A Bibliometric Analysis of Industry 4.0 in Procurement Decision Making Using VOS Viewer and R Studio Bibliometrix

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Asian Journal of Marketing Management

ISSN: 2820-2031 (Printed)
ISSN: 2820-2082 (Online)

DOI:
10.31357/ajmm.v5i1.8541.g6365

Received September 2025
Revised January 2026
Accepted February 2026

Keywords:

Bibliometric analysis, Industry 4.0, Procurement, R-Studio

ABSTRACT

Purpose: This study aims to map and evaluate the emerging body of research on Industry 4.0 in procurement to clarify its intellectual structure, dominant themes, and future research directions.

Design/methodology/approach: 66 documents were selected using Elsevier Scopus. Analysis was conducted using bibliometric and science mapping techniques implemented in R (Biblioshiny). This analysis examined publication trends, collaboration patterns, influential authors, and thematic structures within the field.

Findings: The results highlight the publication trend and reveal that this research domain is growing rapidly but is fragmented, with limited contributions from countries, journals, and authors. Thematic and network analysis reveal a strong emphasis on technology adoption and performance outcomes, whereas views on procurement strategy, organization, and sustainability have yet to be deeply explored.

Originality: This study provides a comprehensive bibliometric overview of Industry 4.0 in procurement research, a field that remains underexplored within the broader digital supply chain literature.

Implications: This study helps not only in the expansion of the knowledge base on the research topic but also in understanding the evolution of the industry 4.0 and procurement, providing research support further in this area.

Introduction

Industry 4.0 (I4.0), commonly referred to as the Fourth Industrial Revolution, signifies a groundbreaking transformation in how industries operate. This era is characterized by the convergence of a variety of advanced digital technologies, including the Internet of Things (IoT), artificial intelligence (AI), machine learning, robotics, and big data analytics. Together, these innovations are reshaping manufacturing and business operations by enabling systems to interact seamlessly, analyzing vast amounts of data, and making autonomous decisions with minimal human oversight. As a result, organizations are witnessing smarter, swifter, and more efficient processes that enhance their entire value chain.

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Procurement, a critical function in both private and public sectors, plays an indispensable role in ensuring that goods and services are available when needed and that they meet established quality and cost criteria. Beyond the immediate goals of operational efficiency and profitability, strategic decisions made in procurement carry significant implications for broader economic factors, including industrial growth, job creation, fostering innovation, and promoting the sustainable utilization of resources. In an increasingly competitive and unpredictable environment, mastering effective procurement practices is vital for achieving supply chain resilience, long-term sustainability, and a robust competitive position. Although industry 4.0 technologies are transforming supply chain management and operations management, and procurement plays a pivotal role in cost optimization, risk management, and sustainability, there are not enough studies which are examining how industry 4.0 reshapes procurement functions. As a result, the intellectual structure, dominant research themes, key contributors, and global collaboration patterns within the industry 4.0 procurement domain remain unclear (Bienhaus and Haddud, 2018)

For this purpose, this research is to support scholars and academics in gaining a comprehensive understanding of the current state of the field, along with its global research connections. In such an emerging and dispersed field, a bibliometric analysis is particularly ideal because it allows systematic mapping of publication trends, influential documents, and the collaboration network. Furthermore, the study seeks to encourage collaboration among diverse countries, institutions, and researchers. To pursue these objectives, a bibliometric approach utilizing relational techniques, such as co-citation analysis, bibliographic coupling, co-authorship analysis, co-word analysis, co-occurrence analysis, collaboration networks by authors and countries analysis, and thematic map analysis, has been adopted. These bibliometric and science mapping techniques are valuable tools for visualizing the structure and evolution of research domains (Doulani, 2020). Previous reviews in this study area are narrative or technology-specific, offering valuable insights but lacking a comprehensive, quantitative overview of the intellectual structure of Industry 4.0 in procurement. Therefore, a bibliometric analysis can clearly clarify how this research domain has evolved, where it is currently concentrated, and which topic underexplored. In this study, research articles in the Scopus database on this topic were employed using advanced software tools like VOS viewer and Bibliometrix in RStudio. This analysis illustrates how Industry 4.0 technologies are influencing the landscape of procurement knowledge. The research will be driven by the following objectives in response to these gaps:

1. To obtain an overview of the currently available scientific literature on Industry 4.0 in procurement.
2. To analyze contributions based on authorship, citations, and geographical areas
3. To identify influential authors in terms of their citation scores and their collaborations with other authors

4. To evaluate the evolution and development of Industry 4.0 in the procurement field

Literature Review

Conceptual background: Industry 4.0, Supply Chain 4.0, and Procurement 4.0

Although Industry 4.0, supply chain management 4.0(SCM 4.0), and procurement 4.0 are closely related, they showed different conceptual levels. Industry 4.0 refers to the broad digital transformation of industrial systems. SCM 4.0 focuses on the integration of Industry 4.0 technologies across the supply chain process, while procurement 4.0 focuses on the application of Industry 4.0 technologies to sourcing, purchasing, and supplier relationship management. So distinguishing these concepts is essential to avoid analytical overlaps and to highlight procurement-specific challenges and opportunities that remain underexplored in existing research.

Procurement 4.0 paradigm

Before the advent of Supply Chain Management (SCM), procurement was considered a part of operations management within businesses, encompassing activities like "sourcing" and "supply management" (Chopra et al., 2018). With a growing emphasis on cost reduction, managers began scrutinizing input functions due to their significant contribution to outgoing funds. Initially, procurement systems primarily focused on maintaining a distant relationship with suppliers, centered on cost-cutting initiatives. Over time, procurement evolved beyond a mere material acquisition process to become an operational function capable of enhancing profitability, incorporating supplier relationship management (Giunipero and Brand, 1996).

Recognizing its strategic importance in competitive landscapes, managers started emphasizing trust, coordination, and transparency in buyer-supplier relationships, as highlighted in studies like Hoejmose et al. (2014). Given the heavy reliance on outsourcing and supplier inputs in various industries, effective management of these inputs became crucial (Weele and Raaij, 2014). In the past decade, a surge in the use of Information and Communication Technology (ICT) to streamline procurement activities has marked by the development of "e-procurement" systems.

Against this background of strategic reorientation and digitalization, the intersection of keywords such as "procurement," "Industry 4.0," and "digitalization" is a relatively recent concept in academic literature. The resulting terminology for the modernized version of procurement is referred to as "Procurement 4.0," aligning with concepts like I4.0 and supply chain 4.0. The term first emerged around 2016 (Tjahjono et al., 2017; Weissbarth et al., 2016).

