The International Maritime Transport and Logistics (MARLOG 15) - ISSN 2974-3141
http://dx.doi.org/10.21622/MARLOG.2026.15.1.73
Smart & Resilient Logistics Corridors Future Gateway to the Green Trade

DIGITAL TRANSFORMATION IN MARITIME LOGISTICS: A BIBLIOMETRIC REVIEW OF PORT MODERNIZATION, CARGO HANDLING EFFICIENCY, AND TURNAROUND OPTIMIZATION

Ahmed Omar [1], Muhammad Arfeen [2], Ahmed Mansour [3] and Aboelhassan Talat [4]

(1) College of International Transport and Logistics, Arab Academy for Science, Technology and Maritime Transport, Aswan, Egypt, dr.ahmedomar@aast.edu

(2) College of International Transport and Logistics, Arab Academy for Science, Technology and Maritime Transport, Aswan, Egypt, arfeen@aast.edu

(3) College of International Transport and Logistics, Arab Academy for Science, Technology and Maritime Transport, Aswan, Egypt, Ahmed.mansour98@adj.aast.edu

(4) College of International Transport and Logistics, Arab Academy for Science, Technology and Maritime Transport, Aswan, Egypt, aboelhassan.talat@adj.aast.edu

Keywords: Digital Transformation, Smart Ports, Port Modernization, Cargo Handling Efficiency, Turnaround Time Optimization, Bibliometric Analysis.

ABSTRACT

This study conducts a bibliometric analysis of scholarly literature on digital transformation in maritime logistics, focusing on port modernization, cargo handling efficiency, and the optimization of turnaround time. This analysis employs 74 papers from the Scopus database (2000–2025) to discern significant research trends, notable authors, collaborative networks, and emerging technologies that are shaping the future of port operations. The findings demonstrate a substantial increase in research activity post-2020, driven by the incorporation of technologies such as artificial intelligence, blockchain, automation, and decision support systems. Thematic mapping shows that there are two main groups: one focused on operations research and optimization, and the other on smart port development and systems automation. Keyword analysis also shows that people are paying more attention to sustainability, digital innovation, and performance evaluation. Asia, particularly China and South Korea, is very good at publishing, but international cooperation is still not very strong. This paper presents a framework that connects digital enablers to operational and environmental outcomes in maritime logistics. It outlines potential directions for future research, including empirical validation of technological impacts, comprehensive geographical comparisons, and the integration of ethical and cybersecurity considerations. The research provides valuable insights for academics and practitioners aiming to align port innovation with strategic performance and sustainability goals.

1. INTRODUCTION

The ocean logistics sector is undergoing significant transformation due to the increasing prevalence of digital technologies and Industry 4.0 frameworks. Digitalization has become a strategic need to enhance cargo handling efficiency, accelerate vessel turnaround times, and modernize port infrastructure in response to the expansion of international trade and the exacerbation of port congestion issues (Alavi-Borazjani et al., 2025; Li et al., 2023). Technologies such the Internet of Things (IoT), blockchain, artificial intelligence (AI), and autonomous systems are pivotal in transforming maritime operations, aiming to enhance real-time decision-making, minimize delays, and promote sustainability (Jović et al., 2022; Xue et al., 2025).

The transition from conventional port models to intelligent port ecosystems entails shifting from manual, isolated operations to integrated, linked logistics platforms. This transformation is particularly critical due to the increasing complexity of global supply chains, which demand greater speed, transparency, and environmental accountability (Paraskevas et al., 2024; Pham, 2023). Consequently, a primary objective for ports to achieve both sustainability and efficiency is the minimization of vessel turnaround time, a crucial indicator of port productivity (Gülşah & Özlem, 2022).

Despite the growing number of academic publications addressing smart ports, digital infrastructure, and maritime AI applications, there remains a lack of synthesized insight into the structure and progression of the field. Recent bibliometric studies have demonstrated that scholarly interest has surged since 2020, yet fragmented research efforts hinder the formation of a cohesive knowledge base (Zou et al., 2025). This fragmentation calls for a comprehensive bibliometric review to map the intellectual landscape, identify thematic clusters, and expose collaboration networks among researchers and institutions.

Consequently, this study undertakes a comprehensive bibliometric analysis based on data retrieved from the Scopus database spanning from 2000 to 2025 to examine the evolution of academic discourse regarding port modernization, innovations in cargo handling, and optimization of turnaround times. The review identifies emerging themes, including AI-driven decision support, automation, and blockchain-enhanced port logistics, while also highlighting discrepancies between technology adoption and measurable performance enhancements. The study seeks to present a framework that connects digital enablers to operational outcomes by visualizing these dynamics, thereby providing a strategic roadmap for researchers and port stakeholders as they navigate the forthcoming wave of maritime digital transformation.

2. METHOD

This study adopts a systematic bibliometric methodology to ensure transparency, reproducibility, and analytical rigor. The bibliographic dataset was retrieved from the Scopus database, selected due to its extensive coverage of peer-reviewed journals and conference proceedings in maritime studies, logistics, engineering, and information systems.

Bibliometric analysis is a straightforward and dependable method for managing extensive collections of documents, offering comprehensive insights into a research field and identifying emerging research trends. This study adhered to the five-step science-mapping workflow depicted in Figure 1.

