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ASSESSING DIGITAL CAPABILITIES IN RELATION TO LOGISTICS STRATEGY: A BIBLIOMETRIC REVIEW

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ABSTRACT

Objective: To analyze the relationship between digital capabilities, logistics strategy, and Industry 4.0 implementation through a bibliometric review of scientific literature, identifying the main authors, institutions, keywords, emerging technologies, implementation barriers, and future perspectives related to strategic logistics and dynamic capabilities.

Originality/Value: The study contributes theoretically by integrating digital capabilities, dynamic capabilities, and logistics strategy through a socio-bibliometric perspective. Furthermore, it expands the discussion on the transition from Industry 4.0 to Industry 5.0 by emphasizing the need for integration between technology, governance, sustainability, organizational culture, and human capital valorization. The article also provides comparative evidence between developed and developing countries, especially China and India.

Methods: The research adopted a bibliometric approach based on the protocol proposed by Tranfield, Denyer, and Smart (2003). Data were collected from the Web of Science (WoS) database, covering publications from 2016 to 2025. Initially, 78 articles were analyzed using VOSviewer software for bibliometric network mapping, cluster analysis, authorship, institutions, and keywords. Additionally, 61 articles were subjected to quantitative coding and statistical analysis using JAMOVI software, including Chi-square tests to evaluate associations between economic context, dynamic capabilities, and coercive and normative factors.

Results: The findings revealed significant growth in publications on Industry 4.0 and logistics from 2020 onward, reaching a peak in 2022. The most influential authors identified were Dev et al. (2020) and Kristoffersen et al. (2020). The main technologies associated with the logistics context were Internet of Things (IoT), Big Data Analytics, and integrated Industry 4.0 systems. Evidence indicates a predominance of studies conducted in developing countries, particularly China and India. The study also revealed that financial constraints, supply chain integration issues, and scalability limitations constitute the main barriers to technological implementation. The results further indicate that digital capabilities such as connectivity, visibility, and continuity are essential for the evolution of strategic logistics, although they are not sufficient alone to achieve Industry 5.0 principles.

Conclusions: It is concluded that digital capabilities represent essential strategic elements for strengthening logistics and organizational competitiveness in dynamic and sustainable environments. However, digital transformation requires integration among technology, governance, organizational culture, sustainability, and the development of dynamic capabilities. The study reinforces the need for future research to deepen the relationship between digital capabilities, logistics performance, organizational resilience, and Industry 5.0 implementation across different economic contexts.

Keywords: Logistics. Industry 4.0. Digital Capabilities. Dynamic Capabilities. Logistics Strategy. Bibliometric Review.

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AVALIAÇÃO DAS CAPACIDADES DIGITAIS EM RELAÇÃO À ESTRATÉGIA LOGÍSTICA: UMA REVISÃO BIBLIOMÉTRICA

RESUMO

Objetivo: Analisar a relação entre capacidades digitais, estratégia logística e implementação da Indústria 4.0 por meio de uma revisão bibliométrica da literatura científica, identificando os principais autores, instituições, palavras-chave, tecnologias emergentes, barreiras de implementação e perspectivas futuras relacionadas à logística estratégica e às capacidades dinâmicas.

Originalidade/Valor: O estudo contribui para o avanço teórico ao integrar capacidades digitais, capacidades dinâmicas e estratégia logística sob uma perspectiva sociobibliométrica. Além disso, amplia a discussão sobre a transição da Indústria 4.0 para a Indústria 5.0, destacando a necessidade de integração entre tecnologia, governança, sustentabilidade, cultura organizacional e valorização do capital humano. O artigo também apresenta evidências comparativas entre países desenvolvidos e em desenvolvimento, especialmente China e Índia.

Métodos: A pesquisa adotou uma abordagem bibliométrica baseada no protocolo de Tranfield, Denyer e Smart (2003). Os dados foram coletados na base Web of Science (WoS), abrangendo publicações entre 2016 e 2025. Inicialmente, 78 artigos foram analisados com auxílio do software VOSviewer para mapeamento de redes bibliométricas, análise de clusters, autores, instituições e palavras-chave. Adicionalmente, 61 artigos foram submetidos à codificação quantitativa e análise estatística utilizando o software JAMOVI, incluindo testes Qui-quadrado para avaliar associações entre contexto econômico, capacidades dinâmicas e fatores coercitivos e normativos.

Resultados: Os resultados demonstraram crescimento significativo das publicações sobre Indústria 4.0 e logística a partir de 2020, com pico em 2022. Os autores mais influentes identificados foram Dev et al. (2020) e Kristoffersen et al. (2020). As principais tecnologias associadas ao contexto logístico foram Internet das Coisas (IoT), Big Data Analytics e sistemas integrados da Indústria 4.0. As evidências indicam predominância de pesquisas em países em desenvolvimento, principalmente China e Índia. O estudo revelou que fatores financeiros, integração da cadeia de suprimentos e limitações de escalabilidade constituem as principais barreiras para implementação tecnológica. Os resultados também indicam que capacidades digitais como conectividade, visibilidade e continuidade são fundamentais para a evolução da logística estratégica, embora isoladamente não sejam suficientes para alcançar os princípios da Indústria 5.0.

Conclusões: Conclui-se que capacidades digitais representam elementos estratégicos essenciais para o fortalecimento da logística e da competitividade organizacional em ambientes dinâmicos e sustentáveis. Entretanto, a transformação digital exige integração entre tecnologia, governança, cultura organizacional, sustentabilidade e desenvolvimento de capacidades dinâmicas. O estudo reforça a necessidade de pesquisas futuras que aprofundem a relação entre capacidades digitais, desempenho logístico, resiliência organizacional e implementação da Indústria 5.0 em diferentes contextos econômicos.

Palavras-chave: Logística. Indústria 4.0. Capacidades Digitais. Capacidades Dinâmicas. Estratégia Logística. Revisão Bibliométrica.

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1 INTRODUCTION

In the 21st century, companies have sought differentiation mechanisms with a focus on resource efficiency, resilience, and sustainability (Schilling & Seuring, 2024). Within this environment, the discussion regarding the role of the logistics function as an intra-functional integrating mechanism and the maintenance of business competitiveness has been vigorously discussed (Albrecht et al., 2024; H. Gupta et al., 2022).

Furthermore, with increasing pressure from society and governments, logistic processes have been utilized to leverage and enable organizational actions for the circular model, exemplified in various distribution channels (Huang et al., 2023a; Jinru et al., 2022; Kristoffersen et al., 2020).

Consistent with these demands, the benefits that digital technologies offer to internal resources are declared (Jinru et al., 2022). That is, the adaptation, alignment, and integration of digital technologies with internal resources have been a way to address the new business environment (Albrecht et al., 2024; Li et al., 2022; Mvubu & Naude, 2024).

In the interim, these digital capabilities are used to monitor service levels and communication among agents, track products from transformation to the point of consumption, control costs, and break paradigms regarding the functionalities and benefits of products and services (Bressanelli et al., 2018; Porter & Heppelmann, 2014).

Thus, digital transformation has played a crucial role in the evolution of internal resources as a means of ensuring an efficient, resilient, and sustainable competitive advantage (Schilling & Seuring, 2024). In this panorama, characterized by the aggregation, processing, and communication of data, Industry 4.0 emerges as a necessary alternative for companies seeking to integrate knowledge, systems, and operations for greater quality and efficiency for their customers through intelligent automation (Porter & Heppelmann, 2014; Rad et al., 2022).

However, consistent with Gupta et al. (2020), digital technology is being implemented only through external (i.e., coercive) forces by supply chain agents. Thus, in academic literature, it is observed that the theme of Industry 4.0, associated with the evolution of internal resources and the logistics function, has been discussed in a limited way. That is, it is not treated as a strategy (Tan et al., 2022; Zhang et al., 2023).

To illustrate, Gupta et al. (2020) describe dynamic capabilities as practices that directly influence the adoption of Industry 4.0 technologies, without describing mechanisms for learning, reorganization, and standardization. Zhang et al. (2020) discuss digital capabilities and state that organizations must embrace this dynamic vision to survive in this new world.

In this sense, Queiroz et al. (2019) assert that digital technologies should offer connectivity with supply chain agents – upstream and downstream –, transparency, and continuity, in a socially and environmentally sound manner to improve supply chain efficiency. The limitation of this study refers to how these capabilities are developed alongside logistics operations.

Facchini et al. (2020) and Nagy et al. (2018) report that methods for evaluating the maturity levels of logistics processes do exist. That is, from the basic level for companies that perform activities manually to the advanced level for organizations seeking total integration of logistics processes. However, they do not highlight the mechanisms of integration with the market, according to the demands of Queiroz et al. (2019).

In this context, Farooq et al. (2021) believe that academic research should assess the readiness level of organizations for the use of digitalization mechanisms and, consequently, Industry 4.0, and propose a unanimous structure for the implementation of these technologies. However, according to Awan et al. (2022), through a literature review, they suggest that companies use digital technologies as a mechanism for improving internal efficiency, but without seeking a sustainable competitive advantage. However, Schilling & Seuring (2024), countering Huang et al. (2023), assert that, through digital transformation, practices directly influence performance, supported by the practice-based view theory. In this way, a sustainable competitive advantage is made possible. In the Brazilian context, the pursuit of better efficiency rates is also seen as the main alternative for the implementation of new technologies (Machado & Moori, 2024).