In contemporary literature, Procurement 4.0 is described as an intelligent system capable of autonomously identifying material demand, generating orders, and transmitting them to suppliers without requiring human intervention (Bienhaus and Haddud, 2018);

Tjahjono et al., 2017). Furthermore, Procurement 4.0 strategies have a positive influence on buyers' intention to optimize procurement process, and it creates a stronger effect on buyers' intention to optimize procurement and the relevance of I4.0 (Bag et al.,2019)

According to Bienhaus and Haddud, (2018), technologies like Artificial Intelligence, Big Data, and Internet of Things are fundamental components related to procurement for automating operational tasks and allowing space for more human-driven strategic initiatives. Additionally, gathering, analyzing, and processing data will be essential for establishing transparency and traceability in a supply chain ecosystem. Moreover, enhancing transparency and traceability will support buyer-supplier relationships and foster greater trust. The procurement function will serve as a strategic link to enhance organizational efficiency, effectiveness, and profitability because of its internal and external interactions. This will allow the procurement function, from a forward-looking standpoint, to utilize its network connections and evolve into a strategic and innovative network entity that aids the organization in making strategic choices such as, for instance, developing new business models, products, and services. Moreover, despite digitization altering personal and business conduct, participants emphasize that individuals will still drive the business, and "face-to-face" meetings and interactions will remain crucial for establishing trust and relationships.

According to these existing studies, procurement 4.0 is noted as an intelligent, networked system that automates routine tasks while enabling more strategic, data-driven decisions. However, these contributions are scattered across different journals, and most of the time they focus on buyer-supplier relationships, transparency, and automation, rather than giving an integrated view of the field. This fragmentation reinforces the need for a systematic mapping of how procurement 4.0 is conceptualized and which theme dominates the research landscape.

Technologies in Procurement 4.0

Klunder et al. (2019) have classified technologies within Procurement 4.0 into four functional areas: (1) Connectivity and communication - encompassing IoT, cloud, and cybersecurity; (2) Data, intelligence, and analytics - involving Big Data (BD), data analytics, and Artificial Intelligence (AI); (3) Human-to-Human (H2H) and Machine-to-Machine (M2M) interaction - incorporating manufacturing technologies, Virtual/Augmented Reality (VR/AR); (4) Logistics - including autonomous transportation and advanced robotics. Similarly, Kumar et al. (2016) identify advanced technologies such as IoT, AI, Machine Learning, BD, and Blockchain (BC) as integral components of modern procurement functions.

Extending this classification, Singh and Lorentz (2018) have also recognized a range of technologies, including IoT, social media, cloud, BD, AI, mobile technologies, VR and AR, BC, and additive manufacturing, highlighting the importance of using multiple technologies to enable interconnected procurement applications. Consistent with this view, Procurement practitioners commonly agree on the transformative potential of a

combination of IoT, BD, AI, and cloud, as evidenced in case studies and surveys (Bals et al., 2019; Gottge et al., 2020; Legenvre et al., 2020).

Among these technologies, IoT is described as a technical architecture integrating various components to transform products into product-service systems with a digital presence (Legenvre et al., 2020). The decreasing cost of sensors and RFID has played a crucial role in enabling IoT and connecting physical objects to digital platforms. IoT-based platforms for information transfer are widely discussed in current procurement literature, emphasizing their popularity. Collaborative platforms for information sharing, especially upstream and downstream, are viewed as influential factors in transforming procurement (Gottge et al., 2020; Hermann et al., 2016; Oesterreich and Teuteberg, 2016).

In addition, Cloud-based solutions and mobile applications are utilized for remote monitoring and performing functions with a unified user interface (Bienhaus and Haddud, 2018). Osmonbekov and Johnston (2018) further propose complete automation of straight and modified rebuys using IoT, with additional emphasis on BD and H2M communication for new purchases and uncertainty reduction. Blockchain (BC) is also proposed as a mechanism for record-keeping, contract enforcement, and transaction security due to cybersecurity concerns (Singh and Lorentz, 2018). Overall, the literature underscores the central role of integrated information sharing platforms as a key enabler of procurement transformation.

Finally, the application of Industry 4.0 technologies will vary based on where they are in the value chain. At different points in the manufacturing value chain, decision-making is supported by a variety of Industry 4.0 technologies. 3D printing and scanning technologies are essential throughout the design phase. Robotization, automation, Big Data analysis, and business intelligence are particularly helpful in the context of inbound logistics. Robotization, automation, cloud computing, 3D printing, scanning, business intelligence, robot-to-machine (M2M) integration, and automation facilitate rapid decision-making and expedite output during the manufacturing stage. During the Outbound Logistics stage, distribution is optimized via sensors and the Internet of Things (IoT). Lastly, business intelligence helps with decisions made at the level of sales and marketing.

Sustainable Procurement

Sustainable procurement is defined as "A procurement that is consistent with the principles of sustainable development, such as ensuring a strong, healthy and just society, living within environmental limits, and promoting good governance" (Walker et al.,2009). Also, in line with this perspective, environmental factors are integrated into decision-making processes within the supply chain (Benedetto, 2013). Therefore, manufacturers are encouraged to produce reusable packaging and pallets, minimize the unnecessary movements in operations, provide more efficient transportation schemes, and use sustainable materials in product designs and manufacturing. Thus, when eco-friendly materials and approaches are considered for product improvement enthusiasm, the

objective of procurement is authorized to concern the factor of environment and its adaptation, and further, this process is known as sustainable procurement. Moreover, empirical evidence suggests that environmentally focused purchasing practices can increase organizational net income and reduce the overall cost of the organization and ultimately enhance overall organizational performance (Chan et al.,2012).

Industry 4.0

With the advent of Industry 4.0, organizations change the way of doing their organizational operations by integrating advanced digital technologies, which are identified as components of Industry 4.0: Modularity, E-Procurement, Big Data, Internet of Things, Additive Manufacturing (AM), Blockchain, and Artificial Intelligence (Althabatah et al.,2023). Industry 4.0 represents the next phase of the industrial revolution that has the potential to enhance production processes and alter the communication between humans and machines, in addition to the interactions among suppliers, manufacturers, and customers. (Rüßmann et al.,2015)

It comprises nine potential pillars, and they are Big Data and Analytics, Autonomous Robots, Simulation Horizontal and Vertical System Integration, The Industrial Internet of Things, Cybersecurity, The Cloud, Additive Manufacturing, and Augmented Reality. Furthermore, it indicates the benefits of Industry 4.0, increasing productivity of the companies, revenue growth, increase the demand for employees who have the knowledge and skills in software development and IT technologies, like mechatronics experts with software skills. Despite these benefits implementation of I4.0 is constrained and driven by multiple organizational factors. Khin et al. (2022) identify six driving factors of Industry 4.0, including operational benefits, market opportunities, labor problems, customer requirements, competition, and quality image. As well as there are major impeding factors that delay the implementation of Industry 4.0 within the organizations, such as difficult to get the right people to handle the I4.0 project, lack of funding, lack of knowledge about technology, fear of workers for the change due to the possibility of unemployment that may come with digital transformation, and ecosystem factors.

E- Procurement

Electronic procurement processes enable streamlined sourcing, ordering, and transactions. Procurement assures the smooth inbound flow of materials, supporting innovation and customer satisfaction. e-procurement manages purchasing activities at the input end of the supply chain, increasing efficiency, transparency, and collaboration between firms (Presutti,2003). The effective implementation of an e-procurement system relies on technologies like electronic marketplaces, intranets, and extranets, which facilitate interactions between buyers and suppliers (Boer et al.,2001). By adopting these e-procurement technologies, companies can reduce their costs by minimizing their paperwork, which reduces translation mistakes and improves efficiency (Davila et al.,2003). Furthermore, e- procurement offers several strategic advantages like simplifying processes, increasing transparency, and maximizing supply chain

performance, ultimately contributing to cost reduction along the value chain (Basak et al.,2015).

