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Industry 4.0 in Logistics Management in Latin America: A Bibliometric Review

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Abstract:

Purpose: This research aims to identify the use of Industry 4.0 in logistics management in Latin America through a bibliometric review of different databases.

Design/methodology/approach: This study used a qualitative, exploratory and descriptive approach methodology, and the PRISMA method was used for a bibliometric review. Recent articles on Industry 4.0 in logistics management in Latin America, obtained from Scielo, Scopus and Science Direct, were included. The Rayyan tool helped in the selection and elimination of duplicates.

Findings: Twenty-nine research articles were included. The articles that were found allow highlighting the benefit of industry 4.0 in competitiveness. In which it is reflected that logistics manages the efficient flow of materials and information to deliver products to the final customer with quality and low costs. Industry 4.0 promises to transform logistics with technologies such as IoT, artificial intelligence and Big Data, optimizing processes, improving flexibility and risk management.

Originality/value: This research allows to expand the knowledge of the application of Industry 4.0 at the Latin American level, as it provides specific and contextual data on how these technologies can optimize logistics processes in the region, thus fostering competitiveness and innovation in a constantly evolving global market.

Keywords: industry 4.0, logistics management, supply chain, bibliometric review

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1. Introduction

Inevitably, the transformation of the industry, under the temporary milestones, has been enhanced by the progress of disruptive technology that modifies the manufacturing paradigms and the ways to meet the demands of users; in

this sense, the accelerated advances in technology and digitization have enabled the immersion of the so-called industry 4.0, also known as the fourth industrial revolution, which aims to achieve greater efficiency of automation and intelligence (Jefroy, Azarian & Yu, 2022). This particularity has been shaped by the so-called "techno-economic paradigm", which focuses on the computerization and digital convergence of production through cyber-physical systems (Feldman & Girolimo, 2021). Its dynamics have been implicit in the vertiginousness of the production and consolidation of intelligent cyber-physical systems, altering the limits of the digital, physical, and biological; and framing human interaction as obsolete, which is also articulated towards the organizational dynamics of production, enabling the so-called "algorithm company" (Zukerfeld, 2020; Galliano, 2020).

Under this perspective, Industry 4.0 has become a timely alternative for companies, mainly to create a value proposition by satisfying the personal demands of users responsively and profitably (Sun, Yu, Solvang, Wang & Wang, 2022), as it is a great incentive for organizational entities, the adoption of industrial 4.0 technologies is gaining more and more strength, mainly in logistics, because it is emphasized as a strategy to gain competitiveness in the market, allowing to streamline different underlying processes of logistics (Chicaiza & Tipantasig, 2023).

For companies, adopting an agile and modern supply chain is nowadays the purpose of every organization since an efficient supply chain is fast-paced, automatic in the process (accepting orders, preparing orders, and distributing to customers), more flexible, and transparent, potentially performing in dynamic and data-intensive systems (Abdirad & Krishnan, 2020). The incentive of Industry 4.0 is that individuals, machines, equipment, logistics systems, and products are interconnected and can thus interact and collaborate directly, which is why it allows the use of a large amount of information not yet captured to make much faster and correct decisions in logistics, thus, the integration of products, equipment and people increases the efficiency of machines and production equipment, reduces costs and saves resources (Holubčík, Koman & Soviar, 2021).

Thus, Industry 4.0 has not only influenced a modification in the way of production or manufacturing but has prominently disrupted logistics operations towards a high degree of digitization, integration, articulation, and responsiveness potential (Winkelhaus & Grosse, 2020). Thus, by leveraging the effectiveness and efficiency of manufacturing processes, Industry 4.0 predominantly emphasizes the paradigm shift led by new technologies (Xu, Lu, Vogel-Heuser & Wang, 2021). From this context, in the modern business dynamics, the market, and the demands of customization, responsiveness, and flexibility of users, manufacturers are developing more strongly the extension of their logistics networks to associate and coordinate with suppliers and enhance external and internal logistics processes, as well as the acceleration of decision making (Cimini, Lagorio, Romero, Cavalieri & Stahre, 2020).

It should be added that in recent years, the dynamics of globalization and the liberalization of international trade have increased logistics flows between different nations and companies, leading to an increase in the level of complexity of the logistics chain; therefore, organizations can take advantage of the technological idiosyncrasy, which implies the development of the fourth industrial revolution (Bigliardi, Casella & Bottani, 2021). Aspects such as saturated markets, demographic change and customer demands for individualized and sustainable products put pressure on logistics systems, turning them from complicated to complex, creating a dynamic and challenging environment for organizations (Winkelhaus & Grosse, 2020).

In this sense, Industry 4.0 technologies have the potential to impact logistics operations, improving resource planning, warehouse management and intelligent transportation systems, with an increasing emphasis on information security. The digitization of manufacturing, marketing, transportation and warehousing processes, based on interconnectivity and technological integration, is of great interest to the business community (El-Hamdi & Abouabdellah, 2022). Therefore, "the importance of technology is reflected in logistics through reduced inventories, shorter delivery schedules and a significant reduction in damages" (Bigliardi et al., 2021: page 2).