Subsequently, Jinru et al. (2022) declare the role of logistical resources as mechanisms for leveraging processes for the implementation of the circular economy. Thus, Huang et al. (2023) assure the mediating role of dynamic capabilities in the implementation of 4.0 technologies, influencing performance criteria, but in a broad way.

Thus, in the context of logistics and supply chain management, the adaptation, reconfiguration, and integration of resources are fundamental for practices to move from an internally neutral stage to achieving market benchmarking. That is, to be considered tacit knowledge, difficult to copy, and insurmountable (Nagy et al., 2018; Teece, 2018; Wheelwright & Hayes, 1985).

In this environment, logistical resources, together with digital technologies, will be used for data collection, storage, and transportation of products, as well as for offering services to consumers and clients.

For this purpose, the objective of this manuscript is to present a set of bibliometric indicators of scientific production. To support the bibliographic review, it was conducted in the Web of Science (WoS) and we constructed a bibliometric network using VOSviewer software (version 1.6.16), allowing for the exploration of the main works and authors (most cited), the research-source educational institutions, the most used keywords, and also opportunities for future research.

Promptly, the objectives of the article are to fill the Industry 4.0 gap regarding the logistics function by conducting a bibliometric review that allows drawing parallels between the application of technologies in different contexts and exploring possible inferences about the challenges faced in developed and developing countries. In this way, the article additionally seeks, beyond the bibliometric review, to analyze how the access and implementation of technologies that permeate the context of industrial advancement vary significantly between developed and developing countries, resulting in distinct challenges for each context (Mukherjee et al., 2022; Nagy et al., 2018). This disparity in contexts highlights the need for studies that investigate how different markets are adapting to new technological requirements, i.e., how coercive, normative, or mimetic factors influence the adoption of such innovations (S. Gupta et al., 2020; G. Zhang et al., 2023).

Another contribution refers to the model for developing resources and capabilities, tacit knowledge that will be differentiation mechanisms in the market (Jinru et al., 2022). It is evident that previous works focus on practices, barriers, and opportunities with the implementation of digital technologies, but they do not highlight the necessary interfaces for the transition to Industry 4.0 through internal resources. That is, the interface between the internal, external environment, and technology (Queiroz et al., 2019).

This article is structured as follows: the next section presents the literature review, addressing the main studies on Industry 4.0, logistics, and Strategy. Subsequently, the adopted methodological procedures are detailed. Afterwards, we discuss the results of the critical analysis, relating them to the evidence found in the literature. Finally, we conclude with reflections on the findings and suggestions for future research, emphasizing the importance of strategic adaptation and competence development for the effective implementation of Industry 4.0 in the logistics sector.

2 BIBLIOGRAPHIC REVIEW

2.1 Resources Applied to the Supply Chain

The supply chain is an interconnected network of organizations focused on aligning operations and services, encompassing the efforts of everyone involved from production to the delivery of a product or service to the customer (Min et al., 2019).

In the interim, the common challenge faced by supply chain organizations is linked to the development of human, material, and technological resources for obtaining and analyzing data that offer a forecast of demand versus supply, and also for reducing production lead times (F. Zhang et al., 2020).

According to studies, these resources can be classified as tangible (financial and physical resources), intangible (technology, reputation, and culture), or human (specialized skills and knowledge, communication, and motivation) (Amit & Schoemaker, 1993). In this sense, for supply chain management to become more efficient and effective to overcome the aforementioned challenges, the 21st century sees a push to improve resource efficiency through digital technological solutions such as IoT (Internet of Things), RFID, Beacons, Protocols, etc., to highlight differences between organizations (Bressanelli et al., 2018; Ciliberto et al., 2021).

In this way, since these resources are idiosyncratic to the organization—that is, they are particular and independent of the sector and scenario—it is precisely these resources that will determine the differences in competitiveness levels. Thus, for resources to provide a sustainable competitive advantage for the organization, they must be supported by the VRIN acronym: valuable; with few substitutes; rare; and difficult to imitate (Barney et al., 2011; F. Zhang et al., 2020).

Thus, smart devices can contribute, for example, to: inventory management (real-time inventory visibility, reducing data collection time); real-time monitoring (sharing demand information with various partners, as technology allows tags to store various product-related information); and logistics transparency (all goods transport information can be monitored by the customer themselves, generating a positive impact on their satisfaction).

Thus, competitive advantage is consolidated through heterogeneous resources, marked by issues of scale and/or pioneering (Huang et al., 2023). It is asserted that resources are unique, valuable, and difficult-to-copy mechanisms to meet customer demands and foster loyalty. Therefore, adopting digital technologies, aligned with Industry 4.0, is, in part, about updating and reconfiguring heterogeneous resources to meet the demands of a changing environment (Teece et al., 1997). In this context, dynamic capabilities are presented.

2.2 Building Dynamic Capabilities

Wang & Ahmed (2007) conceptualize dynamic capabilities as a firm's behavioral orientation to integrate, reconfigure, renew, recreate, update, and reconstruct its resources. The three pillars for forming dynamic capabilities are highlighted: an analytical process view, for analyzing, remodeling, and evaluating opportunities; the assessment of structures, procedures, and incentives for scaled opportunities; and finally, continuous learning mechanisms (Meirelles & Camargo, 2014).

According to these authors, organizations, through digital technologies, envision modifying processes and routines, re-evaluating structures and procedures, with competitive costs, in ways that were not possible even a decade ago. Thus, digital technologies are changing the nature and purpose of business (Annarelli et al., 2021; Warner & Wäger, 2019). Consequently, these authors maintain that digital capabilities are aligned with the concept of dynamic capabilities because they achieve competitive advantage by increasing the ability to manage resources and processes during complex times.

In this new world, digital capabilities extend across various nomenclatures (Queiroz et al., 2019). In this article, the evaluation will focus on three capabilities aligned with the context of dynamic capabilities: connectivity, transparency, and continuity (F. Zhang et al., 2020), in details: First, connectivity will be assessed as a mechanism for verifying, confronting, and reconciling data between involved parties, without duplicating errors, aiming for greater efficiency in resource use. Next, transparency is addressed in the supply chain context, seeking to predict the need for interference with greater efficiency, resilience, and sustainability in the process. This involves online data monitoring and real-time responses to enable greater responsiveness to events. Finally, the continuity approach outlines mechanisms to mitigate the risk of supply disruption, either through product and service traceability issues or via resource-sharing platforms.

These capabilities aim to offer mechanisms for operational improvement as well as environmental and social sustainability, given the potential for reducing waste and losses due to obsolescence, but also for the correct use of resources and transparency throughout the supply chain.

A bibliometric review was conducted with the objective of broadening the discussion on the logistics function and the emerging technologies that enable new strategies. In this regard, the research protocol, coding, and data collection parameters are outlined below.

3 METHODOLOGY

To ensure a rigorous, transparent, and replicable research roadmap, we present the parameters from Tranfield et al. (2003), which advocate the following stages: planning the review, execution, and finally, evidence and recommendations for future studies.

3.1 Methods

First at all, during two weeks, it was realized the review of articles about the subject and besides a brainstorming process among three researchers. After that, a list of keywords was identified to carry out a systematic search and find articles regarding the issues of strategy, logistics and technology. It was assessed that the main concepts were being discussed isolated and it is necessary to discuss the holistic perspective of a study area that is rapidly expanding.

Durach et al. (2017) outline the demerits in conducting a bibliometric review that should be avoided: choosing journals without a peer-review board, selecting irrelevant articles, coding methods with variability, and subjectively synthesizing the works.

In this scenario, the following mechanisms were adopted to mitigate this bias: selecting articles and journals based on their QUALIS/CNPq index or impact factor for international journals, as well as recognizing the editorial policies of the journals. Thus, databases focused on congresses, conferences, and the field of arts were excluded.

Next, categories related to sustainability, operations, and administration were selected, specifically: Environmental Studies; Environmental Sciences; Green Sustainable Science Technology; Business; Management; Operations Research Management; and Transportation.

The authors also established a coding method aligned with the research objectives. These coding criteria were adopted only after a preliminary reading of manuscripts that highlighted the gaps and keywords related to the theme.

Finally, the reading of specific article sections—title, abstract, keywords, and introduction—was performed to reduce subjectivity. If article access was limited, it was discarded. The team consisted of two researchers experienced in the subject.

For the last stage, concerning academic and empirical contributions in the research field, the following protocol is revealed: Firstly, the analysis of networks regarding author citations, works, institutions, and keywords, using VOSviewer, seeks to highlight influence parameters; expose monologic networks; understand research exchange patterns (researchers and research institutions); recognize gaps; and propose directions for future research (Mukherjee et al., 2022; Zupic & Čater, 2015).

Likewise, through VOSviewer, it is possible realized the mapping research, that assess the network, the position of the authors from others – centralized or not (Zupic & Čater, 2015). Through VOSviewer, it is possible to visualize the relationships in the production network. In this visualization, items are indicated by a label - a circle. The more important an item is, the larger its label and circle will be. Each group has a color assigned to the items (Van Eck, Waltman, 2010).