Big Data

Big Data is defined as "datasets whose size is beyond the ability of typical database software tools to capture, store, manage, and analyze" (Manyika et al,2011). In an organizational context, big data enables companies to understand their business environment thoroughly and thereby meet market requirements in relation to products and services (Davenport et al.,2014). As a result, big data can be identified as a highly relevant and important concept in organizational operations. So, it is very helpful in supply chain activities. Through advanced data analytics, it offers significant benefits, such as improved visibility, strengthened bargaining power in negotiations, enhanced risk management, and more informed decision-making. Moreover, it enables better control of spending and facilitates the early identification of potential supply chain disruptions, thereby playing a vital role in strengthening and optimizing the procurement process (Lamba et al., 2017).

Internet of Things

According to (Rose et al., 2015) internet of things defined as "scenarios where network connectivity and computing capability extend to objects, sensors, and everyday items not normally considered computers, allowing these devices to generate, exchange, and consume data with minimal human intervention". Adopting IoT to manage supply chain activities has several benefits including, reducing data distortion and improving business intelligence, reducing delays in data collection, assessment and decision making, transparency from local and international logistics operations, development of reliability, responsiveness, and agility through rapid exchange of real-time information and facilitating process activities improvements and optimization of joint procurement process to the acquirement of used products in remanufacturing operations.(Haddud et al.,2017)

Additive Manufacturing

Additive manufacturing improves supply chain performance and integration. The adoption of AM has strongly enhanced the customer-oriented performance and reliability. As well in automative industry, supply chains are tightly integrated in research and development collaboration (Delic et al.,2019). Furthermore, it enables the production of complex geometries and near-net shape components, parts, or products from raw materials layer by layer. There are several types of AM technologies, such as Selective Laser Sintering (SLS) and Selective Laser Melting (SLM), Electronic Beam Melting (EBM), Digital Light Processing (DLP), and Fused Deposition Modelling (FDM). So, implementing these AM technologies, companies can achieve benefits including the design freedom to produce complex and tailored parts, Reduced material waste and energy consumption

from an operational perspective, A high level of customization, and faster time to market (Zijm et al.,2018).

Block Chain

According to Swan (2015), blockchain is "A distributed database system that records transactional data or other information, secured by cryptography, and governed by a consensus mechanism". There are four main characteristics of blockchain, including being distributed and synchronized across networks. Blockchain consists of smart contracts, an agreement made between participants in advance and stored in the blockchain. The blockchain is built using peer-to-peer (P2P) networks, whereby there must be an agreement between all relevant parties that a transaction is valid, which serves to keep inaccurate or potentially fraudulent transactions out of the database. And fourth, immutability of the data means that agreed transactions are recorded and not altered. (Cole et al.,2019)

Artificial Intelligence

According to Khanzode et al. (2020), artificial intelligence is an integration of computer science and physiology. There are significant advantages as well as challenges in developing AI in industrial environments. Significant savings in labour costs because of troubleshooting, maintenance, and repair. AI enhances reliability and efficiency through accurate demand forecasting to manage goods and inventory storage. Some of the challenges in the development of artificial intelligence are Technology penetration and capability threshold, Integration and modernization of existing production systems, basic and digital infrastructure, technology diffusion and digital divide, and asymmetry in access to technology.

Methodology

Bibliometric analysis

Bibliometric analysis is a method used to examine the emerging body of literature in a specific area, focusing on both its volume and growth pattern. It allows scholars to assess the impact of research and evaluate published literature from an academic perspective. In this case, the study has been performed using performance analysis. The performance evaluation sought to analyze the publications' performance regarding publication output by countries, authors, their affiliating institutions, and growth trajectory over multiple years. Furthermore, science mapping techniques like co- occurrence network, bibliographic coupling, and collaboration network analysis were used to examine conceptual relationships and collaboration patterns.

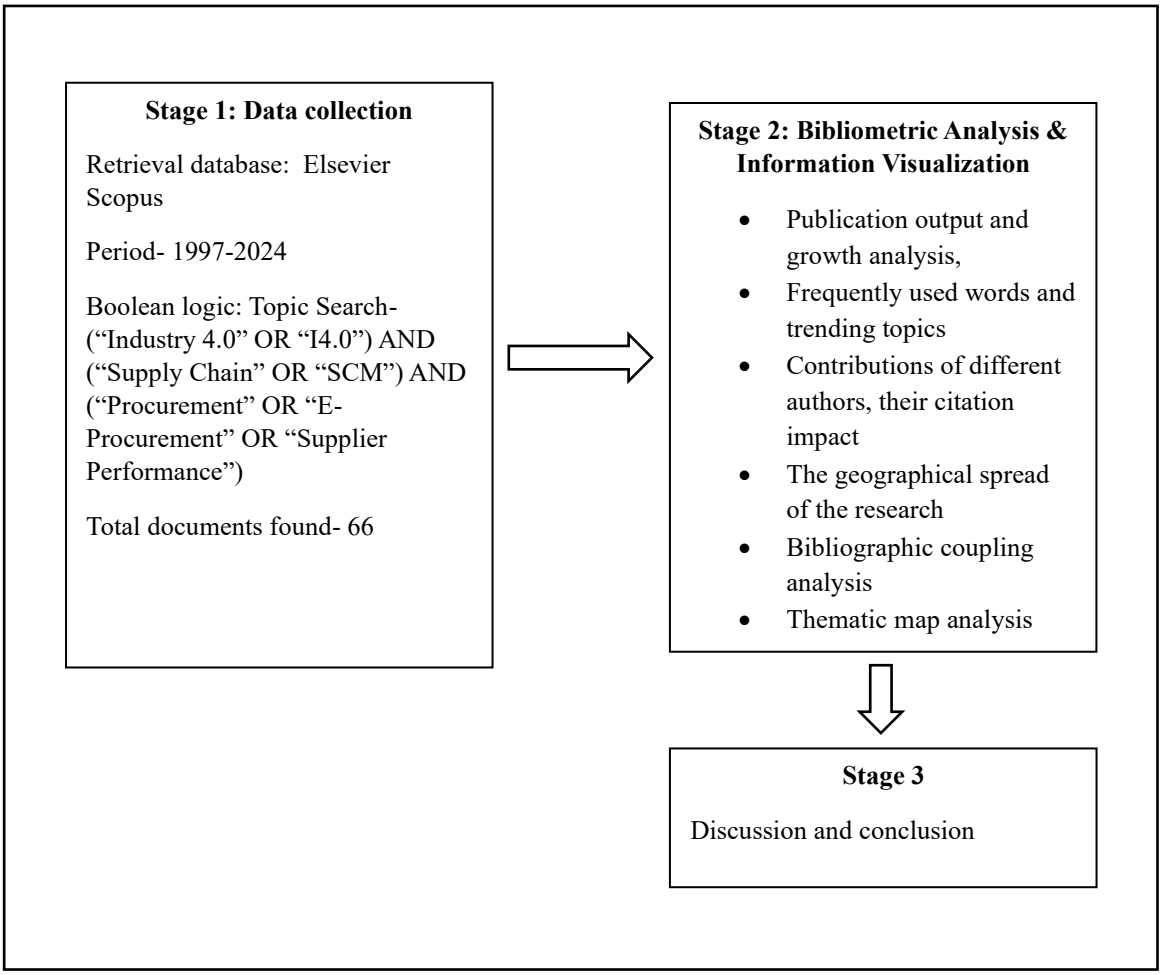
Data Source

The data source considered for the study was the core collection of the Elsevier Scopus database on August 01st, 2025. Scopus is one of the most famous scientific citation index

databases in the world. Searched "Industry 4.0, procurement" and its related keywords in the topic search field. The publications first appeared in 2018, which is also the inception period of this research field.