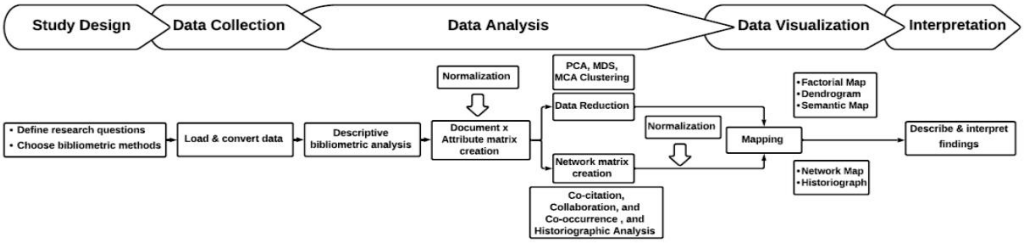

Figure 1 Methodological phases (adapted from Zupic and Čater 2015; Aria and Cuccurullo 2017)

Bibliometric data for this study was obtained from the Scopus database, recognized for its extensive collection of peer-reviewed articles in engineering, technology, and logistics. The investigation into studies examining the correlations among digital transformation, port operations, and performance enhancement employed an advanced Boolean search methodology. The final search query included significant terms such as: ("Smart port" OR "Port 4.0" OR "Port automation" ...) AND (AI OR Blockchain OR ...) AND (port OR terminal ...) AND ("Handling efficiency" OR Optimization ...) AND ("Turnaround time" OR ...). This ensured the inclusion of studies on smart technology, operational efficiency, and performance metrics in ports and terminals.

Data analysis was conducted using Biblioshiny, a component of bibliometrix R-package software. This open-source software provides a suite of tools to perform quantitative bibliometric analyses (Aria & Cuccurullo, 2017). The data were imported from the Scopus in plain-text format via Biblioshiny. For visualization purposes, conceptual structure mapping and network mapping were employed (Zupic & Čater, 2015). Biblioshiny facilitates the identification of the most influential authors, affiliations, journals, and articles. Additionally, it enables the execution of historiography, keyword analysis, three-field plots, and other related analyses.

While the final dataset consists of 74 documents, this reflects a deliberate focus on studies explicitly linking digital technologies to measurable port performance indicators. The relatively small corpus underscores the emerging nature of integrated smart port and sustainability research rather than a lack of scholarly activity.

3. RESEARCH OVERVIEW

3.1 DATA SOURCES

Table 1 Data Sources created by authors

Description	Results
Main Information	
Timespan	2000:2025
Sources (Journals, Books, etc.)	61
Documents	74
Annual Growth Rate %	8.67
Document Average Age	6.46
Average citations per doc	13.53
References	2480
Document Types	
Article	45
conference paper	27
Review	2
Document Contents	
Keywords Plus (ID)	535
Author's Keywords (DE)	259
Authors	

Authors	234
Authors of single-authored docs	12
Authors Collaboration	
Single-authored docs	12
Co-Authors per Doc	3.38
International co-authorships %	18.92

Note: Table created by the author

Table 1 shows Between 2000 and 2025, research on digital transformation in maritime logistics has gradually expanded. Across this period, 74 papers were published in 61 different journals and conference outlets. The annual growth rate sits at about 8.7%, which might not be rapid but clearly shows continued academic interest. On average, each paper received around thirteen citations and was typically about six and a half years old-old enough to attract attention, but recent enough to maintain its relevance.

A closer look reveals a strong pattern of teamwork. There were 234 authors, and most papers were written by small research groups of around three to four people. Only twelve papers were written by a single author. International collaborations appear in roughly one in five papers, demonstrating that global partnerships are forming, but there is still room for growth. The publications themselves come from 45 journal articles, 27 conference papers, and 2 reviews. That mix tells us the field is driven by applied studies yet still includes theoretical contributions. The keyword data 535 from Keywords Plus and 259 from authors show a healthy diversity of topics, linking technology, port management, and logistics performance. All in all, the picture is of a research area that's growing steadily, grounded in collaboration, and increasingly global in its outlook.

3.2 NUMBER OF PUBLICATIONS BY YEAR

To assess the development of growth in this academic discipline, we have collected and visualized the count of publications for several years, shown in Figure 2. According to the data collected, the first academic paper within this discipline was published in 2000, with 1 publication total. After that first paper, the field was relatively small, with inconsistent activity (0-3 publications per year) until 2020, when there was somewhat of a spark in the number of publications, totaling 8 publications. There was then a drop in the number of publications in 2022 (4 publications), but evidence of interest in the topics increased again in 2023. There was a considerable increase in the number of publications, peaking at 12 publications (and when again considering publications overall). The trend then remained stable at 8 publications each for 2024 and 2025 after the increase in the number of publications in 2023. Lastly, it is also important to point out that approximately 73% of all articles (54 out of 74 articles) were published in the last six years (2020-2025). This symbolizes the innovative and fast-developing field of these topics.

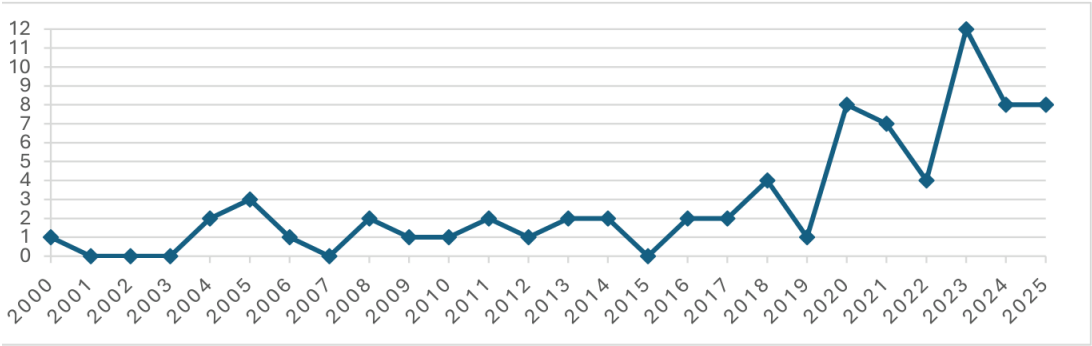

Figure 2 Figure created by the author

3.3 SOURCE OF PUBLICATION

Table 2 lists the top 10 sources of bibliometric analysis. These top 10 sources published a total of 27 documents, which is about 36.5% of the cumulative documents that were recovered. It is noted that Sustainability (Switzerland) was the leading journal stating 4 (17%) published documents, followed by Logistics and Transportation Research Record and Asian Journal of Shipping and Logistics with 3 (13%) each; Engineering Applications of Artificial Intelligence, Expert Systems with Applications, Maritime Policy and Management, Proceedings - Winter Simulation Conference, and Research in Transportation Business and Management with 2 documents and (9%) for each source; and that the 16th ITS World Congress published 1 document (4%).

