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The Evolution of Digital Logistics: A Bibliometric Analysis of Research Frontiers

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Abstract. *The logistics industry turns digital across the whole world and places supply chain management, operational efficiency, and business strategies under a new light. Artificial intelligence, blockchain, cloud computing, and automation spring upward as new technology solutions supporting previously unimagined changes in logistics with visibility in times of real life and threats as well. The upsurge of smart logistics solutions by different industries has promoted the need to adopt the digital processes together with the security, sustainability, and regulatory aspects. Though there has been a growing body of research on this emerging area, it needs a structured review to assess its progress to understand its evolution and future directions. This paper shall account for the digital logistics research evolution in the context of the influences of technological change on strategic priorities for business and policymaking spheres. Where previous analyses centered on automation and process perspectives, new studies now academically manifest related aspects concerning the network of systems and aspects of security vulnerability, as well as the aspect of logistics sustainability. Data-based decision-making into the future of logistics, with a corollary in predictive analytics and a circular economy framework, is more and more where things are heading-aligned to global sustainability objectives. Much progress though has to be made in striking a balance between innovations and regulations, risk management, and leveling the ground as regards access to digital infrastructure. This study contributes to the field with an integrated presentation of how logistics transform in the digital age. It is for this that the implications for business, policy, and future scholars remain valid with changes toward more technology-considering landscapes yet resilient, ethical, and sustainable in the long run with their respect for the operation of logistics.*

Keywords: Digital Logistics, Industry 4.0, Smart Supply Chains, Sustainability in Logistics, Technological Innovation.

Introduction

Digital logistics is not just another step for logistics — it's more about the transformation from the analog, linear systems into the advanced, digitally networked systems. This transformation changes not only the surface but also the very nature of structuring and managing logistics operations (Christopher, 2016).

[1] *This paper was co-financed by The Bucharest University of Economic Studies during the PhD program*

DOI: 10.2478/picbe-2025-308

An integral part of this transmutation is an instant amalgamation of cutting-edge-plus effortless technology that is capable of not only the Internet of Things but also artificial intelligence, blockchain, and cloud computing because only real-time acquisition and processing of data will ensure the ability to effectively manage the dynamic movement of modern supply chains. IoT device deployment, across logistics networks, spills for the first time, and visibility into levels of inventory, conditions during transit, and utilization of an asset. Such at least somewhat improved transparency supports, or rather supports continuous monitoring with, a responsive ability to implement disruptions, sometimes greatly improved efficiency of operations (Waller & Fawcett, 2013).The machine learning algorithms and predictive analytics techniques of AI help in expressing logistics as intelligent decision-making. Here, apart from optimizing routing and scheduling, these tools even raise the capabilities further to anticipate fluctuations in demand and the lessening of risks associated with supply chain uncertainties (Kache & Seuring, 2017).

It, therefore, maintains the contribution of blockchain technology toward the rob of digital logistics by maintaining data integrity and the security of transactions. Since its framework is decentralized, the risks of data being tampered with and fraud occur at a minimum level, augmenting more trust among supply chain partners (Queiroz & Wamba, 2019). It further increases these capabilities by scalable data storage and processing power through cloud computing. Such a technological foundation supports all differences in data sources, which is required to acquire a complete view of logistics operations for strategic planning and resource management (Waller & Fawcett, 2013).

This digital technology convergence has birthed an agile and resilient logistics ecosystem. In principle, it allows the adaptation of supply chains to rapidly changing market dynamics, as well as external shocks emanating from geopolitical disturbances, or global pandemics (Ivanov & Dolgui, 2020). It results in enhanced efficiency, cost dilution as well as improvement in service quality through automation. Which used to be manual, laborious, and inclined to errors are not only much faster but in the long term drive substantial productivity increases across the industry (Christopher, 2016).

The strategic effects of digital logistics are also deep. Through insights, driven by data, enterprises can then perfect their business models, increase customer satisfaction, and seal a competitive advantage in ever-more-volatile markets. This is because digital logistics enables the data that will feed strategic decision-making processes identifying break-even points and key customer satisfaction drivers. This is what will unveil the strategic implications of digital logistics. These and other digital solutions will further save energy and natural resources, helping to again maintain the optimization circle of logistics activities. Such solutions typically entail more energy consumption in their development and installation than that spent on the optimization of logistics, and digital logistics meant to bring some major benefits have not yet played its card. This shall depend on the successful integration of such systems into a productive and sustainable business, only possible with the right quality management within international standards (Marin et al., 2013). Even though it has brought in transformations, the integration of digital technology in logistics introduces what is perhaps the most complex challenge. Indeed, there are serious barriers unless and until that integrity can be assured on a systemic basis looking forward to digital supply chains: strong regulatory frameworks, adequate data privacy, and cybersecurity risks (Büyüközkan & Göçer, 2018).