The stages of article retrieval and further analysis are displayed in figure I, in stage 1, 66 documents were selected after the topic search using Boolean logic which was ("Industry 4.0" OR "I4.0") AND ("Supply Chain" OR "SCM") AND ("Procurement" OR "E-Procurement" OR "Supplier Performance") this search was very limited to journal articles published in English to ensure academic quality and consistency. In step 2, analyze and visualize the relationships between the authors, countries, journals, co-citations, and terms, and in stage 3, develop the discussion and formulate the conclusions based on the analyzed results. Big Data, IoT, and Artificial Intelligence are intentionally excluded from the search string. Although these are core components of Industry 4.0, including them may expand the data set beyond the procurement focus of the study.

Figure 1
Stages of bibliometric analysis on Industry 4.0 research



Results and Interpretation

For the analysis, 66 documents were selected using Elsevier Scopus. Then bibliometric analysis was done using R Studio for co-citation analysis, bibliographic coupling, co-authorship analysis, co-word analysis, co-occurrence analysis, collaboration networks by authors and countries analysis, and thematic map analysis.

Objective 1: A Comprehensive Overview of the Existing scientific literature on Industry 4.0 in procurement

Based on the data presented in Figure II and Table I, the initial study focusing on Industry 4.0 in the realm of procurement made its debut in the Scopus database in 2018, followed by the release of three papers in 2019. Starting from 2021, there has been a significant surge in the number of publications, reaching a remarkable high of 11 articles in 2021. The number of articles peaked in 2023 with 17 publications reflecting heightened academic fascination with the subject matter. Despite this upswing, a total of only 66 articles had been published by the year 2025. Although the output slightly decreased to 13 articles in 2024, there have already been 7 publications up to August 2025, indicating that further progress may occur by the end of 2025. Research on Industry 4.0 in procurement began late, with the first Scopus-indexed publications appearing in 2018, indicating the novelty of applying Industry 4.0 concepts to procurement. The noticeable growth in publications after 2021 suggests the increasing academic attention driven by digital transformation initiatives and awareness about the procurement vulnerabilities following global disruptions like covid 19. So, according to the results of publications, 66 publications from 7 year period, highlight that Industry 4.0 in procurement research remains an emerging and still limited field.

Figure 1
Annual Scientific Production

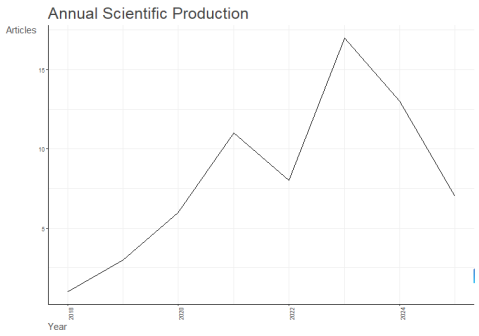


Table 1
Annual Scientific Production

Year	Articles
2018	1
2019	3
2020	6
2021	11
2022	8
2023	17
2024	13
2025	7

Frequently used words related to the Area of study

Industry 4.0, supply chain management, sustainability, supply chain and digital transformation are key concepts that are frequently used in this area of study (illustrated in figures III and IV). The use of these words has significantly increased within the past seven years (as illustrated in Figure V), underscoring their growing relevance and the urgent need for continued exploration and research in this dynamic field. By analyzing this growth, the integration of advanced technologies and sustainable practices innovation, and improvement of efficiency within various industries can be understood.

Figure 3
Frequently used words in the area of study

According to Table II, the word “Industry 4.0” is the word which highly used in the field, with a total of 41 occurrences. Sustainability and supply chain management are the other key words used in the field. The word “digital transformation” is also used from time to time.

Table 2
Trending Topics in the study area

Terms	Frequency
Industry 4.0	41
Sustainability	11
Supply Chain Management	10
Supply Chain	9
Digital Transformation	5
Digitization	5
Logistics	5
procurement	5
Procurement 4.0	5
Artificial Intelligence	3

Figure 4
Tree of frequently used words

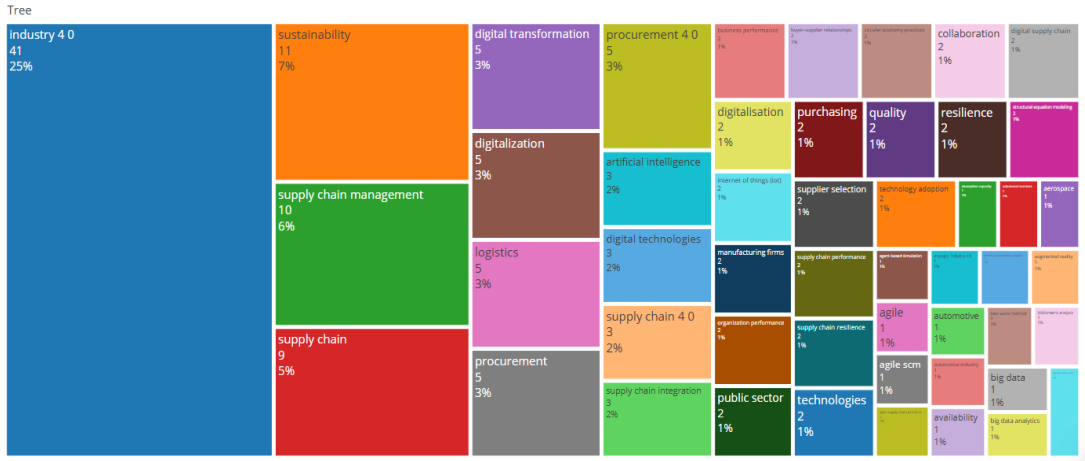
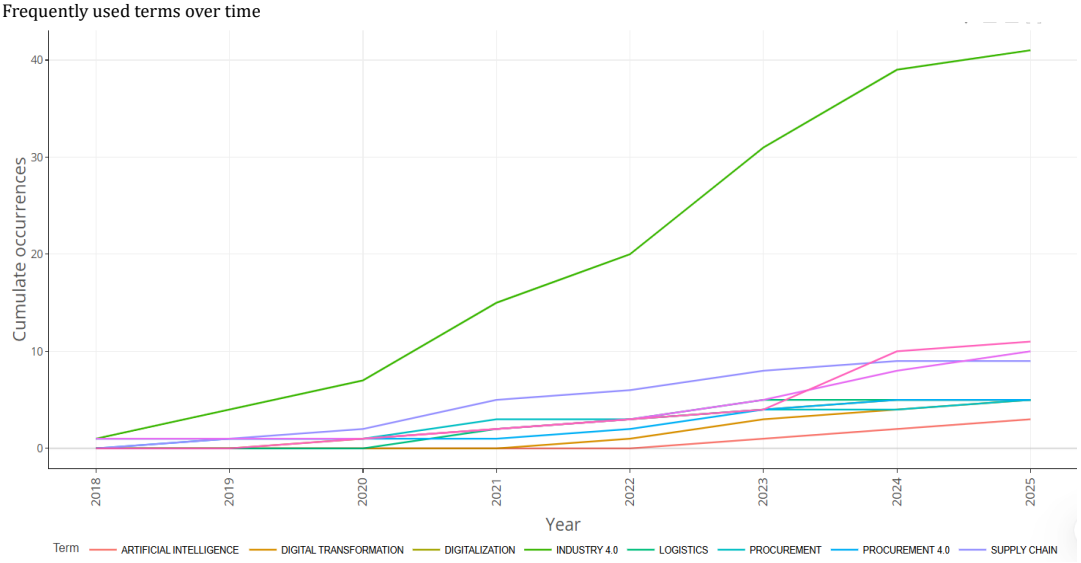


