



Trends and Patterns in Container Terminal Research: A Bibliometric Analysis of Worldwide Publications

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Abstract

This study conducts a comprehensive bibliometric analysis to explore global trends and patterns in container terminal research from 2000 to 2024. The research leverages the Scopus database to evaluate publication productivity, citation impact, collaborative networks, and emerging theme areas. Key findings reveal a substantial increase in research output starting in 2016, with China identified as the leading contributor in publication volume. The study highlights operational optimization as a primary concern, encompassing dock allocation, crane scheduling, environmental initiatives, and integrating emerging technologies such as IoT and blockchain. Articles centered on operational optimization show significant citation impact, underscoring their relevance to the challenges faced by the logistics sector. The analysis stresses the importance of international cooperation in advancing container terminal research. It primarily relies on English-language papers indexed by Scopus, indicating gaps in multi-stakeholder methodologies and cohesive technological solutions. Future research should address these gaps by incorporating diverse approaches and exploring broader geographic contexts to generate more comprehensive insights into container terminal operations.

Keywords: container terminals, bibliometrics, operational efficiency, sustainability, IoT technology, logistics optimization, and global research trends.

1. Introduction

Container terminals are crucial to the global marine supply chain, linking maritime and land transportation (Zhou *et al.*, 2022). With the growth of international trade and the increase in container ship sizes, the efficiency and productivity of container terminals have become vital (Dragović *et al.*, 2023). Over the past two decades, there has been a significant increase in research on container terminals, covering planning, operations, technology, and sustainability (Mohiuddin *et al.*, 2024).

This bibliometric study examines and charts the evolution of container terminal research worldwide from 2000 to 2024. It provides significant insights into essential

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trends, patterns, and focal points within this research domain while identifying gaps and opportunities for future inquiry (Kovač *et al.*, 2023). This study is significant because it 1) offers a thorough overview of the development of container terminal research; 2) identifies the most influential researchers, institutions, and countries in this field; 3) highlights emerging topics and research trends; and 4) assists researchers and practitioners in understanding future research directions. This study encompasses scientific publications indexed in the Scopus database from 2000 to 2024, focusing on journal articles, conference papers, and literature reviews in English. The analysis will cover multiple aspects of bibliometrics, including publication productivity, citation analysis, research collaboration, and topic analysis.

This study will address the following research questions: 1) How will container terminal research papers evolve from 2000 to 2024? 2) Who are the most productive and influential scholars, institutions, and countries in container terminal research? 3) What are the primary research subjects and trends developed in studying container terminals throughout this period? 4) In what manner does the pattern of research collaboration in this subject evolve? 5) What are the present research gaps and prospects for future studies? This study seeks to enhance our understanding of the container terminal research domain and guide subsequent research initiatives by addressing these topics. While earlier reviews have focused on isolated themes such as crane optimization or dry port integration, this study uniquely bridges operational themes with emerging socio-environmental challenges and the evolving spatial dynamics of port systems.

This study offers a more integrated approach by connecting operational optimization topics with broader technological and geopolitical changes in the container terminal sector, as opposed to earlier bibliometric analyses focusing solely on publishing metrics or thematic clustering. This research incorporates insights from transport geography, automation trends, and sustainability challenges to outline scholarly work and provide strategic implications for academic and practical stakeholders. This methodology brings innovative insights to the current knowledge base by linking bibliometric data with potential port development narratives, particularly relevant for developing nations.

2. Literature Review

2.1 Advancement of Container Terminal Research

Research on container terminals has progressed dramatically over the past two decades, in alignment with global trade development and the increasing complexity of port operations. Zhou *et al.* (2022) and Safuan and Syafira (2024) Significant trends in container terminal research have emerged, emphasizing innovative technologies like the Internet of Things (IoT), artificial intelligence, and blockchain. There is a heightened focus on sustainability and operational resilience issues, especially during the COVID-19 pandemic.

Dragović and colleagues conducted bibliometric evaluations of research on container terminal operations from 1973 to 2020 (Dragović *et al.*, 2023). Their findings show that most high-impact publications appeared between 1989 and 2015, primarily focusing on operational optimization, including dock allocation, crane scheduling, and yard management.

Beyene *et al.* (2023) and Kovač *et al.* (2023) emphasize the importance of integrating maritime container terminals with land transportation systems, particularly by establishing dry ports. They highlight dry ports' crucial role in enhancing maritime supply chain efficiency and alleviating seaport congestion.

2.2 Prior Bibliometric Analyses in Maritime and Logistics

Several bibliometric studies have examined research trends in the maritime and logistics sectors. Mohiuddin et al. conducted a bibliometric analysis of maritime supply chain research, highlighting trends such as blockchain integration, supply chain risk management, and green logistics (Mohiuddin *et al.*, 2024). A notable increase in publications since 2015 has been observed, reflecting a growing interest in this field.

Safuan, Ramadian, and Selasdini (2023) and Weerasinghe, Perera, and Bai (2024), a bibliometric examination of container terminal operations was conducted using data from Scopus. They identified critical issues such as operational optimization, automation technologies, and environmental. Bolbot *et al.* (2022) performed a bibliometric analysis of maritime cybersecurity, highlighting an increased emphasis on security concerns in port and container terminal operations.

