

From Smart to Sustainable Logistics: Embracing Industry 5.0 for Human-Centric Resilience.

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Abstract

With the development of digital technologies in the form of the Internet of Things, artificial intelligence, robotics, and big data analytics, smart logistics has become one of the key pillars of contemporary supply chain change. However, the growing complexity of the global supply chains, as well as the growing environmental and social pressures, demonstrates the shortcomings of the efficiency-only models. In this work, a thorough bibliometric review of the Scopus database is performed to trace the development, intellectual organization, and thematic trends in the development of the research topic on smart logistics since 2015. Findings indicate that there was a fast pace of scientific output, especially starting in 2020, which can be explained by the effects of disruptions on the world and the increasing requirements of resilient and data-driven logistical systems. The keyword co-occurrence networks identify five of the largest thematic clusters, including the aspects of technological innovation and algorithmic optimization, sustainability, circular economy, and new Industry 5.0 paradigms. The analysis of collaboration indicates that it is highly geographically concentrated, whereby China is the main research centre, backed by regional and international associations. The results highlight the growing significance of moving towards sustainable and human-focused logistic framework which balances technological progress with environmental sustainability and value generation to the society. By providing a systematic review of the research trends, gaps in knowledge, and emerging tendencies, this bibliometric analysis contributes to the progress of knowledge among scholars, practitioners, and policymakers aiming to define the future of logistics per the principles of Industry 5.0.

Keywords: Smart logistics; Sustainable logistics; Industry 5.0; Smart supply chain; Artificial intelligence; Digital transformation; Bibliometric analysis

Introduction

The contemporary logistics is experiencing a significant transformation due to the globalization process, technological impact, and the growing sustainability demands. The supply chains are currently operating in an environment which is uncertain, volatile and full of frequent disruptions due to pandemics, geopolitical tensions and climate related occurrences. In this regard, the digitalization brought about by Industry 4.0 has been a decisive driver to enhance the efficiency of the operations, optimize flows, and real time visibility with the use of such technologies as the Internet of Things, artificial intelligence, and cyber physical systems (Zhang et al., 2021). Despite the fact that these technologies have produced significant improvements in performance, they are not enough to cope with the environmental and social needs that are reshaping the priorities of the modern logistic systems.

The increased interests regarding the carbon emissions, the use of energy and the depletion of the resources are compelling organizations to reconsider their logistics frameworks with a sustainability oriented lens. Meanwhile, human contribution to highly automated environments has been turned into a strategic concern due to the fact that organizational resilience is rooted in the ability of human creativity, decision making intelligence, and adaptive capacity, which technology cannot eliminate (Demir et al., 2023). This change of direction can be traced in the new vision of Industry 5.0 introduced by the European Commission, according to which sustainable, resilient, and human centric production and logistics systems are to be adopted (European Commission, 2021).

Instead of viewing digital technologies as an endpoint, Industry 5.0 puts them in the role of facilitators that will enhance the quality of life, safeguard the environment, and enhance the resilience of the supply chain. Although interest in this paradigm has been increased, the scientific literature is disjointed. Sustainability logistics, smart technologies, and supply chain resilience research has developed independently and not in a combined way. Such fragmentation restricts the capacity to comprehend the way these streams merge within the idea and working borders of Industry 5.0 (Kamble et al., 2023). Theoretical fragmentation renders it challenging to recognize any of the new trends, conceptual connections, and prominent research fronts in the field.

In order to address these drawbacks, the current paper will use a bibliometric methodology, which is a rigorous and reproducible way to chart the intellectual landscape of the field, examine the patterns of scientific output, and define the prevailing themes. In this manner the study can bring to light the intersection of sustainability, digitalization, and human centricity in the academic discussion to identify research gaps which should be addressed in the future. The objective of this study is to systematically and reproducibly map the intellectual landscape of

research in smart logistics between 2015 and 2025, through a bibliometric analysis of the Scopus database, in order to identify the main thematic clusters, trace the temporal evolution of scientific output, and highlight the convergence between digitalization, sustainability, and a human-centered approach as new frontiers of research.

The consolidation of knowledge of the scattered research streams makes this work help to build the theoretical framework of an emergent area and provide applicable insights in terms of the organization aiming to increase supply chain resiliency and align logistical practice with long term sustainability goals.

This article is organized as follows. Section 1 presents the theoretical framework, addressing smart logistics technologies, the principles of sustainable logistics, and the integrative role of Industry 5.0. Section 2 describes the bibliometric methodology, including the choice of database, the construction of the search query, data cleaning, and the inclusion and exclusion criteria. Section 3 presents the main results across seven analytical dimensions, ranging from the temporal evolution of scientific output to the thematic structure of keyword co-occurrence networks. Section 4 discusses the results in light of the theoretical framework, and Section 5 concludes by presenting the contributions, limitations, and avenues for future research

2. Theoretical Framework

2.1. Intelligent Logistics and Industry 4.0 Technology

Smart logistics is a digitally empowered logistics platform where information is transferred between interconnected actors, devices and platforms. It incorporates the modern technologies of Industry 4.0 to add visibility, agility, accuracy, and responsiveness to the supply chain. They are the technologies that constitute the technological infrastructure that aids decision making in an automated way and turns the traditional logistics into smart and adaptable networks.

Internet of Things (IoT)

IoT is among the foundations of the smart logistics as it enables physical items to exchange information in real-time with built-in sensors, RFID tags, and wireless networks. IoT provides end to end product, transport and storage environment traceability, allowing companies to know the real time position of flows, and identifies anomalies before they turn into disruptions. IoT is used to monitor the condition of sensitive goods such as temperature, predictive maintenance of car and equipment, and routing optimization depending on the real-time traffic and weather conditions (Ben-Daya et al., 2019). IoT in logistic centers like warehouses and ports can further be used in synchronizing operations by providing smooth communication between the equipment, vehicles and control systems (Atzori et al., 2010). IoT in the logistics improves the transparency of operations and minimizes uncertainty, preconditions more sophisticated analytics and automation.

