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MAPPING DIGITAL TECHNOLOGIES IN LOGISTICS: EXPLORING TRENDS AND FUTURE DIRECTIONS

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Abstract[1]

The rapid advancement of technology, the increasing interconnectedness between countries, and the evolving consumer demands have made logistics networks increasingly complex. Consequently, using digital technologies to analyze data sources within logistics networks has become significantly important. These technologies are critically important for minimizing costs, improving service quality, and enabling more flexible and faster decision-making through the digital tracking of every stage in logistics processes. Within this context, this study aims to examine studies on the use of digital technologies in the logistics sector through bibliometric analysis and to identify prominent topics and concepts in this field. Accordingly, a search was conducted in the Web of Science database using keywords related to logistics and digital technologies, and 1,597 publications from the period 1983–2024 were analyzed using the R program. The findings indicate a sharp increase in studies after 2017, coinciding with the rise of Industry 4.0. "Internet," "technology," and "challenges" emerged as the most frequent keywords. China and the USA were identified as leading contributors, while regions such as South America, Africa, and Australia showed weaker collaboration networks. The study contributes to literature by mapping the evolution of key themes and identifying underexplored topics such as ethics, data privacy, cybersecurity, government regulations, and human-centered approaches.

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Practically, it highlights the need for stronger international collaborations and more empirical research on real-life applications of digital technologies in logistics. By identifying trends and research gaps, this study provides insights that can guide both academics and practitioners in advancing the digital transformation of logistics.

Keywords: *Digital Technologies, Digitalization, Logistics, Supply Chain Management, Bibliometric Analysis.*

LOJİSTİKTE DİJİTAL TEKNOLOJİLERİN HARİTALANDIRILMASI: EĞİLİMLERİN VE GELECEK YÖNELİMLERİN ARAŞTIRILMASI

Öz

Teknolojinin hızlı bir şekilde gelişmesi, ülkeler arasındaki bağlantıların artması ve farklılaşan tüketici talepleriyle birlikte lojistik ağlar da giderek karmaşık hale gelmektedir. Bu nedenle lojistik ağlarda yer alan veri kaynaklarının analizinde dijital teknolojilerin kullanımı önem kazanmıştır. Bu teknolojiler; maliyetlerin minimize edilmesi, hizmet kalitesinin artırılması, lojistik süreçlerde her aşamanın dijital olarak takibiyle daha esnek ve hızlı karar alabilme yeteneğinin sağlanması konusunda kritik öneme sahiptir. Bu kapsamda bu çalışmanın temel amacı dijital teknolojilerin lojistik sektöründe kullanımı ile ilgili çalışmaları bibliyometrik analiz yöntemiyle incelemek ve bu alanda öne çıkan konu ve kavramları tespit etmektir. Bu doğrultuda; Web of Science veri tabanında lojistik ve dijital teknolojilerle ilgili anahtar kelimeler ile arama yapılmış, 1983-2024 dönemindeki 1597 yayın R programıyla analiz edilmiştir. Bulgular, 2017 sonrasında çalışmaların hızlı bir şekilde artış gösterdiğini ve bunun Endüstri 4.0'ın yükselişiyle eşzamanlı olduğunu ortaya koymaktadır. En sık kullanılan anahtar kelimeler "internet," "teknoloji" ve "zorluklar" olarak belirlenmiştir. Çin ve ABD başlıca katkı sağlayan ülkeler olarak öne çıkarken, Güney Amerika, Afrika ve Avustralya gibi bölgelerde iş birliği ağlarının daha zayıf olduğu görülmüştür. Çalışma, etik, veri gizliliği, siber güvenlik, hükümet düzenlemeleri ve insan merkezli yaklaşımlar gibi yeterince araştırılmamış konuları tanımlayarak temel temaların evrimini haritalandırmak suretiyle literatüre katkı sağlamaktadır. Uygulama açısından ise, daha güçlü uluslararası iş birliklerine ve lojistikte dijital teknolojilerin gerçek yaşam uygulamaları üzerine daha fazla ampirik araştırmaya duyulan ihtiyacı vurgulamaktadır. Eğilimleri ve araştırma boşluklarını belirleyerek, bu çalışma lojistiğin dijital dönüşümünü ilerletmede hem akademisyenlere hem de uygulayıcılara yol gösterici nitelikte içgörüler sunmaktadır.

Anahtar Kelimeler: *Dijital Teknolojiler, Dijitalleşme, Lojistik, Tedarik Zinciri Yönetimi, Bibliyometrik Analiz.*

INTRODUCTION

The digital technologies emerging with the advancements in Industry 4.0 have significantly transformed logistics processes. Integrating these technologies into the logistics sector facilitates the development of customer-focused, agile, and sustainable logistics systems that can more accurately analyze market demands (Albrecht et al., 2024, p. 757). This digital transformation within the sector also

establishes a robust foundation for transparent bidirectional information flows between organizations, suppliers, and customers (Seyedghorban et al., 2020, p. 4). Consequently, it contributes to logistics firms building strong and long-term relationships with their business partners (Lee et al., 2024, p. 4).

In parallel with these developments, the growing importance of digitalization has attracted increasing attention from both industry practitioners and researchers. Recent empirical and bibliometric research shows that digitalization in logistics networks is now considered a central topic in both academic and professional circles (Admoko et al., 2024; Atzeni et al., 2021). This growing interest highlights the necessity of systematically identifying the key topics and concepts studied in this field and uncovering existing research gaps, which can serve as a roadmap for future academic work.

Within this research domain, the literature contains various empirical studies examining the application of digital technology in logistics and supply chain management (SCM) (He et al., 2023; Liu & Chiu, 2021; Z. Liu et al., 2024; Ma & Chang, 2024; Oubrahim et al., 2023; Zhang et al., 2024). These studies highlight various impacts of integrating digital technologies into the logistics sector, including cost reduction, enhanced customer satisfaction, contributions to sustainability, and improved efficiency. While many works highlight positive outcomes, some of them point to neutral or negative effects such as high implementation costs, infrastructural weaknesses, data-related challenges, and workforce resistance (Indradevi et al., 2024; Moldabekova et al., 2021; Oršić et al., 2022; Pasupuleti et al., 2024; Sharma, 2023). However, beyond these empirical investigations, recent years have also witnessed the rise of bibliometric studies aiming to map the broader research landscape. Some bibliometric analyses on this topic have taken a broader perspective on digital transformation (Admoko et al., 2024; Ivanova & Shkrobot, 2023; Larsen & Lund, 2021), while others have focused on specific technologies as the basis for their analyses (Admoko et al., 2024; Benatiya Andaloussi, 2024; Hiatt et al., 2024; Ivanova & Shkrobot, 2023; Oğuz et al, 2024; Yavas & Ozkan-Ozen, 2023; Yilmaz, 2025). A review of the literature indicates that while there is an abundance of studies focusing on specific technologies, a holistic and comprehensive approach addressing the digital transformation of logistics as a whole remains limited. Most existing bibliometric works are technology-specific such as IoT (Larsen & Lund, 2021), blockchain (Oğuz et al., 2024), robotics (Atzeni et al., 2021), and cybersecurity (Latif et al., 2021) or context-specific such as medical supply chains (Hiatt et al., 2024), air logistics (Yavas & Ozkan-Ozen, 2023), and reverse supply chains (Ivanova & Shkrobot, 2023). In addition, many of these studies rely primarily on Scopus data and VOSviewer software, which constrains both the timeframe of analysis and the variety of visualization.

Accordingly, there is a need for a more integrative analysis that systematically combines multiple Industry 4.0 technologies (AI, IoT, blockchain, big data, automation, cloud computing, augmented reality) within a broad timespan. This

study seeks to respond to that gap by conducting a bibliometric analysis using the Web of Science (WOS) database covering the period 1983–2024 and employing the R Biblioshiny package. In doing so, it contributes to the literature not by emphasizing methodological novelty alone, but by providing a more comprehensive and comparable overview of digitalization trends in logistics research.

This study evaluated findings based on papers obtained from the Web of Science (WOS) database. These evaluations include citation counts of the studies over the years, the keywords used, keyword trends, the most prolific authors, the most productive institutions, and patterns of scientific collaboration among countries. Based on the results obtained, prominent topics and concepts related to the utilization of digital technologies in the logistics sector were identified, and recommendations were provided to guide future research.