2.3 Current Research Deficiencies

Despite the significant expansion of research on container ports, many gaps require further scrutiny. One aspect is technological integration, as current research predominantly examines individual technologies without exploring the amalgamation of diverse technologies in container terminal operations (Dragović *et al.*, 2023). Furthermore, Notteboom, A. Pallis, and Rodrigue (2021) lack empirical studies regarding sustainability performance in these operations, particularly within green maritime supply chains. The COVID-19 pandemic has highlighted the pressing need for research on the operational resilience of container terminals in response to global disruptions (Zhou *et al.*, 2022). Additionally, Heilig, Stahlbock, and Voß (2019) state that there is a shortfall in utilizing big data and predictive analytics to enhance container terminal operations in the industry. Conversely, Roso and Lumsden (2010) state that there is a need for research incorporating a multi-stakeholder approach in the development and operation of container ports. This study thoroughly assesses trends and patterns in container terminal research by examining developments, prior bibliometric studies, and existing gaps while identifying future research opportunities.

3. Methodology

This study employs a bibliometric analysis approach to investigate global trends and patterns in container terminal research from 2000 to 2024. The method adheres to the framework established by Donthu *et al.* (2021) for conducting a thorough and systematic bibliometric study.

3.1 Source

Bibliometric data is sourced from the Scopus database, a well-known and comprehensive academic resource (Baas *et al.*, 2020). Scopus was selected for its extensive coverage of peer-reviewed scientific literature, including journals, books, and conference proceedings (Martín-Martín *et al.*, 2021).

3.2 Search Parameters and Article Selection

We use the following search string in the Scopus database to find relevant articles:

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TITLE-ABS-KEY ( ( "container terminal*" OR "container port*" ) ) AND PUBYEAR > 1999 AND PUBYEAR < 2025 AND ( LIMIT-TO ( DOCTYPE , "ar" ) OR LIMIT-TO ( DOCTYPE , "ch" ) OR LIMIT-
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TO (DOCTYPE, "cp")) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (OA, "all"))

The criteria for article selection are as follows: 1) Document type: journal articles, conference papers, and literature reviews; 2) Language: English; 3) Timeframe: January 1, 2000, to December 31, 2024; 4) Disciplines: engineering, management, computer science, and transportation.

3.3 Methods of Bibliometric Analysis

A bibliometric analysis was performed using Biblioshiny. The analytical methods include:

3.3.1 Analysis of Productivity

The study identifies the leading writers in container terminal research based on publication count and h-index, offering an overview of each individual's contribution to advancing research in this field. Furthermore, institutional funding is assessed based on the authors' affiliations, clarifying the influence of academic or research institutions on fostering innovation and scientific publications. The paper examines the geographical distribution of container terminal research, highlighting the countries that serve as primary research hubs and their contributions to scientific advancement in this domain. This analysis provides insight into the patterns of global collaboration and the distribution of research activity across various regions.

3.3.2 Impact Assessment

This study employed citation analysis to quantify citations from various papers, authors, and journals, aiming to identify the most influential entities in container terminal research. This method underscores the significant contributions to the advancement of this field, including both individual and institutional publications. Additionally, co-citation analysis was performed to illustrate the connections among frequently referenced papers, as shown by Kovač *et al.* (2023). This analysis uncovers patterns of intellectual collaboration and the relationships among different scientific publications in creating a comprehensive knowledge base (Kovač *et al.*, 2023).

3.3.3 Collaboration Analytics

This study utilizes the co-authorship network to illustrate collaboration patterns among authors, institutions, and nations, providing an overview of the cooperative dynamics in container terminal research. This research aids in identifying clusters of significant academic interactions and relationships at local and global levels. Furthermore, the internationalization analysis evaluates the extent of international collaboration in this field, as noted by Mohiuddin *et al.* (2024). This method clarifies the degree of cross-border cooperation in container terminal research, highlighting the importance of cooperative efforts in addressing global challenges within the logistics and port industries (Mohiuddin *et al.*, 2024).

3.3.4 Examination of Research Subjects and Trends

The study employs co-word analysis to identify key research subjects through the co-occurrence of terms in the examined literature, providing insights into the primary focus of container terminal studies. Additionally, temporal trend analysis outlines the evolution of study topics over time, demonstrating the growing academic interest in specific themes.

To explore latent themes more thoroughly, topic modeling utilizes the Latent Dirichlet Allocation (LDA) method, as described. This method helps uncover hidden structures within the data corpus and recognize significant theme patterns. This combination of methodologies offers a comprehensive analysis of trends and dynamics in container terminal research.

3.4 Data Visualization

The investigation results were presented using various methodologies, including bibliometric maps, co-citation networks, and temporal trend plots. Biblioshiny generates network visualizations, supplementary graphs, and plots (Kirby, 2023).

3.5 Validation and Reliability

To ensure the validity and trustworthiness of our analysis, we employ a methodological triangulation approach that combines quantitative analysis with a qualitative examination of key papers. Additionally, a team of experts in container terminal management and bibliometrics evaluates the study's conclusions. This methodology aims to comprehensively assess the container terminal research ecosystem, identify emerging trends, and highlight opportunities for future research.