Big Data Analytics

With big data analytics, smart logistics can be achieved by identifying valuable knowledge with big amounts of heterogeneous data that are produced throughout the supply chain. Information on IoT sensors, transport, customer interaction, and enterprise platforms serve predictive models, which are used to assist in making more accurate demand predictions, inventory management, and route optimization. Big data enables companies to predict disruptions, assess risks, and develop resilient logistic networks (Wamba et al., 2017). The analytics of big data enhances the quality of operational decisions and enhances the performance measure by the use of machine learning and high statistical methods. It promotes sustainability efforts as well, tracking all logistics processes in terms of emissions, energy and resource consumption (Zhang et al., 2021).

Robotics

Robotics changes the logistically related operations in the warehouses and manufacturing through automation of repetitive, labor intensive and high precision tasks. The automated guided vehicles and autonomous mobile robots will make it possible to handle the materials efficiently, optimize the process of picking, and shorten the time required to complete the order (D'Andrea, 2016). Collaborative robots, also known as cobots, enhance the interaction of people with machines by helping employees in activities that are either precise or entail heavy-lifting activities, thereby increasing safety and ergonomics (Bague, 2018). Robotics improves scalability, accuracy and flexibility of logistics, allowing companies to respond to demand fluctuations quickly and increase operational flexibility during 24-hour work with less error rates.

Artificial Intelligence (AI)

Autonomous decision making in smart logistics needs the computational intelligence, which is the role of artificial intelligence to offer. Machine learning, deep learning, natural language processing, and reinforcement learning are AI systems tools that analyze complex data and provide rational predictions or suggestions. AI enhances dynamic routing, demand forecasting, positioning inventory, and risks (Baryannis et al., 2019). With the help of computer vision, AI improves the recognition of objects in warehouses and facilitates automated quality inspections. AI-powered digital twins model logistics conditions and examine strategies, their vulnerabilities, and devise more resilient systems (Ivanov and Dolgui, 2020).

Process Automation

Process automation enhances the efficiency and accuracy of the logistics processes involving automated workflows, cyber physical systems and robotic process automation. These systems minimize the use of manuals, make information flows faster, and coordinate digital and physical

operations. The automation enhances warehouse performance, inventory management, and transport planning via linking machines, software, and data platforms into a single working ecosystem (Ivanov et al., 2021). Digital twins give virtual depictions of logistics processes that can be tracked in real time, simulated in advance, and managed in advance (Tao et al., 2019). Automation improves responsiveness and reliability which increases the logistic resilience.

2.2. Sustainable Logistics

Sustainable logistics is a strategic development in supply chain management that aims at amalgamating environmental protection, social responsibility and long term economic performance. It goes further than the traditional efficiency oriented strategies and includes wider sustainability targets that are congruent with the global systems like the United Nations Sustainable Development Goals. Sustainable logistics is intended to minimise the environmental footprint of logistics operations, encourage ethical practices throughout the value chains and enable circular and low carbon systems to improve resilience and long term competitiveness.

Sustainable Development

Sustainable logistics have the concept of sustainable development as the general theoretical base. Declared in the Brundtland Report as development that satisfies the current needs without impairing the capacity of future generations to satisfy their needs, it introduces the triple bottom line outlook that incorporates the environmental, social, and economic aspects (World Commission on Environment and Development, 1987). Sustainable development in logistics promotes organizations to re-design processes, by reducing waste, maximizing resources and going long term planning the operations in a way that complies with the boundaries of the planet (Geissdoerfer et al., 2017). Sustainable development promotes also the shift toward systemic supply chain transformation, where environmental performance and social value creation are now strategic priorities and not constraints.

Green Logistics

Green logistics is aimed at minimizing the environmental impact linked to transportation, warehousing and packaging, distribution. It aims at reducing emissions, energy use, and amount of waste through embracing eco efficient technologies and re-engineered ways of operation (McKinnon, 2018). This involves streamlining the transport routes, enhancing the consolidation of loads, using energy efficient vehicles and the introduction of renewable energy in the logistics infrastructures. Green logistics also promotes green purchasing, eco-design of the packaging and eco-oriented planning of the facility. With the growing level of environmental regulations and consumer demands, green logistics has been a significant contributor of corporate competitiveness and differentiation of supply chains (Dekker et al., 2012).

Social Responsibility

Social responsibility in logistics goes beyond the environmental issue of sustainability to the ethical labor relations, community welfare, the safety of workers, and the value-inclusivity creation. Corporate social responsibility makes corporations appreciate the importance of incorporating fairness, transparency, and human rights in logistics activities, interactions with suppliers and working environment (Carter and Rogers, 2008). Socially responsible logistics encourages the use of safe working conditions in the warehouse and transport worker modules, fair working standards in the global supply chains and sourcing of materials ethically. It also boosts the organizational legitimacy and trust by stakeholders, increases the resilience of supply chain through better cooperation and long term relationships (Ahi and Searcy, 2015).

Circular Economy and Decarbonization

The term decarbonization means the cut of greenhouse gases emitted by the logistics processes and in particular transportation that is one of the most carbon-intensive processes. Among the strategies, the use of alternative fuels, including hydrogen, biofuels, and electricity, the modal change to rail or maritime transport, and the increase in energy efficiency in freight systems should be mentioned (IEA, 2021). Carbon accounting and science based targets are also used by companies to ensure that they match logistic activities with global climate agreements. The principles of a circular economy are complementary to decarbonization and can yield resource efficiency, reuse, remanufacturing, and closed loop systems that minimize waste production and prolong the lifecycle of substances (Kirchherr et al., 2017). Circular logistics redesigns the reverse logistics, returns flows and material recovery systems to enable regenerative supply chains which can reduce environmental impact and generate economic value.