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

In the logistics sector, accurately analyzing new market demands and responding to these demands quickly and cost-effectively are critical for firms seeking to achieve a competitive advantage globally. Agile responses to market demand and maintaining high operational efficiency are now largely enabled by integrating digital technologies into the logistics sector. The widespread adoption of digital technologies facilitates the collection of large-scale logistics data and the application of complex algorithms to these datasets. Consequently, logistics firms can save expenses while providing more efficient, environmentally friendly, and transparent services (Kayikci, 2018, p. 784). Integrating innovative technologies into the supply chain facilitates information flow, increasing efficiency in both forward and backward flows within the supply chain. Such improvements enhance operational efficiency and help businesses establish more substantial long-term relationships with their partners (Lee et al., 2024, p. 4). Therefore, analyzing the impacts of digital technologies on logistics and SCM is crucial for ensuring operational efficiency (Boute & Udenio, 2023, p. 10; Nour, 2022, p. 1).

The literature includes various empirical studies on this topic. These studies approach the subject from different perspectives, providing diverse findings regarding the impacts of digital technologies on the logistics sector. Liu & Chiu (2021), using structural equation analysis on survey data from participants in the supply chain industry, demonstrated that digital technologies enhance supply chain transparency, positively influencing firm performance and internal integration. He et al. (2023) found that integrating digital technologies into port operations increases operational resilience through regression analysis of data collected from port enterprises in China. Oubrahim et al. (2023), using survey data from international manufacturing firms in Morocco and a structural equation model, identified that digital technologies positively impact sustainable supply chain performance. Z. Liu et al. (2024), employing panel data and the entropy-based TOPSIS method,

emphasized that digital-physical integration fosters the development of innovative business models in logistics firms. Zhang et al. (2024), analyzing panel data from 275 cities in China, concluded that adopting digital technologies enhances the resilience of the logistics sector. Lastly, Ma & Chang (2024), using a structural equation model, determined that artificial intelligence and big data analytics positively affect supply chains' agility.

Empirical findings in the literature demonstrate the contributions of digital technologies in enhancing multiple facets of the logistics sector, including improving supply chain transparency, strengthening operational resilience, supporting sustainable performance, and fostering innovative business models. In addition to these studies, several works employ bibliometric analysis methods to evaluate the utilization of digital technologies in the logistics sector encompassing a wide range of topics, such as the Internet of Things (IoT) (Larsen & Lund, 2021), robotics technology (Atzeni et al., 2021), blockchain applications (Oğuz et al., 2024), big data (Neilson et al., 2019), and cybersecurity (Larsen & Lund, 2021). These studies emphasize the critical role of digital technologies in reducing costs, enhancing customer satisfaction, achieving sustainability goals, and improving the efficiency of logistics operations.

Table 1 highlights studies examining the effects of digital technologies on supply chain and logistics processes. While some studies analyze the effects of digitalization on operational efficiency (Admoko et al., 2024; Benatiya Andaloussi, 2024; Hiatt et al., 2024) and sustainability (Ivanova & Shkrobot, 2023; Yavas & Ozkan-Ozen, 2023), others address topics such as risk management (Fareed et al., 2024) and cybersecurity (Larsen & Lund, 2021). Overall, the findings suggest that while some studies focus on specific technologies related to digitalization (Atzeni et al., 2021; Larsen & Lund, 2021; Neilson et al., 2019; Oğuz et al., 2024), others adopt a broader perspective to evaluate the digital transformation in this field (Admoko et al., 2024; Ivanova & Shkrobot, 2023).

Table 1: Bibliometric Studies in the Related Field

Nr.	Author(s)	Purpose and Methods	Key Findings
1	Larsen & Lund (2021)	This study seeks to identify the evolution of IoT in logistics and SCM. Within this scope, 2,680 publications retrieved from the Scopus database were examined through the bibliometric analysis utilizing VOSviewer software.	The study results reveal that a substantial portion of the studies are concentrated in computer science and technology journals. The findings also indicate that research analyzing the development of IoT in logistics and SCM has progressed from theoretical frameworks to practical applications. Additionally, the University of Hong Kong is a prominent institution in IoT research, with a substantial share of studies originating from Asian nations, particularly China and India.
2	Atzeni et al. (2021)	This research performed a bibliometric analysis of 164 articles pertaining to collaborative robots in Logistics 4.0. The analysis was performed using VOSviewer software.	The analyses reveal that in terms of publication volume, Germany, China, and the United States stand out as leading countries. Furthermore, the findings indicate that research groups in this field are expanding in terms of member composition, with an increasing number of academics and practitioners engaging in studies on this topic.

3	Oğuz et al. (2024)	This study seeks to analyze the impacts of blockchain technology on SCM and logistics and to identify existing research gaps. Accordingly, 1,874 articles in the relevant field were examined utilizing bibliometric analysis through the R programming language.	The analysis indicates that blockchain technology stands out in SCM by offering advantages such as transparency, reliability, cost reduction, and process acceleration. Additionally, it was determined that the most publications in this domain were produced in 2023, with China leading in scientific contributions. Furthermore, the Hong Kong Polytechnic University was identified as the most prolific institution regarding scientific output in this domain.
4	Yavas & Ozkan-Ozen (2023)	This study seeks to evaluate the transformation of air logistics operations concerning digitalization and sustainability using a bibliometric analysis approach. To identify research gaps and provide insights for future studies, 41 studies were selected for analysis following searches conducted in the Scopus database, and the VOSviewer software was utilized for the analysis.	The analyses revealed that more than half of the studies on this topic were conducted in 2020. The most prevalent disciplines in this area are engineering, energy, and environmental sciences, highlighting opportunities for social sciences and management researchers to contribute with scientific publications. Additionally, the USA, China, and the UK were identified as the most productive countries in terms of authorship. Regarding the methodologies employed, most studies were found to be theoretical works proposing frameworks, systematic reviews, or analyses based on secondary data.
5	Neilson et al. (2019)	This study aims to systematically review articles published in the past five years on big data applications in transportation, identifying current research, prospects, and obstacles associated with the topic. Data was collected from various sources, chiefly WOS and Scopus, resulting in a comprehensive analysis of 28 papers.	The study's findings reveal that research on big data technology is predominantly based on academic studies conducted by universities and research institutions, while real-world applications remain relatively limited. The results also highlight the need for long-term and coordinated efforts among various departments in city management to advance studies in this area. Concerns about collecting users' personal data were also identified as a significant issue.
6	Hiatt et al. (2024)	This study aims to identify research gaps related to digitalization in medical supply chains, emphasizing cost reduction and mitigation of drug shortages or surpluses via digitalization. Accordingly, a comprehensive literature analysis examined 51 publications from the Scopus, EBSCO Host, and ABI/Inform databases. The analyses were performed using the VOSviewer software.	As a result of the analyses conducted in the study, it was found that cost, efficiency, sustainability, and blockchain are frequently studied topics in medical SCM. The findings revealed that digital technologies in this field reduce costs, enhance efficiency, improve employee satisfaction, strengthen customer relationships, and positively impact the competitive advantage of organizations.
7	Latif et al. (2021)	This study aims to identify trends in cybersecurity research within SCM. 41 articles published between 2010 and 2020, accessible in the WOS and Scopus databases, were analyzed in this context.	The study's analysis results reveal a rising trend in cybersecurity research within SCM. However, despite the critical importance of cybersecurity in SCM, most studies do not conduct in-depth examinations on the topic. Most existing research focuses on network security, while web application security, IoT, and information security are frequently addressed.
8	Benatiya Andaloussi (2024)	This study seeks to evaluate publications related to digital SCM by bibliometric analysis and to identify the key research themes and influential authors in	The study's findings reveal that digital technologies facilitate data-driven decision-making in SCM and enable predictive analytics that improve inventory management, demand forecasting, and resource allocation. These technologies enhance efficiency, shorten delivery times,