This paper is organized as follows. The next section is an extensive review of the literature that focuses on digital logistics and the transformative impacts of emerging technologies on supply chain. Section 3 goes into the details of the research methodology and the analytical framework

that has been employed in this study. Section 4, then, provides the results and a comprehensive discussion of those results concerning what is happening in current industry practices. The last section sums up the paper with a synthesis of the key insights, implications for academia and practice, and directions for further research.

Literature review

Academic interest in digital logistics evolution has swelled on account of its active role in changing supply chain management, strategic business models, and operational effectiveness. AI, blockchain, IoT, big data analytics, and cloud computing have redrawn real breathing into logistics functions through the exploitation of real-time tracking, predictive automation, and decision-making capabilities. Acceleration in the gain of ground digital logistics further results, as there is also a growing push for agility and efficiency in contemporary supply chains leading firms to turn towards innovative treatments with technology to keep competitive edges.

Technologies of Industry 4.0 have caused highly automated and data-centric supply chain networks to become connected and transparent (Winkelhaus & Grosse, 2020). Demand forecasting, inventory optimization, and route planning have greatly improved through AI analytics which reduces the cost of operations and increases the level of service (Nguyen et al., 2021). Real-time data access and predictive analytics is facilitated through big data and cloud-based logistics platforms for companies to herald disruptions ad maintain resilience within their supply chains (Ben-Daya et al., 2019).

Blockchain technology has turned out as only one single powerful innovation within logistics and has ensured secure and transparent management of data sharing among partners within a supply chain. Blockchain greatly abates risks concerning fraud, the use of assets to generate counterfeited goods, and inefficacious methods of keeping records since it operates from decentralized ledgers (Păcuraru-Ionescu & Hoinaru, 2024). Logistic applications for cross-border trade have been enhanced; smart contracts can run while providing full traceability of items between the point of origin and destination (Hald & Kinra, 2019). Such implementations of logistics-based blockchains increased trust between parties, lowered transaction costs, and also bettered overall supply chain performance (Queiroz et al., 2019).

IoT technologies have been driving change in the logistics sector through the provision of monitoring features of shipments in real-time movement, warehouse management, and asset location. Smart sensors and IoT devices carry the information that can dramatically boost the visibility of the supply chain by providing information about the cargo condition, transportation route, and fleet barely in time (Jabbar et al., 2021). These technologies do not just manage logistics but also support the minimization of waste and energy consumption in a business and management practice, sustaining the green delivery supply chain movement in effect (Kayikci, 2018). The combination of IoT applications with AI-driven analytics empowers companies to be anticipatory in their responses to unanticipated disruptions and drives the development of streamlined decision-making interventions (Nguyen et al., 2021). In digital supply chains, the economic balance is shifting towards environmental concerns by more effective carbon management. Green pressures indirectly include consumer requirements—often not quantifiable but no less important—require new logistics solutions on the one hand and regulatory pressures on the other side. Robust green solutions include electric fleets, circular supply chains, and alternative fuels. In practice, resource preservative logistics has become part of an enabling company. The logistics network can use artificial intelligence and predictive analytics for transportation optimization with environment emissions minimized, making it sustainable and economic.

The digitalization of the supply chain brings another dimension to challenges under cybersecurity, data privacy, and compliance. As companies shift toward more digital logistics, it also means that they are more exposed to threats on cyberspace, which may break into their IT systems, disrupt operations, and sometimes lead to financial loss (Ivanov et al., 2022). In the meantime, governments and international organizations are trying to come up with regulatory frameworks to rein in these risks. Firms have to make sure to secure their logistics infrastructure against cybersecurity attacks as well (Hald & Kinra, 2019).