Thus, through these data, the general laws of bibliometrics will be highlighted – Lotka's Law and Zipf's Law. The first emphasizes that only a small number of authors are prolific on the topic, while approximately 60% of authors have only a single contribution. Additionally, Zipf's Law states that a small sample of keywords has a large representativeness in the topic (Damar & Koksalmis, 2024).

Practical contributions are understood as the evaluation of experiences regarding the implementation of emerging technologies in the logistics process through a cost-benefit analysis, reporting on the following indicators: productivity, efficiency, implementation costs, cybersecurity costs related to data and information sharing, as well as the main emerging technologies aligned with the theme.

The next topic will present the procedure for data collection and analysis through coding roadmap for articles based on the most cited database.

3.2 Procedure for data analysis

We used alphanumeric codes to classify articles for subsequent quantitative data analysis, following established bibliometric review standards (Mukherjee et al., 2022). The category descriptions are an adaptation of the proposals by Huang et al. (2023) and Leitão et al. (2024), presented in Table 1, for future quantification and analysis.

In this context, six criteria were established: the research's country of origin, the barriers to implementing emerging technologies, the reasons for adopting new technologies, the research methods used, the manuscript's assessment against dynamic capabilities, and finally, the main technologies addressed in the study.

Table 1: Categorization and respective research codes

Criterion	Description	Code
Research origin country	Developed	1A
	In developing country	1B
	Not applicable	1C
Barriers to implementation	Lack of supply chain integration	2A
	Lack of scalability	2B
	Limited financial resources for investment	2C
	Does not explicitly address	2D
Reason for Industry 4.0 implementation	Coercive factors	3A
	Normative factors	3B
	Quest for improved operational efficiency and service level (mimetic)	3C
	Does not emphasize	3D
Analysis in the research methodology analyzed	Qualitative	4A
	Quantitative	4B
	Triangulation	4C
	Bibliometric	4D
	Simulation/Modeling	4E
Linked or not to dynamic capabilities theory	Yes	5A
	No	5B
Industry 4.0 technologies addressed	Internet of things	6A
	Artificial Intelligence	6B
	Blockchain	6C
	Big data	6D
	Cloud computing	6E
	Industry 4.0, in general	6F

Source: Adapted from Leitão et al. (2024) for the bibliometric research (2025).

Based on the analysis of Table 1, the analysis criteria aim to elucidate the research objectives through the bibliometric review: (i) Which authors and works were most cited in this context? (ii) What are the dominant keywords regarding technologies applied to the strategic operation of the logistics function? (iii) What are the barriers and opportunities for future technologies in logistics operations? (iv) How is the evaluation of dynamic capabilities carried out in the context of the obtained sample?

3.3 Procedure for data collection

The research was conducted on February 19, 2025, using the keywords: Strateg*; Industry 5.0; Industry 4.0; and Logistic* with the Boolean operators <and>, <or>, and <and> to clarify the research objectives. The asterisk symbol "*" following the key-words aims to expand the search scope within the sample. Table 2 details the research protocol.

Table 2: Bibliometric research protocol

Variables	Descrição
Key-words	Strateg*; Industry 5.0; Industry 4.0; Logistic*
Boolean operators	<and>; <or>; <and>
Web of Sciences (WOS) Categories	Environmental studies; Environmental Sciences; Green Sustainable Science Technology; Business; Management; Operations Research Management
Selection criteria	Open access
Language	English
Document types	Articles, Review articles
Years of publication	2016 to 2025

Research source: https://www.webofscience.com/wos/woscc/summary/4c38f465-33e2-4ca6-9938-791a73f68b0c-01497ed892/relevance/1

To provide greater support for the results obtained in the bibliometric research, only databases within the Web of Science were used: Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI), and Emerging Sources Citation Index (ESCI), with the following research protocol, summarized in Table 3:

Table 3: Results by categorization in WOS

Variables	Number of articles after filter
Keywords ('Strateg*') AND ('Industry 5.0 OR Industry 5.0'); AND ('Logistic*)	275
Selection criteria for Open Access	163
Years of publication from 2016 to 2025	163
Document types Articles, Review Articles	161
Language English	160
Web of Sciences (WOS) Categories Environmental studies; Environmental Sciences; Green Sustainable Science Technology; Business; Management; Operations Research Management; Transportation	78

Research source: https://www.webofscience.com/wos/woscc/summary/4c38f465-33e2-4ca6-9938-791a73f68b0c-01497ed892/relevance/1

Given this, the search returned 78 results, all of which were fully utilized for analysis in VOSviewer software (version 1.6.16) to consolidate the research, with no exclusions. However, for the quantitative analysis, the following files were removed: first, those identified as bibliographic reviews (classified as "review" in Web of Science); second, manuscripts evaluated as bibliographic and bibliometric reviews through reading; and finally, files with restricted access. This resulted in a final count of 61 articles. This activity was carried out from March to April 2025, with three weekly meetings for discussion and alignment of progress.

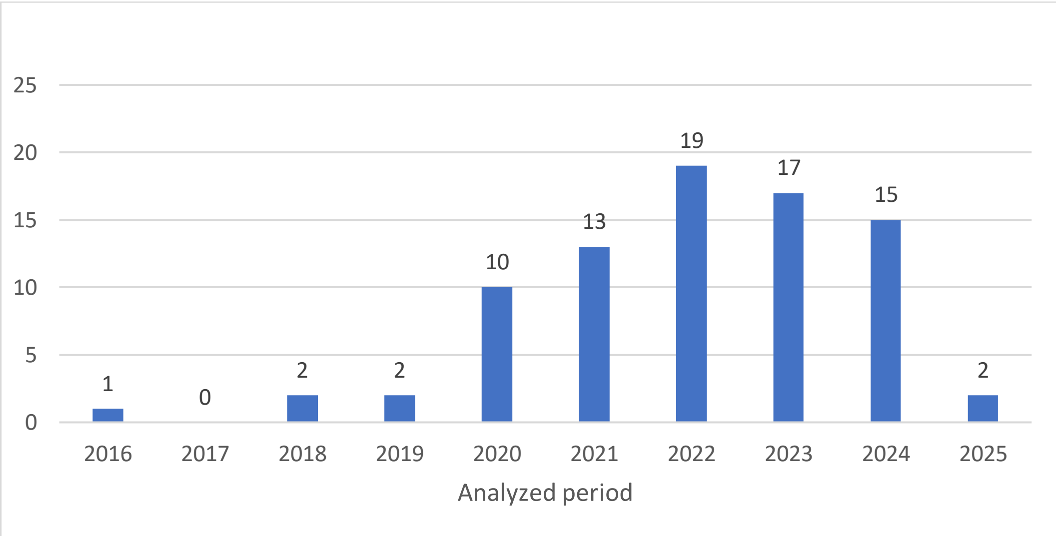
In this context, the key points evaluated in these articles were the potential for the logistics function to be used as a strategic function and an assessment of which technological tools can help logistics fulfill this role.

4 PRESENTATION OF RESULTS

4.1 Descriptive Statistics of Publications per Year

To describe the evolution of publications over the analyzed period (2016 to 2025), here's a breakdown of publications per year within that timeframe.

Figure 1: Evolution of article publications over the period



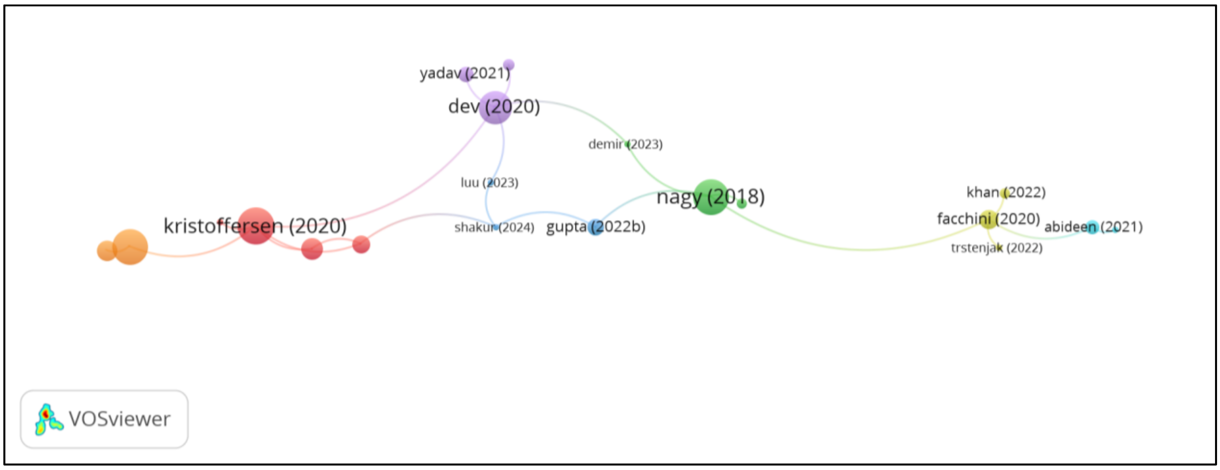
Source: VOSviewer research (2025).

