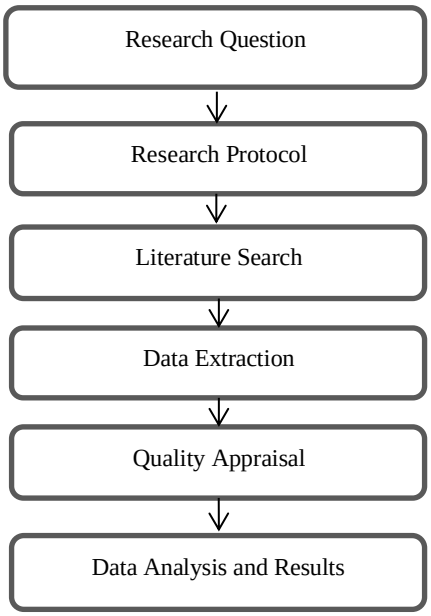

Fig. 1. Systematic review steps

2.1. Research questions

The initial step in conducting a systematic review (SR) is to formulate research questions.

Based on the objectives of this study, the following research questions were formulated:

- RQ1: What are the IoT challenges at the supply chain level, and how are they classified?
- RQ2: What are the IoT drivers at the supply chain level, and how are they classified?

2.2. Research protocol

After the research question is developed, it is essential to develop a comprehensive research protocol. A protocol is a document that contains the methods for literature searching, screening, data extraction, and analysis. The aim of documenting these steps is to minimize bias and ensure a systematic and accurate approach to the literature search. Also, stringent inclusion and exclusion criteria should be established for the studies.

First, the Web of Science database was used, followed by Scopus, to maximize the identification of potentially relevant studies. The search string was used: (supply chain* OR Supply network) AND (Internet of things* OR IoT). In this review, chapters, books and reports have been excluded. Table 2 illustrates the inclusion and exclusion criteria.

2.3. Literature search

To collect the necessary data to address the research questions, a comprehensive literature search was conducted. This involved meticulously examining 32 articles sourced from both the Scopus and Web of Science databases. These databases were chosen for their extensive and reputable collections of peer-reviewed research publications across various disciplines, ensuring that the information obtained would be both reliable and relevant. The process of selecting these articles was systematic and thorough. Initially, a broad search was conducted using specific keywords related to the research questions. These keywords were carefully chosen to encompass all possible relevant studies. The

search criteria were then refined to ensure the relevance and quality of the articles. This refinement included filtering out articles based on publication date to include only recent studies, language to include only those in English, and the impact factor of the journals in which they were published to ensure high-quality sources. Each article retrieved from the databases was carefully reviewed to ascertain its relevance to the research questions. The relevance was determined by reading the abstracts and, where necessary, the full text of the articles. Articles that did not meet the criteria were excluded, ensuring that only the most pertinent and high-quality studies were included in the final selection. The outcomes of this meticulous selection process, including the number of articles screened, excluded, and ultimately included, are visually represented in Figure 2. Figure 2 provides a detailed illustration of the article selection process, presenting a clear overview of how the initial pool of articles was narrowed down to the final 32 that were analyzed in-depth for this study.

2.4. Data extraction

After thoroughly reviewing the selected articles, data extraction was carried out using a standardized form. This form was designed to systematically collect all relevant information from each study, ensuring consistency and completeness. The data extracted included key study characteristics such as the study design, sample size, methodologies used, outcomes measured, and the results obtained. By using a standardized form, the process ensured that no critical information was overlooked and facilitated the subsequent analysis by organizing the data in a uniform manner.

2.5. Quality appraisal

Following data extraction, a rigorous evaluation of the reviewed literature was conducted to appraise the quality of each study. This step was crucial to ensure that the final analysis was based on robust and reliable data. The quality appraisal involved assessing the methodological soundness of each study, including factors such as the clarity of the research questions, appropriateness of the study design, validity of the data collection methods, and the robustness of the data analysis techniques. Studies that did not meet the high-quality standards were excluded from the final analysis. This rigorous evaluation process ensured that only high-quality studies were included, ultimately yielding robust and reliable results.

2.6. Data analysis and results

Eventually, following the inclusion and exclusion of studies through the quality appraisal process, data analysis was conducted on the selected studies. This step involved a detailed evaluation of each study's findings to synthesize the data and draw meaningful conclusions. Various analytical techniques were employed to assess the results, including both qualitative and quantitative methods as appropriate. The synthesis of data from multiple studies allowed for a comprehensive understanding of the research questions. The results of this data analysis provided a clear and evidence-based answer to the research questions, supported by high-quality and relevant studies. Overall, the methodical approach taken in the literature search, data extraction, quality appraisal, and data analysis ensured that the findings of this research were based on a solid foundation of high-quality evidence, providing valuable insights and reliable answers to the research questions.

Tab. 2. The inclusion and exclusion criteria

	Inclusion Criteria	Exclusion Criteria
language	English	Other languages
Time span	Between 2004 and 2023	Beyond this time range
Keyword	supply chain*- Supply network- Internet of Things*- IoT	Articles without relevant keywords
Title	Articles with keyword in their title	Articles that do not include the keyword in their title
Abstract	Articles containing the keyword in their abstract	Articles that do not include the keyword in their abstract
Content	The content of the articles was thoroughly reviewed to assess their eligibility.	Rejected by the Critical Assessment Skills Program