Table 2. Source of publication

Journal Name	No. of articles	%
SUSTAINABILITY (SWITZERLAND)	4	17%
LOGISTICS	3	13%
TRANSPORTATION RESEARCH RECORD	3	13%
ASIAN JOURNAL OF SHIPPING AND LOGISTICS	2	9%
ENGINEERING APPLICATIONS OF ARTIFICIAL INTELLIGENCE	2	9%
EXPERT SYSTEMS WITH APPLICATIONS	2	9%
MARITIME POLICY AND MANAGEMENT	2	9%
PROCEEDINGS - WINTER SIMULATION CONFERENCE	2	9%
RESEARCH IN TRANSPORTATION BUSINESS AND MANAGEMENT	2	9%
16TH ITS WORLD CONGRESS	1	4%

Note: Table created by the author

3.4 SOURCE CITATIONS

The citation analysis is essential for researchers to decide the journals that will yield the most significance in terms of publication. Moreover, it indicates the primary, areas of interest and impact within a community, and allows researchers to identify the most recognizable sources that would cite as an authoritative source in maritime research. Figure 3 indicates a sharp decline from the most cited source Korea Maritime and Ocean University with 7 citations, to the next AMU University, with 4 citations, followed by a sharp decline to 2 citations being Army Logistics University, Bahman Moscow State University, Bowling Green State University, Dong-a University, Khalifa University, Mediterranean University, Monash University, and Nanyang Technological University. The analysis demonstrates how few sources exert significant influence within research or practices. This pattern is characteristic of scholarly citations and often adheres to a power-law distribution in which a small minority of their parents are cited exponentially, and the other majority of studies are cited only a few times.

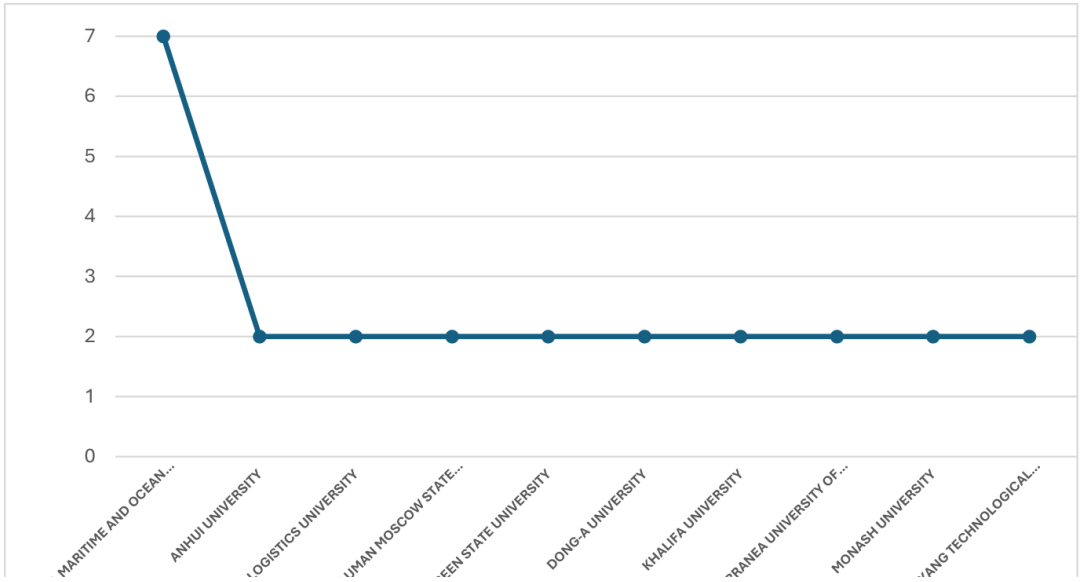

Figure 3. Source citations (Figure created by the author)

3.5 AUTHOR INFLUENCE

Figure 4 is a graphic representation of the top 10 most productive authors in MHRC. Collectively they have contributed to 21 of the 74 documents we identified, which is approximately 28.4% of the documents in our sample. Melian-Batista B is the most productive author among the 10 with three published documents, whereas the others (Ali-Hakoon D, Bucur M, De Leon AD, Dissanayake P, Huang SY, Lalla-Ruiz E, Li J, Liu X, Lokuuge P) have two documents. Frequency of publication suggests that this is an emerging area of study with one lead author and many other productive authors who contribute to the growth of knowledge.

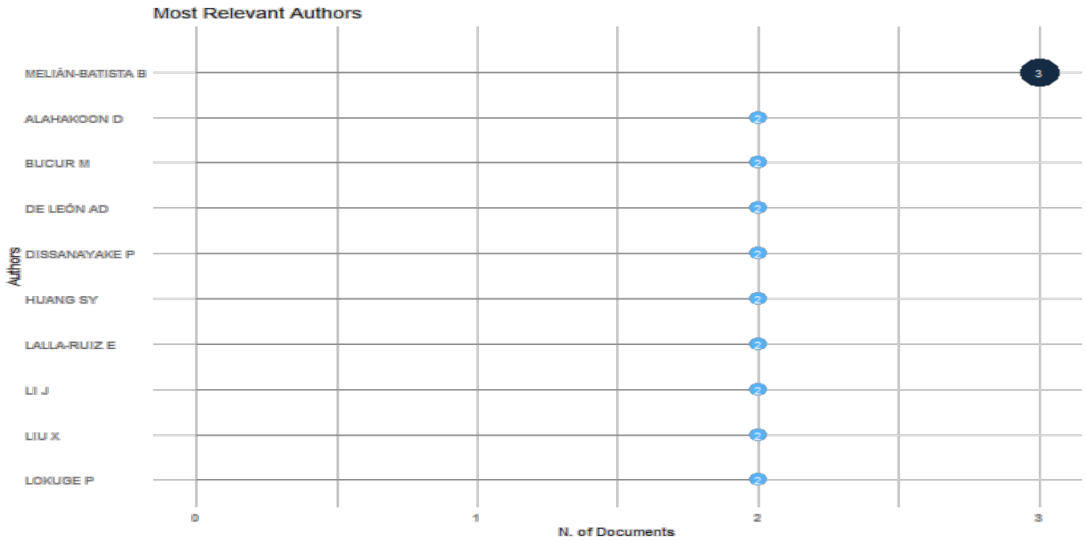

Figure 4. Most Relevant Authors (Figure created by the author)