It's evident that publications grew significantly from 2020, peaking in 2022. The decline observed from 2023 onwards underscores the need for better process integration, improved user and employee interfaces, and stronger alignment with consumer market demands regarding the benefits of technology. The advancements in the internet and technological resources during this period have provided numerous contributions to the field of business strategy and logistics.

4.2 Regarding the Most Cited Articles

The most cited articles in this bibliometric review account for nearly three thousand citations. To analyze this, a VOSviewer filter was applied using the following criteria: documents with a minimum of 5 citations within the analysis period, resulting in 54 authors, as shown in Figure 2.

Figure 2: Research mapping of most cited articles



Source: VOSviewer (2025).

Analyzing the clusters generated by VOSviewer, seven clusters were obtained. The paper by Dev et al. (2020) appears centrally and prominently, with five links and 285 citations. Also notable is the text by Kristoffersen et al. (2020), which accounts for the highest number of citations, five links, and occupies the left lateral portion of the mapping. Table 1 displays, in descending order of citations, the publication type (article or review), the number of links the article presents, the percentage indicating the article's relevance to the sample, and finally, the cumulative percentage.

Table 1: Descriptive statistics on main works

Id	Documents	Citations	Publication type	links	Percentage	Cumulative percentage
1	Kristoffersen et al. (2020)	340	Article	5	11%	11%
2	Bressanelli et al. (2018)	329	Article	2	11%	22%
3	Nagy et al. (2018)	318	Article	4	11%	33%
4	Dev et al. (2020)	287	Article	5	10%	43%
5	Lohmer et al. (2020)	238	Article	0	8%	51%
6	Ciliberto et al. (2021)	118	Article	2	4%	55%
7	Jinru et al. (2022)	112	Article	1	4%	58%
8	Facchini et al. (2020)	99	Article	4	3%	62%
9	Awan et al. (2022)	86	Review	3	3%	64%
10	Preindl et al. (2020)	84	Article	1	3%	67%
11	Godina et al. (2020)	72	Article	0	2%	70%
12	H. Gupta et al. (2022)	72	Article	2	2%	72%
13	Farooq et al. (2021)	68	Review	0	2%	74%
14	G. Zhang et al. (2023)	67	Review	1	2%	77%
15	Others	700				23%
	Total	2.990				100%

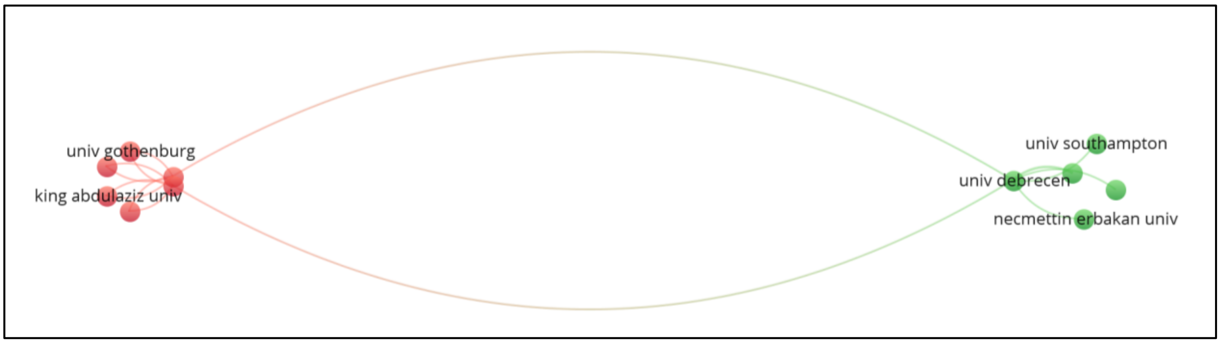
Source: VOSviewer research (2025).

Therefore, from the 14 main authors presented in Table 1 on the topic, it's inferred that for every five publications involving the strategic evaluation of the logistics function through digital technologies, four documents reference this list, supporting the importance of these manuscripts in the studied context. Also, through Table 1, it illustrates Lotka's Law, which states that a small percentage of publications (2%) produce the majority of articles (77% of citations).

4.3 Regarding Research Institutions

A total of 181 research institutions were cited in the bibliometric review. However, applying the filter criteria of a minimum of 2 documents per institution and 2 citations per article, only 13 institutions are reflected, as shown in the VOSviewer filter. Figure 3 illustrates this mapping research.

Figure 3: Research mapping of main research institutions



Source: VOSviewer research (2025).

Analyzing the data with VOSviewer, two distinct clusters were obtained. The prominent institutions acting as interfaces are Poznan University from Poland, located on the left side, and the University of Debrecen on the right side. Following this, Table 2 provides the descriptive statistics for this context.

Table 2: Main research institutions on the topic

id	Organization	Country	Citations	Total Link Strength	Percentage	Cumulative Percentage
1	University of Debrecen	Hungary	348	7	37%	37%
2	Poznan University Tech	Poland	103	5	11%	48%
3	Univ Johannesburg	South Africa	102	2	11%	59%
4	Polytech University Bari	Italy	99	5	11%	70%
5	University of Southampton	Great Britain	76	1	8%	78%
	Other organizations		208		22%	100%
	Total		936		100%	

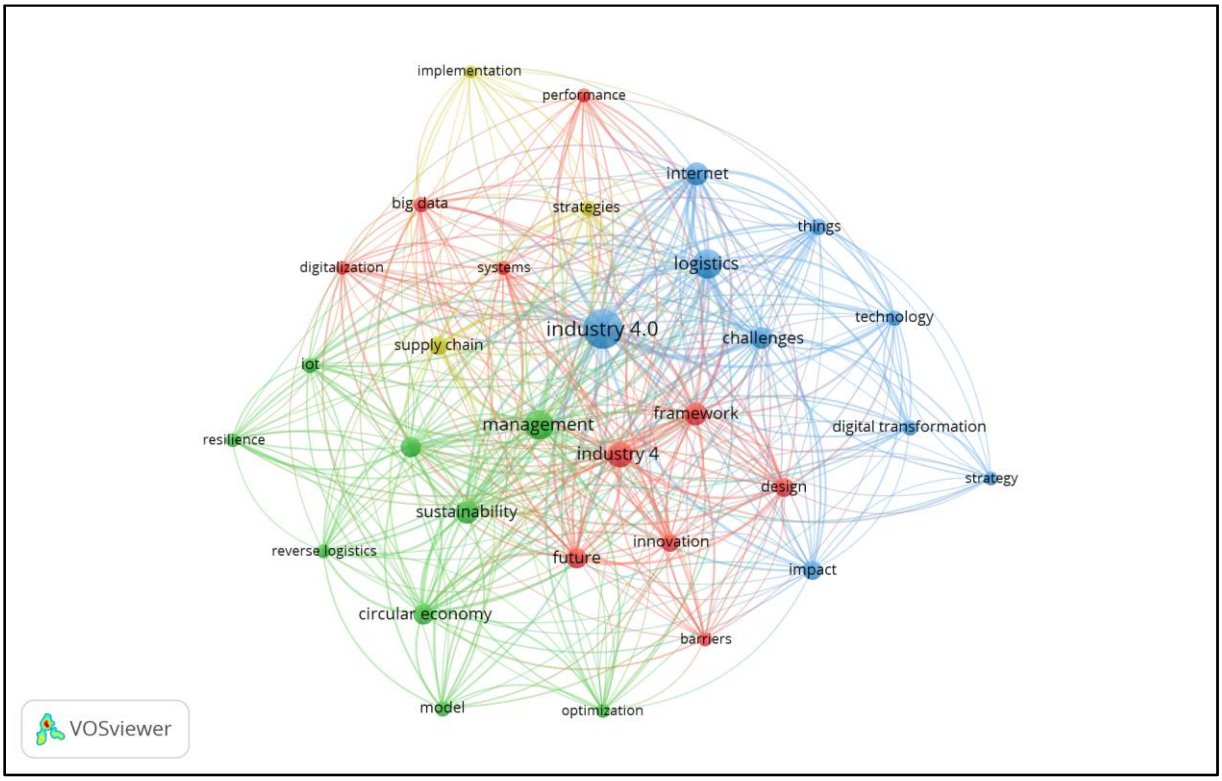
Source: VOSviewer research (2025).

From Table 2, it's clear that the top five institutions account for 80% of the publications on this topic.

4.4 Regarding Keywords

Analyzing the main keywords on the topic, and filtering by "All Keywords" with a minimum of five citations, 31 keywords were selected from the 477 used. Figure 4 displays the resulting clusters.

Figure 1: main key-words



Source: VOSviewer research (2025).

In Figure 4, four clusters are presented: the first features "industry 4.0" as the most relevant word, referencing the use of technology for process, product, and service innovation. Next, the second cluster highlights "Sustainability," emphasizing the importance of reverse logistics for operationalizing issues related to the circular economy. The third cluster, centered on "logistics," relates to the challenges of logistical processes in this digital transformation and in meeting organizational strategy. Finally, the last cluster aims to expose the interface of the supply chain and strategy with digitalization activities and system integration. From Figure 4, it can be inferred that it illustrates Zipf's Law, which states that the frequency of a word is inversely proportional to its position in a frequency list. Thus, we have ten keywords (with only 2% co-occurrence) that produce more than 50% keyword co-occurrence.

