

Research Article

Analysis on Port and Maritime Transport System Researches

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Received 30 August 2018; Revised 17 October 2018; Accepted 24 October 2018; Published 21 November 2018

Guest Editor: Zhiyuan Liu

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This paper examines the past and current research in the container port and maritime field. Using rigorous bibliometric analysis, the paper identifies the core authors/affiliations, their rankings, and collaboration patterns. The analysis of the paper will enable new researchers to quickly build an understanding of the container port and maritime field by reading core authors' papers published in specific journals.

1. Introduction

The maritime industry has made great contributions to the world economy in recent decades. The “Maritime Review by 2015” reported by the United Nations Conference on Trade and Development (UNCTAD) shows that nearly 80% of global commodity trade in volume terms was completed through ports and maritime transport routes. The international maritime transportation industry contributes significantly to the welfare and development of nations adding around \$380 billion a year via freight rates alone to the global economy. At the same time, the total amount of marine transport has steadily increased every year, and in 2014, it reached 9.84 billion tons [1–3]. Standing at the critical interface between inland and sea transportation, the container port is a critical connection between different modes of transportation and represents a critical point in the transportation chain [4]. For a country, maritime transportation not only ensures the import of scarce resources needed for production processes but also facilitates the export of excessive resources, which accumulates more wealth for the country. Maritime transport is also a key to economic globalization [5]. In particular, container transport has become the most important mode of transport in international trade and the new window for the development of foreign economic relationship and trade. Worldwide container port throughput increased from 36 million TEU in 1980 to 614 million TEU

in 2017 and forecasts point to more than 800 million TEU in 2017 [6]. The flourishing industrial growth engendered numerous intellectual problems which, in turn, attracted academic interest. Subsequently, container port and maritime transportation has grown as a unique academic field.

Therefore, it is highly important to develop an overview of this field, which will provide general and historical results that permit a retrospective evaluation. In general, a number of studies have attempted to address conceptualization, methodological issues, theoretical developments, academic taxonomy, and future research directions in areas relevant to maritime logistics literature, such as Lau et al. [7]; Lee and Song [8] survey the extant research in the field of ocean container transport. Shi and Li [5] examine maritime transport researches through a comprehensive review of papers published in 19 transportation journals over the period 2000–2014. Charles [9] provided a global evaluation of the marine academic studies. Woo et al. [10] reviewed published port literature from the 1980s to 2000s in order to investigate the methodological trends in seaport research. Talley [11] reviewed and analyzed maritime transportation academic research, summarized the research topic from maritime journals, and defined future maritime transportation research directions. Chang et al. [12] examined the top 50 authors, 50 affiliations, and 50 countries in the maritime transportation field and discussed the potential correlation between the methodological popularity and author performance.

A number of reviews have been completed on specific aspects of maritime transportation research. For example, Wang et al. [3] pointed out the necessity and importance of port management and operations and suggested more research efforts on potential hot topics. Davarzani et al. [13] examined the past and present research on ‘green ports and maritime logistics’ and identified established research trends and future potential research areas. Several reviews have been more problem-specific and sustainable, such as the review by Mansouri et al. [14], who focused on the use of multiobjective decision methods in sustainable maritime transportation. In addition, with the increasing competition in ports, relevant research also expands rapidly. Sharaf et al. [15] provided an understanding of the efficiency analysis of container port through a comprehensive review of existing studies. Based on empirical evidence, Notteboom [16] analyzed the paths shipping lines and terminal operating companies were walking and also provided an overview of challenges port and maritime companies faced with in an ever-changing competitive environment.