3.6 THREE-FIELDS PLOT (AUTHORS – KEYWORDS – SOURCES)

This three-field map sketches the intellectual circuitry of digital transformation in maritime logistics by tying authors to the themes they work on and to the outlets that host those conversations. Two dense clusters stand out. First, an operations-research/AI stream: authors such as Lalla-Ruiz, Melián-Batista, and Moreno-Vega link strongly to optimization, berth allocation problem, and decision support, with their work flowing into Expert Systems with Applications, Advanced Engineering Informatics, and Engineering Applications of Artificial Intelligence. Second, a systems/automation stream:

Zhang W and Liu X connect to automation, smart ports, automatic identification system, and information system, with visible ties to IEEE venues (e.g., Winter Simulation Conference and CCNC) and practice-oriented conference proceedings. On the policy-and-management flank, Abdul Hamid S and Abdul Rahman NSF show pronounced links to sustainability, logistics, and port operations, converging on Sustainability (Switzerland) and Transportation Research Record, which signals growing attention to performance, governance, and environmental alignment within digital port programs. Across the middle column, container terminal and decision support act as hubs that draw contributions from most authors and radiate to multiple sources, indicating shared, foundational problems for port modernization, cargo-handling efficiency, and turnaround optimization. Peripheral themes blockchain, automated container terminal, and artificial intelligence appear as connectors that bridge the technical and managerial strands rather than isolated niches. Overall, the figure captures a field coalescing around data-driven port operations while maintaining a healthy, multidisciplinary dialogue between algorithmic innovation, systems engineering, and sustainability-oriented management.

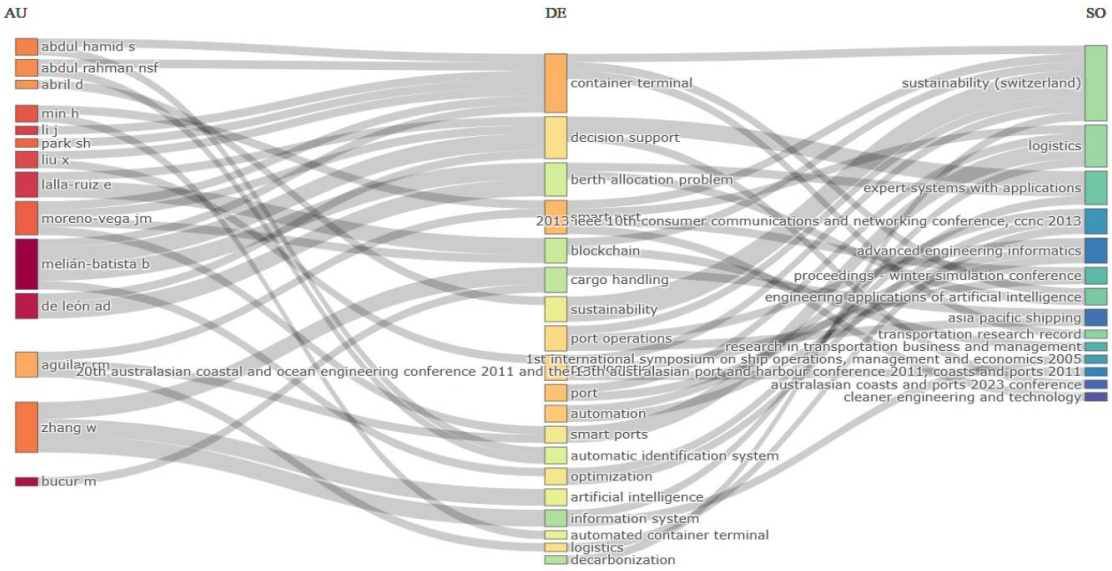

Figure 5. Three-fields plot (Authors – Keywords - Sources) (Figure created by the author)

3.7 AUTHOR COLLABORATION NETWORK ANALYSIS

This figure illustrates how researchers working on digital transformation in maritime logistics collaborate. Each circle represents a single author, and the links between them represent joint publications. The size of the circle varies depending on the extent of the author's collaborative research activity.

At first glance, one can see a dense, central network made up of Lalla-Ruiz E, De León AD, Melián-Batista B, Moreno-Vega JM, and Aguilar RM. These researchers appear to collaborate frequently, likely driven by their shared focus on optimization and digital applications in port operations. Their work forms a consistent partnership that seems to anchor much of the methodological progress in this area.

In contrast, the connection among Liu X, Li J, and Wang Y shows a smaller but clearly defined cluster where automation and artificial intelligence dominate the discussion. This pattern may reflect both technological expertise and regional cooperation within the Asian research community.

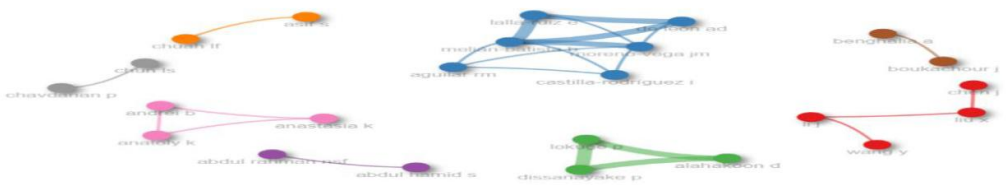

Figure 6. Author collaboration network analysis, (Figure created by the author)

Meanwhile, pairs such as Abdulrahman NSF and Abdulhamid S, as well as Lokuge B with Alahakoon D and Dissanayake P, demonstrated active participation from diverse regions that integrate sustainability with digital transformation themes. The few isolated authors Chuan LF and Asiri S, for instance, might represent either newcomers to the field or scholars exploring specialized, independent directions.