One more burgeoning research area that has emerged in digital logistics is the role of digital twins and cyber-physical logistics systems. In fact, digital twins need to be understood as an emulation of the logistics network in a virtual environment. They allow a company to simulate its supply chain operations, testing different optimization approaches long before real implementation takes place (Ivanov et al., 2022). With this technology in place, combined with AI and big data analytics, companies can make more informed decisions while eliminating inefficiencies and building long-term supply chains resilience (Winkelhaus & Grosse, 2020). Automation in logistics has brought forth autonomous systems such as self-driving delivery vehicles, drones, and robotic warehouse operations. Autonomous logistics solutions lower the extent of human involvement, increasingly increase efficiency while reducing operational costs, however, their full-scale real-world implementation requires further AI advances, as well as improvements in the domain-specific robotics and proper regulatory frameworks (Jabbar et al., 2021). The future development of logistics will rely on much closer integration with automation, which will itself rely heavily on AI optimization tools to coordinate everything in the supply chain in a most efficient and seamless way (Ben-Daya et al., 2019).

The most recent bibliometric studies have identified rapid development in the field of digital logistics research, increasingly noting interdisciplinary collaboration with AI, blockchain, IoT, and sustainability studies. Academic papers published at increasing rates about digital logistics and related grades might prove relevance through topic resonance not only in practice but also within the domain of academia, thereby also pointing to the promising avenues of research in predictive logistics, cyber-physical systems, and modeling adaptive supply chains (Ivanov et al., 2019). The continual evolution of logistics into a fully transformed digitalized environment brings very interesting opportunities and challenges at the same time. AI, blockchain, IoT, and big data are reshaping the industrial landscape, more research is needed to look into the long-ranged effects of these drivers on the resilience of the supply chain, workforce adaptation, and country-wise trade policies" (Winkelhaus & Grosse, 2020). The future of digital logistics is mirrored by escalated automation blended with environmental consciousness and real-time analytics to fuel the industry towards responsive and agile supply chains, and this is what "highlights" the discussion by Nguyen et al. (2021).

Methodology

The study uses bibliometric indicators to spot highly productive authors, source titles, documents, and organizations in the field of digital logistics' study material available from 2000 to 2024. In order to establish research trends and visualize key terminologies within the field of digital logistics, we conducted a study of 6,158 scientific publications culled from the WoS database by means of VOSviewer software.

The study is performed mainly by applying bibliometric analysis, which is a quantitative research method of studying the patterns and relationships within academic literature through analysis of the bibliographical metadata. Bibliometric analysis has recently triggered immense

interest as a means of grasping knowledge structures and research trends (Almajali et al., 2022; Al-Okaily et al., 2021). The paper is centered on digital logistics because it is relatively more important in modern supply chain management and because it encompasses issues of supply chain management implementation at the same time in regards to technological progress. The following search query was applied to obtain relevant publications from the WoS database.

Digital logistics, smart logistics, logistics 4.0, logistics digitalization, digital supply chain, supply chain 4.0, artificial intelligence in logistics, blockchain applications in logistics, Internet of Things in logistics, big data analytics in logistics, cloud-based logistics, autonomous logistics systems, robotics-driven logistics, cyber-physical systems in logistics, electronic logistics (e-logistics), digital freight management, logistics and digital transformation, predictive analytics in logistics, automated logistics solutions, real-time logistics optimization, digital twin technology in logistics, intelligent logistics solutions, logistics process automation, data-driven decision-making in logistics

The extracted dataset was analyzed using VOSviewer, a software tool designed for constructing and visualizing bibliometric networks. For analyzing potential sets of clustered data, VOSviewer is capable of running and displaying both co-citation and bibliographic coupling, besides co-authorship. Such an approach may help the user delve into the research trends and topical developments on digital logistics. It was also applied in the study to apply techniques of overlay visualization to check on the temporal evolution of digital logistics research up to a time limit of 2000-2024 to have a full view of the changes that digital logistics has undergone over time. This diagnostic approach exposed the scientific research frontiers and which made the older research themes, such as RFID and early digital supply chains, differ from the new ones, among them being AI-driven logistics, applications of blockchain, digital twins, and cyber-physical systems. Additionally, we also applied normalization techniques in VOSviewer, like "subtract mean," so that it can increase contrast, and thus make the interpretation of keyword relationships better. This transformation enables us to call attention in a more effective way about changes in research focus.