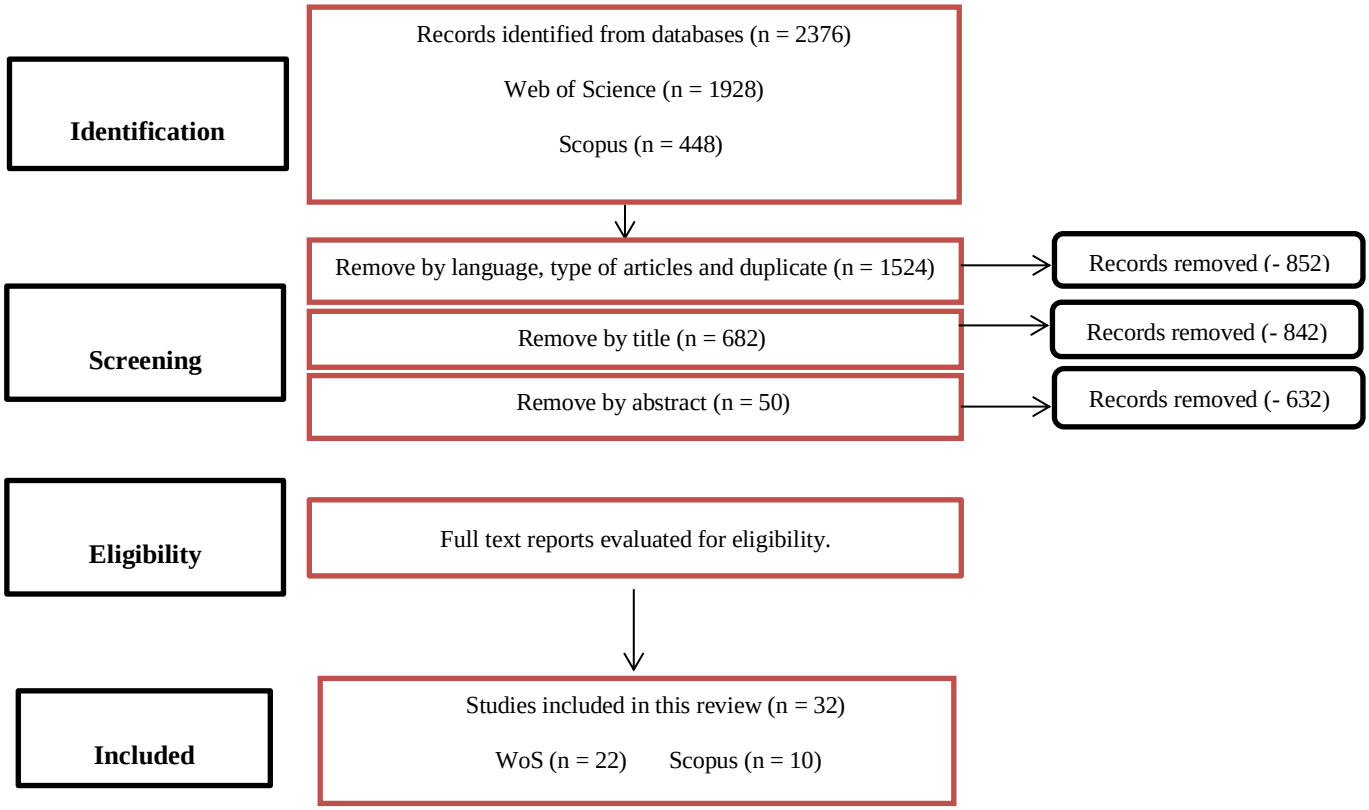

Fig. 2. Article selection process

3. Results

After applying the filtering processes, 32 relevant articles published between 2004 and 2023 were selected from the Web of Science and Scopus databases and underwent a detailed review and the key drivers and challenges of IoT mentioned in these articles were extracted. Of these articles, 16 articles were presented only to the challenge, 6 articles to the drivers only, and 10 articles to both the challenges and the drivers.

Tab. 3. Summary of the included studies and their data

Source	Challenge (s)	Driver (s)
[11]	-	Customer value enhancement, Real-time visibility, Performance tracking, Ease of decision-making, Efficient logistics systems, Integrated information systems.
[2]	Higher cost, Increasing e-waste.	Tracking, Increasing efficiency, Increasing responsiveness.
[28]	Scalability, Issues of IoT architecture, Lack of infrastructure and legislation, Lack of cooperation between government and stakeholders, The high energy requirement for IoT implementation, The community's readiness to understand and use IoT, Data storage, Implementation cost,	-
[19]	High capital investment cost, Lack of security, Lack of interoperability, Network Challenges, Lack of standardization, Energy efficiency, Huge volume of data, Lack of connectivity, Scalability, Heterogeneity, Lack of Legislation, Technical skill requirement, Lack of infrastructure, Data management, User Acceptance.	-
[29]	Lack of knowledge, Complex system implementation, Concerns of employees, High costs, Business model adaptation, Unknown profitability, Privacy concerns, Lack of legal	-