Altogether, this map does more than outline cooperation; it captures the personality of the field itself. Collaboration, it seems, is not evenly distributed but grows where shared goals and long-term trust exist. The pattern of overlapping clusters reflects how digital transformation in maritime logistics is being built through both stable partnerships and fresh interdisciplinary bridges.

3.8 INFLUENTIAL PAPERS

Table 3 presents the five most referenced papers in the dataset to underscore significant contributions to digital marine logistics. (Ahmad et al., 2021) has garnered 150 citations, concentrating on blockchain architectures for port operations, indicating significant interest in trust-based digital systems. (Oloruntobi et al., 2023) examines sustainability transitions, emphasizing environmental considerations in maritime logistics. (Min, 2022) and (Yen et al., 2023) investigate smart port architecture and efficiency through quantitative models, illustrating the transition to data-driven infrastructure. (de León et al., 2017) presents machine learning for berth scheduling, marking an early incorporation of AI into operational processes. These works encompass essential themes such as blockchain, smart infrastructure, AI, and sustainability, which constitute the intellectual foundation for the advancement of the field. The fact that people from all over the world have written about and cited their work shows that research on digital transformation in maritime logistics is both multidisciplinary and international.

Table 3. Influential papers

GC	Title	Author/s	Year
150	Blockchain applications and architectures for port operations and logistics management	Ahmad, R.W., Hasan, H., Jayaraman, R., Salah, K., Omar, M.	2021
78	Sustainable transition towards greener and cleaner seaborne shipping industry: Challenges and opportunities	Oloruntobi, O., Mokhtar, K., Gohari, A., Asif, S., Chuah, L.F.	2023
72	Developing a smart port architecture and essential elements in the era of Industry 4.0	Min, H.	2022
72	A Machine Learning-based system for berth scheduling at bulk terminals	de León, A.D., Lalla-Ruiz, E., Melián-Batista, B., Marcos Moreno-Vega, J.	2017
61	How smart port design influences port efficiency – A DEA-Tobit approach	Yen, B.T.H., Huang, M.-J., Lai, H.-J., Cho, H.-H., Huang, Y.-L.	2023

Note: Table created by the author

3.9 INFLUENTIAL AFFILIATION

Analyzing the affiliations implicated in digital transformation within maritime logistics, a total of 15 institutions were identified as contributors to the field, producing 21 documents in total. Among these, 9 institutions have contributed single publications,

indicating a moderately dispersed yet globally engaged research community. Figure 7 presents the top 10 most productive affiliations based on their publication output. The compilation includes two institutions located in South Korea, along with two from China and one from Australia. This once again highlights the strong involvement of Asian researchers, particularly those from Korea and China, in advancing the academic conversation on port digitalization and smart logistics. The remaining institutions represent countries such as the United Arab Emirates, Italy, Russia, and Malaysia, each hosting at least one organization featured in this list.

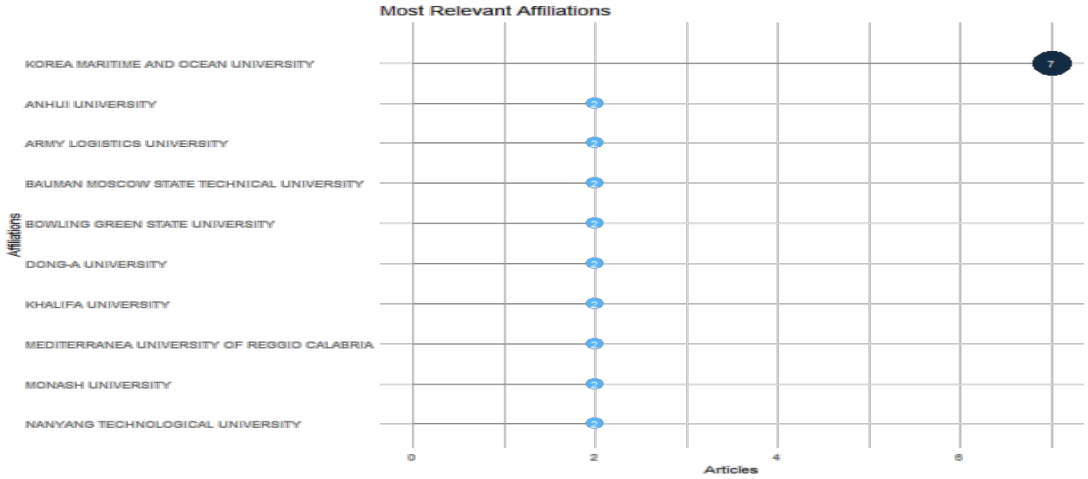

Figure 7. Influential Affiliation (Figure created by the author)

3.10 THREE-FIELDS PLOT (AFFILIATIONS-COUNTRIES-SOURCES)

This plot has three fields that shows a clear visual of the worldwide academic landscape of research addressing the analyzed topic. It visualizes the links between institutions and their respective countries to the outlets that their research is published. The left column (AU_UN) is a registry of universities and research institutions, the middle column (AU_CO) is the countries those institutions are located in, and the right column (SO) is the journals or source outlets utilized for their publications.

The plot clearly shows the international potential of research. Institutions from different parts of the world are visible to be tied together; together they contribute to a varied pool of publications to different sources that may be acted on by another institution. For example, with 'University Malaysia Terengganu' being associated with 'Korea' is a strong descripter of the output of this institution travels through an international provision to be placed in about a highly cited sustainability source. Same is shown with 'Cairo Technological University' and 'National Defense Academy' having ties across multiple source territories, suggesting that this engagement of research is happening through the scopes of the broad area of topic.