The paper presents a contribution to the effect that the digital transformation of logistics and supply chain research has taken over the last two decades, describing the technological evolutions that shape the field. By mapping the main research clusters and highly cited works, as well as tracking the temporal evolution of digital logistics research, the study establishes a foundation upon which future research may develop, with direct industry applications. It would be appropriate to discuss the results of this study in relation to economic and managerial implications of digital logistics innovations. This will then position that study within broader discussions on digital transformation and supply chain efficiency.

Results and discussions

Figure 1 illustrates the academic trend in digital logistics research from 2000 to 2024, gradually accelerating the number of publications made over the years. The recent years of the first decade (2000-2010) show a relatively slow but uniform increase which indicates initial probing of digital logistics notions. A distinct peak centered around 2008-2010 indicates a very early burst of interest, perhaps spurned by the appearance of technologies such as RFID, cloud computing, and very early AI applications in supply chain management. This was followed by some minor swoop; this probably is the period of technological adoption lag between industry skepticism and ultimate adoption.

Exponential growth trends emerge from 2015 onwards, with a sudden surge in publication post-2020. This escalation is precipitated by the surge in AI, blockchain, IoT, big data analytics, as well as COVID-19 disruption in the global supply chains which also increased the demand for research, particularly in the area of digital resilience and automation in logistics. The peak in 2023-2024 proves beyond a reasonable doubt that digital logistics is one of the main themes of research these days, interposing, as it does, technology-innovation-based sustainability and strategic supply chain transformation. This trend maintains that digital logistics will be a mainstay within academia and industry over the next decade.

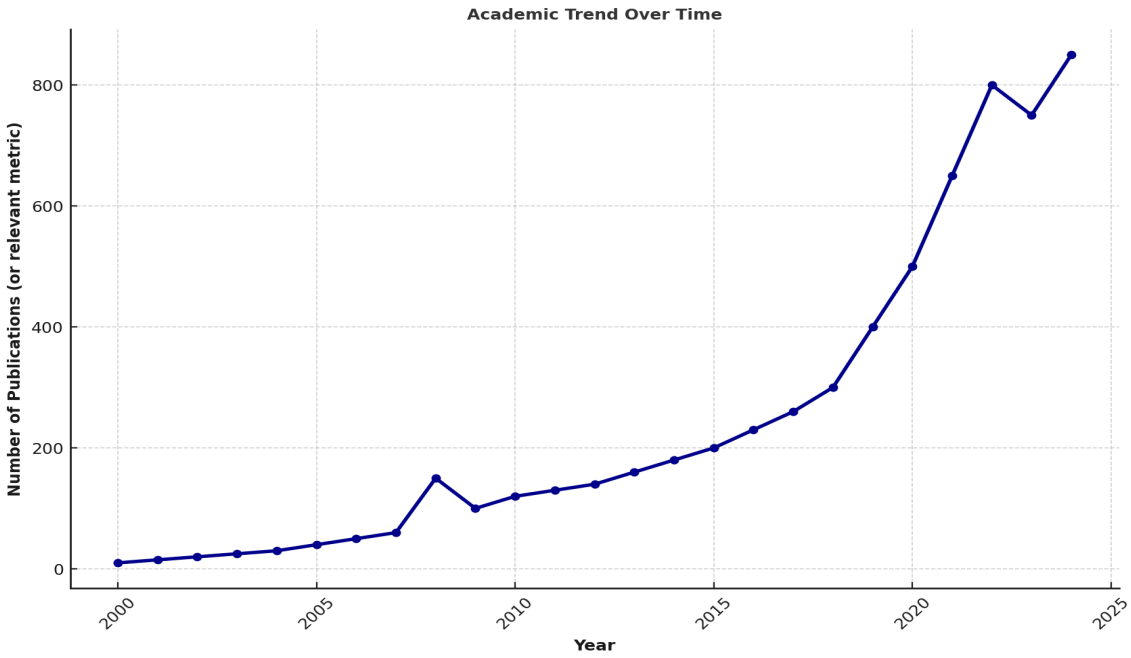

Figure 1. The Evolution of Digital Logistics Research: A Longitudinal Analysis of Scholarly Publications (2000-2024)

Source: Own computation based on the WebOfScience database.

This network visualization shows the development of major themes of research in digital logistics and how they are related to each other. VOSviewer was used to map this bibliometric analysis involving 6,158 scientific publications from the Web of Science database. Very clear clusters emerged where each of them represents major areas in digital logistics. The visualization quite clearly shows the trend from simple models to logisticians embracing AI-driven sustainable, data-centric models of logistics.