The shift of smart logistics to sustainable and human centered logistics does require the clarity of the conceptual underpinnings of how the academic discourse is organized. Although both smart and sustainable logistics focus on technological efficiency by integrating digital systems, the scope of sustainable logistics is much wider, as it incorporates environmental stewardship, social responsibility, and long term value creation. The remainder of the paper presents a synthesis of the main themes found in the literature and their principal contributions in the following comparative table.

2.3. Industry 5.0 as an Integrative Paradigm

While Industry 4.0 has established the technological foundations of smart logistics through automation, connectivity, and data-driven decision-making, Industry 5.0 represents a paradigmatic shift that repositions human beings and sustainability at the core of industrial and logistical systems. Introduced by the European Commission (2021), Industry 5.0 moves beyond efficiency as the primary objective and advances three foundational principles: human-

centricity, sustainability, and resilience. Human-centricity recognizes that technology should serve human well-being rather than replace human judgment, emphasizing the collaboration between intelligent systems and human operators in complex logistics environments (Demir et al., 2023). Sustainability requires that logistics systems operate within planetary boundaries, integrating circular economy principles, decarbonization strategies, and social responsibility into core operational design. Resilience acknowledges that supply chains must be capable of absorbing, adapting to, and recovering from disruptions, whether technological, environmental, or geopolitical. Together, these three principles provide the normative framework within which the transition from smart to sustainable logistics must be understood (Kamble et al., 2023). Industry 5.0 thus serves as the conceptual bridge between the technological capabilities reviewed in Section 2.1 and the sustainability imperatives outlined in Section 2.2.

Table 1. Comparative Synthesis of Smart and Sustainable Logistics Themes

Theme	Main Contribution
Internet of Things (IoT)	Enhances real time traceability, enables communication between connected objects, improves flow monitoring and overall logistics visibility.
Big Data Analytics	Utilizes large datasets to improve forecasting, optimize logistics decisions, reduce operational risks, and strengthen predictive analysis.
Robotics	Automates warehouse operations, reduces human error, increases processing speed, and improves worker safety and operational precision.
Artificial Intelligence (AI)	Supports autonomous decision making, strengthens demand forecasting, enables risk detection, and optimizes logistics processes dynamically.
Process Automation	Integrates digital and automated systems to synchronize physical and informational flows, increasing efficiency and reducing manual intervention.
Sustainable Development	Provides a holistic framework integrating environmental, social, and economic dimensions to guide logistics toward long term sustainability.
Green Logistics	Reduces the environmental footprint of logistics activities through energy optimization, waste minimization, and eco efficient transport practices.
Social Responsibility	Emphasizes ethics, labor protection, worker well being, and social equity across logistics operations and stakeholder interactions.

Decarbonization and Circular Economy	Promotes carbon reduction strategies, encourages circular resource flows, supports reuse and recycling, and decreases waste across supply chains.
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Source: Author's own elaboration

3. Bibliometric Methodology

3.1 Database Selection

Choosing a suitable bibliographic database is one of the basic processes of ensuring that the rigor, reliability, and reproducibility of any bibliometric analysis is achieved. The database used defines which scientific corpus is covered, represented, and of high quality. When carrying out a study on the topic of smart logistics, sustainable logistics, and the shift to the principles of Industry 5.0, two prominent scientific databases were taken into account in the given study: Web of Science and Scopus. These databases are known to be highly indexed in terms of peer reviewed literature, their organization of metadata, and how they have been compatible with bibliometric tools.

Web of Science

One of the most well-established scientific databases is the Web of Science which provides high-quality records on a broad spectrum of disciplines. It is characterized by the selective indexing, strictness of inclusion criteria in journals and its extensive citation tracking system. Its standardized metadata enables such advanced bibliometric methods as co citation analysis, bibliographic coupling and co authorship mapping. Historical depth is one of the qualities that Web of Science is appreciated the most, as it enables a researcher to see how the idea has developed throughout the years. Its coverage of journals, however, is more restrictive and could exclude the emergent areas of research or newly indexed materials.

Scopus

Scopus offers more coverage than Web of Science particularly those areas relating to engineering, technology and applied sciences that the focus of smart and sustainable logistics lies. Scopus has a higher number of journals, conference proceedings and book series, which provide a broader and more varied corpus of bibliometric mapping. It is also highly citable and gives in-depth author, affiliation and subject classification that facilitates advanced analysis processes. Scopus is especially convenient to use in the research of interdisciplinary and fast-changing issues like Industry 4.0 technologies, green logistics, and transitions toward sustainability. The large coverage eliminates the chances of publication bias and increases representativeness. The chosen database is Scopus because the database offers a wide range in terms of discipline as well as its indexation in the areas of logistics and sustainability plus the

fact that Scopus is largely compatible with bibliometric tools used to analyze the chosen database, including VOSviewer and Bibliometrix.

3.2 Data Cleaning and Refinement

The process of data cleaning and refinement is a part and parcel of the bibliometric dataset preparation process. Due to inconsistencies, duplications, missing fields, and changes in the author name, journals, and affiliations in the raw metadata retrieved through Scopus, systematic preprocessing is needed to provide the accuracy of analysis. The aim of this step will be to create a unified, standard, and trustworthy data set that is consistent with the scientific environment of smart logistics and sustainable logistics in the transition to the Industry 5.0.

The initial action was the deletion of duplicate records, which may take place as a result of indexing a publication under more than one type of document or due to the retrieval of different versions of the same article. Automated filtering of Scopus export files and manual verification of titles, authors and digital object identifiers was done to enable precise duplicate detection. The second element was related to standardization of the names of authors and institutional affiliation. Differences including the inclusion or exclusion of initials, a mismatch of spelling, and the abbreviation of the institutional name might disaggregate citation counts and corrupt network plots.