Regarding the temporal aspect, it's notable that more recent articles aim to present modeling or simulation environments to better evaluate the barriers to technology implementation in logistics processes.

4.5 Discussion of Sample Articles

To discuss the main cited articles, the categorization based on the criteria established in Table 1 is presented. This section will detail the evidence found in each article and, finally, the frequency of the evaluated criterion within the sample. For this purpose, the following categories were used:

- Country of Origin: exposes the analyzed context in the studies, denoted as 1A for "developed country(ies)," 1B for "developing country(ies)," and 1C for "not declared."
- Barriers to Implementation: established as 2A for "Lack of supply chain integration"; 2B for "Lack of scalability"; 2C for "Limited financial resources for investments"; and finally, 2D for "Not explicitly addressed."
- Reason for Industry 4.0 Implementation: focuses on the criteria of institutional theory, with 3A for "Coercive factors"; 3B for "Normative factors"; 3C for "Search for operational efficiency and service level improvement (mimetic)"; and finally, 3D for "Does not emphasize any criterion."
- Analysis in the Research Methodology: 4A for "Qualitative Research"; 4B for "Quantitative Research"; 4C for "Triangulation" research; 4D for "Bibliometry"; and finally, "Simulation and Modeling" for 4E.
- Link to Dynamic Capabilities (D.C.) Theory: 5A for “Yes” and 5B for “No”.
- Industry 4.0 Technologies Addressed: the following digital technologies were listed: 6A for "Internet of Things - IoT"; 6B for "Artificial Intelligence"; 6C for "Blockchain"; 6D for "Big Data Analytics"; 6E for "Cloud Computing"; and 6F for "Industry 4.0 Technologies in general."

This categorization aims for future replicability of the research. Thus, Table 4 contains the following columns with criteria: the evaluation of new trends regarding implementation barriers, the reasons for implementation, the most frequently used methodologies, the mechanisms for assessing resources as competitive advantages, and finally, the most used digital technologies. The last row presents the sum of the frequency of criterion evaluation per article. (see the DOI reference of al 78 articles in the Appendix I).

Table 4: Quantitative summary of article categorization

ref	Country of origin			Barriers to implementation				Reason for Industry 4.0 implementation				Analysis in the research methodology analyzed					D.C.		Industry 4.0 technologies addressed					
1	1A			2A		2C		3A	3B					4C		4E	5A		6A			6D		6F
2	1A			2A		2C		3A		3C				4C		4E		5B	6A			6D		6F
3		1B		2A	2B	2C				3C				4C	4D		5A		6A					6F
4		1B				2C		3A		3C						4E	5A						6E	6F
5	1A			2A				3A		3C						4E	5A				6C			6F
6	1A			2A				3A	3B			4A						5B						6F
7		1B					2D	3A	3B					4C				5B						6F
8	1A			2A						3C				4C		4E	5A		6A			6D		6F
10	1A						2D			3C						4E		5B	6A					6F
11	1A				2B			3A	3B							4E		5B						6F
12		1B				2C					3D		4B				6A		6A	6B	6C	6E		6F
15		1B		2A	2B			3A	3B	3C						4E	5A		6A		6C	6D	6E	
16		1B		2A		2C		3A		3C				4C			5A		6A	6B		6D	6E	6F
17		1B		2A						3C					4D			5B	6A	6B		6D		6F
18		1B				2C		3A		3C				4C				5B	6A	6B	6C		6E	6F
19	1A						2D				3D		4B					5B						6F
20		1B					2D			3C						4E		5B						
21		1B				2C		3A		3C							5A							6F
22		1B		2A		2C		3A		3C				4C				5B						6F
23	1A						2D			3C					4D			5B		6B				6F
24		1B				2C				3C		4A						5B		6B				
26	1A			2A	2B				3B	3C					4D			5B						6F
27	1A					2C				3C		4A					5A		6A		6C			6F
28		1B				2C				3C			4B					5B	6A			6D	6E	
29	1A				2B					3C			4B					5B	6A	6B	6C	6D	6E	
30		1B		2A		2C				3C				4C				5B	6A	6B			6E	6F
33		1B					2D			3C				4C				5B	6A	6B	6C			6F
34	1A			2A				3A								4E	5A					6D		6F
37		1B		2A				3A	3B						4D			5B			6C			6F
38	1A					2C				3C			4B				5A		6A			6D	6E	6F
39		1B					2D	3A		3C						4E		5B						6F

ref	Country of origin			Barriers to implementation				Reason for Industry 4.0 implementation				Analysis in the research methodology analyzed					D.C.		Industry 4.0 technologies addressed					
40	1A					2C				3C					4D			5B	6A	6B		6D	6E	6F
41		1B				2C				3C				4C			5A		6A					6F
42	1A						2D			3C						4E	5A		6A			6D	6E	6F
43			1C				2D		3B						4D		5A		6A			6D	6E	6F
44		1B					2D	3A							4C			5B						6F
45	1A						2D			3C		4A					5A				6C			6F
46		1B					2D			3C			4B				5A							6F
47		1B				2C		3A		3C				4C			5A							6F
48			1C			2C		3A		3C					4D			5B						6F
49		1B				2C				3C						4E	5A							6F
50		1B			2B	2C		3A		3C				4C			5A							6F
51	1A						2D				3D			4C				5B						6F
52	1A						2D			3C				4C				5B						6F
55		1B		2A					3B					4C				5B	6A					
56		1B				2C				3C					4D			5B	6A			6D		6F
57			1C		2B	2C			3B					4C			5A							6F
59	1A						2D			3C					4D			5B		6B		6D		6F
60	1A						2D				3D					4E			6A	6B		6D	6E	6F
61			1C				2D				3D					4E		5B						
64			1C		2B						3D					4E		5B						
65		1B				2C				3C								5B						
66		1B				2C			3B			4A					5A							6F
67			1C				2D				3D					4E		5B	6A					
70		1B		2A				3A	3B	3C		4A					5A							6F
71		1B		2A	2B	2C		3A		3C		4A					5A							6F
73			1C				2D			3C						4E		5B						6F
75	1A	1B				2C				3C			4B				5A							6F
76			1C		2B					3C						4E		5B	6A					
77			1C			2C				3C						4E		5B						6F
78		1B				2C				3C			4B					5B						6F
sum	22	31	11	17	10	28	19	21	12	43	7	7	8	17	10	20	24	35	25	12	9	16	12	50

Source: Bibliometric research (2025)

As per the descriptive statistics presented in Table 4, regarding the evidence found in the respective articles, the following analyses are observed. The objective is to expose not only the criteria but also the frontiers for new studies on the topic:

Country of Origin: It is evident that studies are focused on the context of developing countries. Within this environment, India and China stand out as research hubs for digital technologies applied to the logistics function.

Barriers to Implementation: The relevance of "available financial resources for investments" is demonstrated, highlighting the need to quantify the financial benefits of new technologies by seeking financially viable business models. Furthermore, concerning the "lack of supply chain integration" to leverage the use of new digital technologies, this translates into actions for standardization and mitigating distrust among supply chain agents for sharing and cooperation in organizational processes.

Factors for Industry 4.0 Implementation: The need to reduce risks associated with pioneering new technologies is highlighted, seeking mechanisms for improving operational performance and copying from other supply chain participants. The low impact of normative factors (legislation) as a catalyst for new digital technologies is also declared.

Research Methodology: Emphasis is placed on mathematical models that aim to evaluate scenarios using digital technologies. Simultaneously, methods with data triangulation are noted for providing greater breadth in data analysis.

Link to Dynamic Capabilities (DC) Theory: Greater evidence is found for articles that do not support the resource-based view theory, exposing the practical bias of the operations area. In this sense, the evaluation of mechanisms for organizing, updating, and improving resources to meet new standards can be utilized.

Industry 4.0 Technologies Addressed: A higher frequency of studies on digital technologies in a broad sense was listed. Particularly, the topics "Internet of Things - IoT," followed by "big data analytics," are also explored more broadly, assessing the proximity of digital technology application. Simultaneously, gaps for future research regarding other technologies are exposed.

4.6 Evaluation of the Association Between Variables

Considering the Chi-square test, which aims to compare the frequency of observed versus expected events in independent variables, research hypotheses are presented regarding the development of research conducted in developed and developing countries (Assis et al., 2020). In this sense, three analyses were performed: focusing on the evaluation of dynamic capabilities, normative factors, and coercive factors, using JAMOVI software, version 2.6.26.0.

For the correlation analysis, articles classified as belonging to category 1C, i.e., those in which the country where the empirical study was conducted was not explicitly identified, were excluded. This decision aims to ensure greater methodological cohesion and consistency, as the central objective of the analysis is to investigate whether the country's development level (developed or developing) significantly influences the categories of coercive factors, dynamic capabilities, and normative factors.

4.6.1 Regarding the Evaluation of Context versus Dynamic Capabilities

The implementation of dynamic capabilities aims to evaluate learning mechanisms and the reorganization of routines to meet the new digital world (Teece, 2007). In this sense, the research hypotheses are, under p-value < 0.05:

H_0 = There is no association between the variables.

H_1 = There is an association between the variables.