4. Results and Discussion

4.1 Trends in Publication

4.1.1 Annual Increase in Publication Volume

The graph illustrates the trend in the annual number of documents published from 2000 to 2024. Since 2016, there has been a notable rise in the number of records, increasing from 86 in 2016 to a peak of 150 in 2021. After reaching its peak, there was a steady decline, with the document count falling to 143 in 2023 and decreasing to 106 in 2024.

This graph indicates a rapid increase in research productivity until the early 2020s, followed by a downturn, possibly due to governmental changes, evolving research objectives, or external challenges, such as the pandemic. Nonetheless, output levels remain significantly higher compared to the early years before 2016.

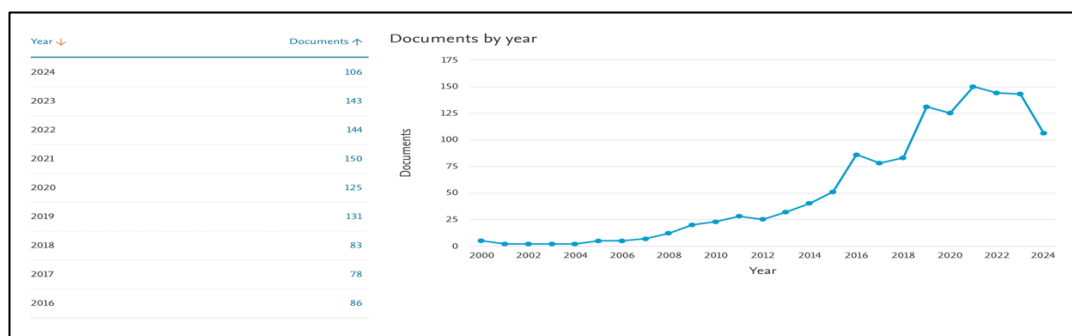


Figure 1: Quantity of Research Publications on "Container Terminal"

Source: Scopus

4.1.2 Allocation of Publications by Document Classification

The graph illustrates the distribution of document types, with scientific papers accounting for 77.4% (1,012 documents) of total publications. The next highest contribution comes from conference papers, representing 21.7% (284 documents), while book chapters comprise only 0.8% (11 papers). The dominance of scientific publications

indicates that journal publishing is the primary medium for communicating research results. At the same time, conference papers significantly enrich academic discourse and the dissemination of research findings. As this data suggests, the small number of book chapters implies that book-based publishing is less preferred within the scientific community.

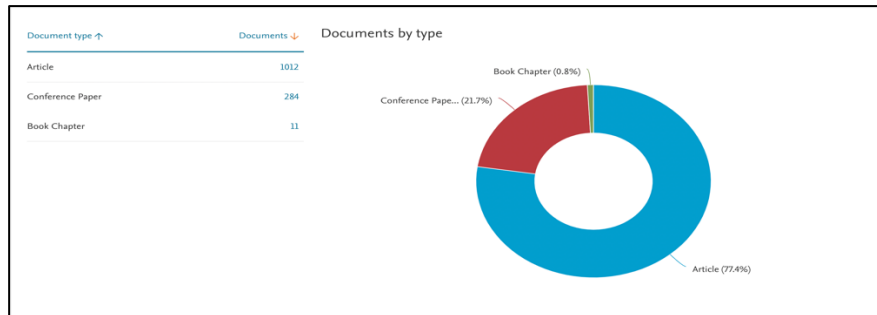


Figure 2: Distribution of Publications by Document Type
Source: Scopus

4.2 Analysis of Productivity

4.2.1 The Most Prolific Author

The graph displays authors ranked by the number of their articles. Yang Y has 20 publications, Wang Y has 19, and Li J has 17. Other authors, including Yang Z, Wang L, and Zhang Y, have each produced between 14 and 15 articles. Authors Notteboom T, Budiyanto MA, Zhang X, and Li W also made 11 to 13 publications, respectively. This graph illustrates the prominence of certain writers in scientific output, with Yang Y identified as the most prolific contributor, underscoring their significant importance in the research field. The inclusion of authors from various regions indicates regionally diverse collaborations.

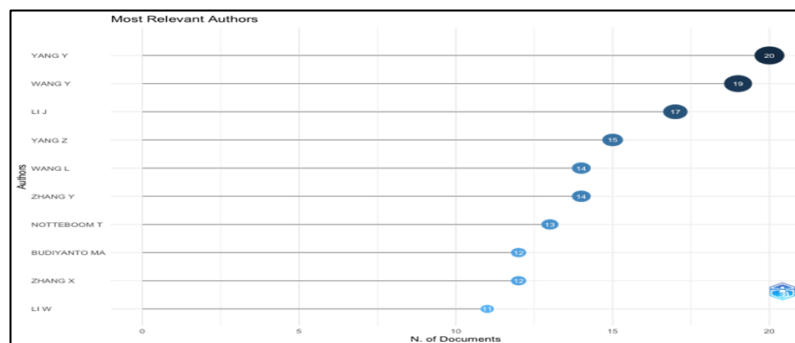


Figure 3: Distribution of Publications by Document Type
Source: Scopus

4.2.2 Preeminent Institutions

The graph illustrates the number of documents by institutional affiliation, with Shanghai Maritime University leading with 96 documents, followed by Dalian Maritime University with 47 papers. Delft University of Technology and The Hong Kong Polytechnic University each authored 32 publications, highlighting their substantial research contributions. Other universities, such as Beijing Jiaotong University (24