Cleaning up of key field was the third feature of preprocessing, as keywords are the main feature of co-word analysis and thematic mapping. This involved the combination of synonymous phrases, spelling variations and unification of singular and plural forms. To illustrate, the names of circular economy and circular economies or artificial intelligence and AI were merged to prevent the analytical splintering. The cleaning stage was done to remove documents that were not pertinent to the research scope. The exclusion criteria were the non-logistics or supply chain field, articles that were not related to sustainability or Industry 4.0 and 5.0 frameworks, and publications that covered only the technical aspects of engineering but not the application in the logistics field. Lastly, the filtered dataset was exported in desirable formats to be used in bibliometric software like VOSviewer to create network maps and Bibliometrix to perform descriptive analysis, thematic evolution, and co citation pattern.

3.3 Search Query Construction

The search of the literature was done with the Scopus advanced search interface. The search was done on the fields of title, abstract and author keywords by using a structured search query of the combination of terms associated with smart logistics and performance results. The last search equation was developed in the following way: TITLE-ABS-KEY (("smart logistics" OR "smart supply chain" OR "intelligent logistics" OR "smart warehouse" OR "IoT logistics") AND ("sustainability" OR "Industry 5.0" OR "circular economy" OR "human-centric" OR

"resilience" OR "green logistics")) AND PUBYEAR > 2014. This query was designed to retrieve studies published since 2015 that address both the technological dimensions of smart logistics and the emerging sustainability and human-centric orientations aligned with Industry 5.0 principles.

3.4 Time Period and Search Execution

The search of the bibliography was carried out within a well-established time frame that would guarantee both the relevance and the depth of analysis. The publications that were reviewed were published in the period between January 2015 and March 2025, which correlates to the development and establishment of smart logistics as a research area of supply chain management. The start of the time frame was established in 2015 to ensure that it encompassed the most recent academic works that directly concerned smart logistics and the adjacent notions of intelligent logistics, smart supply chains, smart warehouses, and Internet of Things enabled logistics systems.

In order to be stable and complete in metadata, the upper limit of the analysis was set to March 2025. This search was conducted in March 2025 with the search interface of Scopus. The limitation of the time frame also guaranteed the homogeneity of trend analysis, and it became possible to identify the pattern of publication growth, the development of the themes, and changes in the research direction with time. Specifically, due to this timeframe, one could spot the dramatic rise in scholarly output since 2020, which was associated with global supply chain shocks and the rise of the focus on resilience, sustainability, and optimization of digital performance.

3.5 Inclusion Criteria

The inclusion criteria were also spelt out to facilitate the identification of quality studies, relevant studies and methodologically sound studies based on the goals of this bibliometric analysis. Peer reviewed journal articles were taken into consideration only to ensure that the scientific rigor and the accuracy of the published results. The search was confined to the English publications since the English language is the most popular means of academic communication in the sphere of logistics, supply chain management, and digital technologies on sustainability dimensions and Industry 5.0 frameworks as applied to logistics and supply chain management, as well as on related concepts such as smart supply chains, intelligent logistics systems, smart warehousing or IoT enabled logistics solutions. Only articles indexed in the Scopus database were considered to ensure standardized bibliographic metadata. Lastly, only the studies published between January 2015 and March 2025 were included in the final corpus.

3.6 Exclusion Criteria

The exclusion criteria were developed to remove studies that failed to possess the conceptual, methodological and analytical eligibility criteria of the bibliometric review. Conference papers, book chapters, editorials, notes, and technical reports were also eliminated as such document types tend to vary in structure, depth and rigor of review as opposed to journal articles. Publications in non-English were filtered out to ensure the consistency of the bibliometric indicators and exclude the possible biases associated with the translation or search of keywords. Books that were not in the direct connection to the logistics or supply chain management were discarded in the screening stage. Moreover, the research works that did not have a focused technological or sustainability aspect were not included. The inclusion and exclusion criteria have helped to achieve a focused and coherent dataset, which adds to the validity and interpretability of the following bibliometric analyses.

3.7 PRISMA Flow Chart and Study Selection

Overall selection can be summarized through a PRISMA flow diagram that visually displays the various steps in identification, screening, eligibility and inclusion. The first search of the Scopus database obtained 412 records. The total number of records screened by title and abstract was 316 after elimination of 96 duplicate records. In the course of this screening stage, 214 articles were excluded as insufficiently relevant to smart logistics, sustainable logistics, or the transition toward Industry 5.0 principles. Eligibility of the remaining 102 articles was evaluated with regard to the full texts. All identified articles fulfilled the inclusion criteria and were retained for the final bibliometric analysis.

Table 2. PRISMA Summary of the Study Selection Process

PRISMA Stage	Description	Number of Records
Identification	Records identified through Scopus database searching	412
Identification	Duplicate records removed	96
Screening	Records screened based on title and abstract	316
Screening	Records excluded after title and abstract screening	214
Eligibility	Full text articles assessed for eligibility	102
Inclusion	Studies included in the final bibliometric analysis	102