Source	Challenge (s)	Driver (s)
	regulations, Security issues, Lack of standards & interoperability, Hardware limitations, Software limitations.	
[18]	High operating costs, Financial constraints/insufficient budget, High energy consumption, e-waste generation, Lack of a corporate vision and no overarching strategy for digitalization, Inadequate collaboration between IT and lines of business/Employee, Risk-aversive culture, Inadequate internet connectivity, Lack of IT infrastructure/Lack of data availability, System failure issue/integrity, Lack of technological knowledge among partners.	-
[30]	Challenges of resistance to change, Uncertainty, Architecture, Scalability, Security, privacy protection, Lack of management support, Financial constraints, and lack of policies by government.	-
[17]	Complex architecture, Energy management, High implementation and operating cost, Legal and regulatory standards, Lack of knowledge management system, Difficulty in big data management, Lack of IoT suppliers & service providers, Lack of internet coverage and IT infrastructure, Technology affordability, Lack of awareness about IoT benefits in the healthcare domain, Lack of security & privacy concerns, Standardization, Data heterogeneity.	-
[16]	Lack of privacy, Financial matters, Waste disposal, Legal framework for IoT governance, New business model, Lack of strategy and scenario planning in IoT, Trust creation and user acceptance, Lack of security, Dynamic environment, The need for open standards, Difficulty of consequences prediction, Scalability and Interoperability, Energy demands, Storage issues.	-
[31]	Lack of standardization, Intangibility, High perceived uncertainty, Privacy issues, Scalability, Interoperability, Technical set up cost, Training cost, Hard to integrate to existing processes and solutions, Security concerns, Technology immaturity, Benefits being ambiguous, Lack of workforce skills and resistance to change.	-
[21]	-	Demand management, Manufacturing flow management, Tracking, Monitoring, Increase in the supply chain's information flow component, Optimizing their operations, Providing transparency, Reducing manufacturing costs, Globalization, Reducing the occurrence of the bullwhip effect, Facilitating inventory reduction, Supplier relationship management.
[23]	Interoperability and integration, Big data management, Internet availability, Hardware challenges, Capital investment, Cooperation among supply chain players, The integration and coordination of information among SC partners, Adequate knowledge of emerging IoT technology, Trust among the SC partners, Industry operating IoT standards, Government regulations and policies.	-
[32]	Costs, Lack of management vision in IoT adoption,	Enhance competitiveness and sustainability, Get

Source	Challenge (s)	Driver (s)
	Concern of sharing information between partners, Lacked a clear understanding of the demands of SCM, Employee resistance, Reliable Internet connectivity and services, Security and privacy issues.	access to Visibility of information, Process optimizations, Improving SC communication, Improve customer experience.
[22]	IoT connectivity, Immaturity and lack of user acceptance, Cost and regulatory challenges.	SC traceability, SC efficiency,
[33]	Lack of standardization, security, Misread information.	Supply chain planning, Collaboration, Traceability, Transparency, Flexibility, Performance Management, Order Management.
[34]	-	Optimize supply chain, Information sharing, Improve the quality of products, Reduce the cost of each link of the SC, Improve the supply chain's competitiveness.
[35]	-	Greater integration, Improve inventory accuracy, Tracking, Improve customer-order delivery process, Improve sustainability.
[36]	-	Improve the SC operation, Increase economic benefits,
[37]	-	Improve the asset utilization and execution efficiency of the SC, Reduce the cost of the raw material SC.
[38]	Data analysis and comprehension, User safety, Lack of financial resources, Lack of skilled workers, Privacy protection, Changing the business model, Underdeveloped infrastructure, Standardization, Lack of internet connection, Lack of awareness.	-
[39]	Software issues, Security issues, Absence of technical knowledge, Lack of IoT-based infrastructure, Internet accessibility and its network availability, The infrastructure innovation expenditure and its repairing capabilities, Big data analysis issues, Scalability of service issues, Congestion and overload issues of IoT network	-
[40]	Scalability, Privacy and security, Gathering and managing large data.	-
[41]	High costs, Unclear benefits, Complicatedness to use and maintain, Interoperability, Lack of sufficient knowledge, Lack of proper training, Scalability, Lack of technologies securing privacy and pertinent safeguard laws, Different digital standards that exist globally.	-
[42]	Lack of government regulations, Lack of standardization, High energy consumption, Security and privacy, High operating and adoption costs, Long payback period, Lack of internet infrastructure, Seamless integration and compatibility issues, Scalability issues, Lack of validation and identification, Architecture.	-
[24]	High costs, Business model adaptation, Unknown profitability, Privacy concerns, Security issues, Lack of standards and interoperability, Hardware limitations, Software limitations, Lack of legal regulations, Trust issues, Complex network implementation, Lack of knowledge, Concerns of employees.	-
[43]	Concerned about security and privacy, Lack of technology standards, Energy demand, Waste disposal that adversely effects the environment.	Increasing efficiency, Ensuring the safety of labor and goods, Reducing operational time, Sustainable value, Competitive pressure, Minimizing the number of workers, Increasing reliability, Government support, Willingness to adopt IoT system by government rules and regulations

Source	Challenge (s)	Driver (s)
[25]	Need for new supply Models,	Inventory management optimization.
[44]	Difficulty of consequences prediction, Lack of strategy and scenario planning in IoT, Storage issues, Lack of security, Lack of privacy, Scalability and Interoperability, Financial matters, The need for open standards, New business model, Responsibility sharing, Energy demands, Waste disposal, Legal framework for IoT governance, Trust creation and user acceptance, Dynamic environment.	-
[45]	Supply chain efficiency, Willing to adopt IoT system by governmental rules.	Customer awareness, Customer pressure, Competitive, Improve cooperation, Cooperation and participation of supply chain managers.
[46]	Security, Integration, Coordination problems among supply chain members.	Developing reliability, Visibility, Increasing responsiveness and reducing supply chain costs, Improving chain asset management, Increasing chain agility by speeding up information flow processes, High potential to solve various supply chain challenges, Social expectations .
[47]	Lack of understanding of benefits from adoption, Integration of IoT technologies with existing operational, Analytical and strategic systems/technologies in supply chains, Development of global IoT communication protocol standard for intelligent objects and systems, Creation of effective security layers to eliminate vulnerable resources across nodes and Supply chain linkages, Shared management understanding of IoT in supply chain, Creation of effective IoT architecture across chains, Immaturity of technological products and services, Unstructured design of new supply chain business models, Challenge with just-in-time production in relation to dynamic planning.	Improving supply chain performance management by reducing delays in data collection and decision-making, better integration of inter-organizational business processes, Transparency of local and international logistics operations, development of reliability, Responsiveness and agility, improvement in just-in-time production, Reduction of Bullwhip effect in the SC, Improving business intelligence.
[48]	Tag readability, Placement of antennas (location), Placement of tags on products, Privacy, Concerns related to people's health.	Increased SC visibility, Better collaboration between business partners, Inventory management, Less waste.