		this discipline. To achieve this, 114 publications from the Scopus database were examined utilizing VOSviewer software.	promote innovation and customer-focused approaches, and minimize waste. The results of the analysis also highlight the need for further scientific research in this area. In particular, more studies are required on resilience dynamics in digital supply chains, the rapid adaptation of organizations to unforeseen challenges, ethical and privacy issues associated with the implementation of digital technologies in supply chains, and human-centered approaches focusing on employee well-being, skill development, and organizational culture during the digital transformation process.
9	Iftikhar et al. (2024)	This study aims to analyze articles on digital technologies, data analytics, and supply chain resilience using systematic literature review and bibliometric analysis methods, as well as to identify the evolution of the topic over time. In this context, 262 articles were collected from the Scopus database and examined utilizing the VOSviewer.	The analysis results reveal an expanding body of research on digital technologies and supply chain resilience. However, most existing studies address the topic conceptually, revealing a gap in empirical research. Additionally, it was found that the IoT enhances collaboration among network partners by facilitating real-time information exchange.
10	Fareed et al. (2024)	This study seeks to examine research trends on digital technology in multimodal logistics systems via a systematic literature review. In the study, data from publications between 2005 and 2023 were obtained from the Scopus database, and the analysis was carried out on 52 publications with the VOSviewer program.	The analysis findings indicate that artificial intelligence, machine learning, and blockchain technologies have become critical concepts for multimodal logistics systems. However, challenges posed by government policies related to digital technologies and the lack of significant advancements in this area within the industry are issues that require attention. Additionally, as traceability and data transparency gain importance in multimodal transportation processes, it has been identified that research on this topic should be expanded, mainly focusing on supply chain risk management.
11	Ivanova & Shkrobot (2023)	This study seeks to examine publications regarding the application of digital technology in reverse supply chain processes and to identify the transformative potential of digitalization and research trends in this field. In this context, 82 publications retrieved from the Scopus database were evaluated utilizing the VOSviewer.	The analysis results indicate that the sustainable utilization of resources in reverse supply chains has gained significance and that scientific research in this area has increased. The findings also highlight that China, USA, UK, India, and Pakistan are the most scientifically productive countries in this field. Furthermore, the digitalization of reverse supply chains offers significant opportunities for optimizing processes, supporting sustainability, and reducing waste.
12	Admoko et al. (2024)	This study seeks to examine the emerging technological landscape in logistics for the period 2019–2023 using bibliometric analysis with the keywords "logistics" and "emerging technology." In this context, 997 publications associated with these keywords were retrieved from Google Scholar, and the analyses were conducted using the VOSviewer software.	The analysis results indicate a significant increase in interest in the topic between 2019 and 2020. Blockchain technology demonstrates the potential to enhance traceability, improve food safety, and ensure product quality. Additionally, Industry 4.0 components are highlighted as crucial for increasing operational efficiency, ensuring transparency, and providing real-time insights. However, challenges such as the complex implementation processes of digital technologies in the logistics sector, uncertain investment costs, and the immature developmental stages of these technologies suggest the need for a more comprehensive examination of such problems in the literature.

Although prior bibliometric works (e.g., Larsen & Lund, 2021; Ivanova & Shkrobot, 2023) have examined digitalization in logistics, these studies are either technology-specific (e.g., IoT, blockchain, robotics, cybersecurity) or context-specific (e.g., medical supply chains, air logistics, reverse supply chains). A comparative overview of existing studies highlights that most contributions focus on narrow domains or specific technologies, leaving the holistic transformation of logistics through digital technologies underexplored.

Table 2 presents a comparative innovation matrix, outlining the differences between this study and earlier works. The table shows how this research contributes by combining a broader scope, a longer time horizon, a unique set of metrics, and the use of R-based visualization techniques, thereby filling a clear gap in the literature.

Table 2: Comparative Innovation Matrix of Bibliometric Studies on Digitalization in Logistics

Author(s)	Database	Time Period	Domain	Metrics Used	Visualization Tools
Larsen & Lund (2021)	Scopus	1998-2021	Cybersecurity in maritime	Systematic Review	VOSviewer
Ivanova & Shkrobot (2023)	Scopus	2013-2022	Reverse supply chain	Publication trends, Prolific authors, Country and institution collaborations, co-citation	VOSviewer
Atzeni et al. (2021)	Scopus	2001-2020	Robotics in logistics	Keyword trends, Co-citation, Co-authorship	VOSviewer
Oğuz et al. (2024)	WOS	2016-2024	Blockchain technology in logistics	Citation and keyword trends, prolific authors, institutions, country collaboration networks	R (Bibliometrix & Biblioshiny)
Neilson et al. (2019)	ACM, WOS, Scopus, DOAJ, IEEE	2012-2017	Big data in transportation	Systematic review	VOSviewer
Admoko et al. (2024)	Google Scholar	2019-2023	Emerging technological landscape in logistics	Cluster analysis	VOSviewer
Benatiya Andaloussi (2024)	Scopus	2000-2023	Digital supply chain	Citation, co-citation and co-authorship analysis, prolific journals and authors	VOSviewer
Hiatt et al. (2024)	WOS and Scopus	2001-2022	Digitalization in medical supply chains	Keyword co-occurrence, Cluster analysis	VOSviewer
Yavas & Ozkan-Ozen (2023)	Scopus	Before 2017-2022	Transformation in air logistics operations	Keyword co-occurrence, co-authorships	VOSviewer
Fareed et al. (2024)	Scopus	2005-2023	Sustainability in multimodal logistics operations	Keyword co-occurrence, Country analysis, Cluster analysis	VOSviewer
This Study	WOS	1983-2024	Digital technologies in	Citation trends, keyword trends, prolific authors,	R (Bibliometrix

	logistics (IoT, blockchain, robotics, AI, big data, cybersecurity)	institutions, country collaboration networks	& Biblioshiny)

As shown in Table 2, this study extends existing bibliometric works by adopting a broader, multi-technology perspective, covering a longer time span, and employing R-based advanced bibliometric techniques. In doing so, it provides a comprehensive mapping of digitalization in logistics that has not been offered in earlier research.

Empirical studies in the field of logistics, aside from bibliometric analyses, also indicate several neutral or even negative effects, suggesting that the benefits of digitalization are not universal. For instance, Sharma (2023) found that although AI-powered automation enhances speed and efficiency, it is also associated with high implementation costs, job displacement risks, and short-term financial uncertainties. Indradevi et al. (2024) similarly argued that disruptive technologies and AI integration do not always yield the expected benefits, because infrastructural deficiencies, workforce resistance, and financial burdens may result in neutral or negative outcomes for certain firms.

In the context of last-mile logistics, Oršić et al. (2022) showed that while machine learning applications hold promise for sustainability improvements, their effectiveness is constrained by data intensity, infrastructure costs, and in some cases, increased energy consumption. Pasupuleti et al. (2024) further stressed that issues such as data quality, scalability, and model transparency may prevent machine learning solutions from consistently delivering the anticipated advantages.

At the organizational level, studies have also highlighted unintended consequences of digital adoption. Çağlar and Karagöz Taşkın (2023) found that awareness of AI and robotics in logistics service firms increased employees' turnover intentions, while the hypothesized mediating effects were not supported. Overvelde (2021) indicated that digitalization outcomes differ depending on firm size, with small and medium-sized enterprises (SMEs) often facing challenges that limit the positive effects of digital tools.

At the country level, Moldabekova et al. (2021) demonstrated that although digital technologies can improve logistics performance, their impact is limited in regions with infrastructural and institutional weaknesses, sometimes even leading to inefficiencies. Similarly, Yılmaz (2025) observed that despite significant digitalization efforts in leading economies, proportional improvements in logistics performance were not always realized, suggesting that short-term impacts may be modest.

Finally, regarding sustainability outcomes, Hejazi (2024) noted that digitalization practices do not always yield strong contributions, as improvements in financial and environmental sustainability dimensions are sometimes weak or

absent. Shi et al. (2023) also emphasized that the effects of digital technologies are highly context-dependent, varying according to firm characteristics, industry conditions, and implementation capacity.

A general evaluation of the literature indicates a growing trend in studies on digital technologies in logistics, with most relying on post-2000 data from Scopus, WOS, or Google Scholar, and often using tools such as VOSviewer for bibliometric analysis. While many works highlight positive outcomes such as cost reduction, enhanced sustainability, and improved efficiency, others point to neutral or negative effects. High implementation costs, infrastructural weaknesses, data-related challenges, and workforce resistance may limit or even offset the expected benefits. Outcomes also vary by firm size, with SMEs facing challenges, and by national context, where institutional deficiencies may reduce effectiveness. Moreover, contributions to sustainability are not always strong or consistent. Alongside these limitations, ethical issues, data privacy, policy barriers, and cybersecurity risks remain important areas for further investigation (Fareed et al., 2024; Latif et al., 2021). Taken together, the literature suggests that digitalization offers significant opportunities but also entails critical challenges that require context-sensitive approaches.

METHODOLOGY, ANALYSIS, AND FINDINGS

Bibliometric analysis is a systematic process that systematically evaluates the prevailing trends in scientific research and their contributions to future studies by examining which topics, concepts, keywords, authors, and institutions stand out in a specific field. It is based on large-scale scientific datasets and provides insights into the overall research landscape within the focus area. These large datasets allow for the examination of the cumulative evolution of scientific knowledge over time, thereby providing a foundation for future studies in the domain (Passas, 2024, pp. 1014–1015). This method is regarded as a critical tool for identifying the growth potential and future directions of research areas (Khanra et al., 2022, p. 1397). Therefore, bibliometric analyses provide insights into the intellectual structures of research fields and yield significant outcomes for academia, industry, and policymakers (Miah et al., 2024, p. 6). The recent proliferation of scientific research has also expanded the datasets used in the bibliometric analysis, enhancing the scope and depth of such evaluations (Donthu et al., 2021, p. 286).