Based on the data, the observed frequencies are presented in Table 3:

Table 3: Contingency Table between the studied context and dynamic capabilities assessment

	Dynamic capabilities assessment		
Study in...	yes	no	Total
Developed countries	9	13	22
Developing countries	14	16	30
Total	25	29	52

Source: Data analysis by JAMOVI – version 2.6.26.0.

Next, we have the statistical significance analysis of the Chi-square test:

Table 4: Chi-Square Tests (χ^2)

	Value	df	P
χ^2	0,171	1	0,680
N	52		

Source: Data analysis by JAMOVI – version 2.6.26.0.

Considering the Chi-Square test values, with a p-value of 0.680 > 0.05, we can infer that "there is insufficient evidence to affirm an association between the variables." Therefore, studies conducted in both developed and developing countries are not associated with the evaluation of dynamic capabilities for implementing Industry 4.0 technologies.

The acceptance of the null hypothesis (H_0) indicates the absence of a statistically significant association between a country's development level and the adoption of the theoretical approach of dynamic capabilities. Thus, it's concluded that the application of this conceptual perspective is not conditioned by the economic context in which the research is situated.

Delving deeper into the analysis, it is observed that 48.08% of the studies directly or indirectly incorporated dynamic capabilities theory into their discussions. This finding reveals a significant trend in the analyzed database: while there's a strong presence of technological themes—such as data analytics, automation, and implementation strategies—there's also a rigorous development focused on the dynamic capabilities of employees. Thus, the studies reflect a more balanced approach between advancements in machinery and the valuing of human capital within the context of Industry 4.0.

4.6.2 Contingency Table: Evaluation of the Studied Context Versus Normative Factors

Organizations implement Industry 4.0 technologies to address issues of operational performance in the logistics function, monitor product losses, enable the evaluation of environmental impacts related to disposal, assess inventories, and facilitate reverse logistics for reuse, as well as traceability mechanisms throughout the supply chain, such as diagnosing registered suppliers.

Thus, we evaluate whether legislation is preponderant for organizations to manifest the implementation of these new technologies for logistics strategy. The research hypotheses, under p-value < 0.05, for the following scenario are:

H_0 = There is no association between the variables.

H_1 = There is an association between the variables.

Table 5: Contingency table between the studied context and the importance of normative factors

	NORMATIVE FACTORS		
Study in...	Yes	No	Total
Developed countries	4	18	22
Developing countries	6	24	30
Total	10	42	52

Source: Data analysis by JAMOVI – version 2.6.26.0.

Following is the statistical significance analysis of the Chi-square test:

Table 1: test χ^2

	Value	df	P
χ^2	0.027	1	0.869
N	52		

Source: Data analysis by JAMOVI – version 2.6.26.0

Based on the Chi-Square test's p-value of 0.869 > 0.05, there's insufficient evidence to state an association between the variables. This means that in both developed and developing countries, legislation isn't a primary driver for logistics strategies when implementing Industry 4.0.

Normative factors didn't provide enough statistical evidence to reject the null hypothesis (H0), indicating no association between the studied context and the relevance attributed to these factors. Based on the absolute frequency—four mentions in developed countries, six in developing countries, and only two in studies without contextual evaluation—it's clear that the normative factor, understood as the influence of legislation and regulations from the state or institutional legal environment, has little impact on the implementation of technologies associated with Industry 4.0.

This result suggests that, regardless of a country's development level, the legal framework isn't a central element in academic discussions or studied cases regarding Industry 4.0 adoption strategies.

4.6.3 Contingency Table: Evaluating Context Versus Coercive Factors

Following the assessment of Industry 4.0 technologies, this criterion evaluates technology implementation under the influence of coercive factors. The literature discusses the role of contracts throughout the supply chain, as well as the economic power within the supply chain, in establishing data and information flow standards between suppliers and customers. So, the research hypotheses, with p-value < 0.05, for the following scenario are:

H_0 = There is no association between the variables.

H_1 = There is an association between the variables.

Table 7: Assessment of context versus the importance of coercive factors

Study in...	COERCIVE FACTORS		
	Yes	No	Total
Developed countries	6	16	22
Developing countries	14	16	30
Total	20	32	52

Source: Data analysis by JAMOVI – version 2.6.26.0.

Tabela 2: test χ^2

	Value	df	p
χ^2	2.02	1	0,156
N	52		

Source: Data analysis by JAMOVI – version 2.6.26.0

The Chi-square test's p-value of 0.156 > 0.05 indicates that there is insufficient statistical evidence to affirm an association between the variables. Therefore, in both developed and developing countries, coercive factors do not show a differentiated prevalence regarding logistics strategies for the implementation of Industry 4.0. Furthermore, even if the observed frequency is numerically higher in developing countries, this difference is not statistically significant.

The statistical analysis of coercive factors—defined as external pressures originating from the supply chain and resource scarcity—did not lead to the rejection of the null hypothesis (H_0). As such, no significant association is found between the studied context and the presence of these factors in the Industry 4.0 implementation process.

The analyzed data does not allow for the conclusion that coercive factors are more recurrent in developing countries, nor that there is a direct relationship between the level of industrial maturity and the intensity of these pressures. Thus, pressures such as input scarcity, supplier dependence, and logistical limitations can occur in different economic contexts, regardless of the country's development level.

4.6.4 Discussion on Dynamic Capabilities and Industry 5.0

The discussion on theories and interface mechanisms between resource development and digital technologies occurs partially across the sample. That is, only 40% address the evaluation of mechanisms for improving practices or logistical manifestations. In this sense, the content validity of the constructs of connectivity, visibility, and continuity was conducted using observable items. Thus, these endogenous variables are characterized in the texts by expressions defined by Zhang et al. (2020) and Huang et al. (2023).

Recent literature demonstrates that the development of dynamic capabilities is an indispensable condition for companies to keep pace with the transformations promoted by emerging technologies, especially in the logistics and supply chain context (Hsu et al., 2024). Authors from different countries and sectors explore, from multiple perspectives, how these capabilities—connectivity, visibility, and continuity—are formed, articulated, and applied in increasingly digital and sustainable business environments.

Connectivity is widely recognized as an essential pillar. According to Domingos et al. (2024), digital technologies should be evaluated as integrated systems that promote a more resilient supply chain, as they enable information sharing and visibility of upstream and downstream actions, without the need to expand inventories or assets. This perspective is broadened by Sindakis, Showkat and Su (2023) who, supported by the Resource Dependency Theory (RDT), emphasize that collaboration, integration, and coordination among supply chain agents are indispensable, especially in e-commerce and sustainability contexts. Brookbanks and Parry (2024) also point out that connectivity provides informational fluidity and reduces redundancies, being enabled by technologies such as blockchain and IoT. In this context, authors such as Kristoffersen et al. (2020), Nagy et al. (2018), and Facchini et al. (2020) demonstrated that interoperability and integrated automation not only increase efficiency but establish continuous digital links between systems, suppliers, and customers. Connectivity also takes on a strategic dimension in the studies of Ali et al. (2024), who associate it with the seizing capability of dynamic capabilities described by Teece (2007), based on RBV and NRBV—that is, it is not enough to connect, it is necessary to actively mobilize these resources for sustainable innovation.

Regarding the dynamic capability of visibility, various approaches highlight the relevance of using real-time data to increase predictive capacity and operational efficiency. Nagy et al. (2018) and Kristoffersen et al. (2020) converge in demonstrating that data collection by smart sensors, the use of big data, and the automation of production processes generate accuracy and speed in organizational response. Mvubu; Naude (2024), through the Diffusion of Innovation Theory (DIT) and the Technology, Organization and Environmental theory (OET), reinforce that the adoption of these technologies must be aligned with market analysis, demand forecasting, and continuous improvement of customer experience, emphasizing the strategic role of visibility as a competitive differentiator.

Visibility also gains strategic contours in the studies of Lohmer et al. (2020), who highlight the role of blockchain for end-to-end traceability and risk assessment. In another field, authors such as Ali et al. (2024) articulate visibility with the sensing capability, that is, the detection and interpretation of environmental signals—an essential competence for anticipating changes and aligning logistics performance with market expectations. Awan et al. (2022) and Yadav et al. (2020) complement this view by pointing out that demand forecasting, enabled by sensors and digital platforms, allows aligning production, logistics, and customer service with a high degree of adaptability.

The dimension of continuity is addressed in direct connection with sustainable and long-term practices. Dev et al (2020) and Awan et al. (2022) highlight the role of digital technologies in reverse logistics systems and their relationship with the circular economy, pointing out that additive manufacturing and emission reduction are clear evidence of an organizational capability focused on continuity. Lohmer et al (2020) show how the use of blockchain strengthens supply chain resilience by ensuring traceability and operational continuity, although they warn of the need for a solid collaborative base for these benefits to materialize. Awan et al. (2022) and Yadav et al (2021), in turn, reinforce that practices such as material reuse and industrial symbiosis are enabled by these capabilities, promoting both economic efficiency and environmental sustainability.