3.1. Classifications of IoT challenges

In spite of the numerous advantages of IoT technology, its implementation in the SC faces several challenges [21]. These challenges have a considerable impact on the attainment of benefits, therefore it is essential to identify and examine them. In this study, 92 challenges were identified and classified into 16 categories. Table 4 provides a comprehensive classification of the IoT challenges in the SC.

Tab. 4. Classification of IoT challenges in the SC

Category	Challenges
Financial	Training cost, High implementation and operating cost, High operating costs, High capital investment cost, Lack of financial resources, Scalability, Technical set up cost, High operating costs, Financial matters, Financial constraints/insufficient budget.
Standards and Government regulations	Lack of standardization, Lack of Legal and regulatory standards, The need for open standards, Lack of Industry operating IoT standards, Different Digital standards that exist globally, Development of global IoT communication protocol standard for intelligent objects and

Category	Challenges
	systems, Lack of government regulations, Willing to adopt IoT system by governmental rules, Lack of Government regulations and policies, Lack of legal regulations, Lack of Legal framework for IoT governance.
Privacy and security	Privacy concerns, privacy protection, Security and privacy issues, Lack of technologies securing privacy and pertinent safeguard laws.
Energy consumption	Increasing energy demand, High energy consumption, Energy management, Energy efficiency.
Health issues	Problems and concerns related to people's health, The problem of e-waste disposal and its adverse effects on the environment.
Hardware and software issues	Software issues, Readability (miss) reading of RFID tags, Placement of tags on products, Connectivity issues, Lack of internet coverage and IT infrastructure, Storage issues, Placement of RFID antennas, Internet access , Lack of internet infrastructure (underdeveloped infrastructure), Hardware limitations and challenges, Lack of internet connection, IoT connectivity, Complex network implementation.
Culture in the SC	Lack of management support, Risk-aversive culture, Concerns of employees, Resistance to change, The community's readiness to understand and use IoT, Employee resistance, Concern of sharing information between partners.
Lack of knowledge and awareness	Lack of technical knowledge among partners, Lack of sufficient knowledge, Lack of knowledge management system, Lack of proper training, Lack of necessary awareness, Lack of awareness about IoT benefits, Lack of workforce skills, Technical skill requirement.
Poor IT management	Data heterogeneity, Poor IT management and support, Gathering and managing large data, Big data analysis issues, Data analysis and comprehension, Lack of infrastructure, Difficulty in big data management, Huge volume of data.
Coordination in the SC	Lack of integration and coordination of information among supply chain partners, Lack of access to supply chain partners' systems, Lack of cooperation between government and stakeholders, Challenges with just-in-time production in relation to dynamic planning, Coordination problems among supply chain members, Interoperability.
Perception	Lack of Shared management understanding of IoT in supply chain, Lack of understanding by senior managers of the demands of the supply chain.
The challenge of uncertainty	Dynamic environment, Difficulty in predicting possible consequences of technology use, High perceived uncertainty.
Lack of plan and strategy	Lack of strategy and planning in IoT technology, lack of structure in the design of new business models of the supply chain, Challenges related to new models of the supply chain, Complex architecture, Lack of corporate vision and lack of comprehensive strategy for digitalization, Issues of IoT architecture.
Incompatibility with existing technology	Immaturity of technological services and products, Insufficient collaboration between IT and business lines, Integration of Internet of Things technologies with existing operational, Analytical and strategic systems in SC, integration, Seamless integration and compatibility issues.
Supply problems	Insufficient suppliers of Internet of Things devices and related service providers.
User acceptance and trust in technology	Trust creation and user acceptance, trust among the supply chain partners.

3.2. Classifications of IoT drivers

Due to the significant impact of drivers on motivating the implementation of IoT technology in the SC, this study conducted a comprehensive investigation to identify and classify drivers. In this study, taking into account the definition of the term "driver" and to provide a more precise classification, the drivers were initially classified into two main categories: antecedent drivers and consequent drivers. Considering the context of the current study, the term "antecedent drivers" refers to the drivers that precede the implementation of IoT and contribute to the motivation for this task. On the other hand, the term "consequent drivers" encompasses the benefits resulting from the implementation and utilization of this technology, which can serve as motivation for implementing IoT in the SC. Table 5 and 6 show the classification of IoT Antecedent drivers and Consequent drivers in the supply chain respectively.

Tab. 5. Classification of IoT Antecedent drivers in the supply chain

Category	Subcategory
Pressures	Competitive pressure/ Globalization Social pressure/ social expectation Customer pressure/ Customer awareness Pressure on supply chain partners
Understand the benefits	Cooperation and participation of supply chain managers
Government regulations	Willingness to adopt IoT system by government rules and regulations
Government incentives	Government support

Tab. 6. Classification of IoT Consequent drivers in the supply chain

Category	Subcategory
Production benefits	Improvement In Just-in-Time manufacturing, Improve the quality of products, Ensuring the safety of labor and goods, Developing reliability, Minimizing the number of workers, Reducing operational time.
Improve competitive advantage	Improving SC competitiveness, Enhancing competitiveness and sustainability, Improve customer experience, Sustainable value, Improve business intelligence, Customer value enhancement.
Inventory management	Inventory management optimization, Order Management, Improving inventory accuracy, Facilitating inventory reduction.
Cost management	Supply chain efficiency, Reducing supply chain costs, Increasing efficiency, Reducing manufacturing costs.
Improve transparency	Transparency from local and international logistics operations, Providing transparency, SC traceability, Enhancement the real-time visibility of demand and capacity fluctuations, Improving visibility of demand, Increased supply chain visibility, Improve tracking, Demand management, Monitoring.
Efficiency of information flow	Information sharing, Increase in the supply chain's information flow component, Visibility of information, Improving SC communication, Integrated information systems, Reduction of Bullwhip effect in the supply chain.
Development of responsiveness and agility	Increasing chain agility by speeding up information flow processes, Responsiveness and agility, Increasing responsiveness, Flexibility.