Additionally, with the advancement of technology, the variety of software available for bibliometric analysis has increased, further sparking researchers' interest in this method. One such software, R, stands out as a preferred tool in bibliometric research due to its open-source nature and free accessibility. The R software, with its Biblioshiny package, is a tool that enables bibliometric and graphical analyses while also facilitating mapping (Büyükkıdık, 2022, p. 167;

Derviş, 2019, p. 158). In this study, R was chosen as the preferred software for the analyses.

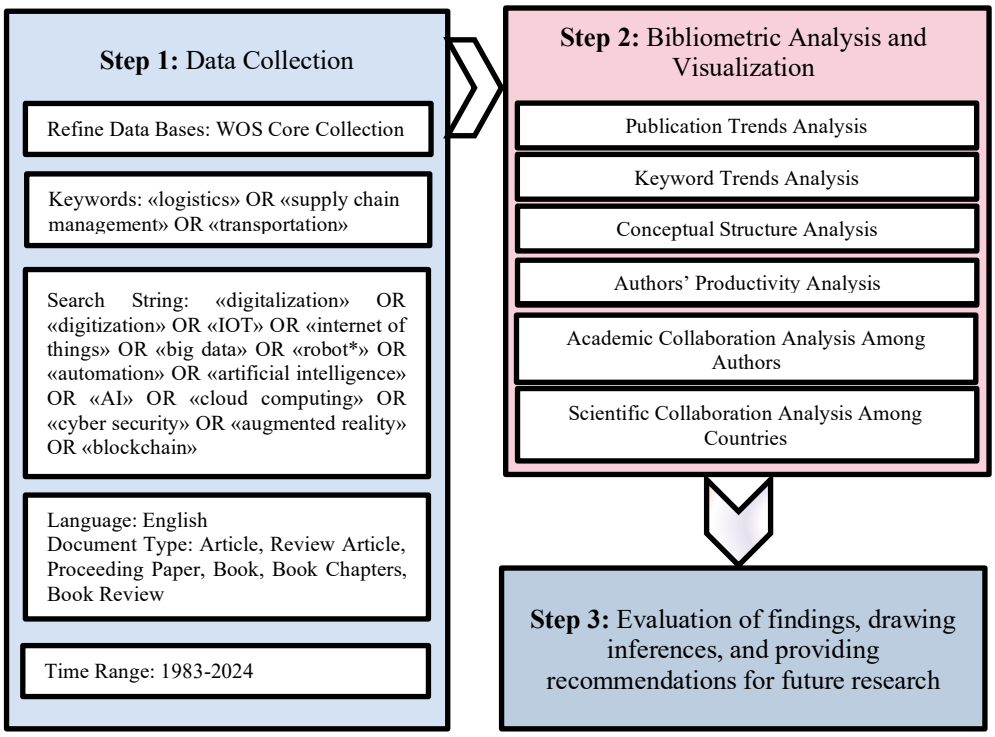
The primary objective of this study is to conduct a comprehensive bibliometric assessment of research on digital technologies in logistics, aiming to uncover the intellectual, conceptual, and collaborative structures that define this domain. To guide the analytical framework, the following research questions were formulated:

RQ1: How has the academic focus on digital technologies in logistics evolved over time, and which countries, institutions, and authors have played leading roles in shaping this research domain?

RQ2: What are the predominant themes, emerging trends, and underexplored areas within the literature on digital transformation in logistics, as revealed through bibliometric mapping and keyword trends analysis?

These research questions clarify how the study interprets the evolution of publication trends, collaboration networks, and thematic developments in the field.

Figure 1: Steps of Bibliometric Analysis of Digital Technologies on the Logistics



The dataset was derived from the Web of Science (WOS) database on 22 November 2024. WOS database was chosen due to its rigorous indexing policies, inclusion of high-impact and peer-reviewed journals, and its widespread use in bibliometric research. Relying on WOS database ensures consistency in citation data, reduces duplication bias, and captures the most influential publications in the field. Therefore, the use of WOS database provides a sufficiently robust dataset for the purposes of this study. The search covered the period 1983–2024 and was limited to the following document types: articles, review articles, proceeding papers, books, book chapters, and book reviews (Figure 1). To ensure consistency, only English-language publications were included, while other languages were excluded. Furthermore, only publications indexed in SSCI, SCI-Expanded, AHCI, and ESCI were considered, since these indexes are internationally recognized for their quality standards and ensure the inclusion of scholarly contributions with high visibility and impact.

The search query was restricted to the Title field to ensure that the retrieved publications explicitly focused on logistics and supply chain management within the context of digital technologies. Specifically, the query combined the core terms "logistics", "supply chain management", and "transportation" with a comprehensive set of keywords representing Industry 4.0 digital technologies. This query was executed in the Web of Science Core Collection for the period 1983–2024, limited to documents published in English and categorized as Article, Review Article, Proceedings Paper, Book, or Book Chapter. The complete and copyable Web of Science search query, expressed in the TS format, is presented below:

TS = (("logistics" OR "supply chain management" OR "transportation") AND ("digitalization" OR "digitization" OR "IOT" OR "internet of things" OR "big data" OR "robot*" OR "automation" OR "artificial intelligence" OR "AI" OR "cloud computing" OR "cyber security" OR "augmented reality" OR "blockchain"))

To ensure the data reliability, internal consistency, and transparency of the dataset, a systematic multi-step cleaning procedure was carried out prior to the bibliometric analysis. Initially, 2,594 publications were retrieved from the Web of Science Core Collection. After restricting the dataset to English-language publications, the total number of records was reduced to 2,548. A further refinement excluded works authored by "Anonymous," resulting in 2,539 publications. Following these refinements, duplicate records were carefully identified and removed through title-level inspection to prevent double counting. In addition, synonymous and semantically equivalent terms (e.g., “AI” and “Artificial Intelligence,” “IoT” and “Internet of Things”) were unified under standardized labels to enhance the accuracy and interpretability of the keyword co-occurrence networks. Finally, the dataset was limited to publications indexed under SCI-Expanded, SSCI, AHCI, and ESCI, yielding a final analytical dataset of 1,597 documents. These procedures ensured that the dataset was both methodologically transparent and

internally consistent, thereby strengthening the reliability of the bibliometric mapping and subsequent interpretations.

The selection of digital technologies was based on the Industry 4.0 framework, which emphasizes technologies that have been most transformative in logistics and supply chain management research. Specifically, the inclusion of terms such as artificial intelligence, blockchain, big data, IoT, automation, cloud computing, cybersecurity, and augmented reality reflects the core components frequently highlighted in conceptual and empirical studies of digital transformation in logistics.

The final dataset of 1,597 publications was analyzed to examine citation patterns, keyword trends, and publication trends. Keywords were interpreted, trends associated with these keywords were analyzed, and clusters were generated to map conceptual structures. Additionally, the number of references cited by these publications and the distribution of citations they received within the WOS database were determined. Furthermore, analyses focusing on authors, institutions, and countries was conducted. The results were visualized through graphs, maps, and tables generated in R (Biblioshiny), ensuring a comprehensive representation of the findings.

The investigation encompassed 1,597 publications indexed in the WOS database, published between 1983 and 2024. These studies were distributed across 598 different journals. The mean number of citations per publication was 27.27, while the average number of co-authors per publication was 3.84. Among the analyzed years, 2023 recorded the highest average annual citation count (Figure 2 and Table 3). The analysis of annual citation averages reveals that the years 2017 to 2021 experienced the peak citation numbers. Publications in this field experienced a significant increase, particularly after 2017, with 2023 identified as the most productive year in terms of annual scientific output, reaching 317 publications. The study by Admoko et al. (2024) also emphasizes that research in this field began to rise and attract attention during the years 2019–2020.

Furthermore, it was noted that scientific production in this area remained at a high level in 2024 (Figure 3). These findings indicate that research on digitalization in logistics has gained momentum in parallel with the rise of Industry 4.0 after 2015. In particular, the significant growth in 2017–2023 suggests that the academic community increasingly perceives digital technologies not as peripheral tools but as core enablers of transformation in logistics and supply chain management. The average number of co-authors (3.84) and the international co-authorship rate (34.25%) in Table 3 underline the collaborative and global nature of research in this domain. This finding highlights that digitalization in logistics transcends a locally confined research domain and represents an international issue requiring knowledge sharing across regions.