It is clear then, that Industry 4.0 manages to impact companies, mainly at the logistics level positively, however, it is necessary to point out that the interference of technology in the logistics system, is framed towards the interrelation of information, optimization of resources and time, involving investment and empowerment in innovation to maintain competitiveness (Barleta, Pérez & Sánchez, 2019). Thus, the new technology represents a challenge for companies, the high cost and education to the respective staff associates a prominent indebtedness for organizations (Erdíl, 2023). Although Industry 4.0 is beneficial for organizations vis-à-vis logistics practice,

operational convergence through the insertion of these modern technologies is not easy. Such processes may have some limitation or structural resistance at intra and inter-company levels (Sony & Naik, 2019); moreover, the technological insertion has the particularity of taking less attention to human aspects, which in effect, could represent as a threat to the sustainable development of human beings and society (Frederico, 2021; Alexa, Pîslaru & Avasilcăi, 2022).

Because of the above, this research compendium aims to identify the use of Industry 4.0 in logistics management in Latin America through a bibliometric review of different databases. This purpose is linked to the questions: How does the use of Industry 4.0 influence logistics management in Latin America, what Industry 4.0 technologies have been implemented in logistics management in Latin America according to the studies reviewed, and how has the adoption of Industry 4.0 impacted logistics management in Latin America? And how has the adoption of Industry 4.0 impacted the efficiency and competitiveness of logistics chains in the region?

As this study pretends to make a bibliometric review of the literature, the main implication is of practical improvements, which could become an inspiration for companies in the same industry as well as for other studies. Therefore, the research presents not only theoretical, but also practical implications. It is also important to mention that the practical implications of this study are the optimization of processes because automation enhances the effectiveness of logistics, which reduces costs, minimizes errors, and speeds up delivery time. In addition, through Industry 4.0, much more accurate and informed decisions can be made due to real-time data volume. Another particularity is that digitalization can facilitate more excellent adaptation of the various actors in the supply chain, from suppliers to users, enabling better coordination and real-time visibility of the logistics process. Another essential aspect is sustainability because optimizing processes and reducing inefficiencies contribute to reducing resources, and promoting environmental sustainability.

This article is structured with an introductory study description, defining its practical implications and relevance. Next, the method is described, and the criteria for selecting the articles, such as inclusion and exclusion criteria, sources and search strategy, and the processing of the selected articles are presented. Subsequently, the results are presented, with a characterization of the selected articles and a discussion of the findings. Finally, the conclusions that were compiled in this research are presented.

This study will serve as a solid foundation for further study and detailed analysis of the implementation and impact of Industry 4.0 on logistics management. It becomes also an inspiration for firms as it identifies some interesting case of success in different industries. It will also provide a framework for future research that seeks to explore how emerging technologies transform logistics processes, improving their efficiency and competitiveness.

2. Methods

This study was developed using a qualitative, exploratory, and descriptive approach. A bibliometric review was performed under the guidelines of the PRISMA method (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) version 2020. This review was carried out over 5 months. In addition, this analysis is replicable since it follows a standardized methodology, which is fundamental to validating the soundness and reliability of the results obtained in this research. The guidelines used for the selection of articles are presented below; these were proposed with mirror criteria to avoid ambiguities as to which studies will be considered or rejected.

Inclusion criteria

- Publication period within the last five years, in this way it will be possible to obtain updated information on research, given that technology is constantly evolving.
- Open access research
- Original articles
- Studies in Latin American countries
- Articles that address the use of Industry 4.0 in logistics management.

Exclusion criteria

- Publication period outside the last five years of age

- Open access research
- Original articles
- Studies in Latin American countries
- Articles that address the use of Industry 4.0 in logistics management.

The sources of information were the scientific databases: Scielo, Scopus and Science Direct. The search strategy used were the terms: industry 4.0 AND logistics, industry 4.0 AND supply chain, industry 4.0 AND logistics management and their variants in English.

In the article selection process, the Rayyan tool was used to process and consider the research according to the inclusion and exclusion criteria and to detect possible duplicates, which were subjected to an additional review by the researcher to confirm their duplicity.

To visually present the results of the studies reviewed, a table will be presented with columns for year of publication, country where the study was carried out, title of the article, names of the authors, country and name of the journal. In addition to its wording in paragraphs in the data analysis section. On the other hand, a co-occurrence analysis of the keywords of the studies was carried out with the VOSviewer tool in order to have a better visual appreciation of the information. Narrative as a method for qualitative research allows to know in depth the nature of the problem and to advance in the construction of knowledge (Rodríguez-Ortiz, 2020). A narrative methodology was employed to synthesize results, highlighting key findings and providing a detailed description of the trends and patterns identified in the included studies.