Category	Subcategory
Sustainable Development	Performance Management, Improving supply chain performance management, Supply Chain Planning, Less waste, Increase economic benefits, Optimize the SC.
Facilitate management	Supply chain risk identification, Decision making, Improving chain asset management, Ease of decision-making, High potential to solve various supply chain challenges, Efficient logistics systems, Supplier relationship management, Improving customer-order delivery process.
Development of cooperation and coordination	Better integration of inter-organizational business processes, Greater integration, Improve cooperation, Better collaboration between business partners, reducing delays in data collection and decision-making.

Ultimately, this review presented a model for implementing IoT technologies in the SC. This model includes antecedent and consequent drivers, the steps of IoT technology implementation in the SC [49], and the identified challenges. Figure 3 shows the model.

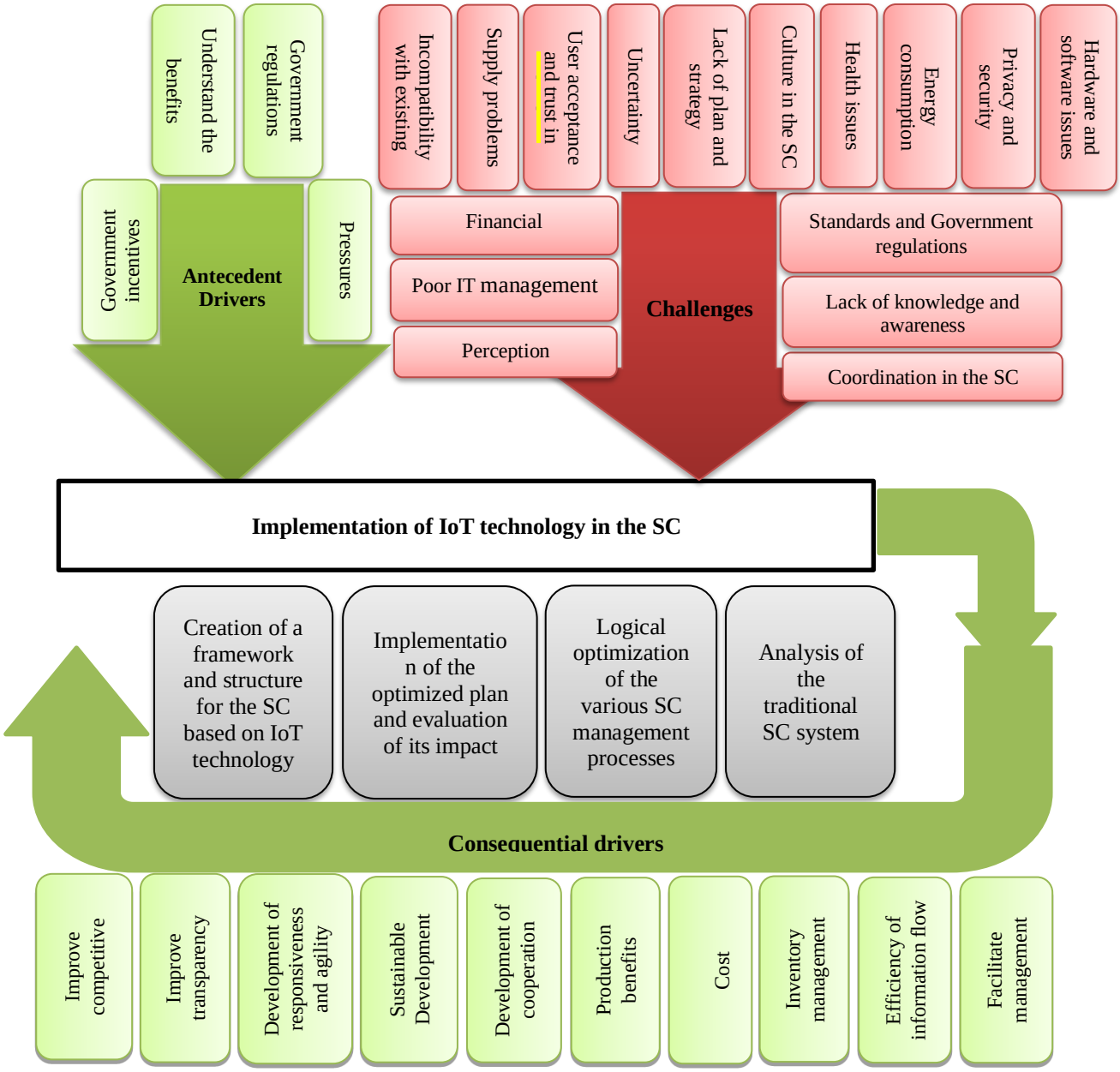

Fig. 3. Model for the implementation of IoT technology in the SC

4. Discussion

IoT, as a cutting-edge technology of the fourth industrial revolution, has the potential to revolutionize the entire SC. Further analysis indicates that supply chains can effectively utilize IoT to improve various aspects, including tracking, monitoring, visibility, agility, adaptability, and responsiveness [50] . This review aimed to comprehensively identify and review the existing literature on IoT challenges and drivers in the SC and classify them. A total of 32 relevant articles published between 2004 and 2023 were selected from the Web of Science and Scopus databases. To effectively harness the potential benefits of IoT technology in the SC, it is essential to identify the drivers and challenges of implementing it. By addressing these drivers and challenges, organizations can generate motivation and develop strategies for successful IoT implementation.