Figure 2: Average Citations per Year

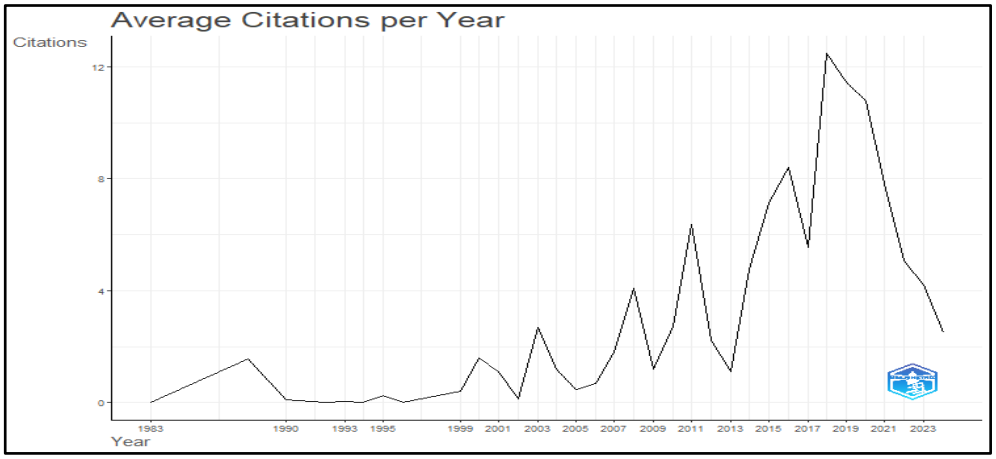


Figure 3: Annual Scientific Production

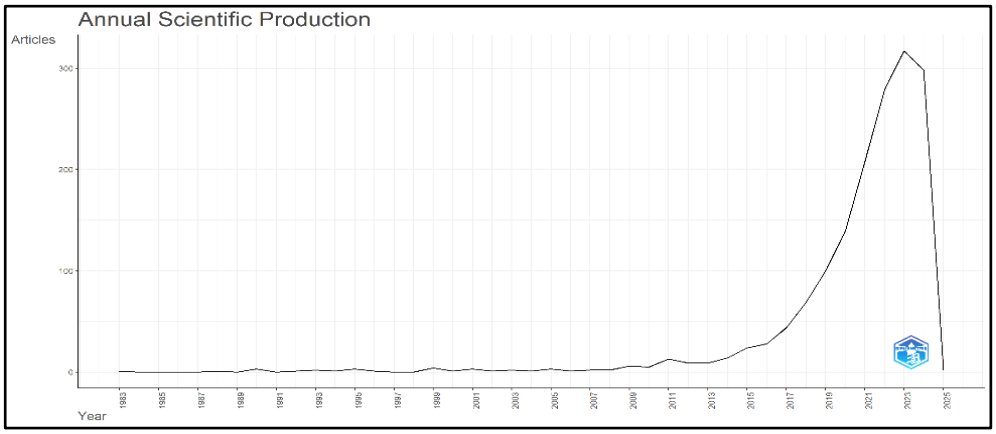


Table 3: General Characteristics of the Analyzed Publications

Timespan	1983-2024	
Publication	1,597	
Journals	598	
Keywords	1,511	
Average Citations per Publication	27.27	
Number of Single-Authored Publications	173	
Average Number of Co-Authors per Publication	3.84	
International co-authorships %	34.25	
Year	**Number of Publication**	**Mean TC Per Year***
2017	44	5.54
2018	69	12.47
2019	100	11.46
2020	139	10.77
2021	208	7.82

2022	463	5.05
2023	317	4.22
2024	298	2.49

* **Mean TC Per Year**: Average Citations per Year

Keywords summarize the content of a publication, making it more comprehensible. This enhances the accessibility of the publication and facilitates more efficient literature searches on the relevant subject. The frequency table and the resulting word cloud obtained from the analysis reflect the commonly discussed concepts and research trends within publication's domain. The frequency table (Table 4) and word cloud (Figure 4), limited to 25 keywords, generated through the R programming environment demonstrate the prevalence and significance of keywords.

Table 4: Most Frequently Used Words

Terms	**Frequency**
internet	181
technology	135
challenges	124
framework	121
performance	114
model	113
system	105
management	88

An analysis of the keywords from 1,597 articles reveals that the most frequently used keyword is "internet," followed by "technology." These are subsequently followed by the keywords "challenges," "framework," "performance," "model," "system," and "management" in order of frequency. According to the findings, the dominance of the term *internet* indicates that it functions as a key element enabling the rollout of digital technologies such as IoT, big data, and blockchain applications in logistics. The frequent occurrence of the term *challenges* reveals that researchers go beyond emphasizing the opportunities created by digital technologies and address the barriers that arise during their adoption processes. The prominence of the terms *framework* and *performance* demonstrates the growing scholarly interest in theoretical inquiries and performance measurement models within digitalization research in logistics.

Figure 4: Word Cloud for Keywords Plus



- The frequency table and word cloud indicate that "internet" (181), "technology" (135), and "challenges" (124) are the most frequently used keywords. The frequent use of the term "internet" in the literature highlights its significance as a critical component and indispensable infrastructure in developing digital technologies and their application in logistics.
- The frequent use of the terms "framework" (121) and "performance" (114) suggests a strong emphasis on theoretical frameworks related to the implementation of digital technologies in the logistics sector, as well as a focus on issues concerning logistics performance.
- The terms "model" (113) and "system" (105) are frequently used and can be defined as conceptual and mathematical tools employed to understand, analyze, and optimize logistics processes. In this context, the term "system" refers to the integration of logistics processes through digital technologies, enabling them to function as a cohesive whole. According to the analysis results, the frequent use of these two concepts in scientific studies is attributed to their complementary roles: while "model" provides a theoretical and mathematical framework for understanding the functioning of logistics processes, "system" ensures the practical applicability of these models in real-world scenarios.
- The term "management" (88) is frequently used in publications within this field, highlighting the transformation brought about by digital technologies in logistics management processes. This indicates that studies on integrating digital transformation into the logistics sector address innovative technologies in both operational processes and strategic issues.

Figure 5 illustrates the annual frequency of keywords used in studies related to the research theme. Analyzing the temporal distribution of these keywords based on their frequency is essential for comprehending the evolution of trends and patterns in the literature throughout time. The graph reveals that studies addressing the interplay between digital technologies and the logistics sector were quite limited prior to 2010. The use of relevant keywords began to show an upward trend after 2015, with a marked increase starting in 2020. The sharp rise after 2020 can also be linked to the COVID-19 pandemic, which accelerated digital transformation in logistics due to disruptions in supply chains and the need for remote, technology-enabled solutions. These findings indicate that the growing prominence of the Industry 4.0 concept has ushered in a period where digital technologies have gained greater significance within the logistics sector. As supported by the word cloud and frequency table, the terms "Internet" and "Technology" are among the most frequently used keywords and have shown the most rapid increase compared to other keywords since 2020. This trend reflects the growing importance of the internet in enabling innovative technologies within logistics processes. Similarly, concepts such as "Challenges," "Framework," and "Performance" have also experienced a notable rise during this period. The prominence of these concepts can be interpreted as an indication that, alongside the opportunities brought by digitalization, the challenges faced during implementation and the search for solutions to these challenges have also begun to occupy a significant place in the literature.

Figure 5: Keywords Trends

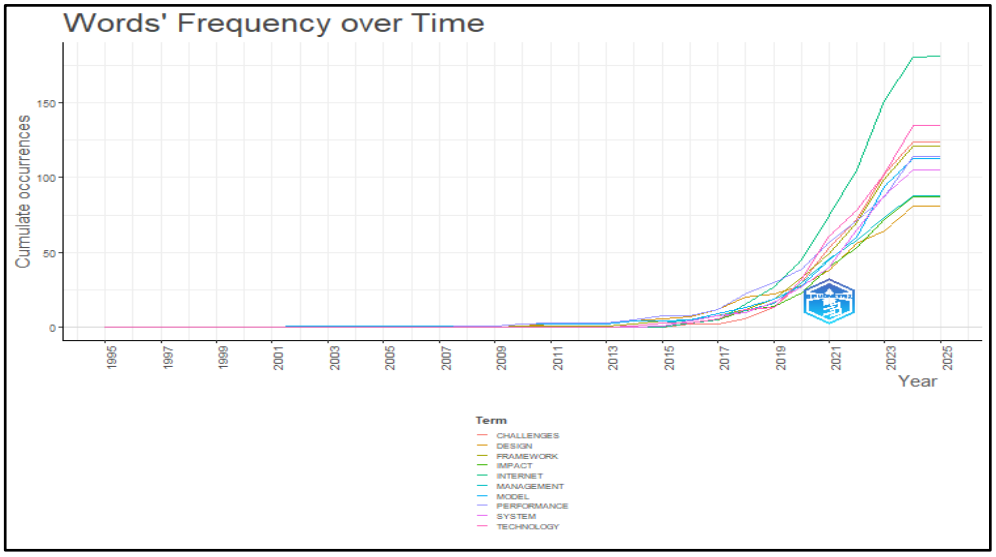


Figure 6 categorizes the topics into three distinct clusters based on centrality and impact. In the conceptual structure map, the minimum cluster frequency was set at five. The topics "Technology," "Challenges," and "Framework" (centrality: 0.251; impact: 7.904) exhibit the highest centrality and moderate impact, representing key

