A SYSTEMATIC REVIEW AND BIBLIOMETRIC ANALYSIS OF RECENT STUDIES ON CONTAINER THROUGHPUT FORECASTING

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ABSTRACT

This study investigates container throughput forecasting by examining recent scholarly contributions and the forecasting methods employed. To ensure a comprehensive and systematic review of the academic literature, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed. A total of 57 documents, published since 2014 and retrieved from the Scopus database were selected from an initial pool of 156 records. Bibliometric analysis of these documents revealed that the most commonly applied methods fall into categories such as neural networks and machine learning approaches, traditional statistical models, optimisation algorithms, decomposition techniques, grey models, and support vector machines. Among these, neural networks and machine learning approaches, along with traditional statistical models, emerge as the most prominent. Elsevier is identified as the leading publisher of journal articles, while IOP Publishing is noted for contributing the most conference articles. Asia is recognised as the dominant region for container throughput forecasting research, with China recognised as the foremost global contributor. Additionally, Dalian Maritime University is highlighted as the most active institution between corresponding authors.

Introduction

Container throughput refers to the measurement of the number of containers, whether inbound or outbound, full or empty that pass through a port within a specific period. It serves as a crucial metric for assessing port activity (Aronietis *et al*., 2023). According to the Statista website, global container throughput at ports reached 622 million twenty-foot equivalent units (TEUs) in 2012 and is projected to grow significantly to 988 million TEUs by 2027. As the demand for containerised maritime shipping continues to rise, driven by globalisation and increased trade volumes, stakeholders-including terminal operators and decision-makers must adopt the most accurate forecasting models.

Predicting container throughput with precision is not only essential for efficient port planning and operational optimisation but also serves broader purposes. It plays a vital role in strategic decision-making at the national level, regional economic development, maritime logistics efficiency, and facilitating global trade flows. Accurate forecasting can lead to more resilient supply chains, better allocation of resources, and more effective responses to future trade demands. For businesses, accurate container throughput data is instrumental in gaining visibility into the supply chain industry (Muñuzuri *et al*., 2016). It enables them to monitor traffic trends, anticipate potential disruptions, and make informed operational decisions.

While several studies have made significant contributions by evaluating forecasting techniques (Gamassa & Chen 2017; Chan *et al*., 2019; Xu *et al*., 2022; Munim *et al*., 2023) and examining key influencing factors (Li *et al*., 2019), Existing literature that presents a comprehensive bibliometric analysis that quantitatively assesses the structure and evolution of academic research on container throughput forecasting remains limited. Bibliometric analysis can provide a structured, evidence-based perspective of research trends, key contributors, and emerging themes in the field of container throughput forecasting. This study addresses this gap by providing a data-driven overview of container throughput forecasting literature. Specifically, it analyses annual publication counts, document types (journal articles and conference articles), publishing sources, citation metrics, author affiliations, frequently studied ports, and the forecasting methods employed.

The remainder of this article is structured as follows: The next section outlines the methodology used to extract relevant research from the academic literature. The "results and discussion" section contains the findings of the bibliometric analysis, including statistics on annual publication counts, contributions by publishers, journals, and conferences, as well as analyses of author affiliations by institution type, continent, and country. It also examines institutional distribution, citation records of the included documents, study locations, and a categorisation of the forecasting methods used. The final section presents the conclusion.

Methodology

The methodology used in this literature review follows the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines, which offer a structured, transparent, and replicable framework for identifying, screening, and selecting relevant documents. This approach ensures consistency of the review process, minimises bias, and enhances the reliability of findings, especially important in a diverse and rapidly developing research area such as container throughput forecasting. The process flowchart of this study is depicted in Figure 1, outlining the step-by-step methodology employed. To gather the necessary academic articles, a comprehensive search was conducted on the Scopus database on August 19, 2024.

An advanced search tool was used, and a detailed search string was applied to the titles, abstracts, and keywords of the documents. The exact search string used was: (TITLE-ABS-KEY ("throughput") AND TITLE-ABS-KEY ("container") AND TITLE-ABS-KEY ("port" OR "terminal") AND TITLE-ABS-KEY ("forecast" OR "prediction")).
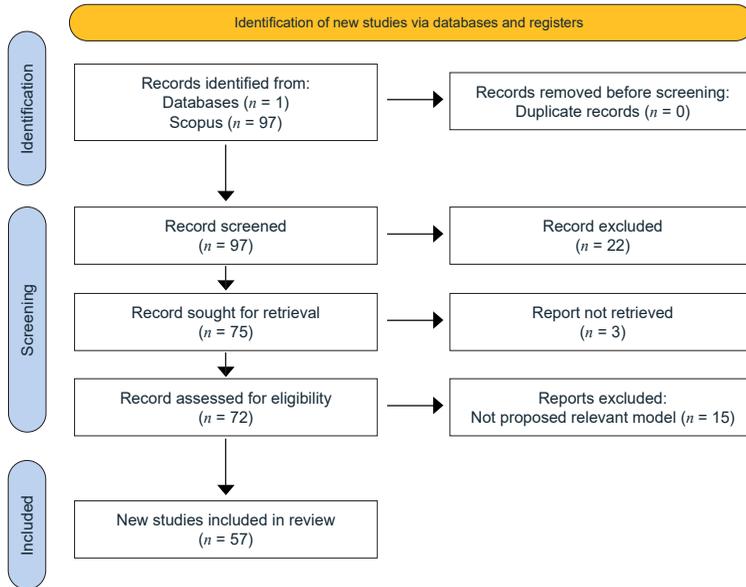
Figure 1: Flowchart of the document selection process
Source: Authors

The initial search yielded 156 documents dating back to 1982. However, since this review focused specifically on the most recent advancements in container throughput forecasting, the selection was refined to include only articles published in the last 10 years (from 2014 onward). Additionally, several criteria were applied to refine the results, including limiting the document types to articles and conference articles, restricting the source types to journals and conference proceedings, and confining the language to English. These filters reduced the search results to 97 documents, which were subsequently extracted for further analysis. Upon review, no duplicates were identified in the dataset.