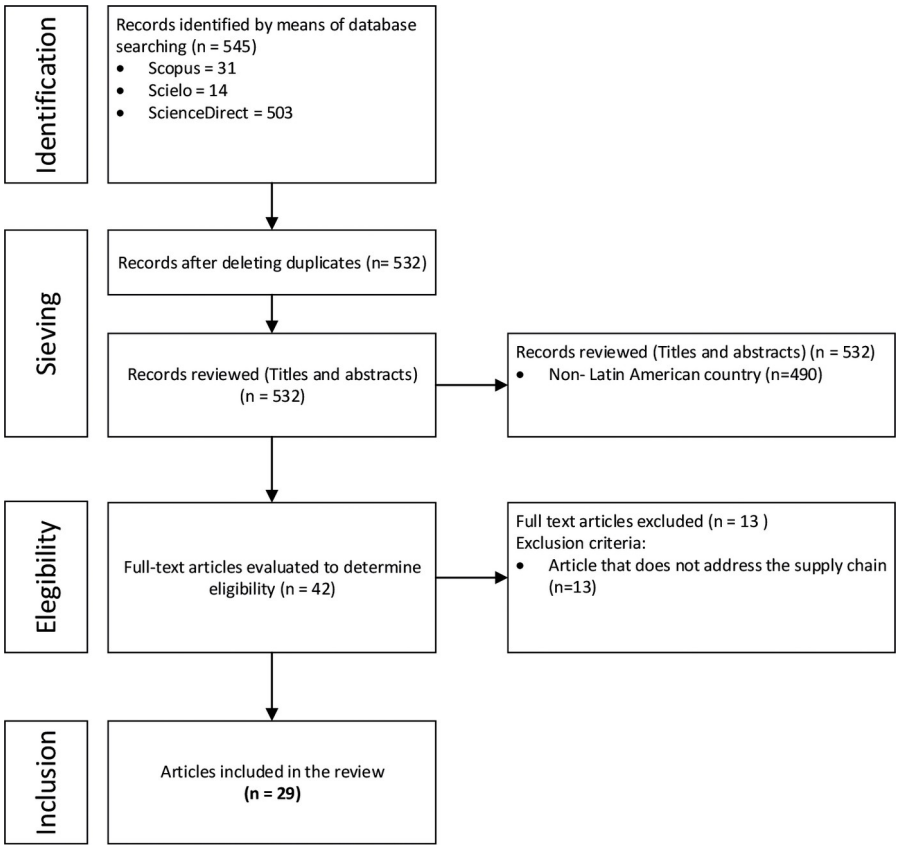

Figure 1. Flowchart for study selection

Figure 1 reflects the review process that was followed in four phases. Using the search strategies, 545 research studies were found in the identification phase, of which 31 were from Scopus, 14 from Scielo and 503 from Science Direct. With the Rayyan platform, we proceeded with the screening phase, possible duplicates were detected, which were subjected to an additional review by the researcher to confirm their duplicity; when the duplicate articles were

eliminated, 532 articles were obtained. Subsequently, the titles and abstracts of the documents were reviewed and 490 were discarded because they did not meet the criteria for studies conducted in Latin America. This led to the eligibility phase, where the documents were reviewed in their entirety, excluding 13 studies that did not focus on the supply chain. Finally, 29 articles were included for their respective bibliometric review.

3. Results

Detailed tables and graphs are presented below to show the findings obtained from the selected research, following the previously mentioned bases and strategies. These displays include information on the year of publication, the country where each study was conducted, the titles of the articles, the names of the authors, and the name of the journal. In addition, narrative analyses are provided to allow a deeper understanding of the trends and patterns identified in the included studies. This combination of tables, graphs and narratives facilitates a clear and detailed representation of the results obtained in the research.

In addition, a co-occurrence analysis of the key words of the studies found in the databases was carried out using the VOSviewer tool, which identified the most commonly used terms corresponding to the subject of this research: industry 4.0, supply chain management, manufacturing, logistics, machine learning and digitalization.