components of digital transformation in the logistics sector. In another cluster that includes the topics "Predictive Analytics," "Challenges," and "Impact," (centrality: 0.293; impact: 3.326) it is shown that these topics are examined in a particular context yet exert minimal influence on the literature. The results suggest that these topics require more extensive investigation. The cluster containing the concepts "Framework", "Big Data" and "Technology" (centrality: 0.444; impact: 4.160) exhibits low centrality but high impact, indicating their significant influence despite their peripheral position in the network. These topics refer to specific yet highly impactful areas in literature. The findings presented visualize the trends and gaps in the literature, highlighting that researchers can identify new research opportunities by focusing mainly on the topics "Predictive Analytics," "Challenges," and "Impact," as well as "Big Data" and "Technology." The study conducted by Fareed et al. (2024) also discusses the challenges related to the applications of digital technologies in the logistics sector, which is consistent with the findings of the present study.

Figure 6: Conceptual Structure Map

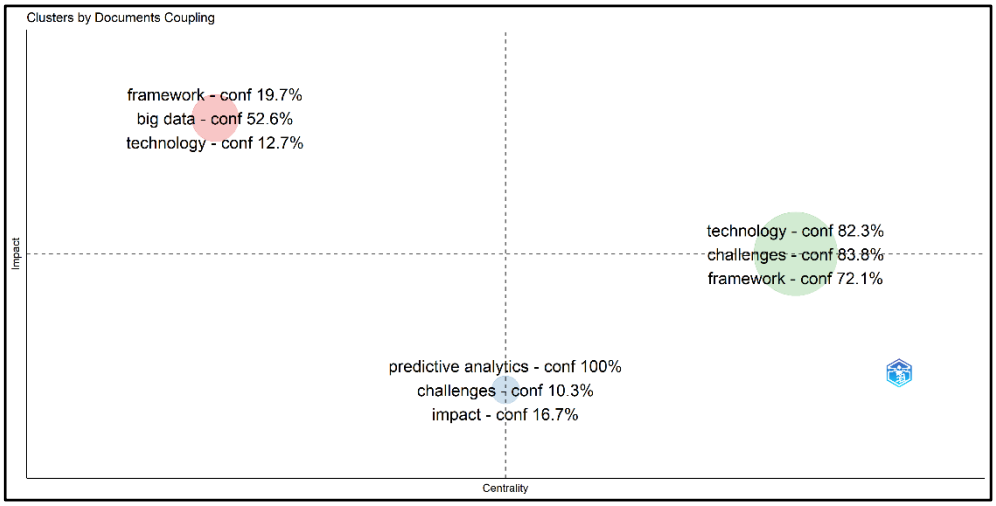


Table 5 evaluates the impact levels of publications according to the h-index, total citations (TC), and total number of articles (NP). The h-index in the table serves as a metric for assessing a journal's productivity and citation impact. According to the information in the table, the journals *"IEEE Transactions on Intelligent Transportation Systems"* and *"International Journal of Production Research"* are the most prominent in the subject, as seen by their h-index and total citation metrics. The journal *"Sustainability"* has 62 publications and an h-index of 20, contributing significantly to the literature. Despite the *"International Journal of Production Economics"* publishing fewer papers than other journals, its cumulative citation count of 2,261 indicates a significant impact on the field. These results suggest that studies published in this journal are frequently cited in scientific works related to digital technologies and the logistics sector.

Table 5: Sources Impact

Source	h_index	TC	NP	PY_start
IEEE Transactions on Intelligent Transportation Systems	22	2,246	61	2016
International Journal of Production Research	21	4,466	33	2017
Sustainability	20	1,516	62	2017
IEEE Access	19	1,199	50	2018
Transportation Research Part E-Logistics and Transportation Review	14	1,487	21	2014
Annals of Operations Research	13	762	15	2018
International Journal of Logistics Management	13	1,094	17	2018
Computers & Industrial Engineering	11	1,112	17	2015
IEEE Internet of Things Journal	11	983	14	2017
International Journal of Production Economics	11	2,261	13	2014
Sensors	11	635	32	2016
Production Planning & Control	10	581	15	2017
Logistics-Basel	9	509	13	2018
Electronics	8	267	18	2019
Cluster Computing-The Journal of Networks Software Tools and Applications	7	223	14	2019
International Journal of Logistics-Research and Applications	7	618	11	2010
Journal of Cleaner Production	7	452	7	2017
Applied Sciences-Basel	6	129	16	2019

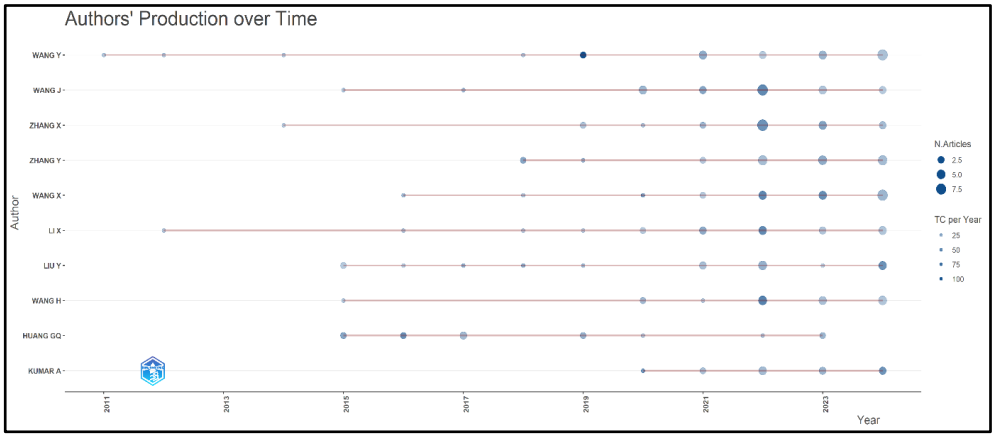
*** TC:** Total number of citations, **NP:** Total number of publications

Table 6 presents the productivity years, publication frequency (freq), total citations (TC), and average annual citations (TCpY) of the top 10 foremost authors with the greatest publication count on digitalization in the logistics field. Figure 7 shows the productivity levels of the authors over the years. Based on the information provided in the table, the authors' quantitative and qualitative contributions to the literature have been analyzed. Notably, George Q. Huang's high citation count (1,057) emphasizes his role in shaping the intellectual structure of the field. Xinyu Wang, with an average annual citation count of 26.52, is also notable. Yong Wang, on the other hand, is distinguished by having the highest number of publications among the authors and by publishing regularly almost every year since 2011.

Table 6: Author Production over Time

Author	Publication years	freq	TC	Mean TCpY
Huang, George Q.	2015-2016-2017-2019-2020-2022-2023	13	1,057	20.29
Kumar, Ashwani	2020-2021-2022-2023-2024	13	353	24.95
Li, Xin	2012-2016-2018-2019-2020-2021-2022-2023-2024	20	366	10.96
Liu, Yang	2015-2016-2017-2018-2019-2021-2022-2023-2024	19	647	16.29
Wang, Huan	2015-2020-2021-2022-2023-2024	18	287	14.89
Wang, Jianxin	2015-2017-2020-2021-2022-2023-2024	24	467	16.81
Wang, Xinyu	2016-2018-2020-2021-2022-2023-2024	21	672	26.52
Wang, Yong	2011-2012-2014-2018-2019-2021-2022-2023-2024	25	828	17.97
Zhang, Xiaojun	2014-2019-2020-2021-2022-2023-2024	22	351	17.18
Zhang, Yingting	2018-2019-2021-2022-2023-2024	22	407	16.03

Figure 7: Authors' Production over Time



Academic collaboration among authors is shown in Figure 8. The nodes' size indicates the author's importance and impact within the network, while the colors represent different collaboration clusters. As can be seen from the figure, the working groups in this field consist of several main clusters. Authors such as Wang Jianxin, Wang Yong, and Zhang Yingting, who are prominent in this domain, occupy a central position in the network and are crucial in fostering collaboration within the literature. However, there is a limited connection between different author groups. The fragmented structure of collaboration networks indicates potential inefficiencies in knowledge diffusion. These results suggest that geographic or institutional limitations influence the scientific studies conducted in this field. Strengthening inter-institutional and cross-country collaboration could accelerate innovation and prevent the duplication of similar research, thereby providing more effective outcomes for practitioners in the sector.