The next step involved screening the titles and abstracts of all 97 documents to assess their relevance to this study. This process revealed that 11 documents were unrelated to container throughput forecasting, and another 11 focused solely on comparing forecasting methods without proposing models, which led to these documents being excluded from this study. Consequently, 75 documents remained for in-depth analysis. In the following stage, the full texts of these 75 documents were meticulously examined. During this screening, it was found that 15 documents did not propose a container throughput forecasting model, and the full text of three documents was unavailable. Therefore, these 18 documents were excluded, leaving 57 documents for further consideration.

A co-occurrence analysis was then performed using VOSviewer software and the resulting map based on author keywords from the included documents is presented in Figure 2.
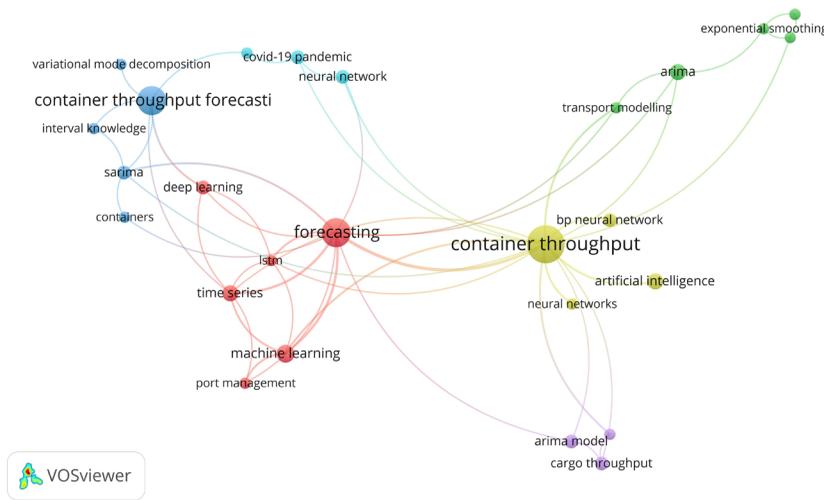
Figure 2: Author keywords map of the included documents
Source: Authors

Results and Discussion

Annual Publication Analysis

The annual distribution of publications reflects an evolving scholarly interest in container throughput forecasting over the past decade. From a relatively modest output between 2014 and 2017, with only two to three publications per year, there is a noticeable upward trend beginning in 2018. This growth may be attributed to increasing global emphasis on port efficiency, digitalisation of maritime logistics, and the broader application of predictive analytics in supply chain management. The peak was in 2021, with 10 publications, which could be linked to heightened academic and industry attention following the global disruptions caused by the COVID-19 pandemic, which highlighted the importance of resilient and predictable port operations.

The subsequent stabilisation of publication numbers in 2022, 2023, and 2024 (with five publications each year) suggests a maturing research area where foundational work has been established, possibly leading to more specialised or application-driven studies. It is also important to interpret the 2024 data cautiously, as it only includes publications up to the date of data collection and may not represent the full year's output. The upward trend reflects increasing academic interest in container throughput forecasting, driven by the need to address port operational complexities and enhance data-driven decision-making (Figure 3).
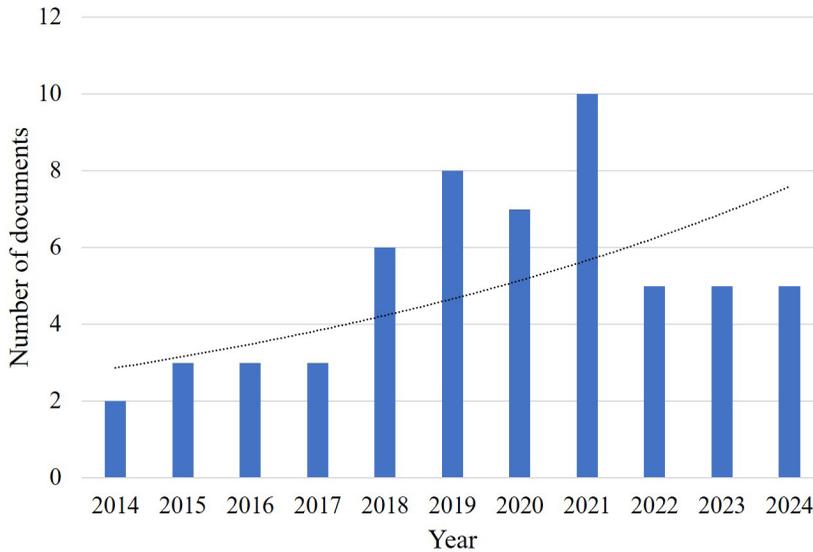
Figure 3: The annual number of published documents
Source: Authors

Document Type Analysis

The distribution of document types indicates a strong preference for journal-based dissemination in the field of container throughput forecasting, with approximately 68% (39 out of 57 documents) of the selected documents being journal articles. This suggests that much of the research in this area is oriented toward peer-reviewed, high-quality publications, reflecting the academic maturity and methodological rigour of the field. Conference articles, which accounts for the remaining 32% (18 out of 57 documents), also play a crucial role, particularly in introducing emerging techniques and facilitating early dissemination of ongoing research.