papers), Nanyang Technological University (22 documents), and Wuhan University of Technology (22 papers), have also made significant contributions to scholarly publications. Meanwhile, institutions beyond Asia, like Erasmus Universiteit Rotterdam (21 documents) and the National University of Singapore (20 papers), have enriched the diversity of contributions. This data indicates the preeminence of Asian maritime universities in research, particularly in the marine and transport domains, while also acknowledging the valuable contributions of European institutions.

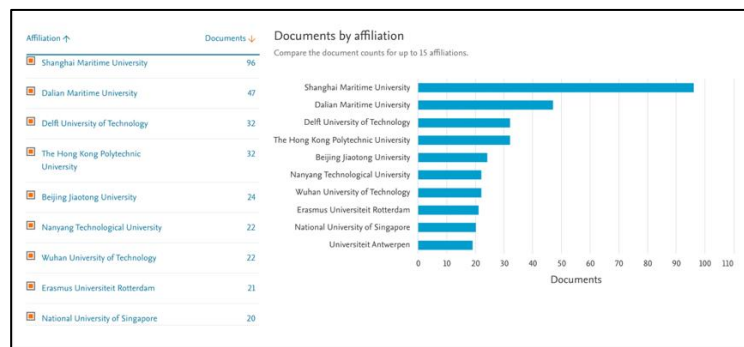


Figure 4: Preeminent Productive Institutions
Source: Scopus

4.2.3 Countries with the Highest Productivity

The graph illustrates the distribution of documents by country or region, with China leading significantly at 343 papers, followed by South Korea (93 documents) and the United States (92 papers). The Netherlands and the United Kingdom made notable contributions, with 86 and 84 publications, respectively. Indonesia ranks sixth with 74 documents, followed by Italy with 66 documents, Germany with 51 documents, and Singapore with 48 papers. This data underscores the dominance of Asian nations, particularly China, in research publications, while European countries and the United States also play a significant role in global research. Indonesia's sixth-place position highlights the substantial contribution of developing nations to international research.

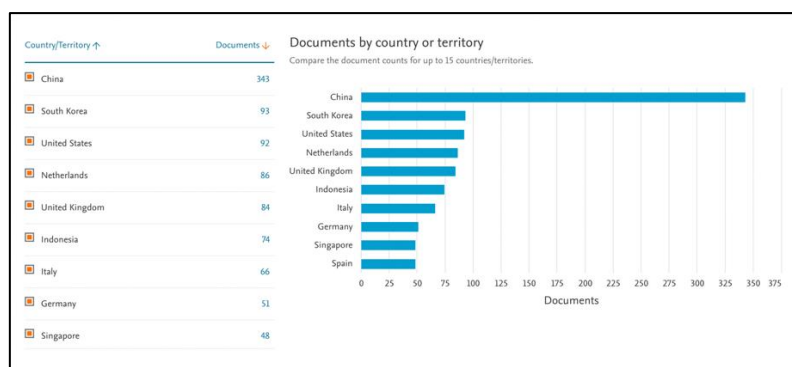


Figure 5: Catalog of the Most Productive Nations
Source: Scopus

4.3 Impact Assessment

4.3.1 Predominantly Referenced Articles

The list includes the ten most frequently referenced scientific articles in container terminal and port operations. The work "Storage Yard Operations in Container Terminals: Literature Overview, Trends, and Research Directions" has received 327 citations, indicating its significant impact on guiding research in this field. Additional publications, including research by Imai *et al.* (2005) on dock allocation utilizing a continuous location methodology (307 citations) and Notteboom, T. Pallis and Rodrigue (2021), which of the effects of the COVID-19 pandemic compared to the 2008-2009 financial crisis on ports (269 citations), also demonstrate considerable implications. The name A. Imai frequently appears, reflecting a substantial contribution to the study, particularly regarding dock allocation and crane arrangement. These papers often address essential themes such as dock allocation, crane scheduling, and container terminal optimization, emphasizing port operational efficiency and global significance.