In studies such as that of Gupta et al. (2022), continuity is linked to organizational resilience, especially in unstable or low digital maturity contexts, being reinforced by capacity-building policies and institutional support. In the theoretical field, Ali et al. (2024) relate continuity to the reconfiguring capability, that is, the ability to restructure processes and practices to ensure alignment with ESG indicators and the new parameters of the global market. Pishdar et al. (2021) and Henríquez et al. (2022) complement this understanding by showing that sustainability—in its environmental, social, and governance aspects—is essential to ensure the longevity and legitimacy of logistical operations in international and port contexts. Even authors who analyze less digitally mature environments, such as Richnák (2022) and Rakyta et al. (2022), indicate that continuity tends to be the most fragile capability, given the absence of structure, funding, and long-term vision in many companies, especially small ones.

Following the advent of Industry 5.0, it is inferred that these digital capabilities are necessary but not sufficient to reach this new stage, especially in emerging and developing sectors, as they demand strategic decision-making, culture and governance change, valuing of human beings by companies, sustainable practices, and also the formulation of public policies. Therefore, the following stages are considered:

Stage 1: Consolidation of Industry 4.0: This should occur through the digitalization of logistics processes using IoT, RFID, WMS, and TMS technologies. Regarding digital capabilities, resource development will continue until digital maturity levels are reached (Facchini et al., 2020; Zhang et al., 2020).

Stage 2: Strategic Integration. In this stage, alignment occurs between departmental objectives and business objectives. At this point, the establishment of ESG indicators, the creation of innovation, disruption, and sustainability KPIs, and the integration of internal and external data take place (Ali et al., 2024; Demir et al., 2023).

Stage 3: Adoption of New Industry 5.0 Capabilities. This stage considers the human-centric approach, essential in Industry 5.0 (Trstenjak et al., 2022). To this end, organizational and cultural programs for a continuous improvement mindset are consolidated. Pimsakul et al. (2021) point out that system integration and technological infrastructure are the main pillars for digital advancement to directly drive the formation of dynamic capabilities. In this vein, Logistics emerges as an element focused on green logistics activities, circularity, and social responsibility.

Stage 4: Culture and Governance. Richnák (2022) broadens the debate by examining the digital maturity of logistics companies in relation to Industry 4.0 technologies. In this panorama, visibility is highlighted as fundamental in response to crises. Connectivity presents itself as a link between systems, people, and processes, and continuity is reflected in the ability to maintain operations even in the face of extreme events. To overcome these challenges, the development of digital leadership, new management models such as open innovation, logistics labs, and an organizational structure with a horizontal vision are crucial.

Stage 5: Intelligent Ecosystem. Use and analysis of resilient and self-adjusting logistics networks. The integration of distribution channels to reduce costs, risks, and delivery times through digital capabilities. Examples include collaborative models based on blockchain and smart contracts (Henríquez et al., 2022 and Sindakis, Showkat & Su, 2023).

5 CONCLUSION

The present research aimed to fill the gap in the literature regarding Industry 4.0 in the logistics function, by mapping and comparing academic discussions on the implementation of these technologies in different contexts.

Accordingly, concerning academic contributions, the main authors and most cited works in this context are presented, also exposing the strength of their connections. Furthermore, it identified the main research institutions on the topic and subsequently, the dominant keywords related to the analyzed context. To this end, it followed the research protocol by Tranfield; Denyer; Smart (2003) and analyzed publications between 2016 and 2025 in databases linked to the Web of Science, with contributions following Mukherjee et al. (2022).

In this sense, the discussion is also supported by the bibliometric laws and by social network analysis elements identified in the previous mappings. Lotka's Law helps explain the concentration of influence around a limited group of authors and articles; Zipf's Law reinforces the concentration of the field around a small set of recurrent keywords; and Bradford's Law may be used as a complementary alert for future refinement of source dispersion, since the present analysis did not organize the sample by journal zones. From the perspective of social network analysis, nodes, links, clusters, and total link strength indicate not only quantitative volume, but also the position of authors, works, and institutions as interfaces for knowledge diffusion in the field.

The theoretical contribution of the research, therefore, lies in organizing the interface between digital capabilities, logistics strategy, and Industry 4.0 through a sociobibliometric lens, articulating bibliometric indicators with social network elements such as clusters, links, and centrality. The practical contribution lies in indicating to managers that the adoption of digital technologies in logistics should be evaluated not only by technological availability, but also by integration capacity, financial feasibility, workforce training, and continuity of operations.

As an academic contribution, the results demonstrate that the number of studies on Industry 4.0 grew significantly from 2020, peaking in 2022, and showed a slight decline in subsequent years. Additionally, the bibliometric analysis identified the main authors and influential articles in the field, with emphasis on the works of Dev et al. (2020) and Kristoffersen et al. (2020), which recorded the highest numbers of citations.

According to the mapping research, challenges for the adoption of Industry 4.0 in logistics stand out, including the need for process integration, workforce training, and adaptation to changes in the consumer market. Thus, studies indicate that strengthening dynamic capabilities requires more than just technology: it demands strategy, collaboration, and a systemic vision.

Organizations that manage to integrate connectivity, visibility, and continuity harmoniously tend not only to survive in disruptive contexts but also to lead transformations with agility, responsibility, and innovation. In this sense, it is inferred that connectivity appears as a technical prerequisite; visibility, as a monitoring criterion; and continuity, as a strategic objective that materializes in social and environmental responsibility practices. Similarly, the Industry 5.0 model, proposed by Trstenjak et al. (2022), reinforces that organizational success depends on the coordinated integration among systems, people, and strategies—exactly what dynamic capabilities aim to structure.

Regarding the organizational theories that emerge related to the topic of Industry 4.0, prominent ones include TOE (Technology, Organization and Environmental), DIT (Diffusion of Innovation Theory), RDT (Resource Dependency Theory), and RBV (Resource-Based View). TOE and DOI, employed by Mvubu & Naude (2024), explain how the adoption of technologies depends on environmental, organizational, and technological factors, in addition to the pace of innovation diffusion. RDT, used by Sindakis et al. (2023), clarifies interdependencies and power relationships in the supply chain. RBV, on the other hand, is evident in authors such as Domingos et al. (2024) and Kristoffersen et al. (2020), when treating dynamic capabilities as strategic resources to sustain competitive advantage in volatile environments.

Regarding the empirical contribution, statistical analysis showed the predominance of studies in developing countries, specifically China and India. In such contexts, the implementation of technologies associated with Industry 4.0 faces significant challenges, with high financial cost being the main obstacle, especially in these emerging countries. Thus, the adoption of digital technologies primarily occurs to level competitiveness with competitors, fitting into the "Internal with Support" concept proposed by Wheelwright and Hayes (1985), where the organization seeks to achieve the same level as its peers, corroborating the research by Huang et al. (2023). It is also noted that, in these contexts, managers tend to invest in new technologies when they perceive a competitive advantage, given the uncertainty of returns on these large-scale investments (Gupta et al., 2022).

Based on these findings, it is concluded that strategic adaptation and the development of competencies are fundamental for the effective implementation of Industry 4.0 in logistics. The research reinforces the importance of more empirical studies that evaluate the practical impacts of these technologies, contributing to a deeper understanding of their applicability and benefits.

The research results also regarding coercive and normative factors corroborate the research by Pereira and Cardoso (2020). In this context, technology removes the need for intermediaries or the bargaining power of agents in the supply chain, or compliance with rigid local access regulations. Therefore, it allows companies to autonomously access new markets through global service and commerce platforms in both developed and developing countries.

Regarding the limitations of the research, it is stated that they are numerous, including: the research protocol outlining the determination of keywords, and the coding proposal leading to subjective evaluation by the researchers (Schilling & Seuring, 2024). In this scenario, the research protocol may result from an erroneous selection of keywords, categories, and databases. However, the team conducted a preliminary reading on the topic to mitigate this drawback.

Regarding coding, the choice of categorization criteria sought to align them with the proposed objectives of the research as well as to have pragmatism in their evaluation. In this environment, there is a limitation of researchers regarding the analysis of these categories versus presented concepts. To mitigate this bias, an effort was made to select articles that allowed full access. The aim was to read the title, abstract, keywords, and introduction in order to seek evidence or lack thereof for the presented categories.

Finally, it is recommended that future research explore the long-term implications for mapping digital capabilities—connectivity, visibility, and continuity. In addition to this long-term perspective, future studies may compare developed and developing economies using primary data, test the relationship between digital capabilities and logistics performance indicators, and deepen the analysis of source dispersion and thematic communities, especially through journal zones, co-citation networks, and longitudinal network centrality measures.