Figure 5
Frequently used terms over time



The dominance of the keyword “Industry 4.0” indicates the central positioning of digital transformation disclosure within the procurement research. However, the relatively lower frequency of keywords like “procurement 4.0” and “Artificial Intelligence” suggests that even though the industry 4.0 is widely discussed at a conceptual level, its operationalization within procurement is underexplored.

Objective 2. To analyze contributions based on authorship, citations, and geographical areas

According to the analysis (Figure VI), Business Process Management Journal (3 articles), Business Strategy and the Environment (3 articles), Technological Forecasting and Social Change (3 articles), and Benchmarking (2 articles) are the leading journals that have published articles in the field. These sources are key platforms for I4.0 + procurement research. The limited number of publications in the field highlights the importance of conducting studies in this area, particularly with the advancements in the latest technology. Furthermore, when considering the authors, Sharma M is the most prolific and likely collaborative, given the fractionalized authorship that reflects early leadership and academic influence in this niche (Table III).

Figure 6
Leading journals that have published articles in the field

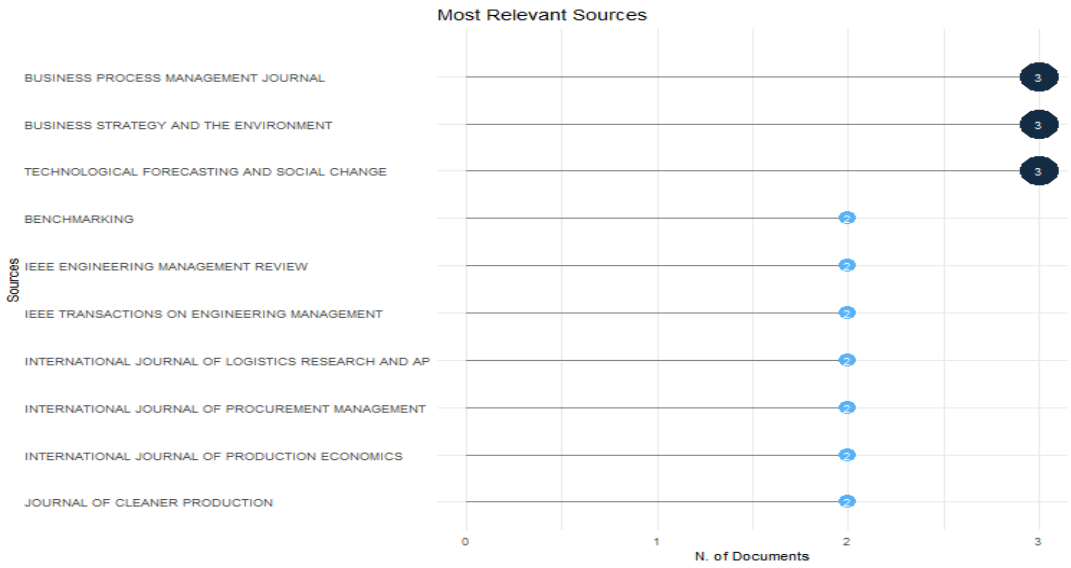


Table 3
Most Influential Authors

Author	Article
SHARMA M	3
ARCIDIACONO F	2
JOSHI S	2
KHARAT MG	2
SCHUPP F	2

The concentration of publications within a few journals suggests that research on Industry 4.0 in procurement is currently embedded within the broader management, sustainability, and operations-oriented outlets rather than being established as a standalone research stream. This indicates that this research field is still in the developing

stage. Also, a relatively low publications count per author, and the most influential author contributing only three articles, denotes a fragmented authorship structure and the absence of a dominant research community. However, all these results indicate that there is a need for a stronger scholarly collaboration to advance theoretical and empirical depth into this research domain.

Top contributing affiliations

According to Table IV, the Federal University of ABC dominates institutional output, hinting at a strong research group focused on digital procurement. However, compared to other research areas, I4.0 is still at a minimal level of improvement.

Table 4
Top Contributing Affiliations

Institution	Articles
FEDERAL UNIVERSITY OF ABC	4
UNIVERSIDAD DE CÁDIZ	4
UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL	4
ABU DHABI UNIVERSITY	3
FEDERAL UNIVERSITY OF SANTA CATARINA	3

Table 5
Geographical Distribution of the Citations

Country	TC	Average Article Citations
UNITED KINGDOM	907	151.2
CHINA	470	78.3
INDIA	270	20.8
BRAZIL	190	47.5
AUSTRALIA	174	87
SPAIN	132	44
DENMARK	90	90
SAUDI ARABIA	71	71
ITALY	57	14.2
USA	47	47
OMAN	44	44
GERMANY	43	21.5
NETHERLANDS	35	17.5
IRAN	19	9.5
PAKISTAN	18	9
SLOVAKIA	15	15
CZECH REPUBLIC	12	12

UNITED ARAB EMIRATES	11	3.7
INDONESIA	10	10
THAILAND	8	8
MALAYSIA	3	3
TURKEY	3	3
SOUTH AFRICA	1	1

According to Table V, the UK has the highest citation impact, suggesting its work is highly recognized and influential. China follows the UK with 470 citations, which is substantial and relatively lower citation impact compared to the UK. Also, India, Brazil, Australia, and Spain have demonstrated significant academic contributions to the field of I4.0 and Procurement.

The dominance of countries from Europe, South America, and parts of Asia suggests that research on Industry 4.0 in procurement is geographically concentrated within regions that have strong policy emphasis on digital transformation and sustainable industrial development. However high citation impact of the United Kingdom suggests that early or conceptually influential studies originating from this region have subsequent research directions, while India and China demonstrate growing research volume with comparatively lower average citation, indicating an emerging but still maturing scholarly engagement with the topic.