Table 1: Ten Most Frequently Cited Articles

NO	Authors	Year	Title	Cites	Ref
1	H.J. Carlo, I.F.A. Vis, K.J. Roodbergen	2014	Storage yard operations in container terminals: Literature overview, trends, and research directions	327	(Carlo, Vis and Roodbergen, 2014)
2	A. Imai, X. Sun, E. Nishimura, S. Papadimitriou	2005	Berth allocation in a container port: Using a continuous location space approach	307	(Imai <i>et al.</i> , 2005)
3	T. Notteboom, T. Pallis, J.-P. Rodrigue	2021	Disruptions and resilience in global container shipping and ports: the COVID-19 pandemic versus the 2008–2009 financial crisis	269	(Notteboom, T. Pallis and Rodrigue, 2021)
4	A. Imai, E. Nishimura, S. Papadimitriou	2003	Berth allocation with service priority	260	(Imai, Nishimura and Papadimitriou, 2003)
5	A. Imai, H.C. Chen, E. Nishimura, S. Papadimitriou	2008	The simultaneous berth and quay crane allocation problem	225	(Imai <i>et al.</i> , 2008)
6	Ng W.C.; Mak K.L.	2005	Yard crane scheduling in port container terminals	194	(Ng and Mak, 2005)
7	G. Giallombardo, L. Moccia, M. Salani, I. Vacca	2010	Modeling and solving the Tactical Berth Allocation Problem	189	(Giallombardo <i>et al.</i> , 2010)
8	J. He, Y. Huang, W. Yan, S. Wang	2015	Integrated internal truck, yard crane, and quay crane scheduling in a container terminal, considering energy consumption	182	(He <i>et al.</i> , 2015)
9	S. Limbourg, B. Jourquin	2009	Optimal rail-road container terminal locations on the European network	172	(Limbourg and Jourquin, 2009)
10	A. Imai, E. Nishimura, M. Hattori, S. Papadimitriou	2007	Berth allocation at indented berths for mega-containerships	166	(Imai <i>et al.</i> , 2007)

Source: Scopus

4.3.2 Preeminent Impact Author (*h-index*)

This graph illustrates the local effect of writers as measured by the H-index, reflecting their research productivity and impact within the scientific community. The Yeo GT has

the highest H-index of 10, indicating a substantial contribution to the discipline. Authors Notteboom T, Wu Y, and Yang Y have an H-index of 9, demonstrating their significant influence. Budiyanto MA, Nishimura E, and Roy D each have an H-index of 8, while Yang Z, De Koster R, and Hsu HP each possess an H-index of 7. This graph shows that while certain writers are predominant, there is also a notable distribution of contributions from other authors, who are crucial in advancing research in this domain. This highlights strong collaboration among authors with significantly varied levels of impact.

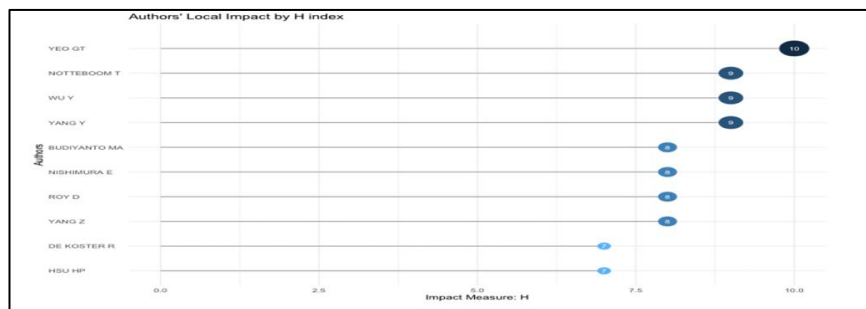


Figure 6: Catalog of the Most Productive Nations
Source: Scopus

4.3.3 Journals with the Greatest Impact

This dataset comprises the top 10 journals focused on container terminals. It features information about journal titles, publishers, and the total number of citations that reflect their impact in relevant study areas. The Journal of Transportation Research Part E: Logistics and Transportation Review, published by Elsevier Ltd, leads with 1385 citations, followed by the Asian Journal of Shipping and Logistics from the Korean Association of Shipping and Logistics with 1251 citations. Additionally, publications such as Transportation Research Part B: Methodological from Elsevier Ltd (1131 citations) and Sustainability (Switzerland), published by MDPI (539 citations), are also included in this compilation. This list illustrates the prominence of publishers like Elsevier and MDPI in providing high-quality research platforms while underscoring the significance of container terminal logistics and operations in the global academic discourse.

Table 2. Ten Premier Journals Addressing Container Terminals

No	Journal	Publisher	Total Citations
1	Transportation Research Part E: Logistics and Transportation Review	Elsevier Ltd	1385
2	Asian Journal of Shipping and Logistics	Korean Association of Shipping and Logistics, Inc.	1251
3	Transportation Research Part B: Methodological	Elsevier Ltd	1131
4	Sustainability (Switzerland)	MDPI	539
5	European Journal of Operational Research	Elsevier B.V.	508
6	Journal of Transport Geography	Elsevier Ltd	408
7	Transportation Research Part D: Transport and Environment	Elsevier Ltd	374

nations such as Hong Kong, the United Kingdom, Singapore, and the United States, underscoring its leading position in global research networks. The United States maintains strong collaborations, particularly with the United Kingdom (9), the Netherlands (8), and Singapore (6). Regional collaborations are evident, exemplified by the partnerships between the Netherlands and India (9) and South Korea and the UK (8). Furthermore, countries like Japan, Germany, and Australia contribute significantly through collaborations with European and Asian nations. This pattern illustrates the strong international ties in research, with developed countries leading the establishment of extensive collaborative networks while emerging countries gradually integrate into global frameworks.