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Apendix I: List of articles evaluated in the bibliometric research.

ref	**Authors**	**DOI reference**
1	Kristoffersen, E; Blomsma, F; Mikalef, P; Li, JY	http://dx.doi.org/10.1016/j.jbusres.2020.07.044
2	Nagy, J; Oláh, J; Erdei, E; Máté, D; Popp, J	http://dx.doi.org/10.3390/su10103491
3	Bressanelli, G; Adrodegari, F; Perona, M; Saccani, N	http://dx.doi.org/10.3390/su10030639
4	Dev, NK; Shankar, R; Qaiser, FH	http://dx.doi.org/10.1016/j.resconrec.2019.104583
5	Lohmer, J; Bugert, N; Lasch, R	http://dx.doi.org/10.1016/j.ijpe.2020.107882
6	Ciliberto, C; Szopik-Depczynska, K; Tarczynska-Luniewska, M; Ruggieri, A; Ioppolo, G	http://dx.doi.org/10.1002/bse.2801
7	Long, JR; Zhong, CBA; Ahmad, B; Irfan, M; Nazir, R	http://dx.doi.org/10.1080/1331677X.2021.2004437
8	Facchini, F; Olesków-Szlapka, J; Ranieri, L; Urbinati, A	http://dx.doi.org/10.3390/su12010086
9	Awan, U; Sroufe, R; Bozan, K	http://dx.doi.org/10.3390/su14127084
10	Preindl, R; Nikolopoulos, K; Litsiou, K	http://dx.doi.org/10.1080/16258312.2020.1716633
11	Godina, R; Ribeiro, I; Matos, F; Ferreira, BT; Carvalho, H; Peças, P	http://dx.doi.org/10.3390/su12177066
12	Gupta, H; Yadav, AK; Kusi-Sarpong, S; Khan, SA; Sharma, SC	http://dx.doi.org/10.1016/j.techsoc.2022.101970
13	Farooq, MU; Hussain, A; Masood, T; Habib, MS	http://dx.doi.org/10.3390/su13052504
14	Zhang, GQ; Yang, YQ; Yang, GQ	http://dx.doi.org/10.1007/s10479-022-04689-1
15	Yadav, S; Luthra, S; Garg, D	http://dx.doi.org/10.1007/s11356-020-11676-1
16	Kannan, K.S.P.N.; Garad, A	http://dx.doi.org/10.1108/IJQRM-04-2019-0124
17	Abideen, AZ; Sundram, VPK; Pyeman, J; Othman, AK; Sorooshian, S	http://dx.doi.org/10.3390/logistics5040084
18	Krykavskyy, Y; Pokhylchenko, O; Hayvanovych, N	http://dx.doi.org/10.24136/oc.2019.014
19	Tozanli, Ö; Kongar, E; Gupta, SM	http://dx.doi.org/10.3390/su12135416
20	Fathi, M; Ghobakhloo, M	http://dx.doi.org/10.3390/su12166669
21	Slusarczyk, B; Tvaronaviciene, M; Ul Haque, A; Oláh, J	http://dx.doi.org/10.3846/tede.2020.13376
22	Khan, S; Singh, R; Haleem, A; Dsilva, J; Ali, SS	http://dx.doi.org/10.3390/logistics6010013
23	Shahbakhsh, M; Emad, GR; Cahoon, S	http://dx.doi.org/10.1016/j.ajsl.2021.11.004
24	Khalifa, N; Abd Elghany, M; Abd Elghany, M	http://dx.doi.org/10.1080/23311975.2021.1965459
25	Belmoukari, B; Audy, JF; Forget, P	http://dx.doi.org/10.1186/s12544-023-00581-6

26	Sidiropoulos, V; Bechtsis, D; Vlachos, D	http://dx.doi.org/10.3390/su131910929
27	Henríquez, R; de Oses, FXM; Marin, JEM	http://dx.doi.org/10.1016/j.rtbm.2022.100803
28	Gupta, S; Prathipati, B; Dangayach, GS; Rao, PN; Jagtap, S	http://dx.doi.org/10.3390/su141711103
29	Ferrari, A; Mangano, G; Cagliano, AC; De Marco, A	http://dx.doi.org/10.1007/s12063-022-00304-5
30	Shakur, MS; Lubaba, M; Debnath, B; Bari, ABMM; Rahman, MA	http://dx.doi.org/10.3390/logistics8010027
31	Wangsa, ID; Vanany, I; Siswanto, N	http://dx.doi.org/10.1007/s11356-021-17805-8
32	da Silva, RM; Frederico, GF; Garza-Reyes, JA	http://dx.doi.org/10.3390/logistics7010011
33	Luu, TV; Chromjaková, F; Nguyen, HQ	http://dx.doi.org/10.1002/bsd2.286
34	Pishdar, M; Shakib, MD; Antucheviciene, J; Vilkonis, A	http://dx.doi.org/10.3390/su13116497
35	Patil, A; Shardeo, V; Dwivedi, A; Moktadir, MA; Bag, S	http://dx.doi.org/10.1002/bse.3547
36	Yang, KH; Thoo, A	http://dx.doi.org/10.3390/su15021105
37	Gao, YR; Lin, RH; Lu, YH	http://dx.doi.org/10.3390/su14031708
38	Richnák, P	http://dx.doi.org/10.3390/logistics6040079
39	Portna, OV; Iershova, NY; Tereshchenko, DA; Kryvytska, OR	http://dx.doi.org/10.14254/1800-5845/2021.17-1.11
40	Bootz, JP; Michel, S; Pallud, J; Monti, R	http://dx.doi.org/10.1016/j.techfore.2022.121962
41	Pimsakul, S; Samaranayake, P; Laosirihongthong, T	http://dx.doi.org/10.3390/su132212890
42	Trstenjak, M; Opetuk, T; Dukic, G; Cajner, H	http://dx.doi.org/10.3390/su14116514
43	Demir, S; Gunduz, MA; Kayikci, Y; Paksoy, T	http://dx.doi.org/10.1080/10429247.2022.2050129
44	Chen, Y; Zhou, R; Zhou, Y	http://dx.doi.org/10.3390/su142416812
45	Brookbanks, M; Parry, GC	http://dx.doi.org/10.1108/SCM-07-2023-0333
46	Almoslehy, SAM; Alkahtani, MS	http://dx.doi.org/10.3390/su13094727
47	Vuta, DR; Nichifor, E; Chitu, IB; Bratucu, G	http://dx.doi.org/10.3390/su141710741
48	Saura, JR; Skare, M; Riberio-Navarrete, S	http://dx.doi.org/10.7441/joc.2022.04.10
49	Rakyta, M; Bubenik, P; Binasova, V; Micieta, B; Staffenova, K	http://dx.doi.org/10.3390/su141912659
50	Barbalho, SCM; Dantas, RD	http://dx.doi.org/10.14488/BJOPM.2021.011
51	Zielske, M; Held, T; Kourouklis, A	http://dx.doi.org/10.3390/logistics6010019
52	Núñez-Merino, M; Maqueira-Marín, JM; Moyano-Fuentes, J; Castaño-Moraga, CA	http://dx.doi.org/10.1108/IJPDLM-02-2023-0065
53	Kunrath, TL; Dresch, A; Veit, DR	http://dx.doi.org/10.14488/BJOPM.1263.2023

54	Vance, D; Jin, MZ; Price, C; Nimbalkar, SU; Wenning, T	http://dx.doi.org/10.1108/JMTM-03-2022-0103
55	Hakim, IM; Singgih, ML; Gunarta, IK	http://dx.doi.org/10.3390/su15042909
56	Tiwong, S; Ramingwong, S; Tippayawong, KY	http://dx.doi.org/10.3390/su12062394
57	Narula, S; Tamvada, JP; Kumar, A; Puppala, H; Gupta, N	http://dx.doi.org/10.1109/TEM.2023.3344373
58	Rajak, BK; Chatterjee, S; Upadhyay, A	http://dx.doi.org/10.1109/TEM.2023.3330912
59	Cyplik, P; Zwolak, M	http://dx.doi.org/10.17270/J.LOG.2022.733
60	Mesarosova, J; Martinovicova, K; Fidlerova, H; Chovanova, HH; Babcanova, D; Samakova, J	http://dx.doi.org/10.22306/al.v9i2.292
61	Dobos, P; Cservenák, A; Skapinyecz, R; Illés, B; Tamás, P	http://dx.doi.org/10.3390/su132111914
62	Riso, T; Morrone, C	http://dx.doi.org/10.3390/su15031911
63	Gomes, AC; de Lima, FB Jr; Soliani, RD; Oliveira, PRD; de Oliveira, DA; Siqueira, RM; Nora, LARD; de Macêdo, JJS	http://dx.doi.org/10.7769/gesec.v14i5.2119
64	Dabo, AA; Hosseinian-Far, A	http://dx.doi.org/10.3390/logistics7040097
65	Mustapic, M; Trstenjak, M; Greguric, P; Opetuk, T	http://dx.doi.org/10.3390/su15129557
66	Ali, SS; Torgul, B; Paksoy, T; Luthra, S; Kayikci, Y	http://dx.doi.org/10.1002/bse.3892
67	Pereira, GRB; Guimaraes, LGD; Cimon, Y; Barreto, LKD; Nodari, CH	http://dx.doi.org/10.3390/admsci13040114
68	Kavota, JK; Cassivi, L; Léger, PM	http://dx.doi.org/10.3390/logistics8010019
69	Hsu, CH; Cai, XQ; Zhang, TY; Ji, YL	http://dx.doi.org/10.3390/su16219183
70	Sindakis, S; Showkat, S; Su, JF	http://dx.doi.org/10.3390/su152416642
71	Mvubu, M; Naude, MJ	http://dx.doi.org/10.4102/jtscm.v18i0.1023
72	Salas-Navarro, K; Castro-García, L; Assan-Barrios, K; Vergara-Bujato, K; Zamora-Musa, R	http://dx.doi.org/10.3390/su16135279
73	Vasyuchenko, P; Liubokhynets, L; Stelmashenko, O; Grytsenko, S; Filipova, N	http://dx.doi.org/10.46925//rdluz.41.36
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