As is shown in Figure 2, the red cluster is concerning mainly optimization models and algorithmic solutions, which relates to network design, vehicle routing problems, and demand forecasting; machine learning, heuristic optimization, and reinforcement learning indicate that AI is increasingly used to improve the optimization of logistics. The green cluster relates to Industry 4.0, digital supply chains, and sustainability, with the former including blockchain, big data analytics, and the latter discussing the framework for the circular economy. This indicates an increasing interest in greener and more resourceful logistics solutions, supported by the possibility of real-time information exchange and secure digital transactions.

The blue cluster circles competition and strategic management and centers it on supply chain risk. The courses are game theory and principles of pricing, uncertainty management to also explain how digitalization reshapes market competitions and logistics decision-making when based on information shared in class. Similarly, the purple cluster would highlight Internet of Things (IoT) with cloud computing and digital twins, as advances enable real-time tracking plus warehouse automation and predictive maintenance in logistics-related situations.

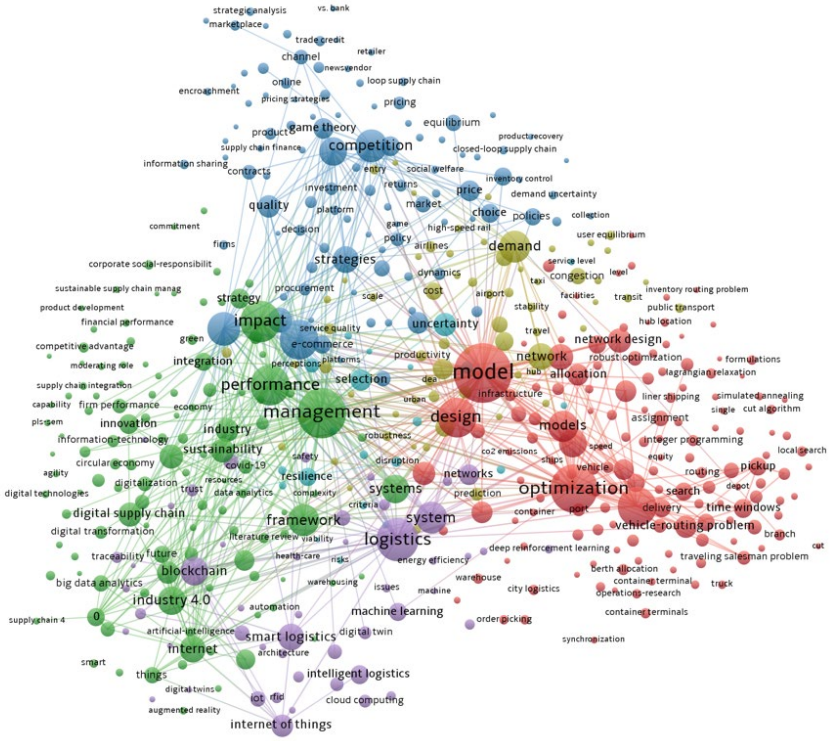

Figure 2. Network Visualization of Digital Logistics Research (2000-2024): Thematic Clusters and Research Interconnections

Source: Own computation using VOSviewer.

Table 1 presents the principal research groupings in digital logistics, pinpointing the major thematic areas, related keywords, and the weight they carry in academic writing. This table conducts a preview of the leading avenues of study, with some of the factors being supply chain optimization plus such technological racehorses as Blockchain and AI, attendant sustainability efforts, and strategic management dormant within logistics.

Table 1. Key Research Clusters in Digital Logistics: Themes, Keywords, and Significance

Cluster	Main Keywords	Key research Themes	Significance
Sustainability & Performance	sustainability, resilience, performance, management, supply chain integration	Focuses on sustainable logistics practices, resilience in supply chains, and efficiency improvements.	Highlights the shift towards environmentally conscious logistics and performance-driven strategies.
Technological Innovation	artificial intelligence, blockchain, IoT, big data analytics, smart logistics	Explores the role of emerging technologies in optimizing logistics and automating supply chain operations.	Demonstrates how digital transformation reshapes logistics through AI-driven decision-making and real-time analytics.