4.5 Examination of Research Subjects and Trends

4.5.1 Keyword Examination

The graph illustrates the distribution of the most relevant terms frequently encountered in research about ports and logistics. The term "container terminal" emerged as the most prevalent, occurring 454 times, followed by "containers" with 438 instances and "port terminals" with 344 occurrences, highlighting the primary emphasis on container terminal infrastructure and operations. Keywords such as railroad yards and terminals (303 occurrences) emphasize the focus on multimodal logistics connectivity, while cranes (124 occurrences) and scheduling (100 occurrences) indicate a concentration on technical elements and operational planning. Furthermore, terms like ports and harbors (104 occurrences), ships (99 occurrences), optimization (97 occurrences), and port operation (89 occurrences) underscore the topic of efficiency and transportation management. This distribution exemplifies the primary focus of the research on enhancing infrastructure, equipment, and operational processes to provide effective and integrated logistics management.

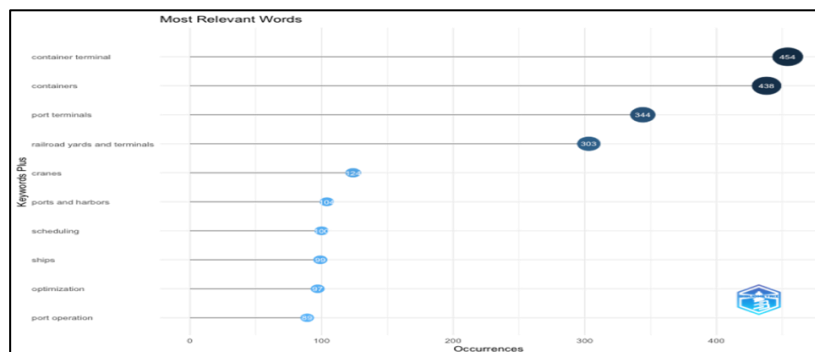


Figure 9: Principal Keywords

Source: Scopus & Biblioshiny

4.5.2 Principal Research Subjects

This picture illustrates a map of study subjects related to container terminals, featuring various terms linked by their significance and frequency in the literature. The emphasis is on topics like "berth allocation" and "combinatorial optimization," showcasing research on berth allocation and complex optimization. In contrast, the central region includes terms such as "container terminal," "logistics," and "supply chains," highlighting a focus on terminal operations and logistics in general. Additionally, themes associated with automation, like "automated container terminals" and "automated guided vehicles," indicate a shift toward advanced technologies for operational efficiency. The terms

"sustainable development" and "risk assessment" in the bottom right corner focus on sustainability and risk management within container terminals and international trade. This graphic encompasses the research spectrum, from technological optimization to strategic management in the container terminal sector.

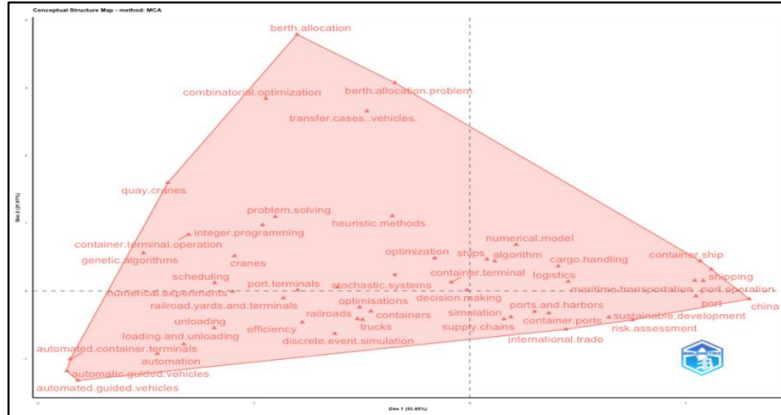


Figure 10: Primary Research Areas
Source: Scopus & Biblioshiny

4.5.3 Ascendant Research Trends

This graphic illustrates the trend of research topics related to container terminals and logistics from 2007 to 2023. Each phrase represents a central theme in the study, with the size of the circle indicating its frequency of occurrence in the literature. Initially, subjects like "container terminals," "heuristic methods," and "optimization" were predominant, highlighting an emphasis on operational efficiency and problem-solving techniques.

Terms such as "supply chain management," "automation," and "strategic approach" have increasingly emerged, signaling a shift towards integrated supply chain management and the adoption of automation technology. Recently, topics like "COVID-19" and "energy utilization" have surfaced, emphasizing the pandemic's impact and the need for energy sustainability. This animation depicts the transition of research objectives from technical to strategic as the global logistics sector evolves.