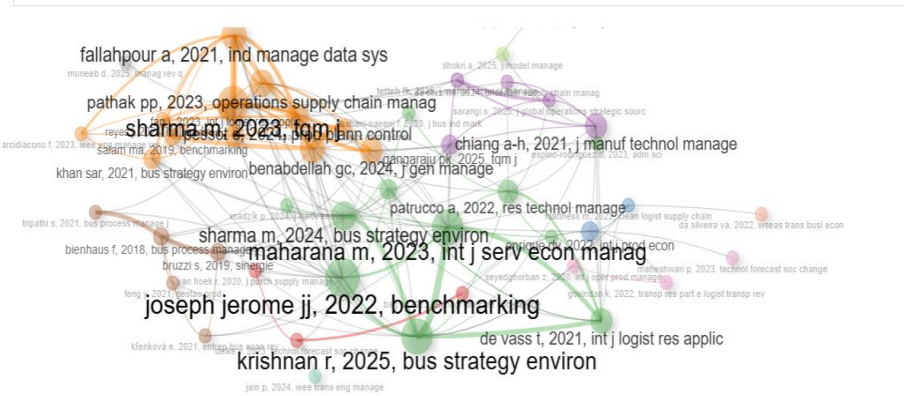
Clustering by Coupling

In bibliometric coupling, two nodes are linked if they cite the same references. Each cluster represents a group of studies that show similar references. The size of the circle indicates the document's citation score, while the colored circles are several documents co-linked with the same-colored links. The more citations a circle receives, the higher its credit score.

The green cluster is represented by authors Joseph Jerome JJ (2022, benchmarking) and Krishnan (2025, business strategy and environment), while the orange color is coupled to fallahpour A (2021, industrial management and data systems), Pathak pp (2023, operations supply chain management), and Khan Sar (2021, business strategy environment).

The distinct bibliographic clusters indicate the existence of multiple, partially isolated research streams within the Industry 4.0 and procurement literature. The green cluster presents an emphasis on performance measurement and strategic alignment of digital procurement initiatives. In contrast to the green cluster, the orange cluster indicates a more implementation- focused perspective on Industry 4.0 adoption. This separation indicates a conceptual fragmentation in the field, where the operational perspective of digital procurement evolves in parallel rather than a unified theoretical framework.

Figure 7
Clustering by coupling



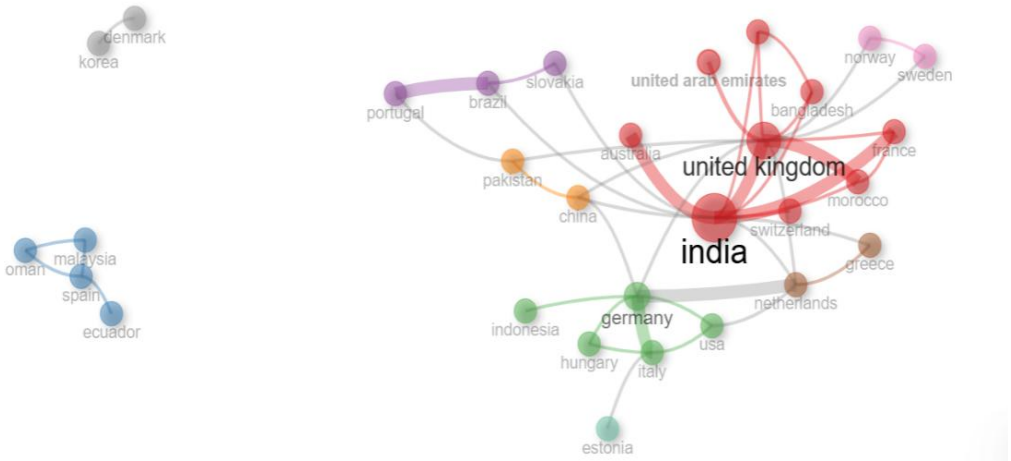
Objective 3: To identify influential authors in terms of their citation scores and their collaborations with other authors.

Collaboration Network by Authors and Countries

Figure IX indicates that there is a collaboration among different countries, such as India, the UK, China, and Australia. India and the UK are the major hubs, as shown in the countries' collaboration network, acting as central bridges between other countries. The collaboration network by authors indicates the interactions among the scholars in this research field. According to Figure VIII, Arcidiacono f. and Schupp f. have the most central collaboration in this network. However, the collaboration network structure suggests that the research field is still emerging and relies on a limited number of authors and countries. The dominance of India and the United Kingdom as collaboration hubs indicates their stronger research capacity and engagement in digital procurement-related studies, likely supported by higher digital readiness and research infrastructure.

Figure 8
Collaboration Network by Authors

Figure 9
Collaboration Network by Countries



Objective 4: To evaluate the evolution and development of Industry 4.0 in the procurement field

Thematic Map

According to Figure 10, circular economy practices, structural equation modeling, supply chain performance, buyer-supplier relationships, and Internet of Things are in the upper right quadrant representing the motor theme, which has high density and high centrality, indicating that it is well researched and important. This indicates a shift from conceptual discussion towards more empirical and performance-based research. Industry 4.0, sustainability, supply chain management, supply chain, procurement, and logistics are in the lower right quadrant representing a basic theme that has high centrality and low density, indicating that is important and not yet well developed in the research field. This indicates that, even though these concepts are central to the field, they remain underdeveloped in terms of theoretical depth and methodological consolidation.so considering the thematic map's present status and the future direction of the research development within the field can be understood. So according to the positions of themes in the thematic map represent the maturity and evolution of industry 4.0 research in procurement.

Co-occurrence Network

According to Figure XI, the connection of these nodes indicates their proximity to each other. so co- occurrence network represents how frequently keywords appear together within the same document. Industry 4.0 appears as the central node of this network, indicating it is the dominant and primary focus concept of the research in this field. The size of the node indicates the frequency of the keyword, so Industry 4.0 has the highest frequency, as shown in Figure XI. Supply chain 4.0, procurement 4.0, sustainability, digital

transformation, internet of things, supply chain integration, logistics, digitalization, and digital technologies show a direct and strong connection to industry 4.0. so industry 4.0 is the core concept connecting digital technologies, sustainability, and procurement-related themes. Strong linkages between Industry 4.0 and procurement 4.0, digitalization, and internet of Things denote a technology-driven orientation in the literature. The absence of theory-related keywords indicates that the field of study remains application-focused, highlighting the need for future studies to integrate established theoretical frameworks to explain digital procurement transformation processes.

Figure 10
Thematic Map

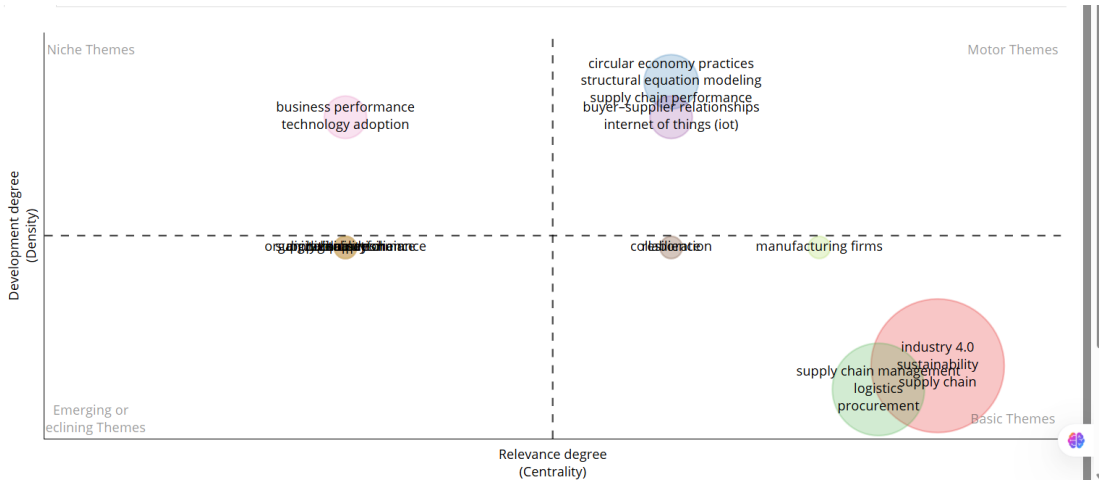


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Figure 11
Co-occurrence network