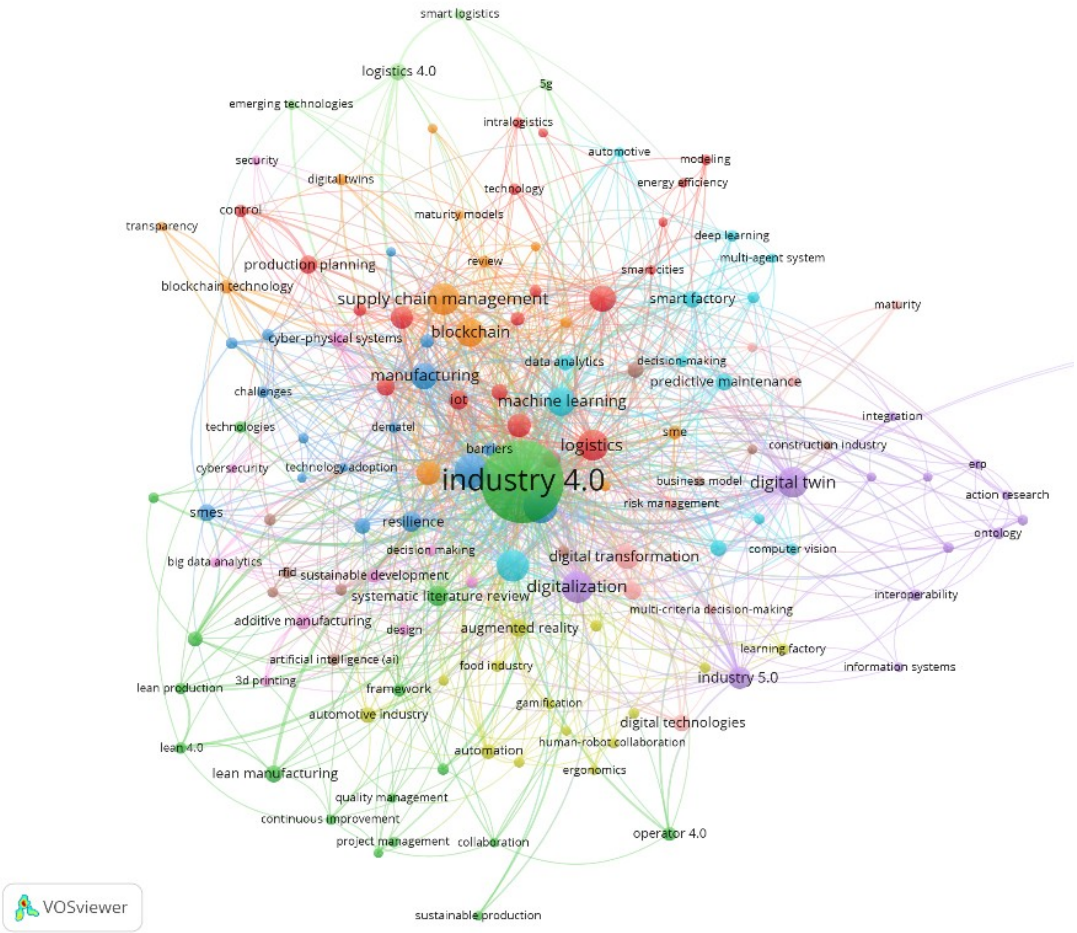

Figure 2. Keyword co-occurrence map

3.1. Description of Selected Articles

Figure 3 shows the number of articles per year within the period considered. It can be seen that in 2021 (n=3) and 2022 (n=5) there is a lower number of research studies, compared to 2020, 2023 and 2024, which show 7 articles, respectively. With the statistical analysis of r-squared, although there was a decrease from 2020 to 2021, an upward trend is observed with 12.5% variability.

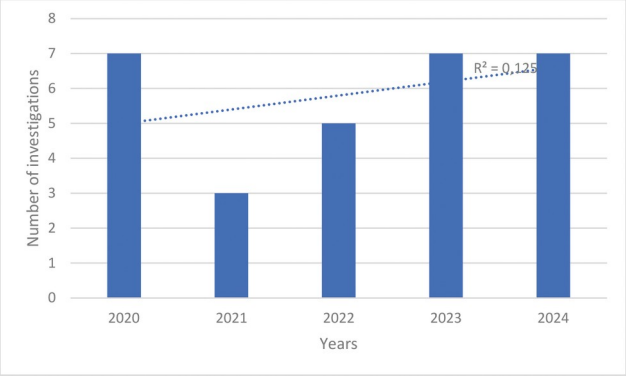

Figure 3. Number of investigations per year

On the other hand, Figure 4 shows six Latin American countries where the selected articles were produced. Of these countries, Brazil stands out with the presence of 14 studies, making it the leader in the production of studies in this area. This is followed by Colombia and Mexico, each with 5 studies, respectively. These data show the significant contribution of Brazil and underline the relevance of Colombia and Mexico in the production of scientific research in the region.

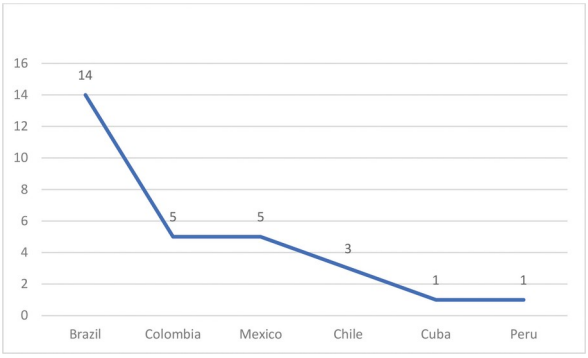

Figure 4. Number of investigations per country

An organized table with the selected articles is presented below. The table includes detailed columns for each article, specifying the author, title, country and journal of publication. This structure allows a clear and orderly visualization of the information, facilitating the identification and analysis of relevant studies.