The visualization similarly indicates that several countries-Korea, Spain, France, Italy, Australia, Singapore, Sri Lanka, Greece, and Germany-function as prominent research output destinations, as observed in the various bands branching out from different organizations, across them, to different journals. This may occur due to strong international collaborative relationships, or the relative scholarly specialization and investment related to this research in these countries. Besides, the other journals featured on the right side of the screen, that provide articles for publication in related research, such as Sustainability (Switzerland), Advanced Organization of Robotics, Engineering Applications of Artificial Intelligence, Transportation Research Proceedings, or all the others, clearly demonstrates that the research is interdisciplinary in nature, including for example sustainability, technological innovation, engineering applications, and transportation systems.

The distribution of affiliations and publications represented on the plot suggests an increasingly established international collaborative research network that fosters exchange and input from prominent global institutions. Institutions including, for example, Bowling Green State University, Shanghai Maritime University, Zhejiang University, or Chulalongkorn University, contribute substantially to research output across various organizations and publication pathways. This type of visualization can be very helpful to new researchers as it identifies possible institutions for collaboration and will introduce them to potential geographic spread of specialized expertise in this field.

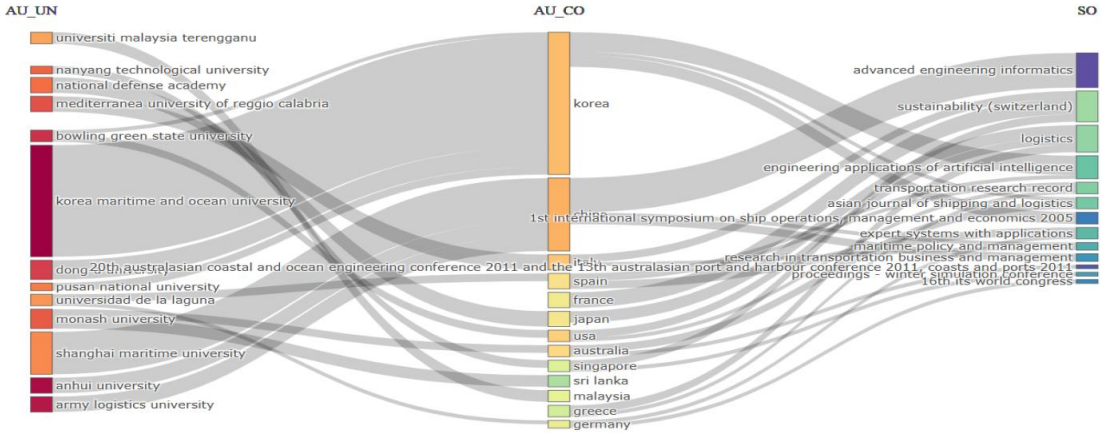

Figure 8. Three -fields plot (Affiliations-Countries-Sources) (Figure created by the author)

3.11 INFLUENTIAL COUNTRIES

By utilizing the support provided by Biblioshiny, it has been determined that several organizations within many countries have published scientific articles on the topic under review. In fact, several nations have published varying amounts of articles to this research area. In Table 4., the ten countries with the most published articles listed by overall number of publications. China, surprising, is ranked the first overall for total publications listed by country of the institution and has published 28 articles overall, including both co-authored and non-co-authored articles. This impressive rank contributed to the significant amount of money that the nation invested to develop research infrastructure, and its interest in scholarly output in this field has developed. After China, South Korea was ranked the second most productive country with 19 publications and illustrates that East Asian countries have a significant amount of research activity in this area. In addition, one must note that Italy has also been highly productive at a level of third among the nations with 10 articles, according to Table 4.

The United States of America is in the fourth place with 7 articles, which contributes more evidence of a global research community. In addition to this observation made in Table 4., we can also see that interest in this area results in contributions from both Asian and Western countries, both of which have a four-country presence in the top ten publications. Asian representation is evident with China, South Korea, Japan, and Malaysia in the top ten publications, demonstrating growing regional research capacity. A strong presence of European countries is noted across Italy, Spain, France, and Germany, suggesting a continuing commitment by European institutions toward knowledge generation in this area. Australia's inclusion in the fifth position, with 6 publications, contributes to the publication total of the Oceania region.

Table 4. Influential countries

#	Country	Number of articles
1	CHINA	28
2	SOUTH KOREA	19
3	ITALY	10
4	USA	7

5	AUSTRALIA	6
6	SPAIN	6
7	JAPAN	5
8	FRANCE	4
9	GERMANY	4
10	MALAYSIA	4

Note: Table created by the author

3.12 COUNTRY COLLABORATION NETWORK ANALYSIS

This network diagram visually depiction the interdependence among countries in the research field of study. The nodes represent countries, and the size of each node may reflect the research capacity of each country or the number of collaborations each country is active in, for this topic.

Countries such as China and Korea emerge as major nodes, demonstrating their status as prominent central places of research measuring output and international collaboration around research internationally. China, the largest red node in the network, is particularly strong in the network and has linkages across other countries including Hong Kong, Taiwan and Italy. Similarly, Korea illustrated as a similarly responsive blue node, demonstrates equally strong collaborative activity as well as being identifiable also as a major node of research measurement and output and international engagement in terms of research. The USA, as a blue node, occupies a prominent position within the network, and is distinguishable from the nodes of other countries for its linkages with other countries. These indicators may reflect the overall larger investments that the USA makes regarding research outcomes, and arguably of the globally significant quality of the products that they produce. Smaller and peripheral nodes like Tunisia, and other countries that sit at the margin of the network compared to countries like China or Korea appear to stand out among the major node of activity. This may suggest that these countries are more nascent in their involvement in the topic of study or in international collaboration related to research. However, they do highlight instances of international

There are also regional clusters and collaboration networks in the diagram. For example, the Asian region shows a strong partnership with research ties; China clearly has direct ties to Hong Kong and Taiwan, and Korea and Japan (all depicted in orange) are direct, but outside of the same cluster. The orange cluster includes Japan, along with Mexico and Iran, which indicates a long-established collaborative network within a different nation representation among the orange coding. The green cluster includes Australia and India, showing a high degree of research collaboration in the Oceania region paired with South Asia. European nations remain connected to the network of countries depicted in red with Italy, which remains a direct collaboration with the China cluster, while Spain has its own direct collaboration networks depicted in purple. The inclusion of European nations implies active cross-continent partnerships in research.