Figure 8: Academic Collaboration Among Authors

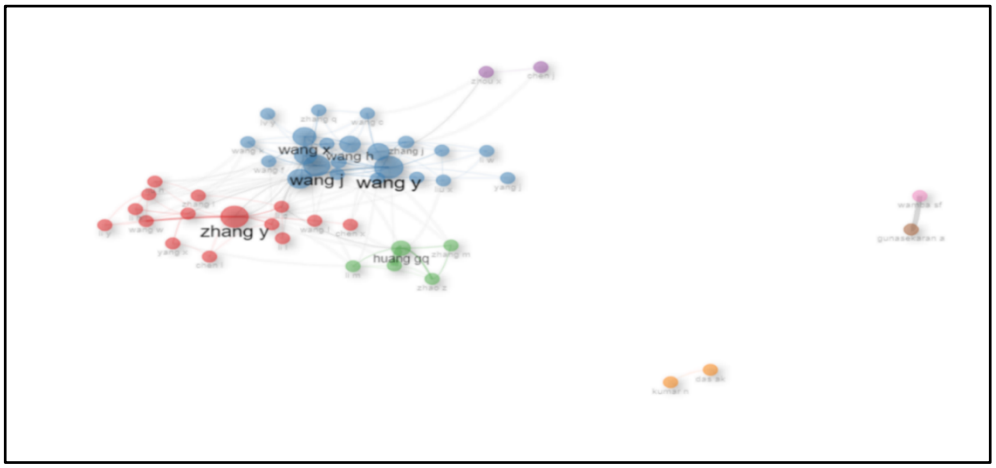


Table 7 lists the countries with greatest volume of publications on this research topic. Analyzing the data from the table, the five countries with the highest number of publications from 1983 to 2024 are: China (2,045 publications), India (489 publications), the USA (423 publications), the UK (270 publications), and Saudi Arabia (213 publications). In the study by Oğuz et al. (2024), China was identified as a leading country, while in the study by Yavas & Ozkan-Ozen (2023), the USA, China, and the UK were determined to be the most productive countries, respectively. These results also support the findings of the present study.

China's various investments in digital technologies, such as the establishment of smart factories and digitized workshops in key sectors as part of its "Made in China 2025" plan to promote smart manufacturing (Institute for Security and Development Policy, 2018), its achievement of 50% of global industrial robot installations by 2022 (United Nations, 2024), and the promotion of 5G and industrial internet innovation (Jiang & Xu, 2024), have contributed to the country becoming a significant player in the global manufacturing and logistics sectors. Based on this information, it can be stated that, alongside China's investments in this field, its scientific production has increasingly guided sectoral applications. In India, businesses prioritize digital transformation, focusing on areas such as artificial intelligence, cloud computing, and data analytics. The provision of services by several U.S.-based cloud service providers to Indian businesses has led these companies to quickly digitalize their operations to reduce costs (International Trade Administration, 2024). India's advancements in information technology will likely play a significant role in developing and implementing digital logistics systems. These developments could impact increasing the country's R&D investments and strengthening scientific research centers and academic infrastructure. Accordingly, scientific studies focused on integrating smart technologies into the logistics sector are expected to be positively influenced by these developments.

The USA is regarded as a foremost nation in the advancement and application of digital technologies. In 2023, the U.S.'s information and communication sector's growth rate exceeded 9%. In recent years, the quantity of scientific papers has consistently risen, especially in the domain of artificial intelligence, within the USA (OECD, 2024). The total transaction value of the nation’s digital investment market is projected to attain 2.2 billion USD by 2028 (Statista, 2024). The inclusion of technologies such as the IoT (Chen et al., 2024; Masoomi et al., 2024; Ran et al., 2024; Rejeb et al., 2020; Shoomal et al., 2024), artificial intelligence (Abdulrashid et al., 2024; Jackson et al., 2024; Li et al., 2024; Q. Liu et al., 2024; Rashid et al., 2024), big data (Park & Singh, 2022; Patrucco et al., 2023; Srivastava et al., 2024; Tavana et al., 2024; Zheng et al., 2023), and blockchain (Autore et al., 2024; Dreyfus, 2024; Lotfi et al., 2024; Patro et al., 2024; Zhao et al., 2024) is extensively discussed in scientific studies in the United States, particularly with regard to their integration into logistics processes.

Table 7: Top 10 Nations by Publication Count*

Country	Publication Count
China	2,045
India	489
USA	423
United Kingdom	270
Saudi Arabia	213
Korea	159
Pakistan	154
Germany	140
Japan	120
Italy	114

*Country-level publication counts are based on full counting; therefore, the sum of country publications may exceed the total number of analyzed documents.

Table 8 compares studies from 1983 to 2024 based on total citation count (TC) and average article citations (AC) for each country. The average citation values were calculated following the bibliometrix computation logic in R, where the mean number of citations per document was obtained by dividing the total citations (TC_i) by the number of publications (NP_i) for each country ($AC_i = TC_i / NP_i$). This ensures a standardized comparison of citation impact across countries. According to the results, China has the highest total citation count (10,708) and is a global leader in studies on the use of digital technologies in the logistics sector. The USA, with the second-highest number of citations (8,825) in this field, produces more impactful publications than China regarding average citations per article. Although the UK lags behind China and the USA in terms of the number of citations (2,712), it has been found that its publications receive a higher average citation count, indicating that they are influential works often referenced by other studies in the literature. The United Arab Emirates, while having fewer publications in this field compared to these countries, stands out as a leading country in the area due to its high average citation count, guiding research in the domain.

Table 8: Most Cited Countries

Country	TC	Average Article Citations
China	10,708	18.0
USA	8,825	78.8
United Kingdom	2,712	49.3
India	2,320	18.4
Germany	2,121	43.3
Australia	1,501	65.3
Italy	1,374	42.9
Canada	1,095	49.8
United Arab Emirates	862	71.8
Brazil	836	55.7
France	820	41.0
Korea	808	16.2
Austria	769	64.1

*Note: Average article citation values ($AC_i = TC_i / NP_i$) were calculated using the bibliometrix package in R through the Biblioshiny interface.

Table 9 and Figure 9 display the academic collaboration network among countries in studies on using digital technologies in logistics. The data in the table quantitatively express the collaborations between countries involved in this area of research. Meanwhile, the global collaboration map in Figure 9 shows the geographic distribution of these data.

As shown in Table 9, the countries with the most collaborations are China and the USA (f: 53). China and the UK also engage in significant collaboration in their scientific studies in this area (f: 50). India and the USA (f: 33), as well as China and India (f: 32), frequently collaborate on the use of digital technologies in the logistics sector. China's extensive scientific collaboration network with countries from different regions can indicate the country's intention to strengthen its central role in the logistics sector.

Figure 9 geographically illustrates the collaboration network among countries in research on using digital technologies in the logistics sector. The darker regions on the map represent the countries with the most collaboration, while the connections indicate the network of scientific studies conducted between these countries. In the countries' collaboration map, the minimum edge parameter was set at two. Highlighted in the darkest color, China holds a central position in the international collaboration network and has strong connections with countries from various regions. The USA ranks second, following China, in terms of the total number of connections. The collaboration networks in South America, Africa, and Australia are clearly less dense than those of China and the United States. Therefore, it can be stated that scientific studies conducted in these regions hold significant potential for enhancing international collaboration.