Author/s	Title	Country	Journal of publication	Number of citations	Full text views
Santos, Correa, Sampaio, de-Casto-Barros & de-Castro-Hilsdorf, 2020	IoT and BDA in the Brazilian future logistics 4.0 scenario	Brazil	Production	13	1.824
Muniz-Junior, Pessin-Moschetto & Wintersberger, 2023	Industry 4.0 at Brazilian modular consortium: work, process and knowledge in engine supply chain	Brazil	Production	7	42
Tascón, Mejía & Rojas-Sánchez, 2022	Flexibility of operations in developing countries with Industry 4.0. A systematic review of literature	Brazil	Production	4	63
Alvarez-Aros & Bernal-Torres, 2021	Technological competitiveness and emerging technologies in industry 4.0 and industry 5.0	Brazil	Anais da Academia Brasileira de Ciências	12	18

Author/s	Title	Country	Journal of publication	Number of citations	Full text views
Martins, Tadeu-Simon & Stenico-de-Campos, 2020	Supply Chain 4.0 challenges	Brazil	Gestão & Produção	8	3.078
Schreiber, Sander & Becker, 2023	Analysis of the feasibility of reverse logistics in footwear production employing technologies RFID and Cloud Computing	Brazil	Revista de Administração da UFSM	-	3
Cabrera, Rodríguez-Pérez, León-González & Medina-León, 2020	Ideas y conceptos básicos para la comprensión de las industrias 4.0.	Cuba	Revista Universidad y Sociedad	10	939
Corrêa, Sampaio & Barros, 2020	An exploratory study on emerging technologies applied to logistics 4.0	Brazil	Gestão & Produção	6	2.270
Hernandez, Ramos-Alvarez & Soler-Anguiano, 2023	Project management and supply chain 4.0 improvement: the case of infant formulas in the face of the challenge of COVID-19	Mexico	Procedia Computer Science	4	-
Pozzo, Correa, Madrid, Campo, Donado & Biegelmeyer, 2022	Logistics 4.0: a review of current trends using bibliometric analysis	Colombia	Procedia Computer Science	5	1.583
Gómez-Ramírez & Soler-Anguiano, 2023	Simulation based optimization of drilling equipment logistics: a case of study	Mexico	Procedia Computer Science	1	35
Rojas-García, Elias-Giordano, Nallusamy & Quiroz-Flores, 2024	Enhancement of the distribution process on light logistics SMEs in times post-pandemic Covid-19 with Ukraine-Russia conflict by lean logistics and big data	Peru	Social Sciences & Humanities Open	1	49
Velásquez-Rodríguez, Cómbita-Niño, Parra-Negrete, Mercado & Fontalvo, 2022	Optimization of the distribution logistics network: a case study of the metalworking industry in Colombia	Colombia	Procedia Computer Science	9	121
El-Warrak, Nunes, Lyra, Barbosa, Lima, Salazar et al., 2022	Analyzing Industry 4.0 trends through the Technology Roadmapping Method	Brazil	Procedia Computer Science	6	49
Fierro, Cano & García, 2020	Modelling of a multi-agent supply chain management system using Colored Petri Nets	Colombia	Procedia Manufacturing	12	73
Frederico, 2023	ChatGPT in Supply Chains: Initial Evidence of Applications and Potential Research Agenda	Brazil	Logistics	32	136
Pereira, Montevechi, Pinto & Santos, 2023	Simulation and digital twins to support reverse logistics decisions: A review	Brazil	International Journal of Simulation Modelling	5	49
Bonamigo, de-Azeredo, Monteiro-de-Camargo Filho, & de-Souza-Andrade, 2024	Lean 4.0 in the value co-creation in agro-industrial services: An agenda for future studies for the efficient resource use	Brazil	Systems Research and Behavioral Science	4	51
Hennemann & Sehnem, 2024	Circular supply chains and Industry 4.0: an analysis of interfaces in Brazilian foodtechs	Brazil	RAUSP Management Journal	1	29

Author/s	Title	Country	Journal of publication	Number of citations	Full text views
Gerrero-Molina, Vásquez-Suárez & Valdés-Mosquera, 2024	Smart, Green, and Sustainable: Unveiling Technological Trajectories in Maritime Port Operations	Colombia	IEEE Access	2	57
Machado, Scavarda, Caiado & Santos, 2024	Industry 4.0 and Sustainability Integration in the Supply Chains of Micro, Small, and Medium Enterprises through People, Process, and Technology within the Triple Bottom Line Perspective	Brazil	Sustainability	5	2.231
Bas, Astudillo, Rojo & Trigo, 2023	Opinions Related to the Potential Application of Artificial Intelligence (AI) by the Responsible in Charge of the Administrative Management Related to the Logistics and Supply Chain of Medical Stock in Health Centers in North of Chile	Chile	International Journal of Environmental Research and Public Health	6	56
Cano, Salazar, Gómez-Montoya & Cortés, 2021	Disruptive and Conventional Technologies for the Support of Logistics Processes: A Literature Review	Colombia	International Journal of Technology	15	566
Durán, Fernández-Campusano, Carrasco & Carrillo, 2024	DMLBC: Dependable machine learning for seaports using blockchain technology	Chile	Journal of King Saud University - Computer and Information Sciences	1	86
Gatica-Neira & Ramos-Maldonado, 2022	Differences in the capacity of adoption of the enabling ICTS for industry 4.0 in Chile	Chile	E a M: Ekonomie a Management	1	79
Barbalho & Dantas, 2021	The effect of islands of improvement on the maturity models for industry 4.0: The implementation of an inventory management system in a beverage factory1,2	Brazil	Brazilian Journal of Operations and Production Management	11	358
Pacheco-Velazquez, Rodes-Paragarino & Marquez-Uribe, 2024	Exploring educational simulation platform features for addressing complexity in Industry 4.0: a qualitative analysis of insights from logistics experts	Mexico	Frontiers in Education	553	1.129
Granillo-Macías, Simón-Marmolejo, González-Hernández, & Zuno-Silva, 2020	Traceability in industry 4.0: A case study in the metal-mechanical sector	Mexico	Acta Logística	12	1.821
Saucedo-Martínez & Noriega, 2020	Literature review: Evaluation of the feasibility of implementing industry 4.0 technologies in the intralogistic processes of the logistics operators of the department of the Atlantic, a look towards the continuous improvement of organizational efficiency	Mexico	EAI/Springer Innovations In Communication and Computing	173	1