Discussion and Conclusion

The article aims to understand the knowledge of Industry 4.0 on procurement, and to achieve the same a bibliometric analysis was conducted using the Bibliometrics package of R. The relational technique for bibliometric studies applied five major methods. Including co-authorship analysis, citation analysis, co- citation mapping analysis, keyword co-occurrence analysis, and bibliographic coupling analysis.

According to the analysis, it is very clear that the procurement management and supply chain management research are very limited on Industry 4.0, even though it is an essential area to study, which supports daily business and administrative tasks and complex decision-making (Bienhaus and Haddud, 2018). According to the systematic literature review conducted here, it is also found that there are only 66 research papers published in the Elsevier Scopus database during the period of 1997 to 2025, marking a very low number of publications in the field of study within 28 years. This confirms that procurement 4.0 is still an emerging and fragmented research area. But we cannot forget digitalization, which is a disruptive and rapidly evolving business discipline, and in the agenda of senior management in any organization. The industrial revolution is continuing at a rapid pace, but the actual evolution of "Industry 4.0" is still ongoing in the field of procurement. (Schrauf and Berttram, 2016).

Most frequently used keywords in this study area are “industry 4.0”, “sustainability”, and “supply chain management”, and there is a strong connection between those keywords according to the cooccurrence network. This connection indicates that Industry 4.0 in procurement is highly interconnected with sustainability goals and supply chain activities. These findings align with earlier bibliometric studies on Industry 4.0, which present that existing studies primarily focus on technological applications and operational performance and less theoretical development (Liao et al.,2017; Frank et al., 2019). Similar to prior supply chain research, procurement focus research is limited, as procurement is often discussed as part of the broader supply chain rather than as an independent strategic function. This indicates that industry 4.0 research in procurement

is still in early stages compared to more established areas, such as manufacturing and logistics research domains

The geographical distribution of the citations indicates the global interest in this field. The United Kingdom, China, and India have the highest number of citations, indicating the strong academic and industrial focus on the digital transformation of the procurement process. The collaboration network between India and the United Kingdom suggests that an international partnership between these countries, acting as bridges in the diffusion of Industry 4.0-related procurement knowledge. According to the thematic map, circular economy practices, structural equation modeling, supply chain performance, buyer-supplier relationships, and internet of things are in the motor theme quadrant, indicating that is well researched and important. However, Industry 4.0, sustainability, supply chain management, supply chain, procurement, and logistics are undeveloped in the field, suggesting it requires deeper conceptual and empirical contributions. Industry 4.0 in procurement is still maturing and a developing research field.

These findings can be addressed through dynamic capabilities theory, which describes how organizations sense, seize, and reconfigure resources in response to technological change (Teece et a.,1997). The dominance of themes like supply chain performance, Internet of Things, and buyer-supplier relationships primarily focuses on the adoption and operational use of Industry 4.0 technology in procurement. However, there is limited attention to how these technologies reshape procurement capabilities and structures. So, according to that its clear procurement 4.0 is still emerging and has not been fully conceptualized within established strategic management frameworks.

As a conclusion, this study provides a comprehensive overview of Industry 4.0 on procurement from an academic perspective. There is a rising awareness about the strategic procurement role in digital supply chain transformation. It is indicated by the results of annual scientific production, which has grown steadily since 2018 with notable expansion in recent years. Sustainability, industry 4.0and supply chain management are the dominant keywords in this field of research, while procurement has low frequency, creating a gap in positioning procurement as a fully digitalized functionality. The importance of international partnerships in fostering the diffusion of knowledge on Industry 4.0 and procurement is indicated by the collaboration networks. Thematic map and co-occurrence network indicate that supply chain performance, buyer-supplier relationships, and Internet of Things are dominant concepts in the field, while procurement and Industry 4.0 remain underdeveloped and need further research. Procurement can move beyond its traditional operational role to a more strategic value focus by leveraging digital technologies.

Theoretical, managerial implications, and future research

Theoretically, this study identifies digital procurement as an emerging dynamic capability rather than a purely operational function. According to the thematic map and co-occurrence network around technology adoption and performance, stronger integration

of digital transformation, dynamic capabilities, and technology adoption in future research is needed.

From a managerial perspective, findings of this study indicate that organizations can leverage Industry 4.0 technologies to transition procurement from cost-based operations to strategic value creation, supplier collaboration, and sustainability-driven decision-making. Also, this study has several limitations. The analysis is done by using only the Elsevier Scopus database, which may exclude relevant studies elsewhere. Then the keyword-focused search strategy can omit related procurement research using alternative terminology. Future studies can extend this work by using multiple databases and empirical validation of procurement 4.0 capability frameworks.

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Acknowledgment

The authors would like to acknowledge the financial support given by the University of Sri Jayewardenepura (Grant number: RC/URG/MGT/2024/40)

References

Althabatah, A., Yaqot, M., Menezes, B., & Kerbache, L. (2023). Transformative Procurement Trends: Integrating Industry 4.0 technologies for enhanced procurement processes. Logistics, 7(3), 63. https://doi.org/10.3390/logistics7030063

Bag, S., Wood, L. C., Mangla, S. K., & Luthra, S. (2019). Procurement 4.0 and its implications on business process performance in a circular economy. Resources Conservation and Recycling, 152, 104502. https://doi.org/10.1016/j.resconrec.2019.104502

Bals, L., Schulze, H., Kelly, S. and Stek, K. (2019), "Journal of purchasing and supply management

Basak, M. (2015). Achieving e-procurement benefits in an aviation MRO environment. Operations and Supply Chain Management an International Journal, 50–60. https://doi.org/10.31387/oscm0230160

Benedetto, G. (2013) 'The environmental impact of a Sardinian wine by partial life cycle assessment', Wine Economics and Policy, Vol. 2, No. 1, pp.33–41

Bienhaus, F., Haddud, A., (2018), "Procurement 4.0 : factors influencing the digitization of procurement and supply chains", Business Process Management Journal, Vol. 24 No. 4, pp. 965-984

Boer, L. de, Labro, E., & Morlacchi, P. (2001). A review of methods supporting supplier selection. European Journal of Purchasing & Supply Management, *7*(2), 75–89. https://doi.org/10.1016/S0969-7012(00)00028-9

Chan, T., & Wong, C. W. (2012). The consumption side of sustainable fashion supply chain. Journal of Fashion Marketing and Management, 16(2), 193–215. https://doi.org/10.1108/13612021211222824

Chopra, S., Meindl, P., and Kalra, D.V. (2018**).** Supply Chain Management: Strategy, Planning, and Operation*.* 7th ed. Harlow: Pearson.