Table 9: Countries with the Highest Collaboration Frequency

From	To	Frequency
China	USA	53
China	UK	50
India	USA	33
China	India	32
India	UK	31
Saudi Arabia	Pakistan	28
China	Canada	27
India	Saudi Arabia	23
USA	UK	23
China	Saudi Arabia	21

Figure 9: Countries Collaboration Map

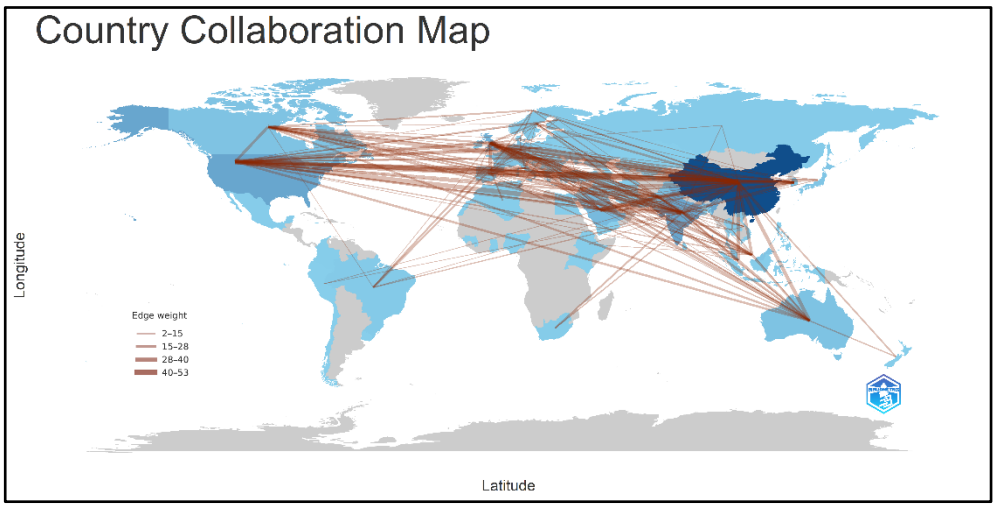


Table 10 presents the ranking of universities with the most publications between 1983 and 2024. The university with the highest number of publications in this discipline is Hong Kong Polytechnic University, totaling 55 publications. The University of Hong Kong, situated in Hong Kong, has 47 publications. King Saud University in Saudi Arabia follows with 40 articles, while Shenzhen University and Jinan University in China with 37 and 36 publications, respectively.

Table 10: Universities Ranked by Number of Publications

Affiliation	Countries	Number of Articles
The Hong Kong Polytechnic University	Hong Kong	55
The University Of Hong Kong	Hong Kong	47
King Saud University	Saudi Arabia	40
Shenzhen University	China	37
Jinan University	China	36
University Of Jeddah	Saudi Arabia	32
Shanghai Maritime University	China	28
King Abdulaziz University	Saudi Arabia	28
Wuhan University	China	24
Beihang University	China	23

Hong Kong promotes digitalization in trade logistics and e-commerce applications. With significant investments and improvements in digitalization, it has established a reliable trade logistics infrastructure, making it an important hub for international trade and logistics (Fan et al., 2024, pp. 638–639). The country supports the renewal of the logistics sector by adopting smart logistics applications more intensively (Transport and Logistics Bureau, 2024, p. 51). The findings presented indicate that the efforts made by Hong Kong, one of the leading logistics hubs in the world, to digitalize logistics operations are also supported by scientific research. King Saud University in Saudi Arabia plays a significant role in scientific studies on using digital technologies in logistics. In recent years, the country has invested

significantly in smart technologies including artificial intelligence, data analytics, the IoT, robotics, 5G, and blockchain (Bendary & Rajadurai, 2024, p. 8). The country's Vision 2030 project, which aims to position it as a modern and global information technology hub (Aziz et al., 2024, p. 2), and its view of this transformation as a strategic necessity (Alnasser et al., 2024, p. 22), can be linked to its emphasis on scientific research in the field of digitalization. According to the findings obtained from the analysis, China's high scientific productivity in digital technologies reflects the country's efforts to maintain and enhance its global role in the logistics sector.

CONCLUSION AND RECOMMENDATIONS

Digital technologies have proliferated with the idea of Industry 4.0, resulting in profound changes in logistics operations and supply chain structures. These technologies accelerate processes, enhance efficiency, and diminish expenses. Smart technologies, including the IoT, robotics, blockchain, big data analytics, artificial intelligence, and autonomous systems have expanded their logistics sector application areas, enhanced supply chain transparency, strengthened operational resilience, supported sustainable performance, and promoted innovative business models. The practical implementation of digital technologies in the logistics sector requires in-depth research into theoretical frameworks related to integrating these technologies, real-life applications, and any obstacles that may emerge during this process. In this context, analyzing scientific studies on this issue becomes crucial for identifying current trends in the literature, pinpointing research gaps, and making forward-looking inferences.

The primary aim of this study is to evaluate scientific studies on the use of digital technologies in the logistics sector using bibliometric analysis and to identify research gaps by thoroughly examining key trends in the literature, influential journals, prominent authors, leading countries, and emerging topics. Key findings reveal an increasing scholarly focus on digitalization after 2017, the predominance of terms such as "internet," "technology," "challenges," and "framework" and the central role of China and the USA in scientific collaboration. However, empirical applications, cross-continental collaborations, and human-centered approaches remain underexplored.

The findings indicate that governments need to take certain policy actions. In this context, it is particularly important to establish incentive mechanisms that facilitate firms' adoption of digital technologies, to ensure data privacy against potential cyberattacks that may arise with the digitalization of the logistics sector, and to implement comprehensive cybersecurity regulations. Furthermore, in order to enable countries in South America and Africa—regions that score low in the infrastructure component of the World Bank's (2023) Logistics Performance Index—to integrate more effectively into digital technologies, strengthening

international research collaborations in these regions is essential. Such measures are expected to encourage the adoption of digital technologies in logistics and enhance the resilience, transparency, and sustainability of global supply chains.

For practice, the bibliometric evidence suggests that logistics firms should prioritize investments in big data, predictive analytics, and risk management systems to close existing gaps. Managers also need to consider not only the efficiency dimension but also ethical, human-centered, and environmental concerns, aligning their digital transformation strategies with broader sustainable development goals.

It has been found that while theoretical studies are extensively conducted, empirical and real-life applications remain relatively limited in the literature. This is attributed to the fact that these technologies have only started to mature in recent years (Yavas & Ozkan-Ozen, 2023). It has been identified that key topics creating research gaps in this field include the challenges related to ethics and data privacy in the adoption of digitalization in the logistics sector, human-centered approaches (Benatiya Andaloussi, 2024), barriers created by government policies (Fareed et al., 2024), and cybersecurity and risk management (Latif et al., 2021). Therefore, future studies should investigate these challenges and develop concrete frameworks, simulation models, and decision-support tools to guide logistics companies and policymakers in overcoming them.

Recommendations for future research

Future bibliometric research on digitalization in logistics could be expanded and refined in several ways. First, studies should consider adopting multi-database approaches by combining sources such as Scopus, Web of Science (WOS), Dimensions, and IEEE Xplore to enhance the representativeness of the dataset. Comparative analyses across these databases would help assess coverage bias and provide more robust results. Moreover, rather than relying solely on VOSviewer, future research could incorporate a wider range of visualization and mapping tools, such as CiteSpace for identifying research fronts, SciMAT for strategic diagrams, or R-biblioshiny for advanced statistical modeling. Comparative evaluations of these tools would generate methodological perspectives on how visualization techniques influence the interpretation of bibliometric results.

Another crucial issue for future research is to address the gap between theory and practice in the digitalization of logistics. The results of this study bring forward dominant themes such as “technology,” “challenges,” and “framework,” which clearly highlight the need for existing research to be backed up with more field studies, real-world applications, and empirical investigations. Moreover, the findings also point out the importance of looking into emerging yet underexplored topics, particularly “big data” and “predictive analytics,” which, despite exhibiting relatively low centrality scores, hold strong potential to open up new lines of inquiry in logistics research. Bridging theoretical advances with practice-oriented studies and giving greater attention to these nascent themes would be beneficial for

practitioners and policymakers striving to accelerate digital transformation in the logistics sector. In addition, topics such as ethics, data privacy, cybersecurity, and risk management were identified as peripheral in the current bibliometric analysis, yet they represent critical barriers to the digital transformation of logistics. These themes could be examined more comprehensively through complementary methods, including policy document analysis or expert interviews, thereby generating insights with direct policy and managerial relevance.

The collaboration networks in South America, Africa, and Australia remain relatively weak compared to regions such as China and the USA. Future studies may propose frameworks to strengthen international cooperation, particularly through knowledge transfer and joint research projects. Such collaborations could also contribute to improving the logistics infrastructure performance of South American and African countries, where the current performance levels remain relatively low. Research in this area may facilitate the development of stronger logistics systems based on digitalization in these regions, thereby enhancing infrastructure performance and closing academic gaps that would reinforce such progress.

Finally, within the scope of the systematic literature review and the conceptual structure map, it is observed that the role of government policies, sectoral regulations, and incentive mechanisms in the diffusion of digital technologies in the logistics sector has not been sufficiently examined. Future studies may analyze, through different approaches, how regulatory environments contribute to or hinder digital transformation. In addition, although specific technologies such as drones, autonomous guided vehicles, RFID, and 5G were not included among the keywords in this study, these technologies are increasingly playing a central role in logistics operations. Therefore, future bibliometric research could expand the set of keywords to include them as well.

In conclusion, this study identifies past and current trends and delineates a roadmap for future academic research and practical applications. The bibliometric insights presented here provide a foundation for designing supportive policies and advancing managerial strategies toward a sustainable logistics sector driven by digitalization.

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