In spite of Chang et al. [12], to the best of the authors’ knowledge, no other studies have analyzed the authors’ affiliations, and countries in maritime research. Our paper differs from Chang et al. [12] in four aspects. First, Chang et al. [12] prespecified a set of journals which are the most closely related to maritime research and they confined the literature search within these journals. In contrast, we search the literature in the whole Web of Science database. Second, different from Chang et al. [12], we conduct a more refined literature search; for example, papers that are related to “maritime” and “fish” are excluded. Third, Chang et al. [12] investigated the whole field of maritime papers and we focus on shipping and container port research. Fourth, Chang et al. [12] judged whether a paper is relevant based on its correlation with seven authors’ papers, which may not be accurate. We judge the relevance of all papers manually. Despite the differences, our research is based on Chang et al. [12]’s seminal work which provided a number of insightful ideas. Using rigorous bibliometric analysis methods, this paper reviews the literature of container port and maritime logistics research to accomplish the following goals. First, we provide some initial statistics of the key journals, authors, and institutions that have contributed to the field. Second, we identify the most active researchers, affiliations, and countries in the container port and maritime field and rank them by different scoring methods. Thus, we provide a better understanding of how maritime transportation research has been undertaken in a quantitative manner. And the ranking also helps to identify active authors. Research of active authors tends to be more advanced. Following their articles can help new comers to obtain new research hotspot more quickly.

The remainder of this paper is organized as follows. Section 2 explains the methodology and details the scope of articles, database searching, scoring methods, and measures of collaborative network. Section 3 reports the ranking of authors and affiliations by all periods of study (1996-2016) and changes over five-year periods (1996-2000, 2001-2005, 2006-2010, and 2011-2017). Section 4 discusses countries/regions’ ranking performance. Section 5 analyzes and

identifies research topics and seminal research areas. Finally, we present the study’s conclusions and discuss the study’s limitations and potential future research directions in Section 6.

2. Methodology

The purpose of the literature review is to map and evaluate the body of the literature and identify potential research gaps. Structured literature reviews are completed by Saunders et al. [17] by iterative using search keywords defined appropriately, searching in the databases, and accomplishing the analysis. Rowley and Slack [18] recommend a structured methodology for scanning resources, designing the mapped structure of the literature review, writing the study, and building the bibliography. Inspired by Rowley and Slack [18] and Seuring and Gold [19], we design a four-step method to collect data and conduct a methodical, comprehensive analysis of the field. We aim to identify the remarkable research, make sure about the classical areas of current research interest, and provide insights for present research and directions for the future.

2.1. Choice of Search Word and Database. Through several trials and errors, we identify suitable search terms and keyword structures. We design the following method to establish the keywords search structure effectively inspired by Rowley and Slack [18] and Soring and Gold [19].

- (i) Build original unit of keywords.
- (ii) Review the search results and make sure whether typical papers and considerable journals are contained in obtained results, and make corresponding modifications to keyword set.
- (iii) Identify the keywords needed to exclude, and make corresponding modifications to keyword set.
- (iv) Search for ‘exclusion research areas’ to confine the search scope, and make corresponding modifications to keyword set.

Initially, we relied on the prior work of Chang et al. [12] in the maritime logistics review papers to define the initial set of keywords. Thirteen search words were suggested based on these previous works. They were “port OR shipping OR maritime OR marine OR terminal OR ship OR liner OR vessel OR seaport OR water transport* OR ocean freight OR container” and “waterway transport*.” First, search words were typed in the Web of Science database. This paper only retrieves academic articles (or journal papers) and rules out conference proceedings, book chapters, dissertations, and theses. The space of journals selected in this paper narrows down to Science Citation Index (SCI), Social Science Citation Index (SSCI), SCI (E), and SSCI-registered ones. Afterwards, we check the resulting articles and journals. A mass of words have a polysemic effect. For example, “vessel” means either a ship or a duct or canal holding or conveying blood or other fluid. The polysemy effect of “vessel” causes the initial search results to include a mass of papers about biological research. We also ruled out the articles that include the following irrelevant words, including “highway OR intersection OR

TABLE 1: Process of the material collection.

		Search results
Step1	Search keywords port OR shipping OR maritime OR marine OR terminal OR ship OR liner OR seaport OR (water transport*) OR (ocean freight) OR container OR (waterway transport*)	81,126
Step2	Exclusion keywords AND NOT highway OR intersection OR helmet OR pedestrian OR fish OR guardrail OR aviation OR airport OR airline OR fishery	78,482
Step3	Remove the irrelevant subject areas	12,279
Step4	Manual refinement of the search results	5,534

helmet OR pedestrian OR fish OR guardrail OR aviation OR airport OR airline” and “fishery.”