Cole, R., Stevenson, M., & Aitken, J. (2019). Blockchain technology: implications for operations and supply chain management. Supply Chain Management an International Journal, 24(4), 469–483. https://doi.org/10.1108/scm-09-2018-0309

Davenport, T. H. (2014). How strategists use "big data" to support internal business decisions, discovery and production. Strategy and Leadership, 42(4), 45–50. https://doi.org/10.1108/sl-05-2014-0034

Davila, A., Gupta, M., & Palmer, R. (2003). Moving procurement systems to the internet: European Management Journal, 21(1), 11–23. https://doi.org/10.1016/s0263-2373(02)00155-x

Delic, M., Eyers, D. R., & Mikulic, J. (2019). Additive manufacturing: empirical evidence for supply chain integration and performance from the automotive industry. Supply Chain Management an International Journal, 24(5), 604–621. https://doi.org/10.1108/scm-12-2017-0406

Doulani, A. (2020). A bibliometric analysis and science mapping of scientific publications of Alzahra University during 1986–2019. Library Hi Tech, 39(4), 915–935. https://doi.org/10.1108/lht-06-2020-0131

Frank, A. G., Dalenogare, L. S., & Ayala, N. F. (2019), Industry 4.0 technologies: Implementation patterns in manufacturing companies.International Journal of Production Economics, 210, 15–26.

Giunipero, L.C. and Brand, R.R. (1996), "Purchasing' s role in supply chain management", International Journal of Logistics Management, Vol. 7 No. 1, pp. 30-39.

Gottge, S., Menzel, T. and Forslund, H. (2020), "Industry 4.0 technologies in the purchasing process", Industrial Management and Data Systems, Vol. 120 No. 4, pp. 730-748.

Haddud, A., DeSouza, A., Khare, A., & Lee, H. (2017). Examining potential benefits and challenges associated with the Internet of Things integration in supply chains. Journal of Manufacturing Technology Management, 28(8), 1055–1085. https://doi.org/10.1108/jmtm-05-2017-0094

Hermann, M., Pentek, T. and Otto, B. (2016), "Design principles for industries 4. 0 scenarios", 49th Hawaii International Conference on System Sciences Design, pp. 3928-3937.

Hoejmose, S., Brammer, S. and Millington, A. (2014), "An empirical examination of the relationship between business strategy and socially responsible supply chain management", April 2013, doi: 10.1108/01443571311322733.

Khanzode, K. C. A., & Sarode, R. D. (2020). Advantages and disadvantages of artificial intelligence and machine learning: A literature review. International Journal of Library & Information Science (IJLIS), 9(1), 3.

Khin, S., & Kee, D. M. H. (2022). Factors influencing Industry 4.0 adoption. Journal of Manufacturing Technology Management, 33(3), 448–467. https://doi.org/10.1108/jmtm-03-2021-0111

Klunder, T., Niklas, J. and Steven, M. (2019), "Procurement 4.0 : how the digital disruption supports cost-reduction in procurement", Production, Vol. 29, doi: 10.1590/0103-6513.20180104.

Kumar, M., Graham, G., Hennelly, P., & Srai, J. (2016). How will smart city production systems transform supply chain design: a product-level investigation. International Journal of Production Research, 54(23), 7181–7192. https://doi.org/10.1080/00207543.2016.1198057

Lamba, K., & Singh, S. P. (2017). Big data in operations and supply chain management: current trends and future perspectives. Production Planning & Control, 28(11–12), 877–890. https://doi.org/10.1080/09537287.2017.1336787

Legenvre, H., Henke, M. and Ruile, H. (2020), "Making sense of the impact of the internet of things on Purchasing and Supply Management: a tension perspective", Journal of Purchasing and Supply Management, Elsevier, Vol. 26 No. 1, doi: 10.1016/j.pursup.2019.100596.

Liao, Y., Deschamps, F., Loures, E. F. R., & Ramos, L. F. P. (2017), Past, present and future of Industry 4.0 – a systematic literature review and research agenda. International Journal of Production Research, 55(12), 3609–3629.

Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., & Byers, A. H. (2011). Big data: The next frontier for innovation, competition, and productivity. McKinsey Global Institute.

Oesterreich, T.D. and Teuteberg, F. (2016), "Understanding the implications of digitization and Operation, 6th ed., Pearson, India.

Osmonbekov, T., & Johnston, W. J. (2018). Adoption of the Internet of Things technologies in business procurement: impact on organizational buying behavior. Journal of Business and Industrial Marketing, 33(6), 781–791. https://doi.org/10.1108/jbim-10-2015-0190

Presutti, W. D. (2003). Supply management and e-procurement: Creating value added in the supply chain. Industrial Marketing Management, *32*(3), 219–226. https://doi.org/10.1016/S0019-8501(02)00265-2

Rose, K., Eldridge, S., & Chapin, L. (2015). The Internet of Things: An Overview.

Rosin, F., Forget, P., Lamouri, S., & Pellerin, R. (2022). Enhancing the Decision-Making Process through Industry 4.0 Technologies. Sustainability, 14(1), 461.

Rüßmann, M., Jr., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015). Industry 4.0: The future of productivity and growth in manufacturing industries. https://picture.iczhiku.com/resource/paper/shiWTJKeGqfAdvNb.pdf

Singh, J. and Lorentz, H. (2018), "Journal of Purchasing and Supply Management Developing design principles for the digitalization of purchasing and supply management", Journal of Purchasing and Supply Management, Elsevier July 2017, pp. 1-21.

Schrauf, S., & Berttram, P. (2016). Industry 4.0: How digitization makes the supply chain more efficient, agile, and customer-focused. Strategy&, PwC.

Swan, M. (2015). Blockchain: Blueprint for a new economy. O'Reilly Media, Inc.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. Strategic Management Journal, 18(7), 509–533. https://doi.org/10.1002/(SICI)1097-0266(199708)18:7

Tjahjono, B., Esplugues, C., Ares, E. and Palaez, G. (2017), "What does industry 4.0 mean to supply Chain ?", Procedia Manufacturing- Manufacturing Engineering Society International Conference 2017, Vol. 13, pp. 1175-1182.

Weele, V. A. J., & Raaij, V. E. M. (2014**).** Purchasing and supply chain management: Analysis, strategy, planning and practice (6th ed.). Cengage Learning.

Walker, H., & Brammer, S. (2009). Sustainable procurement in the United Kingdom public sector. Supply Chain Management an International Journal, 14(2), 128–137. https://doi.org/10.1108/13598540910941

Weissbarth, R., Geissbauer, R. and Wetzstein, J. (2016), "Procurement 4.0: are you ready for the digital revolution ?", PwC Strategy, available at: https://www.strategyand.pwc.com/gx/en/insights/2016/procurement-4-digital-revolution/procurement-4.pdf (accessed 01st February 2024).

Zijm, H., Knofius, N., & Van Der Heijden, M. (2018). Additive manufacturing and its impact on the supply chain. In Lecture notes in logistics (pp. 521–543). https://doi.org/10.1007/978-3-319-92447-2_23