Source: Author's own elaboration

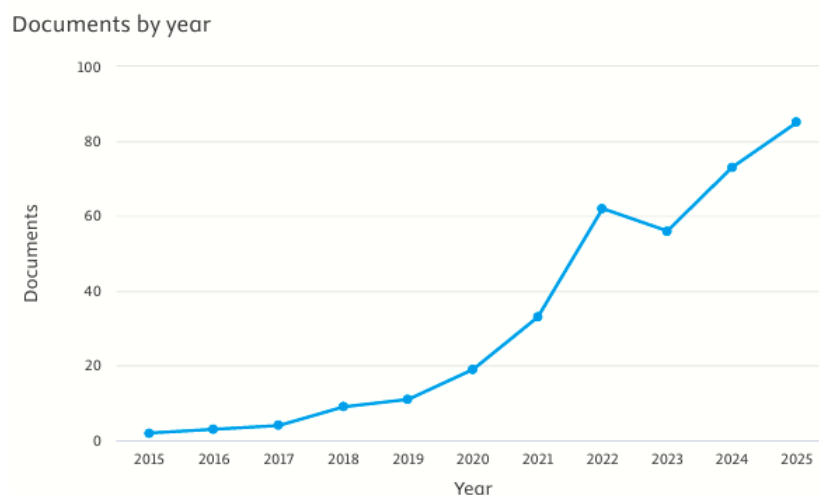
4. Results

4.1. Annual Scientific Production and Temporal Evolution of Research Output

The number of publications distributed annually between 2015 and 2025 clearly demonstrate the acceleration of the scientific interest in the smart logistics field. The first years of the period were characterized by a small amount of research output, which is due to the nature of exploration of smart logistics prior to the extension of Industry 4.0 technologies to a broad audience. This tendency is consistent with conceptual development in the field of digital transformation in logistics at the early stage when the combination of IoT, automation, and data analytics was only developing (Ben-Daya et al., 2019; Xu et al., 2018). The positive growth is observed following 2019, a year when the world started using digital tools with a rapid pace and being more aware of the vulnerabilities of supply chains.

The drastic increase in publications in 2021-2022 is related to the general move to data driven and technology enabled logistics solutions and the great urgency of resilient supply chain models due to disruption events like the COVID-19 pandemic. The impact of pandemic has been noted as stimulating research on digital and smart logistics since its core in ensuring operative continuity (Ivanov, 2020; Queiroz et al., 2020). Though a minimal decrease can be noticed in 2023, the growing trend is maintained in 2024 and peaks in 2025 to demonstrate the consistent and increasing interest in the convergence of smart logistics, sustainability objectives, and Industry 5.0 principles. This trend reflects the overall shift towards the use of big data analytics, advanced automation, and sustainability measurements within the logistics systems (Wamba et al., 2017; Zhang et al., 2021).

Figure 1. Annual Scientific Production and Temporal Evolution of Research Output



Source: Scopus

This temporal evolution confirms the theoretical argument presented in Section 2, where global disruptions and sustainability pressures were identified as structural drivers accelerating the

transition toward smarter and more resilient logistics frameworks (Ivanov, 2020 ; Wamba et al., 2017).

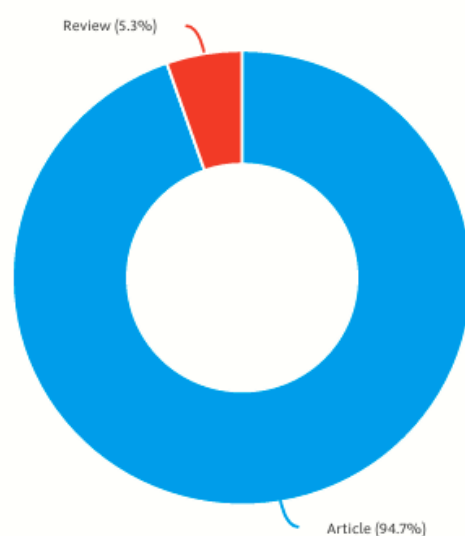
4.2. Distribution of Document Types in the Scientific Corpus

The distribution of document types shows that the corpus is saturated with research articles and they constitute about 94.7 percent of all the publications. Such superiority shows that smart logistics is still an area that is mostly led by empirical research, methodological progression and practical research contributions. The fact that review articles were relatively few and only 5.3 percent is an indication that despite the fast growing nature of the field, it has not achieved conceptual integrity that is typical of new areas of research. This imbalance is common in technologically based disciplines whereby the speed of innovation is high and academics focus on experimental rather than theoretical synthesis.

The trend can be attributed to a larger body of research dynamics related to Industry 4.0 and digital logistics, where the rapid changes in technology, including the use of IoT, robotics, and artificial intelligence, promote the spread of application based studies (Ben-Daya et al., 2019; Wamba et al., 2017). Furthermore, the scarcity of review papers that were published to date indicates a chance and need to conduct additional integrative syntheses since the shift towards sustainable and human centric logistics in line with Industry 5.0 is yet to be embraced by academics (Xu et al., 2018; Zhang et al., 2021).

Figure 2. Distribution of Document Types in the Scientific Corpus

Documents by type



Source: Scopus

The scarcity of review articles further justifies the theoretical synthesis attempted in Section 2 of this study, which sought to bridge the fragmented streams of smart logistics, sustainable logistics, and Industry 5.0 into a coherent conceptual framework.

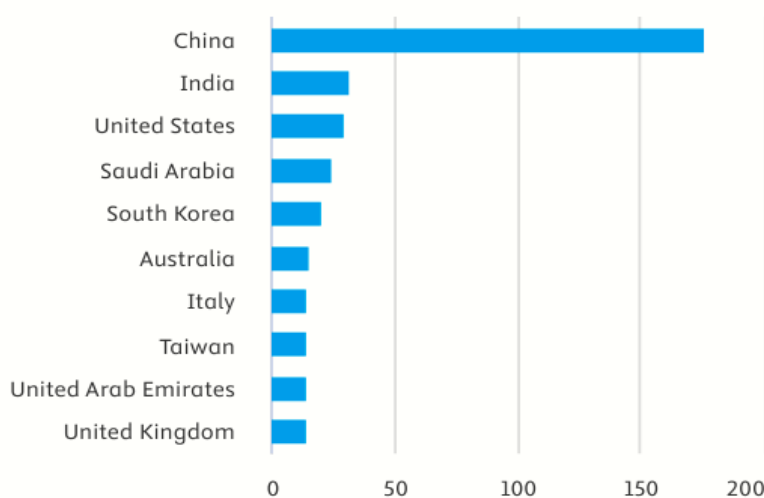
4.3. Geographic Distribution of Scientific Production

The geographical distribution of publications is biased towards China who is by far the world leader in terms of publication on smart logistics. The high ranking of China can be attributed to the fact that it made strategic national investments in digital infrastructure, artificial intelligence, and smart manufacturing, which are the basis of smart logistics systems. Such leadership is aligned with the fact that the country is already accelerating its transition to Industry 4.0 technologies and fact that it cares about intelligent supply chain innovation in the most important industries.