Cluster	Main Keywords	Key research Themes	Significance
Optimization & Algorithms	optimization, vehicle routing, network design, allocation, simulation	Covers mathematical models and algorithmic solutions for logistics optimization and transportation efficiency.	Underlines the importance of computational methods for improving routing, scheduling, and overall logistics management.
Strategic Management & Competition	competition, strategy, pricing, market dynamics, game theory	Analyzes strategic approaches in logistics, pricing models, and competitive dynamics.	Provides insights into how logistics firms adapt strategies to market shifts and competitive pressures.
Digital Supply Chain & Industry 4.0	digital supply chain, logistics 4.0, internet, cloud computing, digital twin	Discusses the integration of digital tools, smart infrastructure, and connected logistics ecosystems.	Highlights the role of Industry 4.0 in fostering end-to-end visibility and data-driven supply chain operations.

Source:Own computation based on Figure 1.

The figure 3 shows the developed landscape of digital logistics research from 2016 to 2022. The color changes from blue to yellow, going through green, would be reflecting the different foci over time on such emerging topics as AI, blockchain, and automation. The increasing density of nodes is indicative of growing interest in digital transformation within logistics.

In recent years, nodes are increasingly in hyper-connection, spotlighting an aggregation of sustainability, resilience, and smart logistics as principal concerns. Terms that have since come into being concerning CO_2 emissions, energy efficiency, and the digital integration of supply chains show that contemporary logistics research not only keeps moving forward technologically but also is brought to bear on global challenges, such as climate change and operational resilience. The heightened interlinkages among blockchain, cloud computing, and smart logistics further underscore the increased complexity and interdisciplinarity of research in the digital logistics field. It is within this context that the above findings confirm the fact that logistics is shifting from static, cost-through strategies of managing the supply chain to dynamic, technology-driven solutions that sustain the management of the supply chain and guarantee sustainability, resiliency, and efficiency.

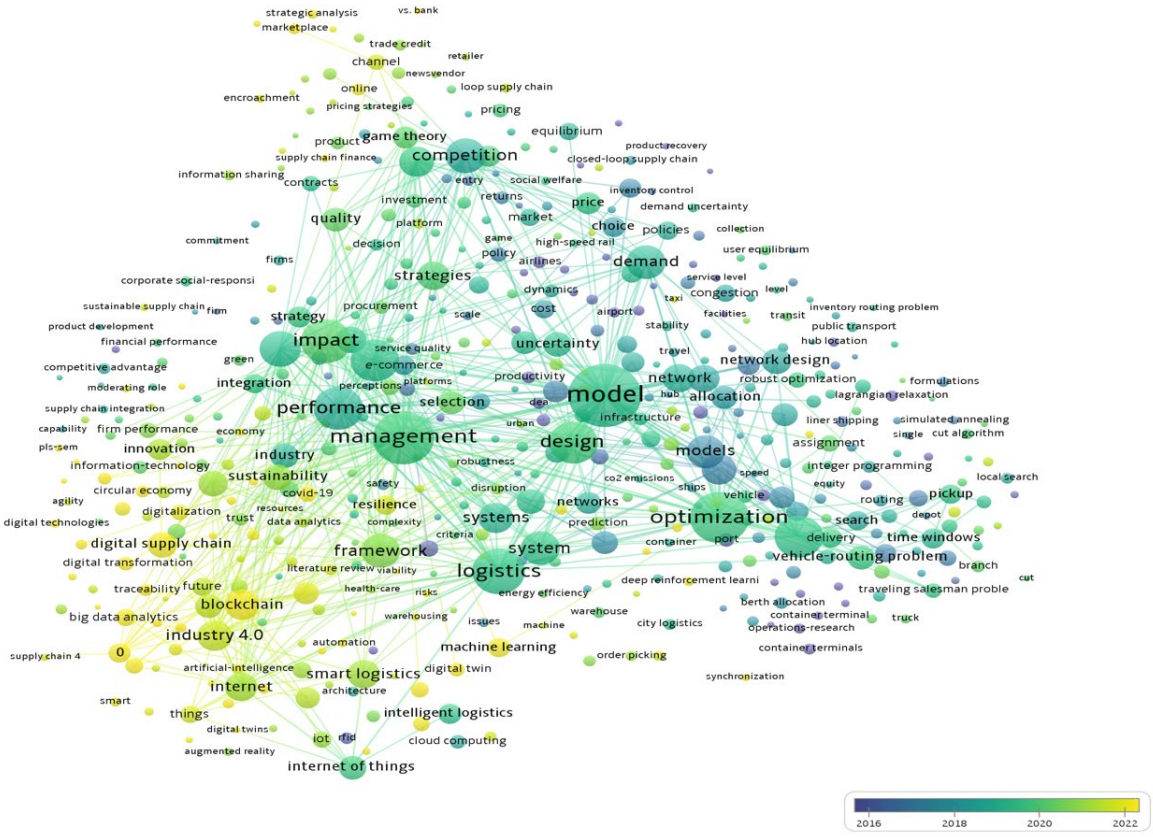

Figure 3. Evolution of Digital Logistics Research (2016-2022): Emerging Trends and Technological Shifts

Source: Own computation using VOSviewer.