The fact that 39 articles are spread across 31 different journals illustrates the interdisciplinary nature of the field, spanning domains such as maritime studies, transportation policy, systems engineering, and applied artificial intelligence. The presence of recurring journals, such as Journal of Coastal Research and Maritime Economics and Logistics, suggests that certain outlets serve as key platforms for scholarship in this area. Furthermore, the diversity of journals implies that container throughput forecasting is not confined to a narrow academic niche but intersects with a range of broader research communities, including those focused on operations research, coastal management, and smart logistics. This widespread distribution may also reflect the varied methodological approaches and applications that characterise the domain.

The inclusion of both journal and conference publications ensures a comprehensive view of the academic landscape, capturing both well-established research and more experimental or preliminary findings that may shape future developments. A complete list of the journals involved, and their associated publisher is provided in Table 1.

Table 1: Contributing journals and publishers for journal articles

Journal	Publisher	No. of Articles
Journal of Mathematics	Hindawi	1
Computers and Industrial Engineering	Elsevier	1
Journal of Marine Science and Engineering	MDPI	2
Maritime Economics and Logistics	Palgrave Macmillan	3
Journal of Coastal Research	Coastal Education Research Foundation Inc.	3
Applied Soft Computing Journal	Elsevier	1
Maritime Policy and Management	Taylor & Francis	1
Industrial Management and Data Systems	Emerald	1
Journal of Systems Science and Complexity	Springer	2
Expert Systems with Applications	Elsevier	2
Journal of Maritime Research	University of Cantabria	1
Applied Mathematical Modelling	Elsevier	1
Physica A: Statistical Mechanics and its Applications	Elsevier	1
Maritime Business Review	Emerald	1
Transport Policy	Elsevier	2
International Journal of Shipping and Transport Logistics	Inderscience Publishers	1
KSCE Journal of Civil Engineering	Springer	1
Promet - Traffic and Transportation	University of Zagreb	1
Transportation Research Record	SAGE	1
Industrial Management and Data Systems	Emerald	1
Transportation Research Part A: Policy and Practice	Elsevier	1
International Journal of Computer Science and Applications	Technomathematics Research Foundation	1
International Journal of Intelligent Systems and Applications in Engineering	Auricle Global Society of Education and Research	1
International Journal of Information Technology and Decision Making	World Scientific Publishing	1
Sustainability (Switzerland)	MDPI	1
Mathematics	MDPI	1
Journal of International Maritime Safety, Environmental Affairs, and Shipping	Taylor & Francis	1
Systems	MDPI	1
Knowledge-Based Systems	Elsevier	1
International Journal of Production Research	Taylor & Francis	1
Journal of Forecasting	John Wiley and Sons	1

Publisher Analysis

The 39 journal articles were distributed across 16 different publishers (Figure 4 and Table 1). The publisher distribution revealed that container throughput forecasting research was concentrated, being carried out by a small number of prominent academic publishers. Of the 39 journal articles, a significant portion; more than 75% were published by just seven publishers, indicating a degree of consolidation in the dissemination of knowledge within this domain. Elsevier emerged as the leading publisher, accounting for approximately 26% of the total journal articles. This aligned with Elsevier's strong presence in the fields of transportation, operations research, and applied sciences.

The relatively high output from MDPI (5 out of 39 or 12.8%) also reflected the growing influence of open-access publishing platforms, which may facilitate faster dissemination and broader accessibility of research findings. Other key publishers, including Palgrave Macmillan, Springer, Emerald, Taylor & Francis, and the Coastal Education Research Foundation, each contributed around 7.7% (3 out of 39) of the articles, this suggests a balanced representation across both traditional and open-access publishers. The presence of nine articles each published by a different publishers further indicates that research on container throughput forecasting finds relevance across a wide range of scholarly audiences and publication channels. This diversity may also reflect differences in methodological focus, regional interests, or the evolving nature of the research topic.
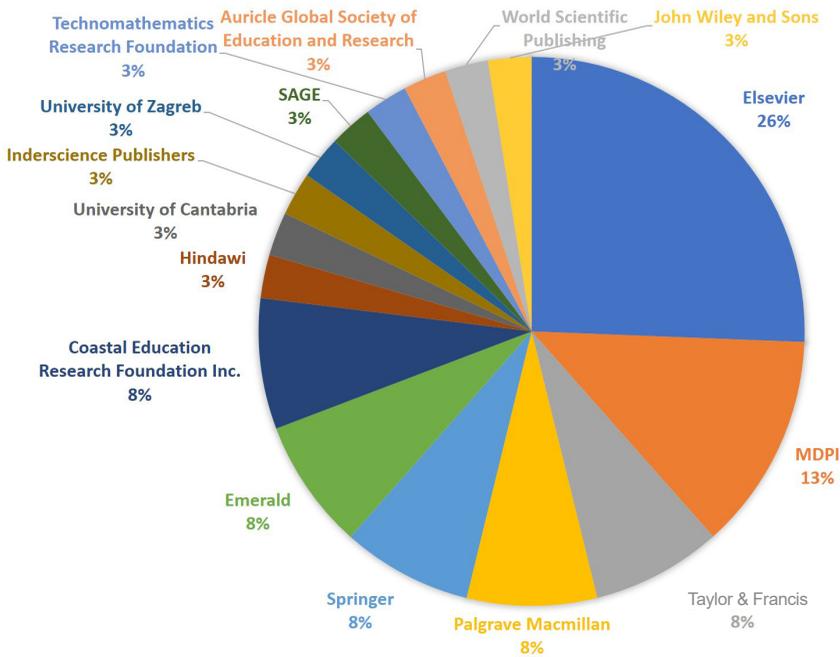
Figure 4: Contribution of the publishers for journal articles
Source: Authors