In the wake of China, India, the United States, Saudi Arabia, South Korea and Australia, are also producing moderate amounts of scholarly work, which has shown a more diverse but skewed international interest in smart logistics research. The involvement of such countries as Saudi Arabia and the United Arab Emirates points to the increased attention to digitalization in logistics among the Gulf economies. European input seems relatively small in the dataset though such countries as Italy and the United Kingdom have a stable research representation. In general, the distribution implies that the interest of smart logistics is mostly led by the Asian economies where the accelerating industrialization, urbanization, and high density logistics systems provide ample reasons to pursue using smart and automated systems (Xu et al., 2018; Queiroz et al., 2020; Ivanov, 2020).

Figure 3. Geographic Distribution of Scientific Production

Documents by country/territory



Source: Scopus

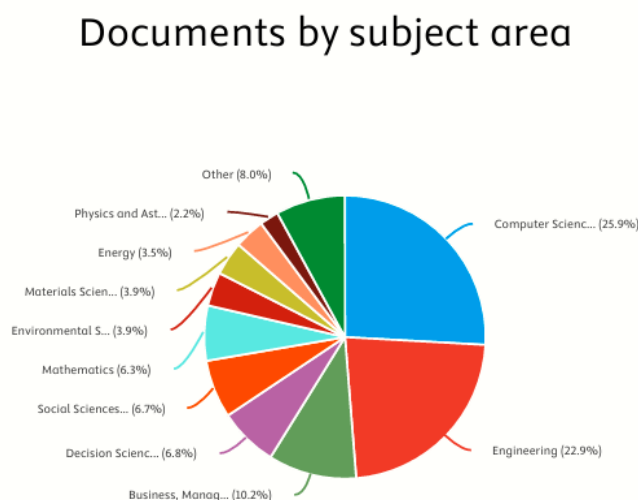
This geographic concentration is consistent with the theoretical observation in Section 2.1 that the adoption of Industry 4.0 technologies in logistics is closely linked to national investment strategies in digital infrastructure and smart manufacturing (Xu et al., 2018).

4.4. Subject Area Distribution of Publications

The subject area analysis shows that studies of smart logistics are mostly focused on the field of computer science and engineering, which actively comprise almost 50 percent of the overall scientific workload. Such a powerful representation agrees with the fact that smart logistics is a technologically-intensive sector, which is ultimately propelled by digital systems, automation, artificial intelligence, and data engineering. Computer science which has the largest share would provide algorithms, architecture and computing models that facilitate intelligent decision making and optimization of real time logistics processes.

The inclusion of business, management and decision sciences points to the emergence of a managerial and strategic outlook where researchers inquire about the implications of performance, efficiency in operations and change in an organisation. A smaller but notable portion is also made up of social sciences and environmental sciences, which indicate the increased focus on sustainability, human centricity, and socio technical side of logistics systems. The interdisciplinary character of the smart logistics field is evidenced by the contributions of other fields like energy, materials science, and mathematics (Wamba et al., 2017; Xu et al., 2018; Ren et al., 2021).

Figure 4. Subject Area Distribution of Publications



Source: Scopus

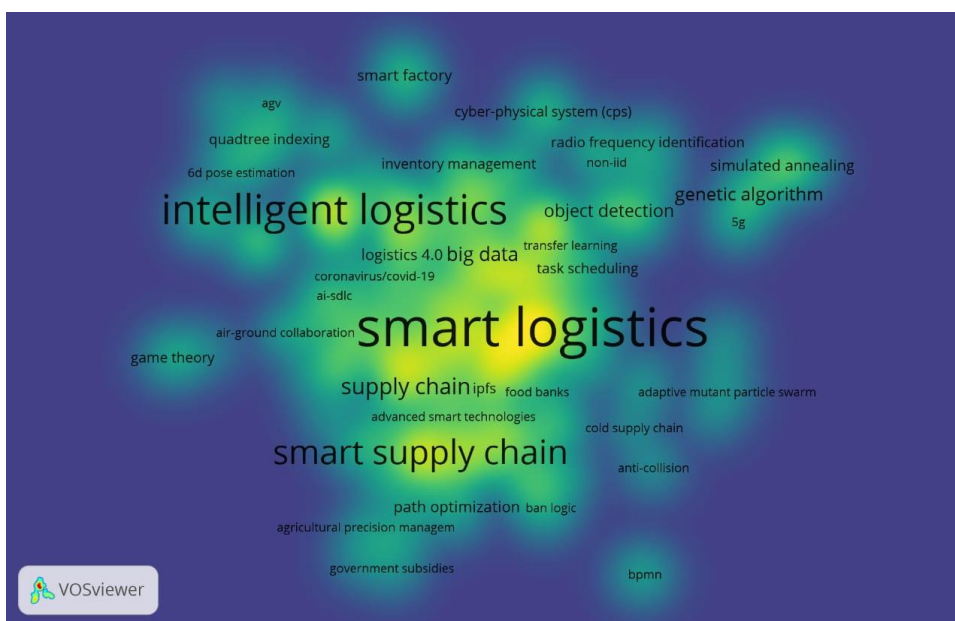
The growing presence of environmental and social sciences in the corpus reflects the theoretical shift described in Section 2.2, where sustainable development, green logistics, and social responsibility are increasingly recognized as strategic dimensions of modern supply chain management (Ahi and Searcy, 2015 ; Carter and Rogers, 2008).

4.5. Keyword Co-Occurrence Network and Thematic Structure of the Field

The intellectual map and thematic clusters of the present research in smart logistics can be determined using the keyword co-occurrence map created by VOSviewer. The fact that the terms smart logistics, smart supply chain, and intelligent logistics are positioned in the middle of the list means that they are the main conceptual pivots of the discipline. The fact that they co-occur so frequently is indicative of the increased overlap between logistics digitalization and supply chain intelligence, where the focus is on the transitioning of the traditional operational model in favor of the systems that are data driven, automated, and interconnected.