Table 1. Information about selected articles

3.2. Application of Industry 4.0 in Logistics Management

The use of Industry 4.0 logistics in Latin America is an important opportunity to change the supply chain system despite the numerous challenges compared to more developed economies. The introduction of technology such as the Internet of Things, artificial intelligence, Big Data Analytics, robotics, and additive manufacturing promises to improve savings and optimize all logistics processes. However, the reality of the transition reveals a variety of structural and financial obstacles that restrict their scope for use.

Logistics manages the efficient flow of materials and information to deliver products to the final customer with quality and low costs. With industry 4.0, through technologies such as IoT, artificial intelligence, Big Data Analytics (BDA), advanced robotics and additive manufacturing, promises to transform logistics (Cabrera et al., 2020; Martins et al., 2020; Saucedo-Martínez & Noriega, 2020; Tascón et al., 2022). However, there are few studies on its practical application and effectiveness in Latin America, as they consider that countries with more developed economies strongly focus on Industry 4.0, in contrast to emerging ones that still address more basic technologies (Alvarez-Aros & Bernal-Torres, 2021). However, there is a growing interest in the challenges and solutions for implementing these technologies.

It's important to highlight that Industry 4.0 transforms logistics management. Key trends in this field include China's and Germany's leadership in manufacturing, the global spread of AI and automation until 2030, and the focus on clean energy (El-Warrak et al., 2022).

Supply chain management requires vision, precision, and strategy, as well as integrating activities to obtain value and satisfy everyone, including the end consumer. Industry 4.0 facilitates supply chain integration through connectivity between physical and digital domains, enabling real-time decision making (Machado et al., 2024). Tools such as Big Data, Artificial Intelligence and Collaborative Robotics optimize processes and improve flexibility and risk management (Cano et al., 2021; Hernandez et al., 2023; Pacheco-Velazquez et al., 2024; Pozzo et al., 2022).

According to studies by Santos-Correa et al. (2020) applied to a non-probabilistic sample of 108 companies in Brazil, describe that these companies operate in logistics services (32%). Respondents are primarily senior management (60%) and between 41-50 years old (42%). 82% of the companies plan to invest in IoT, with 65% already investing to maintain competitiveness as the main reason (30%). However, they recognize high costs in software/hardware and human resources as limitations. These findings contrast the study by Corrêa et al. (2020), where they reveal that companies of various sizes, including huge ones, show interest in emerging technologies such as IoT and cloud to improve logistics. Investment is focused on maintaining competitiveness. Although there are barriers, such as high costs, expectations of short-term gains are high, especially in the cloud.

In addition, Muniz-Junior et al. (2023) recognize that the application of Industry 4.0 in logistics management focuses on labor, process, and knowledge transformation. Workers must adapt to new technologies, and organizations support their training. Mass customization and efficiency improve competitiveness. Thus, dissemination and understanding of I4.0 are crucial, emphasizing continuous knowledge and cultural and structural adaptation within organizations.

On the other hand, Schreiber et al. (2023), in their case study in the footwear industry, where they use technologies such as RFID to improve efficiency, found that RFID allows tracking and managing products in real-time without physical contact. At the Brazilian footwear company, the convergence of RFID and cloud computing facilitates reverse logistics, enabling product tracking and real-time returns data management. The cloud offers public, private, community, and hybrid options, improving sustainability and operational efficiency.

The use of Industry 4.0 technologies has enabled advances in supply chain management, facilitating greater integration between physical and digital domains and enabling real-time decision-making (Machado et al., 2024). These technologies improve flexibility and risk management in logistics operations, particularly in the case of large companies, as evidenced by the growing interest in IoT in Brazilian companies, with 82% planning to invest in this technology (Santos-Correa et al., 2020). The benefits are seen in the ability to monitor inventories and transport routes in real-time, with practical applications in sectors such as footwear, where RFID and cloud computing have facilitated reverse logistics and improved sustainability (Schreiber et al., 2023).