The 18 conference articles were presented at various conferences, as detailed in Table 2. These articles were distributed across five different publishers, reflecting the diversity of platforms that hosted these contributions. Notably, a significant portion of the articles were published by IOP Publishing and the Institute of Electrical and Electronics Engineers

(IEEE), these publishers accounted for 38.9% (7 out of 18) and 33.4% (6 out of 18) of the total number of published articles, respectively. Additionally, 11.1% (2 out of 18) of the articles were published by both the Association for Computing Machinery (ACM) and Elsevier. The remaining one conference article was published by the Society of Photo-Optical Instrumentation Engineers (SPIE). The data also indicates that the conferences ICTIS, CISAT, and ITQM made the largest contributions, each featuring two articles.

Table 2: Contributing publishers and conferences for publishing conference articles

Publisher	Conference	No. of articles
IEEE	11th International Conference on Measuring Technology and Mechatronics Automation, ICMTMA 2019	1
	International Conference on Security, Pattern Analysis, and Cybernetics, SPAC 2018	1
	32nd Chinese Control and Decision Conference, CCDC 2020	1
	International Conference on Logistics, Informatics and Service Sciences, LISS 2016	1
	7th International Conference on Transportation Information and Safety, ICTIS 2023	1
	3rd International Conference on Transportation Information and Safety, ICTIS 2015	1
IOP Publishing	3rd International Symposium on Traffic Transportation and Civil Architecture, ISTTCA 2020	1
	3rd International Conference on Computer Information Science and Application Technology, CISAT 2020	1
	4th International Conference on Computer Information Science and Application Technology, CISAT 2021	1
	2nd International Conference on Applied Physics and Computing, ICAPC 2021	1
	7th International Conference on Advances in Energy, Environment and Chemical Engineering, AEECE 2021	1
	5th International Conference on Materials Science, Energy Technology and Environmental Engineering, MSETEE 2020	1
	International Conference on Information Technology and Mechanical Engineering, ITME 2021	1
ACM	8th International Conference on Industrial and Business Engineering, ICIBE 2022	1
	5th International Conference on Computer Science and Application Engineering, CSAE 2021	1
Elsevier	2nd International Conference on Information Technology and Quantitative Management, ITQM 2014	1
	3rd International Conference on Information Technology and Quantitative Management, ITQM 2015	1
SPIE	2nd International Conference on Internet of Things and Smart City, IoTSC 2022	1

Citation Record Analysis

The citation analysis highlighted the presence of a few influential publications that have significantly shaped the academic discourse on container throughput forecasting. The most highly cited work, Niu *et al*. (2018), was referenced more than 100 times, indicating its strong impact and recognition within the scholarly community. Followed by Niu *et al*. (2018) there are two other significant contributions: Mo *et al*. (2018), with 78 citations, and Du *et al*. (2019), with 56 citations, which rank as the second and third most-cited documents, respectively. It is important to note that the citation records are based on the Scopus database, and no other sources such as Google Scholar. A broader look at the dataset shows that a total of 16 documents garnered between 10 and 50 citations.

This mid-range level of citation activity indicates that these works have gained some recognition within the academic community. It is worth noting that, a large portion of the documents (30 in total) received fewer than 10 citations, reflecting the limited academic impact of those articles. Among these, 8 documents have yet to receive any citations, suggesting that they have not yet been recognised or integrated into subsequent research. These findings illustrate the variability in the influence and reach of the included documents.

Affiliation Analysis

The affiliation analysis of the corresponding authors of all 57 included documents made several noteworthy discoveries.

Affiliations by Institution Type

The institutional affiliation analysis revealed a clear dominance of academic institutions in the field of container throughput forecasting. With 51 out of 57 documents authored by individuals from universities, it is evident that this research area is primarily driven by academic inquiry. This strong academic presence reflects the theoretical, methodological, and exploratory nature of the field, where universities continue to play a central role in developing models, conducting simulations, and advancing forecasting techniques. However, the contribution of six documents from non-educational organisations highlights an important dimension of applied research.

These institutions, likely including private companies, government agencies, and dedicated research institutes, bring practical perspectives, access to proprietary data, and real-world problem-solving priorities that complement academic studies. Their involvement, although limited in quantity, emphasises the field's relevance to operational decision-making in port management and maritime logistics. The balance, though skewed toward academia, suggests potential for deeper collaboration between universities and non-academic entities. Such partnerships could enhance the practical applicability and impact of forecasting research, ensuring that academic models are better aligned with industry needs and policy challenges.

Affiliations by Continent

The continental distribution of corresponding author affiliations reveals a pronounced geographic concentration of research activity in Asia, which accounts for an overwhelming majority of the contributions. With 52 out of 57 affiliations originating from Asian institutions, this finding highlights Asia's central role in advancing research on container throughput forecasting. This dominance is likely influenced by the region's high concentration of major global ports, such as those in China, Singapore, South Korea, and Japan, which face intense throughput demands and are key nodes in international trade.