To address the research questions, the selected articles were carefully examined. This meticulous examination led to the identification and classification of the challenges and drivers of IoT in the SC. The first research question focused on identifying the challenges associated with IoT in the SC. Through this investigation, a total of 92 IoT challenges were identified and classified into 16 categories. This research has provided a comprehensive and unique classification of IoT challenges in the SC, contributing distinctively to the existing body of knowledge compared to previous studies. The drivers of IoT in the SC, on

the other hand, have not been thoroughly investigated and categorized in previous studies. Considering the importance of understanding what motivates the adoption of IoT, the present study reviewed articles in the field to identify these drivers. The second research question centered on uncovering the drivers of IoT in the SC. After a careful review of the articles, we identified a total of 67 drivers. These drivers were initially divided into two main groups: antecedent drivers and consequent drivers. Antecedent drivers consisted of four categories, while consequent drivers were further classified into ten categories.

By thoroughly identifying the challenges and drivers of IoT technology in the SC and classifying them, the study provides valuable insights for organizations looking to implement IoT solutions. These classifications not only highlight the potential obstacles and facilitators of IoT adoption but also offer a structured approach to addressing them. Comprehending these factors is essential for developing effective implementation strategies that can enhance the overall efficiency and effectiveness of supply chains.

The results of this study make a significant contribution to the field by offering a comprehensive and systematic classification of both the challenges and drivers of IoT in the SC. Previous research has often focused on isolated aspects of IoT implementation, but this study provides a holistic view, integrating various factors into a coherent framework. This framework can serve as a foundation for future research and practical applications, guiding organizations in their IoT adoption journey.

After thoroughly identifying and classifying the challenges and drivers of IoT in the SC, an implementation model for IoT in the SC was presented. This model synthesizes the insights gained from the literature review and offers a practical roadmap for organizations. By following this model, organizations can systematically address the identified challenges, leverage the drivers, and achieve successful IoT integration into their supply chains. This structured approach ensures that the potential benefits of IoT, such as improved tracking, monitoring, visibility, agility, adaptability, and responsiveness, are fully realized, leading to more efficient and resilient supply chains.

5. Conclusion

The emergence of IoT technology has brought about a new industrial revolution, driving transformative changes in numerous sectors, including supply chains. The summary of previous studies shows that many researchers have recognized the significance of this technology in recent years. However, existing literature has not adequately examined the challenges and especially drivers of IoT. Hence, the current study used a systematic review to identify and then classify the challenges and drivers of IoT at the SC level.

To address the first research question, 92 challenges were identified and classified into 16 categories sucha as: Financial, Standards and Government regulations, Privacy and security, Energy consumption, Health issues, Hardware and software issues, Culture in the SC, Lack of knowledge and awareness, Poor IT management, Coordination in the SC, Perception, The challenge of uncertainty, Lack of plan and strategy, Incompatibility with existing technology, Supply problems, and User acceptance and trust in technology. Also, To address the second research question, 4 Antecedent drivers (Pressures, Understand the benefits, Government regulations, Government incentives) and 10 Consequent drivers (Production benefits, improve competitive advantage, Inventory management, Cost management, improve transparency, Efficiency of information flow, Development of responsiveness and agility, Sustainable Development, Facilitate management, and Development of cooperation and coordination) were identified. Finally, a model for implementing IoT technology in the supply chain is presented. This model synthesizes the findings from the literature review and offers a practical roadmap for organizations seeking to leverage IoT in their supply chains. By addressing the identified challenges and utilizing the drivers, organizations can effectively integrate IoT technology, thereby enhancing the efficiency, transparency, and overall performance of their supply chain operations.

6. Limitations and Future Suggestions

Similar to other studies, this research also has limitations that future researchers should pay attention to and seek to resolve in subsequent investigations. We searched the Scopus and Web of Science databases to find relevant articles. Therefore, it is possible that this analysis might have missed articles that are not indexed in these databases. In addition, this review only focuses on peer-reviewed journal articles. Future researchers can consider other sources, such as books, chapters, and conference proceedings.

Previous research provides a foundation for further studies, inspiring innovative research ideas and motivating researchers. The results of this study have the potential to significantly benefit future researchers and IoT implementation

practitioners in various industries, particularly at the supply chain level. This technology presents many advantages for supply chains, including improving efficiency and productivity, reducing costs, and creating transparency. Furthermore, considering each category of challenges and drivers can provide a valuable research topic for future researchers in the domain of IoT.

References

[1] Rejeb, A., Simske, S., Rejeb, K., Treiblmaier, H., and Zailani, S., "Internet of Things research in supply chain management and logistics: A bibliometric analysis," *Internet of Things*, Vol. 12, (2020), p. 100318.

[2] Khan, Y., Su'ud, M. B. M., Alam, M. M., Ahmad, S. F., Ahmad , A. Y. A. B., and Khan, N., "Application of Internet of Things (IoT) in Sustainable Supply Chain Management," *Sustainability*, Vol. 15, No. 1, (2023), p. 694.

[3] Ding, S., Ward, H., Cucurachi, S., and Tukker, A., "Revealing the hidden potentials of Internet of Things (IoT)-An integrated approach using agent-based modelling and system dynamics to assess sustainable supply chain performance," *Journal of Cleaner Production*, Vol. 421, (2023), p. 138558.

[4] Koohang, A., Sargent, C. S., Nord, J. H., and Paliszkiewicz, J., "Internet of Things (IoT): From awareness to continued use," International Journal of Information Management, Vol. 62, (2022), p. 102442.