A significant area of cluster is associated with digital technologies, including cyber physical systems, radio frequency identification, detecting objects, 5G connectivity, and big data analytics. The other cluster revolves around the optimization and algorithmic methods, where words such as genetic algorithm, adaptive particle swarm, game theory and task scheduling support the usefulness of mathematical modeling and artificial intelligence in enhancing performance and responsiveness of logistics. In general, the keyword network illustrates an interdisciplinary and technologically advanced research area that combines digital innovation, optimization strategies, and the application of the sector (Wamba et al., 2017; Ren et al., 2021; Xu et al., 2018).

Figure 5. Co-Occurrence Map of Author Keywords in Smart Logistics Studies



Source: Vosviewer

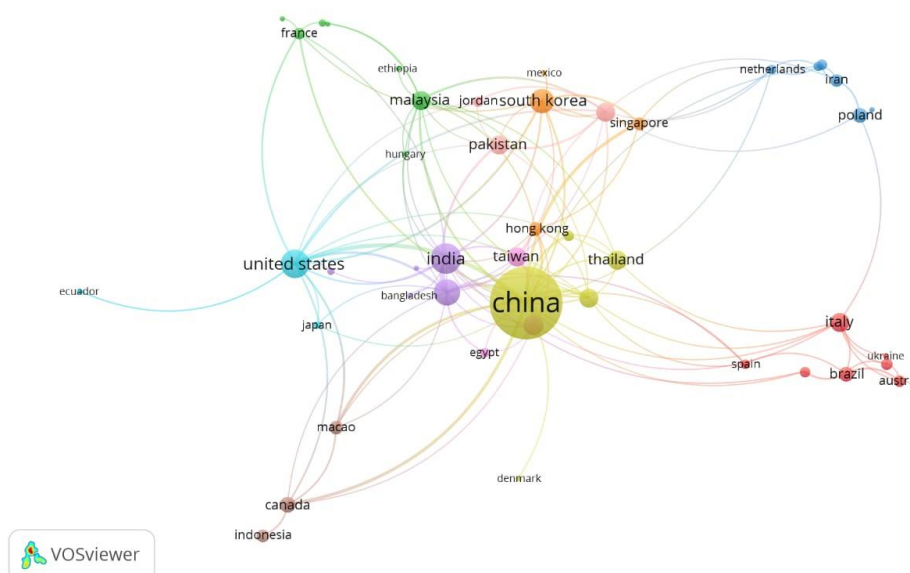
These thematic clusters directly validate the conceptual framework developed in Section 2, confirming that the research field is organized around the same technological and sustainability pillars identified in the theoretical review (Ben-Daya et al., 2019 ; Kamble et al., 2023).

4.6. International Collaboration Network in Smart Logistics Research

The map of the international collaboration reveals a very well-interconnected world of research in which China is the central hub that is over-powering. The high centrality of China shows that it not only leads in the production of research but also on the international scientific collaborations with other countries, more so those in the Asian continent like Malaysia, Thailand, South Korea, Taiwan and Pakistan. This concentration map depicts the concentration of the research activity in the area of Industry 4.0 technologies, logistics digitalization, and smart supply chain innovation.

The other two cross-linked hubs are India and the United States. India has close and active cooperation with Bangladesh, Japan, and the United States, which indicates the emergence of increased integration into the scientific networks of the world with an orientation towards the digital transformation of logistics. European nations such as Italy, Poland, Spain, Netherlands as well as France are smaller yet consistent groupings. The pattern of this network proves that the production of science in this field is not just technologically oriented, but it is distributed on the global scale (Xu et al., 2018; Queiroz et al., 2020; Ivanov, 2020).

Figure 6. International Co-Authorship Network in Smart Logistics Research



Source: Vosviewer

This collaborative structure reflects the globalized nature of smart logistics innovation described in the theoretical framework, where cross-border knowledge flows and institutional

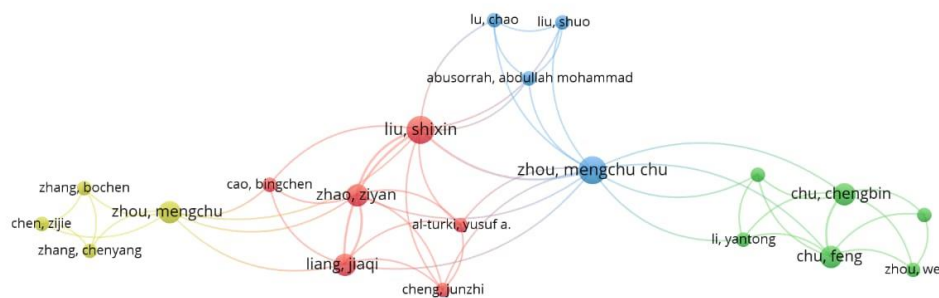
partnerships are essential to advancing digitalization and sustainability in supply chains (Queiroz et al., 2020).

4.7. Co-Authorship Network and Leading Research Groups

The network of co-authors offers the emphasis on the framework of scientific cooperation in the sphere of smart logistics that demonstrates the presence of multiple research groups being interconnected and at the same time dominated by the main authors. Zhou Mengchu is the biggest and most central node and he is seen as the linking point between several research groups. It has centrality which means that it has a high level of scholarly influence and active participation in collaborative research in the fields of logistics automation, cyber-physical systems and intelligent supply chain solutions.

This central cluster is closely connected with another well-known and very influential writer Liu Shixin that is a member of a close-knit network of collaboration that spreads to other co-authors including Zhao Ziyang, Cao Bochen, and Liang Jiaqi. This implies that there is a team that is coherent in terms of algorithm optimization, smart warehousing, and intelligent decision-making models. Another cluster appears around Li Yalong, Chu Chengbin, and Zhou Wei. On the whole, the co-authorship map indicates a very cooperative research environment with a small number of prominent researchers holding an intellectual role of connecting research groups (Xu et al., 2018; Ren et al., 2021).