Europe, while contributing only four affiliations, still represents a region with established academic and maritime research infrastructure. Its smaller share may reflect either different research focuses or greater integration of such topics within broader supply chain or transportation studies. The minimal representation from Africa and the complete

absence of affiliations from North America, South America, and Oceania are particularly noteworthy. This suggests a potential underrepresentation or limited visibility of research efforts in these regions within the Scopus-indexed literature.

It may also reflect differing regional priorities, resource availability, or access to publication platforms. The geographic concentration observed in this analysis emphasises the need for even more balanced global engagement. Broader international collaboration could diversify perspectives and enhance the generalisability and applicability of forecasting models across a host of different port environments.

Affiliations by Country

The country-level affiliation analysis clearly illustrates China's overwhelming dominance in container throughput forecasting research, with 42 out of 57 corresponding author affiliations tied to Chinese institutions. This strong presence aligns with China's global leadership in port activity and maritime trade, housing some of the busiest container ports in the world, such as Shanghai, Ningbo-Zhoushan, and Shenzhen. The operational scale and strategic significance of these ports likely drive a strong national research focus on forecasting techniques to improve efficiency and manage port congestion. India ranks second, albeit distantly, with four affiliations, followed by South Korea with two. These countries also host significant maritime trade operations and are home to growing academic and industrial interest in port logistics and forecasting.

The presence of single affiliations from a range of other countries, including those in Europe, Southeast Asia, and North Africa, demonstrates broader, though limited, international engagement in this research domain. The geographic skew, particularly the concentration of research output in China, suggests that national economic priorities, government support for logistics innovation, and access to port data may influence research productivity in this field. While China's leading role is understandable given its port infrastructure and trade volume, the limited representation from traditionally research-intensive countries such as the United States, Canada, or Australia is notable and may point to different thematic focuses or publication practices. This distribution stresses the need for more cross-country collaboration to diversify research perspectives and extend the applicability of forecasting models across different port systems and economic contexts.

Institutional Distribution

Another critical finding is that the corresponding authors of approximately 42% (24 out of 57) of the documents were affiliated with just eight institutions (Figure 5). This indicates that a small number of institutions hold significant influence in the research domain, serving as major hubs of knowledge and activity. These institutions appear to be leading contributors, likely due to stronger research capacities or specialised expertise in container throughput forecasting.

In contrast, the corresponding authors of the remaining 33 documents were affiliated with 33 different institutions, suggesting a broad diversity in institutional participation beyond the dominant few. In total, 41 distinct institutions contributed to the research. While some institutions act as central players, many others are involved in a smaller, more distributed capacity, reflecting a wide and globally dispersed pattern of research activity.
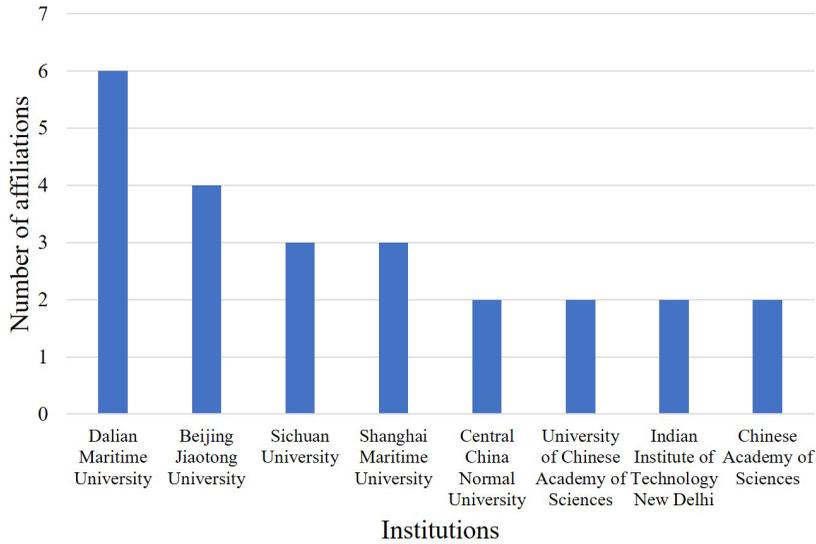
Figure 5: Affiliation appearance of institutions
Source: Authors

Case Study Analysis

The case study analysis reveals a significant geographic concentration in the selection of ports for container throughput forecasting research, with a pronounced focus on Chinese ports (Figure 6). Eight of the 10 most frequently studied ports are located in China, with Shanghai Port and Qingdao Port standing out as the most prominent cases, featured in 16 and 11 studies, respectively. This trend reflects China's central role in global maritime trade and its investment in port development, data infrastructure, and smart logistics, which makes its ports ideal candidates for detailed forecasting studies. The repeated selection of major Chinese ports such as Shenzhen, Guangzhou, Ningbo-Zhoushan, and Tianjin further reinforces the country's dominance in both operational scale and academic research within this field. These ports serve as critical gateways for China's international trade and are often early adopters of advanced technologies, making them relevant to case studies for methodological innovation in forecasting.

Outside of China, only Singapore Port and the Port of Los Angeles were selected more than once. This limited repetition underscores a broader imbalance in case study distribution, with non-Chinese ports being underrepresented. While other ports from regions such as Southeast Asia, South Asia, Europe, and Africa were included, their appearance was infrequent and often limited to single studies.