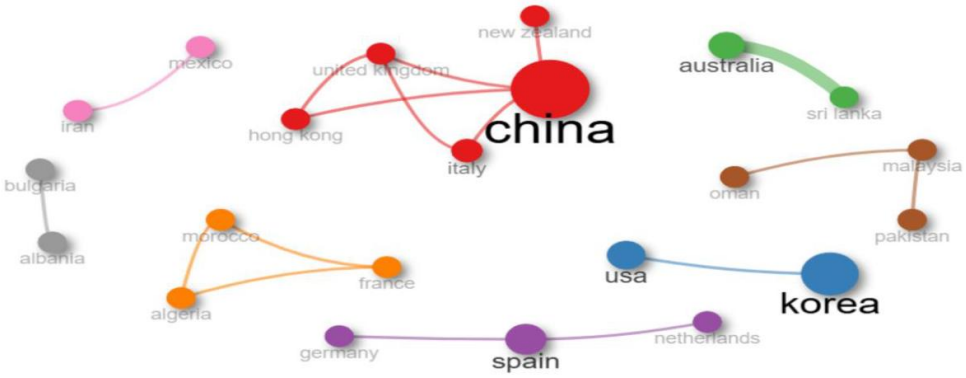

Figure 9. Country collaboration network analysis (Figure created by the author)

This type of network analysis is significant in understanding the geopolitical dynamics of the collaborations of research. It can expose which countries are dominating the region of research, possible collaboration partners for the future for research, and the flows of knowledge between regions. The positioning of Asian countries, primarily China and Korea, as central points is indicative of a changing structure of global leadership in research. In addition, it shows the importance of global collaboration as a mode to solve global issues globally within research, while highlighting existing and newly formed paths of collaboration that cross geographical and economic boundaries.

3.13 EVOLUTION OF AUTHOR'S KEYWORDS

The line graph displays the cumulative frequency of the significant terms found across the published research literature that spans across almost two decades of studies as well as it is reflective of the study on the separation of historical/advancement timescales from August 2000 until May 2025. It shows changing trends and themes in the area, as represented through the authors' use of keywords in relation to their study in his articles.

The word 'automation' shows an interesting trajectory, that illustrates focus in early phase of the research period- from 2004 to 2009 - then flat-lined, then began steadily rising around 2019 until 2022, and sharply rising after that from 2020 onwards. Overall, this demonstrates a corresponding developing and increased focus on automation, which became even more accentuated in recent times. Overall, the term 'sustainability' has demonstrated the steepest increase out of all the tracked keywords, and, like the last keyword remained flat in frequency of use until about 2020, but has taken off since then, with special emphasis on what will occur between the years 2023-2025. Taken this shows an emphasis on environmental issues, sustainability practices and greater global awareness surrounding climate change and operation in a responsible manner. The keyword 'Smart Ports' represents one of the most distinct developments in recent, with this term becoming increasingly prominent and evident with sustained growth occurring throughout the period 2020-2025, potentially correlated because of the changing technology -focused digital transformation agenda occurring within port facilities around the world.

Remarkably, 'Port Operations' has a presence as early as the mid-2000s, maintains a relative stability attending to the topic for, in total, just over a decade, and then significant growth from 2019 onwards, with a sharp increase evident after 2021. This observation suggests the inherent importance of operational aspects, while also suggesting increased scholarly interest to optimize port activities in a contemporary era. The keyword 'Innovation', addressing an ongoing and gradually intensifying concern, noticeably grows, especially in the period of 2020-2025, that evidences the

commitment of the field to innovate with new approaches and solutions. Words like 'Digitization', 'Blockchain', 'Port Logistics', 'Decision Support', and 'Green' all track various patterns of growth, with most of them indicating growth concentrated around the recently presented years of 2020-2025, suggesting multiple technological and environmental themes converging in a contemporary research agenda.

In summary, the graphic provides a visual narrative of a changing stance toward researching topics, and where the attention of academics and possibly policy makers, has been or may be heading. The graphic provides an indication that a paradigm shift began around 2019-2020 when multiple terminologies identified with technology, sustainability, and digital transformation began several concurrent accelerations. The convergence in terminology may suggest a cohesive strategy on modernizing the sector through technological innovation and also address some environmental imperatives. This information is highly beneficial for both researchers and practice, not only to know where the attention has been drawn, but also to provide some speculation on where research and practice may go, and especially the role of digital technology, automation and sustainability in the future of the field.

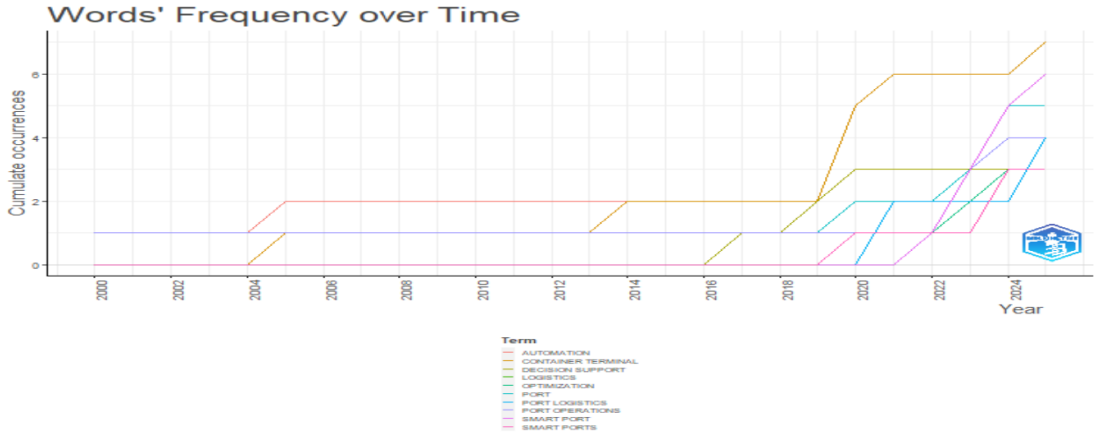

Figure 10. Evolution of Author's Keywords (Figure created by the author)