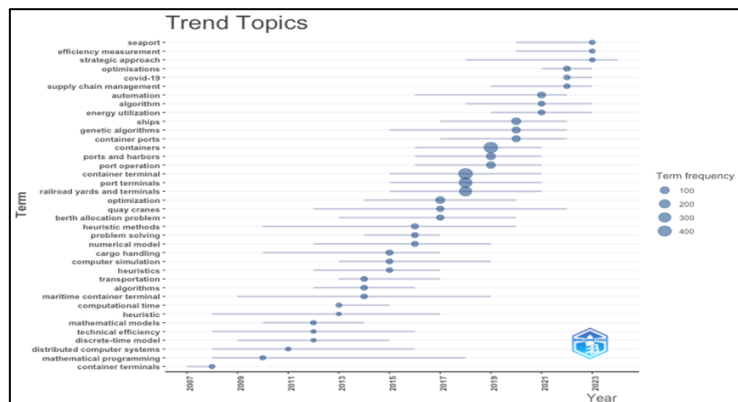


Figure 11: Developing Research Trends
Source: Scopus & Biblioshiny

5. Conclusion

Between 2000 and 2024, the study of container ports has shown a significant increase, especially marked by a surge in publications after 2016. The current body of research mainly focuses on improving operational efficiency through berth allocation, crane scheduling, and adopting technologies such as IoT and blockchain. China stands out as the most prolific nation, with Shanghai Maritime University recognized as the leading institutional contributor. The industry's demand for real-time optimization solutions drives much of the berth and crane scheduling research. Using modular automation and AI-driven scheduling tools, port authorities in developed and emerging nations can enhance operational resilience and throughput efficiency without substantial capital investment. The increasing citation impact underscores the practical importance of operational optimization studies in addressing congestion and cost challenges at container terminals.

Moreover, research indicates a shift towards sustainability and risk reduction in response to global events like COVID-19. Policymakers and terminal planners, who must balance supply chain resilience with environmental responsibility, will find these insights particularly valuable. The increasing emphasis on energy consumption, green logistics, and digital transformation directs academic and industry stakeholders toward new opportunities. The report also highlights the vital role of global collaboration in shaping container terminal research. Countries with advanced marine infrastructure, including China, the United States, and various European nations, frequently work together to tackle shared logistical challenges, creating a model for developing countries to emulate. However, the study's reliance on English-language articles indexed by Scopus limits its scope, potentially overlooking Indigenous knowledge not represented in significant databases or regionally specific innovations.

The research primarily employs quantitative methodologies. Future studies should integrate bibliometric data with qualitative case studies to better understand container port management's sociopolitical, technical, and policy complexities. A multi-stakeholder approach must be adopted, incorporating perspectives from operators, regulators, logistics companies, and local communities while broadening the scope to consider various technologies such as digital twins, big data analytics, and predictive modeling. According to Rodrigue (2020), various sources Notteboom and Rodrigue (2005), the changing geography of port development- transitioning from core-periphery models to more network-oriented configurations- demands further scrutiny. These perspectives offer a more comprehensive and practical understanding of global container terminal dynamics. The study mainly uses quantitative methodologies; however, a detailed qualitative analysis of the social and policy implications remains crucial.

Future research on the deeper integration of various technologies in container terminal operations, including predictive analytics and big data, should take a multi-stakeholder approach to achieve a more comprehensive understanding. Moreover, it should encompass a broader geographic and statistical range to reflect better the context of developing nations, which often present unique challenges to the logistics industry.

The findings of this study offer practical recommendations for port administrators and logistics planners. The ongoing emphasis on berth and crane scheduling highlights the need for real-time container port optimization tools. Implementing AI-based scheduling systems, modular automation, and predictive analytics can reduce congestion and alleviate cost inefficiencies. Moreover, the growing focus on energy efficiency and

environmental performance underscores the importance of green logistics initiatives. Port operators, particularly in developing regions, can leverage these insights to adopt scalable solutions that improve throughput and sustainability without significant capital investment.

References

Baas, J. *et al.* (2020) ‘Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies’, *Quantitative Science Studies*, 1(1), pp. 377–386. doi: 10.1162/qss_a_00019.

Beyene, Z. T. *et al.* (2023) ‘Research Trends in Dry Port Sustainability: A Bibliometric Analysis’, *Sustainability*, 16(1), p. 263. doi: 10.3390/su16010263.

Bolbot, V. *et al.* (2022) ‘Developments and research directions in maritime cybersecurity: A systematic literature review and bibliometric analysis’, *International Journal of Critical Infrastructure Protection*, 39, p. 100571. doi: 10.1016/j.ijcip.2022.100571.

Carlo, H. J., Vis, I. F. A. and Roodbergen, K. J. (2014) ‘Storage yard operations in container terminals: Literature overview, trends, and research directions’, *European Journal of Operational Research*, 235(2), pp. 412–430. doi: 10.1016/j.ejor.2013.10.054.

Donthu, N. *et al.* (2021) ‘How to conduct a bibliometric analysis: An overview and guidelines’, *Journal of Business Research*, 133, pp. 285–296. doi: 10.1016/j.jbusres.2021.04.070.

Dragović, B. *et al.* (2023) ‘A bibliometric analysis and assessment of container terminal operations research’, *Maritime Business Review*, 8(3), pp. 269–293. doi: 10.1108/MABR-07-2022-0035.

Giallombardo, G. *et al.* (2010) ‘Modeling and solving the Tactical Berth Allocation Problem’, *Transportation Research Part B: Methodological*, 44(2), pp. 232–245. doi: 10.1016/j.trb.2009.07.003.