[5] Furstenau, L. B. et al., "Internet of things: Conceptual network structure, main challenges and future directions," *Digital Communications and Networks*, Vol. 9, No. 3, (2023), pp. 677-687.

[6] Pal, D., Zhang, X., and Siyal, S., "Prohibitive factors to the acceptance of Internet of Things (IoT) technology in society: A smart-home context using a resistive modelling approach," *Technology in Society*, Vol. 66, (2021), p. 101683.

[7] Golpîra, H., Khan, S. A. R., and Safaeipour, S., "A review of logistics internet-of-things: Current trends and scope for future research," Journal of Industrial Information Integration, Vol. 22, (2021), p. 100194.

[8] Bahtat, C., El Barkany, A., and Abdelouahhab, J., "Reconfigurable Manufacturing Systems: From Automation Through Industry 4.0," *International Journal of Industrial Engineering*, Vol. 34, No. 2, (2023), pp. 1-22.

[9] Varriale, V., Cammarano, A., Michelino, F., and Caputo, M., "Sustainable supply chains with blockchain, IoT and RFID: A simulation on order management," *Sustainability*, Vol. 13, No. 11, (2021), p. 6372.

[10] Jarašūnienė, A., Čižiūnienė, K., and Čereška, A., "Research on Impact of IoT on Warehouse Management," Sensors, Vol. 23, No. 4, (2023), p. 2213.

[11] Ali, S. M. et al., "Drivers for Internet of Things (IoT) adoption in supply chains: Implications for sustainability in the post-pandemic era," *Computers & Industrial Engineering*, Vol. 183, (2023), p. 109515.

[12] Ahmetoglu, S., Che Cob, Z., and Ali, N. A., "A systematic review of Internet of Things adoption in organizations: Taxonomy, benefits, challenges and critical factors," *applied sciences*, Vol. 12, No. 9, (2022), p. 4117.

[13] Kaur, A., Singh, G., Kukreja, V., Sharma, S., Singh, S., and Yoon, B., "Adaptation of IoT with blockchain in Food Supply Chain Management: An analysis-based review in development, benefits and potential applications," Sensors, Vol. 22, No. 21, (2022), p. 8174.

[14] Iftitah, N., Qurtubi, Q., and Sugarindra, M., "Class-Based Storage: Bibliometric analysis for Research Mapping," *International Journal of Industrial Engineering & Production Research*, Vol. 34, No. 4, (2023), pp. 1-14.

[15] Prajapati, D., Chan, F. T., Chelladurai, H., Lakshay, L., and Pratap, S., "An Internet of Things embedded sustainable supply chain management of B2B e-commerce," *Sustainability*, Vol. 14, No. 9, (2022), p. 5066.

[16] Yang, K., Duan, T., Feng, J., and Mishra, A. R., "Internet of things challenges of sustainable supply chain management in the manufacturing sector using an integrated q-Rung Orthopair Fuzzy-CRITIC-VIKOR method," *Journal of Enterprise Information Management*, Vol. 35, No. 4/5, (2022), pp. 1011-1039.

[17] Desingh, V., "Internet of Things adoption barriers in the Indian healthcare supply chain: An ISM-fuzzy MICMAC approach," *The International journal of health planning and management*, Vol. 37, No. 1, (2022), pp. 318-351.

[18] Yu, Z., Khan, S. A. R., Mathew, M., Umar, M., Hassan, M., and Sajid, M. J., "Identifying and analyzing the barriers of Internet-of-Things in sustainable supply chain through newly proposed spherical fuzzy geometric mean," *Computers & Industrial Engineering*, Vol. 169, (2022), p. 108227.

[19] Narwane, V. S., Gunasekaran, A., and Gardas, B. B., "Unlocking adoption challenges of IoT in Indian agricultural and food supply chain," *Smart Agricultural Technology*, Vol. 2, (2022), p. 100035.

[20] Kumar, D., Singh, R. K., Mishra, R., and Wamba, S. F., "Applications of the internet of things for optimizing warehousing and logistics operations: A systematic literature review and future research directions," *Computers & Industrial Engineering*, Vol. 171, (2022), p. 108455.

[21] Rebelo, R. M. L., Pereira, S. C. F., and Queiroz, M. M., "The interplay between the Internet of things and supply chain management: Challenges and opportunities based on a systematic literature review," *Benchmarking: An International Journal*, Vol. 29, No. 2, (2022), pp. 683-711.

[22] Rejeb, A., Rejeb, K., Zailani, S., Treiblmaier, H., and Hand, K. J., "Integrating the Internet of Things in the halal food supply chain: A systematic literature review and research agenda," *Internet of Things*, Vol. 13, (2021), p. 100361.

[23] Aamer, A. M., Al-Awlaqi, M. A., Affia, I., Arumsari, S., and Mandahawi, N., "The internet of things in the food supply chain: adoption challenges," *Benchmarking: An International Journal*, Vol. 28, No. 8, (2021), pp. 2521-2541.

[24] Birkel, H. S. and Hartmann, E., "Impact of IoT challenges and risks for SCM," *Supply Chain Management: An International Journal*, Vol. 24, No. 1, (2019), pp. 39-61.

[25] Aryal, A., Liao, Y., Nattuthurai, P., and Li, B., "The emerging big data analytics and IoT in supply chain management: a systematic review," *Supply Chain Management: An International Journal*, Vol. 25, No. 2, (2020), pp. 141-156.

[26] Tranfield, D., Denyer, D., and Smart, P., "Towards a methodology for developing evidence-informed management knowledge by means of systematic review," *British journal of management*, Vol. 14, No. 3, (2003), pp. 207-222.