The visualization from Figure 4 give us an appropriately normalized view across what has gone as the research landscape in digital logistics within the interval between 2016 and 2022. Dynamic overlay over the map that has been generated now would highlight the relative importance of research themes, hence distinguishing more precisely between emerging and well-established topics. Nodes colored with green and yellow represent research areas which are recently growing in significance; these, in other words, reflect strong academic interest and growing contributions. Terms like "blockchain," "digital supply chain," and "artificial intelligence" have higher word prominence reflecting their rising role in logistics digitalization and supply chain transformation.

Blue-colored nodes, on the other extreme, mean earlier well-established research themes in "management", "performance", and "optimization,", which might have sustained solid footings though never really seen the same sharp increase in corpus contributions over the last few years. This clustering structure remains as in the earlier figures: the main research pillars concerning sustainability, network design, and intelligent logistics. Normalized results ensure more informed conclusions by eliminating biases contained in raw counts of citations, thus affording a most balanced view about the academic trajectory in digital logistics.

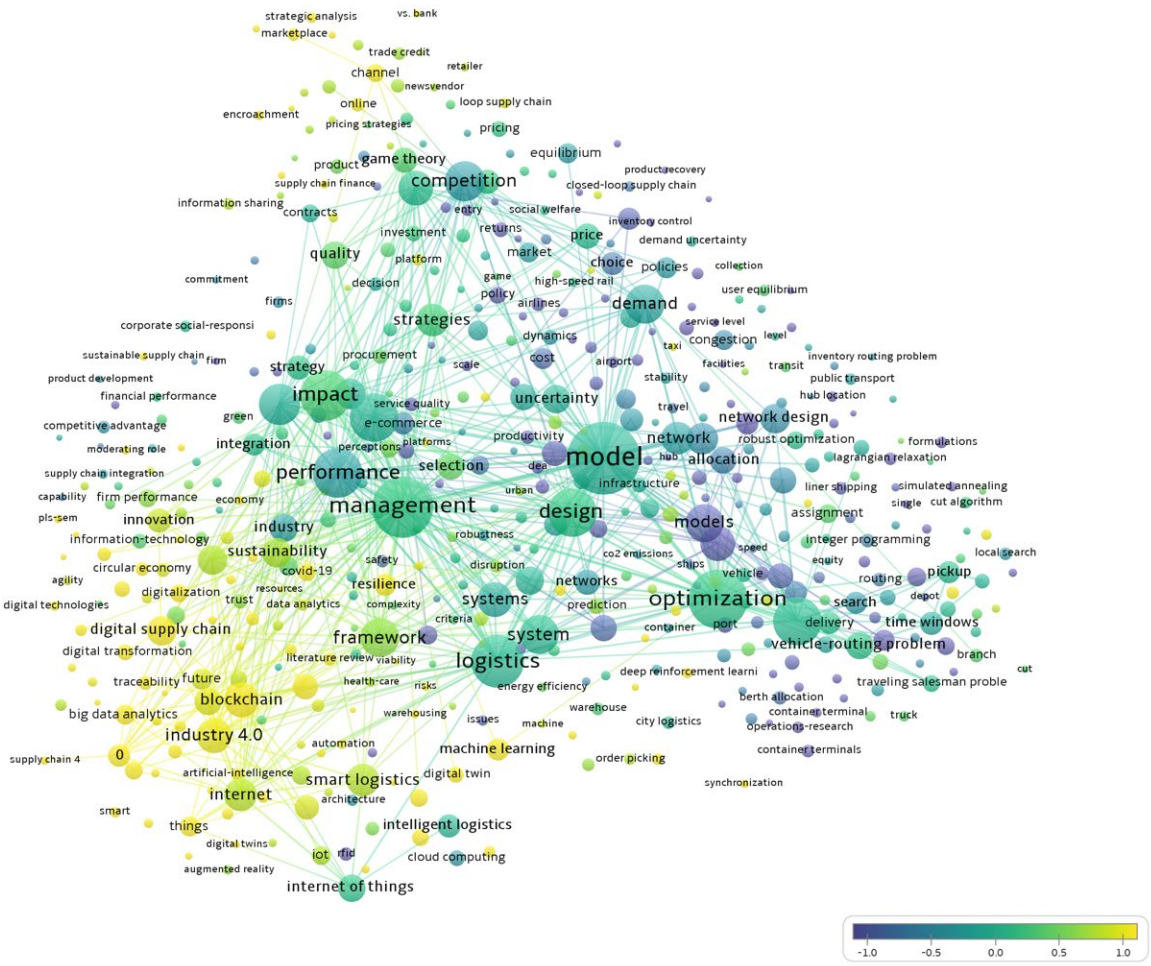

Figure 4. Normalized Evolution of Digital Logistics Research (2016-2022): Standardized Trends and Key Developments

Source: Own computation using VOSviewer.

Therefor, digital logistics bibliometrics paint a picture of a dynamic field with evolving academic interest that attracted significant attention post-2016. Driving themes in the key clusters are supply chain optimization, sustainability, smart logistics, and technological works on blockchain and AI. Overlay visualization also underlines the temporal trends and shifts the research perspectives on ever more emerging concepts, such as predictive logistics, machine learning applications, or automation, having recent origins in backgrounded notions, such as Industry 4.0 or digital supply chains. In addition, a citation-based discovery explains that topics associated with strategic management, resilience, and network optimization rank to be some of the most impactful in the field. Such results pinpoint the heightened fortification of the convergence of digital change and logistics, where enthusiasm should persist in the search for restoring efficiency, security, and sustainability in global supply chain systems.

Conclusion

The results highlight several of the major research trajectories that have characterized digital logistics. Early research was mainly concentrating on the automation of optimization networks and