Figure 7. Co-Authorship Network of Leading Authors in Smart Logistics Research



Source: Vosviewer

The concentration of intellectual influence around a small number of central authors mirrors the early-stage dynamics of an emerging research field, consistent with the theoretical observation that Industry 5.0 frameworks in logistics remain underdeveloped and in need of broader scholarly engagement (Kamble et al., 2023 ; Demir et al., 2023).

4.8. Full Keyword Co-Occurrence Network: Thematic Constellations in Smart Logistics Research

The entire keyword co-occurrence network presents a highly connected and rich thematic space, which is multidisciplinary in nature of smart logistics. A number of large clusters can be identified which belong to the specific research streams but which, on the whole, reveal the conceptual framework of the field.

Cluster 1: Intelligent Logistics, Internet of Things and Real-Time Systems (Yellow-green Zone)

The central node of the network is a high-profile cluster, which includes Internet of Things, logistics, intelligent logistics, and real-time systems. This cluster is the technological foundation of smart logistics, where the IoT connectivity, sensor networks, and cyber-physical systems are important to provide the possibility to monitor in real-time, gather data, and integrate systems. The use of the terms digital storage, authentication, security and privacy, and network security demonstrates that cybersecurity is a more significant element of IoT-enabled logistics (Xu et al., 2018; Ren et al., 2021).

Cluster 2: Deep Learning, Autonomous Systems, and Machine Learning (Red Zone)

A second significant cluster is dominated by deep learning, learning systems, feature extraction, mobile robots and automatic guided vehicles. The field is the AI-driven development of smart logistics, machine learning, and computer vision algorithms will be used to improve perception, decision-making, and autonomous actions. Keywords like path planning, kernel methods, object recognition, and tracking are some examples of the incorporation of intelligent algorithms into the robots, specifically to automate warehouses and autonomous transport vehicles.

Cluster 3: Decision-Making, Optimization, and Supply Chain Models (Blue Zone)

The other highly concentrated area is around decision making, optimisation, planning, scheduling, numerical models, and transportation system. The relevance of mathematical optimization, simulation models and the use of heuristics (including ant colony optimization) in resolving complex logistics issues, is shown through this methodological cluster. Multi-criteria decision-making and optimising supply chains indicate that there has been a new interest in the application of integrated models, which incorporate performance, sustainability, and resilience.

Taken together, the five thematic clusters identified in this network provide strong empirical support for the theoretical framework outlined in Section 2, demonstrating that smart logistics research is progressively incorporating sustainability, circularity, and human-centric dimensions in alignment with the Industry 5.0 paradigm (European Commission, 2021 ; Kirchherr et al., 2017).

5. Discussion

The bibliometric results presented in this study offer a comprehensive picture of the intellectual evolution of smart logistics research and its progressive alignment with sustainability and Industry 5.0 principles. The rapid growth in annual scientific production, particularly after 2020, confirms the theoretical framing established in Section 2, where the convergence of digital disruption and global supply chain vulnerabilities was identified as a key driver of academic interest (Ivanov, 2020 ; Queiroz et al., 2020).

The dominance of computer science and engineering in the subject area distribution is consistent with the technological infrastructure described in Section 2.1, where IoT, artificial intelligence, robotics, and big data analytics constitute the foundational pillars of smart logistics systems. The keyword co-occurrence network further validates this theoretical structure, as Cluster 1 and Cluster 2 directly mirror the digital and autonomous technologies discussed in the framework (Ben-Daya et al., 2019 ; Baryannis et al., 2019).

More importantly, the emergence of Cluster 5, centered on sustainable development, circular economy, reverse logistics, and Industry 5.0, provides empirical confirmation that the academic community is progressively integrating the dimensions outlined in Section 2.2. This finding aligns with the sustainability framework of Kirchherr et al. (2017) and the human-centric paradigm introduced by the European Commission (2021), suggesting that the transition from efficiency-driven to value-driven logistics is already underway in the scientific discourse.

The geographic and collaboration patterns reveal that this transition remains unevenly distributed, with Asian economies, particularly China, leading both in research volume and international partnerships. This concentration raises questions about the generalizability of findings to Western and emerging market contexts, where regulatory frameworks, labor conditions, and infrastructure readiness may produce different adoption trajectories (Xu et al., 2018 ; Kamble et al., 2023).

Overall, the results suggest that while Industry 4.0 technologies continue to dominate the research agenda, the seeds of a more sustainable and human-centered logistics paradigm are clearly visible in the literature. The gap between technological sophistication and sustainability

integration represents both a limitation of current research and a promising avenue for future theoretical development.

Table 3. Summary of Key Bibliometric Findings in Smart Logistics Research (2025-2025)

Analysed dimension	Main finding
Scientific production	Strong growth since 2020, peak in 2025
Document types	94.7% research articles, 5.3% reviews
Leading country	China
Dominant subject areas	Computer science + engineering
Emerging cluster	Sustainability
Most central author	Zhou Mengchu

Source: Author's own elaboration

6. Conclusion

This bibliometric study maps the intellectual landscape of smart logistics research between 2015 and 2025, revealing a field in rapid expansion and progressive thematic diversification. The analysis confirms that while technological innovation remains the dominant research driver, sustainability, circularity, and human-centricity are emerging as structuring dimensions of the field, consistent with the principles of Industry 5.0.

The findings contribute to the theoretical consolidation of a fragmented research area by identifying five major thematic clusters and highlighting the growing convergence between digital transformation and sustainable logistics frameworks. For practitioners and policymakers, the results underscore the strategic importance of aligning logistical investments with long-term environmental and social objectives, rather than pursuing efficiency gains in isolation.

Future research should address the underrepresentation of qualitative and case-based approaches in the corpus, the limited geographic diversity of collaboration networks, and the need for integrative frameworks that operationalize Industry 5.0 principles within real-world supply chain environments.

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