[27] Wright, R. W., Brand, R. A., Dunn, W., and Spindler, K. P., "How to write a systematic review," *Clinical Orthopaedics and Related Research* (1976-2007), Vol. 455, (2007), pp. 23-29.

[28] Dutta, P., Chavhan, R., Gowtham, P., and Singh, A., "The individual and integrated impact of Blockchain and IoT on sustainable supply chains: a systematic review," *in Supply chain forum: An international journal*, Vol. 24, No. 1, Taylor & Francis, (2023), pp. 103-126.

[29] Kazmi, Z. A. and Sodangi, M., "Modeling the constraints to the utilization of the internet of things in managing supply

chains of off-site construction: An approach toward sustainable construction," Buildings, Vol. 12, No. 3, (2022), p. 388.

[30] Eryarsoy, E., Kilic, H. S., Zaim, S., and Doszhanova, M., "Assessing IoT challenges in supply chain: A comparative study before and during-COVID-19 using interval valued neutrosophic analytical hierarchy process," *Journal of Business Research*, Vol. 147, (2022), pp. 108-123.

[31] Sodhi, M. S., Seyedghorban, Z., Tahernejad, H., and Samson, D., "Why emerging supply chain technologies initially disappoint: Blockchain, IoT, and AI," *Production and Operations Management*, Vol. 31, No. 6, (2022), pp. 2517-2537.

[32] De Vass, T., Shee, H., and Miah, S., "IoT in supply chain management: Opportunities and challenges for businesses in early industry 4.0 context," *Operations and Supply Chain Management*: An International Journal, Vol. 14, No. 2, (2021), pp. 148-161.

[33] Ahmed, S. et al., "Towards supply chain visibility using internet of things: A dyadic analysis review," *Sensors*, Vol. 21, No. 12, (2021), p. 4158.

[34] Fang, Q. and Su, C., "Evaluation of agricultural supply chain effects and big data analysis based on internet of things technology," *Discrete Dynamics in Nature and Society*, Vol. 2021, (2021), pp. 1-11.

[35] De Vass, T., Shee, H., and Miah, S. J., "Iot in supply chain management: a narrative on retail sector sustainability," *International Journal of Logistics Research and Applications*, Vol. 24, No. 6, (2021), pp. 605-624.

[36] Wu, M., "Optimization of e-commerce supply chain management process based on Internet of Things technology," Complexity, Vol. 2021, (2021), pp. 1-12.

[37] Cui, Y. and Feng, X., "An optimization model of raw material supply chain using improved genetic algorithm for primary and secondary school uniform under IoT environment," *Mobile Information Systems*, Vol. 2021, (2021), pp. 1-11.

[38] Končar, J., Grubor, A., Marić, R., Vučenović, S., and Vukmirović, G., "Setbacks to IoT implementation in the function of FMCG supply chain sustainability during COVID-19 pandemic," *Sustainability*, Vol. 12, No. 18, (2020), p. 7391.

[39] Yadav, S., Garg, D., and Luthra, S., "Analysing challenges for internet of things adoption in agriculture supply chain management," *International Journal of Industrial and Systems Engineering*, Vol. 36, No. 1, (2020), pp. 73-97.

[40] Shahzad, A., Zhang, K., and Gherbi, A., "Intuitive development to examine collaborative iot supply chain system underlying privacy and security levels and perspective powering through proactive blockchain," *Sensors*, Vol. 20, No. 13, (2020), p. 3760.

[41] Telukdarie, A. and Dhamija, P., The IoT research in sustainable agricultural supply chain management: a conceptual framework, in Research Anthology on Strategies for Achieving Agricultural Sustainability: IGI Global, (2022), pp. 516-530.

[42] Kamble, S. S., Gunasekaran, A., Parekh, H., and Joshi, S., "Modeling the internet of things adoption barriers in food retail supply chains," *Journal of Retailing and Consumer Services*, Vol. 48, (2019), pp. 154-168.

[43] Mostafa, N., Hamdy, W., and Alawady, H., "Impacts of internet of things on supply chains: a framework for warehousing," Social sciences, Vol. 8, No. 3, (2019), p. 84.

[44] Pishdar, M., Ghasemzadeh, F.,

Antucheviciene, J., and Saparauskas, J., "Internet of things and its challenges in supply chain management: a rough strength-relation analysis method," (2018).

[45] Tu, M., "An exploratory study of Internet of Things (IoT) adoption intention in logistics and supply chain management: A mixed research approach," *The International Journal of Logistics Management*, Vol. 29, No. 1, (2018), pp. 131-151.

[46] Dweekat, A. J., Hwang, G., and Park, J., "A supply chain performance measurement approach using the internet of things: Toward more practical SCPMS," *Industrial Management & Data Systems*, Vol. 117, No. 2, (2017), pp. 267-286.

[47] Haddud, A., DeSouza, A., Khare, A., and Lee, H., "Examining potential benefits and challenges associated with the Internet of Things integration in supply chains," *Journal of Manufacturing Technology Management*, Vol. 28, No. 8, (2017), pp. 1055-1085.

[48] Bardaki, C., Kourouthanassis, P., and Pramatari, K., "Deploying RFID-enabled services in the retail supply chain: Lessons learned toward the internet of things," *Information Systems Management*, Vol. 29, No. 3, (2012), pp. 233-245.

[49] Hou, J. and Chen, C., "Intelligent logistics supply chain management based on Internet of Things technology," *in 2022 IEEE Asia-Pacific Conference on Image Processing, Electronics and Computers (IPEC), IEEE*, (2022), pp. 1266-1270.

[50] Katoch, R., "IoT research in supply chain management and logistics: A bibliometric analysis using vosviewer software," *Materials Today: Proceedings*, Vol. 56, (2022), pp. 2505-2515.

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