He, J. *et al.* (2015) ‘Integrated internal truck, yard crane and quay crane scheduling in a container terminal considering energy consumption’, *Expert Systems with Applications*, 42(5), pp. 2464–2487. doi: 10.1016/j.eswa.2014.11.016.

Heilig, L., Stahlbock, R. and Voß, S. (2019) ‘From Digitalization to Data-Driven Decision Making in Container Terminals’. doi: 10.48550/arXiv.1904.13251.

Imai, A. *et al.* (2005) ‘Berth allocation in a container port: using a continuous location space approach’, *Transportation Research Part B: Methodological*, 39(3), pp. 199–221. doi: 10.1016/j.trb.2004.04.004.

Imai, A. *et al.* (2007) ‘Berth allocation at indented berths for mega-containerships’, *European Journal of Operational Research*, 179(2), pp. 579–593. doi: 10.1016/j.ejor.2006.03.034.

Imai, A. *et al.* (2008) ‘The simultaneous berth and quay crane allocation problem’, *Transportation Research Part E: Logistics and Transportation Review*, 44(5), pp. 900–920. doi: 10.1016/j.tre.2007.03.003.

Imai, A., Nishimura, E. and Papadimitriou, S. (2003) ‘Berth allocation with service priority’, *Transportation Research Part B: Methodological*, 37(5), pp. 437–457. doi: 10.1016/S0191-2615(02)00023-1.

Kirby, A. (2023) ‘Exploratory Bibliometrics: Using VOSviewer as a Preliminary

Research Tool', *Publications*, 11(1), p. 10. doi: 10.3390/publications11010010.

Kovač, M. *et al.* (2023) 'Modelling Dry Port Systems in the Framework of Inland Waterway Container Terminals', *Computer Modeling in Engineering & Sciences*, 137(1), pp. 1019–1046. doi: 10.32604/cmescs.2023.027909.

Limbourg, S. and Jourquin, B. (2009) 'Optimal rail-road container terminal locations on the European network', *Transportation Research Part E: Logistics and Transportation Review*, 45(4), pp. 551–563. doi: 10.1016/j.tre.2008.12.003.

Martín-Martín, A. *et al.* (2021) 'Google Scholar, Microsoft Academic, Scopus, Dimensions, Web of Science, and OpenCitations' COCI: a multidisciplinary comparison of coverage via citations', *Scientometrics*, 126(1), pp. 871–906. doi: 10.1007/s11192-020-03690-4.

Mohiuddin, K. *et al.* (2024) 'A Bibliometric Analysis: Mapping the Evolution of Maritime Supply Chain Research Trends Across Academic Tides', *Operations and Supply Chain Management: An International Journal*, pp. 182–196. doi: 10.31387/oscm0570421.

Ng, W. C. and Mak, K. L. (2005) 'Yard crane scheduling in port container terminals', *Applied Mathematical Modelling*, 29(3), pp. 263–276. doi: 10.1016/j.apm.2004.09.009.

Notteboom, T. E. and Rodrigue, J.-P. (2005) 'Port regionalization: towards a new phase in port development', *Maritime Policy & Management*, 32(3), pp. 297–313. doi: 10.1080/03088830500139885.

Notteboom, T., Pallis, A. and Rodrigue, J.-P. (2021) *Port Economics, Management and Policy*, *Port Economics, Management and Policy*. London: Routledge. doi: 10.4324/9780429318184.

Notteboom, T., Pallis, T. and Rodrigue, J.-P. (2021) 'Disruptions and resilience in global container shipping and ports: the COVID-19 pandemic versus the 2008–2009 financial crisis', *Maritime Economics & Logistics*, 23(2), pp. 179–210. doi: 10.1057/s41278-020-00180-5.

Rodrigue, J.-P. (2020) *The Geography of Transport Systems*. Fifth edition. | Abingdon, Oxon ; New York, NY : Routledge, 2020.: Routledge. doi: 10.4324/9780429346323.

Roso, V. and Lumsden, K. (2010) 'A review of dry ports', *Maritime Economics & Logistics*, 12(2), pp. 196–213. doi: 10.1057/mel.2010.5.

Safuan, Ramadian, A. and Selasдини, V. (2023) 'Environmental, Social and Governance implementation in Indonesian ports. A qualitative approach and its impact on global sustainability', *Visions for Sustainability*, 2023(20), pp. 395–419. doi: 10.13135/2384-8677/8448.

Safuan and Syafira, A. (2024) 'Artificial Intelligence in Indonesian Ports: Opportunities and Challenges', *Transactions on Maritime Science*, 13(2). doi: 10.7225/toms.v13.n02.w07.

Weerasinghe, B. A., Perera, H. N. and Bai, X. (2024) 'Optimizing container terminal operations: a systematic review of operations research applications', *Maritime Economics & Logistics*, 26(2), pp. 307–341. doi: 10.1057/s41278-023-00254-0.

Zhou, C. *et al.* (2022) 'Emerging technology and management research in the container terminals: Trends and the COVID-19 pandemic impacts', *Ocean & Coastal Management*, 230, p. 106318. doi: 10.1016/j.ocecoaman.2022.106318.