Gómez-Ramírez and Soler-Anguiano (2023), points out that Industry 4.0 is applied in the logistics management of drilling equipment transportation to reduce costs and time. A routing simulation was performed using algorithms such as TSP and MST to optimize the transportation distribution. The results show that using three transportation agents significantly reduces the total oilfield service time, demonstrating the effectiveness of optimization in logistics under Industry 4.0.

In the study by Rojas-García et al. (2024), which focused on the retail sector, Industry 1.0 is intended to improve the productivity of light logistics SMEs by refining processes and creating an information framework to plan efficient delivery routes. The study covers the synergy between Lean Logistics and Big Data, with the implementation of models that optimize distribution and improve customer satisfaction.

Also, Velásquez-Rodríguez et al. (2022) focus on site selection for two distribution platforms with Industry 4.0 that meet store demand with affordable logistics costs, considering constraints such as production capacity, inventory policies, and truck types. The Gusek tool is used to optimize product transportation and minimize costs. Two distribution centers are selected, the most efficient truck type is determined, and store demand is optimally met.

Based on the above, Fierro et al.'s (2020) contributions emphasize that Industry 4.0 has driven the evolution of complex and dynamic supply chains. It is recommended that formal tools be used to accurately design integrated processes and systems. Petri Net techniques, such as colored Petri nets, are effective for modeling logistics management systems in the context of Industry 4.0. This article presents a systematic approach to developing supply chain management models, highlighting their advantages through a product assembly case study.

In another aspect, with artificial intelligence, especially ChatGPT, the technological advances of Industry 4.0 show potential to innovate and improve supply chains, especially in communication, relationships, and process integration. While ChatGPT technology can support logistics activities and improve efficiency, it will not generate massive transformations initially. Challenges such as staff training, regulatory compliance, and data accuracy exist (Frederico, 2023).

In another aspect, Industry 4.0 is said to offer potential applications in logistics management through simulation and digital twins. Simulation differs from digital twins in that the former mimics systems without changing them, while digital twins are virtual replicas that exchange information with physical systems. Although only a small number of articles address simulation in reverse logistics, its potential for improving efficiency and decision-making is highlighted. However, challenges remain in terms of staff training, regulatory compliance, and data accuracy in these implementations (Pereira et al., 2023).

The concept of Lean 4.0, according to (Bonamigo et al., 2024), has emerged as a leading technique in logistics management by combining the Lean philosophy with Industry 4.0 technologies to improve resource management and reduce waste. This approach reorganizes business processes and fosters circular supply chains through intelligent services and data sharing among chain actors.

With food companies, Hennemann and Sehnem (2024) identified circular supply chain (CSC) practices, I4.0 technologies, and the involvement of strategic stakeholders. It was found that all the companies analyzed implement CSC practices, some without knowledge of circular economy (CE). Fifteen CE practices and seven I4.0 technologies were identified, although not all companies use these technologies. Active participation of key stakeholders was observed in suppliers, customers and employees. The potential of CE practices and I4.0 technologies to improve the sustainability and efficiency of supply chains is highlighted. Still, the challenge of high financial costs for adoption, especially for SMEs, is noted.

Regarding the application of Industry 4.0 in maritime logistics management, addressing digitization, big data, artificial intelligence, and IoT technologies in port operations and fleet management will be highlighted. Efficiency in the supply chain and optimization of operations with emerging technologies such as Digital Twins, machine learning, and blockchain will also be highlighted (Gerrero-Molina et al., 2024).

In the same maritime sector, Durán et al. (2024) propose a logistics management system based on Industry 4.0 for the Port of Valparaiso, using the Data Integration and Transformation (DITC) method and blockchain technology.

This system improves decision-making and efficiency by collecting and processing data in real-time using machine-learning techniques. The blockchain ensures data security and traceability, facilitating document management and port operations monitoring and promoting stakeholder collaboration.

According to the application of Industry 4.0 in the logistics management of hospitals in northern Chile. It identifies a dependence on traditional models with high human intervention, generating control failures, stock ruptures, and errors. Despite budgetary investment, there is a lack of interest in adopting technologies such as artificial intelligence (AI) to improve efficiency and reduce costs. Lack of knowledge about AI and resistance to change are obstacles. The need to implement AI systems to optimize logistics management and ensure the availability of medical supplies is highlighted (Bas et al., 2023).

In addition, the study of Gatica-Neira and Ramos-Maldonado (2022) analyzes the adoption of Industry 4.0 technologies in Chilean companies, highlighting Big Data, RFID, Cloud Computing, ERP, CRM, SCM, and IT security. It was identified using logistic regression and decision trees that larger companies with ICT professionals invest more in these technologies. Companies tend to start with Cloud Computing and ERP, increasing technological complexity gradually. It is suggested to implement policies to level the technological adoption in SMEs, offering an intersectorial and multivariate vision of the technological diffusion process.

In Brazil, they integrated i4.0 technologies into a beverage manufacturing company, saving inventory costs and improving integration in their supply chain. However, digitalization has not maximized its potential due to insufficient integration. Adopting digital competencies and an open mindset is essential to use new technologies and business models (Barbalho & Dantas, 2021).