This concentration of case studies in China likely stems from the availability of data, the accessibility of institutional partnerships, and the strategic importance of Chinese ports in the global supply chain. However, the underrepresentation of ports from other major trading nations, especially in North America, Europe, and Oceania, suggests an opportunity for future research to broaden its empirical base. A more diversified set of case studies would enhance the generalisability of forecasting models and provide comparative insights across different port systems and governance structures.
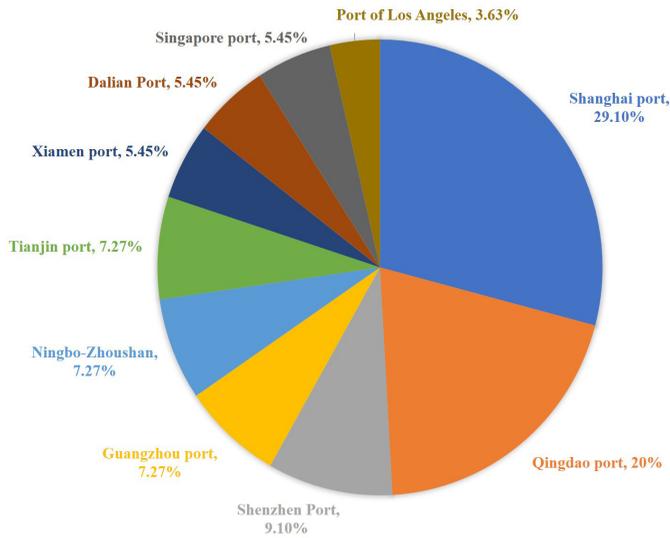
Figure 6: Distribution of the top 10 ports selected as case studies
Source: Authors

Analysis of Techniques Used

The data collected from 57 articles on container throughput forecasting reveal a diverse range of forecasting models and techniques, as summarised and illustrated in Figure 7. These methods are divided into six main groups: Neural networks and machine learning approaches, traditional statistical models, optimisation algorithms, decomposition techniques, grey models, and support vector machines. Table 3 presents a comprehensive list of methods used in all included documents, along with additional information such as study areas and corresponding author affiliations.

The combination of neural networks and machine learning approaches has gained significant popularity in container throughput forecasting, as evidenced by their application in 31 studies. Following this trend, traditional statistical models have been employed in 23 studies. In addition to these two dominant categories, several other forecasting techniques have also been explored. Optimisation algorithms, used in 12 studies, aim to enhance forecasting model performance by fine-tuning parameters and improving predictive accuracy. Decomposition techniques, applied in nine

studies, break down complex time series data into simpler, more manageable components to facilitate more accurate modelling. Grey models, featured in eight studies, are particularly useful when data is limited or uncertain. Grey system theory enables forecasting based on partial or incomplete information, making it valuable in contexts with sparse historical data. Finally, support vector machines (SVMs) were considered in six studies. SVMs are effective in handling high-dimensional data and identifying optimal boundaries for classification or regression tasks.

Among the various forecasting approaches employed for container throughput prediction, the autoregressive integrated moving average (ARIMA) model and its extensions (SARIMA, ARIMAX, ARDL) have demonstrated the highest number of applications, totalling 15 studies. ARIMA is a classical time series forecasting method that combines autoregressive terms, differencing to achieve stationarity, and moving average terms to model the temporal dependencies and noise in the data. Its popularity stems from its robustness and simplicity, which makes it suitable for

capturing trends and seasonal patterns in container throughput data. Following ARIMA, backpropagation (BP) neural networks have been used in eight studies. Backpropagation is a supervised learning algorithm commonly used for training artificial neural networks. In the context of container throughput forecasting, BP networks can effectively model intricate patterns and dependencies that traditional statistical models might miss, providing more accurate predictions.

Long short-term memory (LSTM) networks have been employed in 7 cases for forecasting container throughput. LSTMs are a type of Recurrent Neural Network (RNN) specifically designed to handle long-term dependencies and sequential data. Their adoption allows for retaining information over extended periods. This feature makes LSTMs particularly suited for forecasting tasks where the historical data spans long time horizons and where previous observations significantly impact future values. Grey models (GM), utilised in six applications, were based on grey system theory. These models are valued for their ability to generate forecasts despite data limitations, providing useful insights in challenging forecasting environments. Finally, Variational Mode Decomposition (VMD) has been applied in five instances. VMD is a signal processing technique used to decompose a time series into a set of intrinsic mode functions with different frequency components. This method is particularly useful for handling non-stationary and complex time series data, making it a valuable tool in forecasting container throughput where multiple frequency components are present.
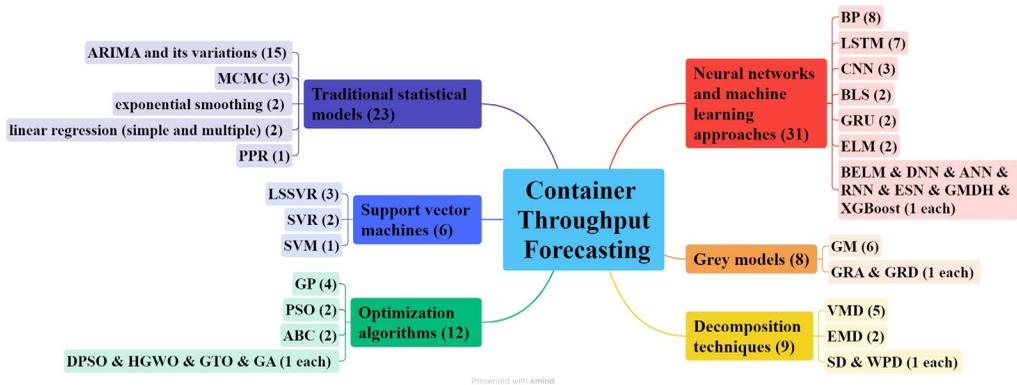