4. CONCLUSION

This bibliometric review analyzed 74 publications from 2000–2025 related to digital transformation in maritime logistics, focusing on the modernization of ports, efficiency in cargo handling, and vessel turnarounds. Interest in the subject was seen to increase rapidly since 2020. This is so because an increasing number of ports have started using AI, blockchain, automation, and decision support systems.

Key findings underline an increasingly interdisciplinary and collaborative domain, with nascent research clusters connecting technological innovation to operational and sustainability objectives. While China, South Korea, and Italy are the leading countries, international co-authorship remains low. This means the potential for greater global collaboration is still open.

This evolution of keywords reflects a conceptual shift in thinking toward smart ports, sustainability, and automation, especially since 2019. Prominent authors and institutions shape relevant knowledge in applied engineering, logistics management, and policy integration.

The study contributes to the literature by mapping the intellectual structure of the field, identifying key sources and themes, and pointing out where longitudinal performance assessments and implementation outcomes are still lacking. A fundamental insight is the intersection of digital innovation and environmental accountability as simultaneous catalysts for port transformation.

Future Research Directions

- Empirical studies linking digital adoption to measurable performance.

- Comparative analyses between developed and developing port ecosystems.
- Broader inclusion of topics like cybersecurity, ethics, and interoperability.

In conclusion, the maritime sector is transitioning from fragmented digital trials to integrated smart port systems. This review offers a strategic foundation for researchers and stakeholders to align innovation efforts with efficiency and sustainability imperatives.

5. REFERENCES

1. Ahmad, R. W., Hasan, H., Jayaraman, R., Salah, K., & Omar, M. (2021). Blockchain applications and architectures for port operations and logistics management. Research in Transportation Business and Management, 41. https://doi.org/10.1016/j.rtbm.2021.100620
2. Alavi-Borazjani, S. A., Bengue, A. A., Chkoniya, V., & Shafique, M. N. (2025). An Overview of Critical Success Factors for Digital Shipping Corridors: A Roadmap for Maritime Logistics Modernization. Sustainability (Switzerland), 17(12). https://doi.org/10.3390/su17125537
3. Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of Informetrics, 11(4), 959–975. https://doi.org/10.1016/j.joi.2017.08.007
4. de León, A. D., Lalla-Ruiz, E., Melián-Batista, B., & Marcos Moreno-Vega, J. (2017). A Machine Learning-based system for berth scheduling at bulk terminals. Expert Systems with Applications, 87, 170–182. https://doi.org/10.1016/j.eswa.2017.06.010
5. Gülşah, A. S., & Özlem, S. (2022). A Bibliometric Analysis of The Impact of COVID-19 on Maritime Logistics and Ports. The Journal of International Scientific Researches, 2, 131–148.
6. Jović, M., Tijan, E., Brčić, D., & Pucihar, A. (2022). Digitalization in Maritime Transport and Seaports: Bibliometric, Content and Thematic Analysis. Journal of Marine Science and Engineering, 10(4). https://doi.org/10.3390/jmse10040486
7. Li, K. X., Li, M., Zhu, Y., Yuen, K. F., Tong, H., & Zhou, H. (2023). Smart port: A bibliometric review and future research directions. Transportation Research Part E: Logistics and Transportation Review, 174. https://doi.org/10.1016/j.tre.2023.103098
8. Min, H. (2022). Developing a smart port architecture and essential elements in the era of Industry 4.0. Maritime Economics and Logistics, 24(2), 189–207. https://doi.org/10.1057/s41278-022-00211-3
9. Oloruntobi, O., Mokhtar, K., Gohari, A., Asif, S., & Chuah, L. F. (2023). Sustainable transition towards greener and cleaner seaborne shipping industry: Challenges and opportunities. Cleaner Engineering and Technology, 13. https://doi.org/10.1016/j.clet.2023.100628
10. Paraskevas, A., Madas, M., Zeimpekis, V., & Fouskas, K. (2024). Smart Ports in Industry 4.0: A Systematic Literature Review. Logistics, 8(1). https://doi.org/10.3390/logistics8010028
11. Pham, T. Y. (2023). A smart port development: Systematic literature and bibliometric analysis. Asian Journal of Shipping and Logistics, 39(3), 57–62. https://doi.org/10.1016/j.ajsl.2023.06.005
12. Xue, J., Li, Q., Song, Y., Yang, P., Feng, Y., & Hu, H. (2025). A bibliometric analysis of the development of autonomous ships in inland waterway transport. Frontiers in Marine Science, 12. https://doi.org/10.3389/fmars.2025.1624596
13. Yen, B. T. H., Huang, M. J., Lai, H. J., Cho, H. H., & Huang, Y. L. (2023). How smart port design influences port efficiency – A DEA-Tobit approach. Research in Transportation Business and Management, 46. https://doi.org/10.1016/j.rtbm.2022.100862

14. Zou, Y., Xiao, G., Li, Q., & Biancardo, S. A. (2025). Intelligent Maritime Shipping: A Bibliometric Analysis of Internet Technologies and Automated Port Infrastructure Applications. Journal of Marine Science and Engineering, 13(5). https://doi.org/10.3390/jmse13050979
15. Zupic, I., & Čater, T. (2015). Bibliometric Methods in Management and Organization. Organizational Research Methods, 18(3), 429–472. https://doi.org/10.1177/1094428114562629