algorithms, along with due consideration for cost reductions and the efficiency of operations. Since 2016, however, there has been a major shift in interest towards more complex, technology-integrated, and sustainable logistics systems. The emergence of artificial intelligence, blockchain, IoT, big data analytics, and cloud computing has created quite a different operating environment by enabling real-time tracking as well as predictive analytics. Highly automated supply chain operation comes in here as well. Overlay visualization confirmed that logistics research evolutionary transitioned from the old conventional optimization models to the AI-driven, predictive, and autonomous system, hence stating an ever-increasing emphasis on resilience, sustainability, and digital security within the supply chain management context.

One of the most important conclusions of this study is the growing interdisciplinarity of digital logistics research. The bibliometric clusters show how logistics is now related to sustainability, cybersecurity, strategic management in both operative and strategic terms, and policy frameworks: indeed, digital transformation in logistics is not only a technological change but requires systemic modifications of the supply networks. Blockchain security for logistics transactions, AI for prescriptive supply chain analytics, and IoT for monitoring are among the highest growing areas of research that draw attention to the movement in trends to data-centric logistics ecosystems. The other important aspect of the analysis is sustainable development plus regulatory compliance issues. This study should further investigate cybersecurity issues because digital platforms are becoming increasingly used in logistics business operations.

The normalization approach taken in this study would clarify the actual frame of understanding of research impact and real differences between established research areas and emerging topics. Topically, rising over the last years would certainly be green logistics, smart logistics, and digital supply chains due to the carbon emission slash and resource use optimization agendas worldwide. The incorporation of digital twins, AI-driven logistics, and autonomous systems indicates future research directions that would revolve around smart, flexible, and eco-efficient supply chain models. Other findings indicate that logistics resilience and cybersecurity are emerging as major two critical areas of research interest, especially post disturbances like the COVID-19 pandemic and geopolitical instability. These study findings can be taken up at the ground level for business strategies, policymaking changes, and future research directions. Businesses that will adopt their decisions to be AI-improved, security to be blockchain-improved, and visibility to be IoT-improved will be much better at managing the disturbances in the supply chains, the changes in the regulations, and the growing pressure of competition. Proper attention is also required of the regulators to fill in the gaps in regulation and also the cybersecurity issue that comes in parallel with the process of making the logistics digital. The all-around development has to be aligned with privacy and ethics with sustainability issues.

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