Although in the metal-mechanical industry, Granillo-Macías et al. (2020) evaluated asset control solutions using identification strategies and software for inventory traceability. They initially proposed RFID, but due to the need to track assets in external locations, they also considered GPS. Ultimately, they opted for GPS because of its effectiveness in external environments. The implementation improved the automatic updating of locations, achieving close to 99% inventory reliability and estimated annual savings of $553,634 USD. In addition, integrating GPS and RFID improved the efficiency and reliability of equipment control.

However, there are persistent challenges in Latin America. Among the critical issues are the high costs of adopting Industry 4.0 technologies and the lack of staff training. According to Alvarez and Bernal, companies often find it challenging to justify substantial investments in software, hardware, and staff training, and respondents consider this factor to be one of the most critical constraints to ICT adoption. Resistance to change is also observed, particularly in sectors with a strong emphasis on traditional management models. For example, Bas et al. (2023) point to hospital logistics in Chile, which relies heavily on human intervention and constantly struggles with inefficiencies and additional costs.

Finally, the application of Industry 4.0 in logistics management represents a significant transformation through technologies such as IoT, artificial intelligence, Big Data, advanced robotics, and additive manufacturing. Although there are few studies on their practical application in Latin America, adopting these technologies promises to optimize logistics processes, improve real-time decision-making, and increase operational efficiency. However, companies face challenges such as high costs and the need to train personnel. Examples of implementation include using RFID and GPS for asset tracking, optimizing transportation routes, and improving inventory management. Despite the barriers, integrating Industry 4.0 technologies in logistics has excellent potential to enhance the competitiveness and sustainability of companies, highlighting the importance of digital transformation and continuous adaptation.

Regionalization of the Industry 4.0 literature is essential to understanding the specific challenges and solutions applicable in Latin America. The region's socioeconomic, regulatory, and technological contexts differ from those of developed economies, which requires studies that reflect these particularities. In addition, regional analysis favors creating public policies and technology adoption strategies adapted to local needs. This regionalization makes it possible to identify opportunities and barriers specific to Latin America, thus optimizing the implementation of emerging technologies in logistics management and other key sectors.

4. Conclusion

Logistics management is critical to deliver products of high quality and low cost to the end customer. Industry 4.0, with technologies such as IoT, artificial intelligence, Big Data analytics, advanced robotics, and additive manufacturing, promises to transform logistics. In addition, the authors' contributions highlight the importance of continuing to develop studies about the adversities and benefits that Latin American organizations face when adopting advanced technologies such as IoT, Big Data, and artificial intelligence due to the technological inequality for the most outstanding or developed economies. In that sense, the growth of logistics management through Industry 4.0 evidence an exciting perspective to optimize procedures and increase competition, despite barriers such as high investment costs and staff training.

On the other hand, the most prominent obstacles or gaps within the organizational dynamics are the little or no technological or digital infrastructure because, in that aspect, it is notorious for visualizing the resistance to change of companies and the dependence on conventional logistics models, which is still an inherent aspect of companies with a marked trajectory. Thus, integrating technological arrangements in the supply chain requires vision and strategy because the integration of Industry 4.0 appropriately facilitates this adaptation through physical and digital connectivity. Tools such as Big Data, Artificial Intelligence, and Collaborative Robotics optimize processes and improve flexibility and risk management. Dissemination and understanding of I4.0 are crucial, emphasizing continuous training and organizational cultural and structural adaptation to maximize logistics management benefits.

However, Industry 4.0 is still in the incipient stage of implementation in logistics management in Latin America. The examples of successful adoption mentioned in this essay demonstrate the potential to transform logistics operations, which means increasing competitiveness and business sustainability. However, challenges such as prohibitive implementation costs and lack of technical readiness for companies still need to be addressed. Digitalization and automation remain areas of great interest, and their success depends on policies that support SME adoption and a concerted effort to train the workforce and adapt organizational structures to the new technological paradigms.

On the other hand, it is essential to allude to future lines of research because, in literature, it is evident to note the lack or lack of in-depth study on the adaptability of these technologies in medium and small organizations and the consequences it would have on sustainability. In fact, in Latin America, there are few studies on their practical application and effectiveness; although there is a growing interest in the challenges and solutions for their implementation, however, it is still a problem. It should be added that it is necessary to study solutions that integrate low costs that allow overcoming technological barriers to be implemented satisfactorily.

One of the main limitations identified in this study was the limited amount of research conducted specifically in the context of Latin America, which restricts the possibility of obtaining a more representative picture of the region. This lack limits the ability to adequately contextualize the findings within the social, economic, and cultural realities of Latin American countries. In addition, limited availability of studies was found due to restrictions on access to scientific databases, which could have resulted in the exclusion of relevant literature, particularly that not indexed in open-access repositories. This study will serve as a solid foundation for further study and detailed analysis of the implementation and impact of Industry 4.0 on logistics management. It will also provide a framework for future research that seeks to explore how emerging technologies transform logistics processes, improving their efficiency and competitiveness.

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