Figure 7: Classification of methods and techniques

Source: Authors

Table 3: Details of all included documents

Reference	Method	Study Area	Corresponding Author Affiliation
He and Wang (2021)	GM(1, 1)-BP	Tianjin-Hebei Port Group	Hebei University of Engineering, China
Nie and Zhao (2019)	BP-GA	NA	Central South University, China
Sanguri *et al.* (2022)	TH-BU cross	Port of Los Angeles	Indian Institute of Technology (IIT) Kharagpur, India
Awah *et al.* (2021)	RF-MLP	Douala Port	Korea Maritime and Ocean University, South Korea
Youlin *et al.* (2021)	Exponential smoothing	Shenzhen Port	Fuzhou University of International Studies and Trade, China
Rashed *et al.* (2017)	ARIMA-ARIMAX	Port of Antwerp	Department of Transport and Regional Economics City Campus, Belgium
Huang *et al.* (2019)	growth rate method	Yangluo Port	Dalian Maritime University, China
Mo *et al.* (2018)	GMDH-SARIMA-SVR-BP-GP	Xiamen and Shanghai Ports	Sichuan University, China
Xie *et al.* (2019)	LSSVR-ANN	Dalian, Tianjin, and Qingdao Ports	Chinese Academy of Sciences, China
Huang *et al.* (2014)	MCMC	Guangzhou Port	University of Chinese Academy of Sciences, China
Shankar *et al.* (2021)	LSTM	Port of Los Angeles	Indian Institute of Technology Delhi, India
Huang *et al.* (2015a)	PPR-GP	Qingdao Port	Beihang University, China
Yang *et al.* (2018)	BLS	Shanghai and Shenzhen Ports	Dalian Maritime University, China
Wu *et al.* (2024)	GRA-Choquet fuzzy integral	Shanghai, Ningbo-Zhoushan, Shenzhen, Guangzhou, Qingdao, Tianjin, Hong Kong, and Xiamen Ports	Ningbo University of Technology, China
Farhan and Ong (2018)	SARIMA	20 International container ports	National University of Singapore, Singapore
Liu (2020)	GM (1,1)	NA	Henan Polytechnic University, China
Jusoh *et al.* (2024)	SLR	Major Malaysian seaports	Universiti Malaysia Terengganu, Malaysia
Jin *et al.* (2022)	PSO-BP	Shenzhen Port	Dalian Maritime University, China
Huang *et al.* (2015)	IKBF	Qingdao Port	Beijing Jiaotong University, China
Niu *et al.* (2018)	VMD-HGWO	Singapore and Shanghai Ports	Lanzhou University, China

Zhang *et al.* (2020)	ARIMA-BP	Qingdao Port	Dalian Maritime University, China
Li *et al.* (2019)	SD-SE-WPD-ELM	Shanghai Port	Beijing University of Technology, China
Gosasang *et al.* (2018)	VECM	Bangkok Port	Port Authority of Thailand, Thailand
Jin *et al.* (2021)	EMD-LSTM-GRU-CNN	Xiamen and Shanghai Ports	Sichuan University, China
Grifoll (2019)	MCMC-ARIMA	Barcelona-Tarragona-Valencia multi-port gateway	Polytechnic University of Catalonia, Spain
Tang *et al.* (2019)	GM, triple exponential smoothing, multiple linear regression-BP	Lianyungang and Shanghai Ports	Southeast University, China
Wang *et al.* (2024)	GRD-ISRF-VMD-GTO	Shanghai, Tianjin, and Dalian Ports	Dongbei University of Finance and Economics, China
Xiao *et al.* (2014)	TF-DPSO	Shanghai and Ningbo Ports	Sichuan University, China
Intihar *et al.* (2017)	ARIMAX	Port of Koper	University of Maribor, Slovenia
Xiao *et al.* (2023a)	VMD- SARIMA-CNN-LSTM	Four ports in Asia	Central China Normal University, China
Li *et al.* (2020)	BLS	Lianyun Port	Dalian Maritime University, China
Jiang *et al.* (2021)	LSTM	Qingdao Port	Chinese Academy of Sciences, China
Shankar *et al.* (2020)	LSTM	Port of Singapore	Indian Institute of Technology New Delhi, India
Rashed *et al.* (2018)	ARDL	Hamburg-Le Havre range of ports	Arab Academy for Science Technology and Maritime Transport, Egypt
Cai *et al.* (2022)	Multi-factor dynamic model	ports in China	China Waterborne Transport Institute, China
Zou *et al.* (2022)	Nonparametric Functional Data Analysis	Shanghai Port	Shanghai Maritime University, China
Huang *et al.* 2016a	SARIMA-LSSVR-GP	Qingdao Port	Beijing Jiaotong University, China
Huang *et al.* (2016b)	SARIMA	Qingdao port	Beijing Jiaotong University, China
Liu (2021)	GM (1, 1)	Shanghai port	Shanghai Maritime University, China
Jayaprakash *et al.* (2023)	ABC-RNN	VOC Port in Tuticorin	Sri Venkateswara College of Engineering and Technology, India

Huang *et al.* (2016)	Judgment model (JM)-MCMC	Guangzhou Port	University of Chinese Academy of Sciences, China
Huang *et al.* (2022)	EMD-ARIMA-SVR	Shanghai Port	Beijing Wuzi University, China
Yang and Chang (2020)	CNN–LSTM	Five ports in Taiwan	National Kaohsiung University of Science and Technology, Taiwan
Tan *et al.* (2021)	ESN	Singapore and Busan Ports	Korea Maritime and Ocean University, Korea
Yao (2021)	ARIMA	Dalian Port	Shanghai Maritime University, China
Huang *et al.* (2020)	ABC-BP	Qingdao Port	Dalian Maritime University, China
Jin *et al.* (2023)	XGBoost	Ningbo Zhoushan Port	University of Nottingham, Ningbo, China
Zhu and Jiang (2023)	BP	Chongqing Port	Chongqing Jiaotong University, China
Huang *et al.* (2015)	SARIMA-LSSVR-GP	Qingdao Port	Beijing Jiaotong University, China
Liang *et al.* (2024)	SVM, DNN, LSTM	Shanghai and Shenzhen Ports	Shanghai University, China
Du *et al.* (2019)	VMD-ELM-BELM	Shanghai Port	Dongbei University of Finance and Economics, China
Feng *et al.* (2019)	ARIMA	Ningbo-Zhoushan Port	Ningbo University, China
Wang and Zhang (2021)	GM(1, 1)	Tianjin Port	The Navigation Guaranteen Center of North China Sea, China
Pang and Gebka (2017)	SARIMA-MSHW-VECM	Tanjung Priok Port	Newcastle upon Tyne, United Kingdom
Yang and Guo (2020)	Grey method	Zhoushan Port	University of Science and Technology, China
Xiao *et al.* (2023)	EWT-TCN-KMSE	Shanghai and Ningbo-Zhoushan Ports	Central China Normal University, China
Zhang *et al.* (2024)	VMD-PSO-GRU	Guangzhou, Qingdao and Shanghai Ports	Wuhan University of Technology, China

Conclusions

Container throughput forecasting involves predicting the volume of containers handled by ports over a specific period, which is essential for strategic planning, operational efficiency, and infrastructure development. This study systematically reviewed published articles available in the Scopus database that are relevant to container throughput forecasting. It contributes to the body of knowledge by conducting a bibliometric analysis focused on specific criteria including annual publication counts, document types, publishing sources,

citation metrics, author affiliations, and frequently studied ports, which are essential for understanding the field's development, key focus areas, and influential contributors. In addition to these aspects, the review also identified the forecasting methods employed, as the choice of method directly impacts prediction accuracy.

The analysis shows that this research area is growing, with rising interest and investment from universities and government institutions. Among the key findings, Elsevier and IOP Publishing emerged as the primary publishers of journal articles and conference articles on this topic, highlighting their influential role in disseminating container throughput forecasting research. The impact of research in this field is notable, with approximately one-third of the documents receiving at least 10 citations, indicating that a substantial portion is considered valuable within the academic community.

Geographically, Asia dominated the research in container throughput forecasting. The vast majority of corresponding author affiliations are linked to Asian institutions, reflecting the region's leading role in advancing this field. Within Asia, China was the foremost contributor, with most of the top affiliations associated with Chinese institutions. Moreover, the study highlighted the influence of Chinese ports on container throughput forecasting research, with 8 of the 10 most frequently selected case study ports located in China. The Shanghai and Qingdao ports, in particular appear most frequently in the available literature.

Several factors contribute to China's leadership in this area. First, China handles a significant share of global container traffic, with ports such as Shanghai, Ningbo-Zhoushan, Shenzhen, and Qingdao consistently ranking among the highest in global throughput. The operational scale and complexity of these ports generate a substantial demand for accurate forecasting models to support capacity planning, congestion management, and strategic investment.

Second, China has heavily invested in smart port initiatives and digital infrastructure, enabling access to high-quality, real-time data essential for developing and testing forecasting models. With regards to the methods used, both conventional and modern practices were identified. Traditional models such as ARIMA, SARIMA, and grey models are often used alongside contemporary techniques, playing a crucial role in enhancing prediction accuracy and offering valuable insights when integrated with advanced algorithms.

In terms of modern practices, there is a notable prevalence of hybrid approaches, including neural networks, machine learning, optimisation algorithms, and decomposition techniques. Machine learning and hybrid models are particularly effective in adapting to irregular patterns, managing large datasets, and improving predictive performance. Furthermore, optimisation-based methods enable the integration of forecasting with resource planning and decision-making processes, supporting real-time applications in container throughput forecasting. Decomposition techniques simplify complex time series data by separating it into distinct components, thereby enhancing the precision and effectiveness of modelling.

There are two key areas that warrant further review to deepen and broaden the current understanding of container throughput forecasting research. First, to achieve a more comprehensive view of the research field, future bibliometric studies should incorporate additional academic databases, such as the Web of Science. Second, to determine the most effective forecasting techniques and their combinations for various forecasting scenarios, a more detailed systematic review is essential.

This review should focus on key factors influencing methodology selection, including data availability, data quality, scalability, forecasting horizon, complexity of data patterns, accuracy requirements, computational resources, and model interpretability.

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

Author Contributions Statement

The authors confirm contribution to the article as follows: Study conception and design: Adel Gohari, Olakunle Oloruntobi; data collection: Adel Gohari, Teh Sabariah Abd Manan, Haspinor Teh; analysis and interpretation of results: Adel Gohari, Kasypi Mokhtar, Amir Sharifuddin Ab Latip; draft manuscript preparation: Adel Gohari, Arife Tugsan Isiacik Colak, Rudiah Md Hanafiah, Mohammed Salih Mohammed Gismalla. All the authors have reviewed the results and approved the final version of the manuscript.

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