The initial search results left about 12279 articles after several trial and error attempts. The search results have expanded to a wide range of thematic areas beyond the scope of this paper. Hence, papers from irrelevant thematic areas need to rule out. Irrelevant subject areas are those that do not belong to the space of container and marine transport system. The unrelated areas were identified through discussions with other senior researchers in the field. The unrelated areas included (1) astronomy, planet sciences, and related areas, (2) agricultural sciences and related areas, (3) medicine, biology, and related areas, (4) physics and related areas, and (5) psychology. Finally, the authors went through 12,279 references and reduced the number of relevant articles to 5,534 as a refinement. Table 1 shows the whole process of the material collection.

2.2. Scoring Method. In this paper, we used two criteria to rank researchers, affiliations, and countries, the number of their publications, and their impact score. The following text describes the composition of each indicator and the rationale for how to use them in detail. The number of publications is an important indicator of academic performance. Numerous studies have used this indicator to approximate author performance [13, 20]. However, only calculating the number of publications has the limitation of measuring the impact of authors on the whole field. In this case, the more crucial part the authors played in an article, the more important evaluation they should be given.

Authors who publish their work in more prestigious journals deserve more respect and higher scores. In this case, it seems appropriate to use the impact factor of a journal to adjust the authors' impact score. There is, in general, a widespread consensus among the authors that the impact factor measures the quality of journals approximately and reasonably. And usage of impact factor is prevalent [21, 22]. The Journal Citation Reports published by Thomson Reuters provided statistical data over the years. A number of journals had no statistical results for certain years, since they recently entered SCI (E) or SSCI, including *Maritime Policy and Management*. In such a case, the impact factor in the entry year was applied to the nonentrance periods. For example, the 2011 impact factor for *Maritime Policy and Management*

was applied to 2000-2010. Afterwards, the impact score was denoted by

$$Score_j = \sum_{y=2000}^{2017} \sum_i \frac{1}{I_j^i} \times IM_y^i \quad (1)$$

where $Score_j$ is the impact score of author j , N is the number of papers published by author j , I_j^i represents the number of corresponding authors in paper i with author j , and IM_y^i is the impact factor of journals that paper i was published in in year y .

Apart from impact score assessment, the number of citations of each paper is also included in the database we have obtained, which is more basic and fundamental and also a good indicator of the author's performance. We measured the total number of citations of an author i by

$$c_i = \sum_{n \in N} ct_n \quad (2)$$

where c_i is the citation score of authors i , N is the total number of publications of author i , and ct_n is the citations of paper n .

3. Analysis of Author and Affiliation

Section 3.1 illustrates the overall trend of publications. Sections 3.2-3.3 report rankings of author and affiliation for 1996-2017, respectively.

3.1. Overall Trend. Figure 1 shows the number of papers published each year. Between 1996 and 2012, the published paper counts in maritime transport system field increased every year. The number peaked in 2012 and decreased thereafter. In 2015, this number began to rise again. The rising paper numbers may be due to the Chinese government vigorously promoting the economic strategy of the Silk Road Economic Belt and the 21st Century Maritime Silk Road. The paper number of Chinese scholars has improved, thereby causing the total number of papers to increase in 2015. Section 3.3 reports the country rankings from 1996 to 2016 and supports this conclusion.

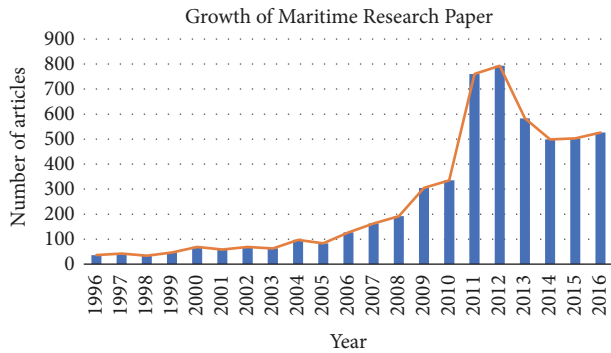


FIGURE 1: Growth of maritime research paper.

3.2. Author Ranking Analysis

3.2.1. Author Ranking for 1996-2016. Table 2 displays the ranking of top 50 authors in the port and maritime transport system field according to the three metrics we mentioned above. Column 3 shows the ranking of the first metric, which is calculated based on the number of papers published. Numbers are counted when the author is one of all coauthors or the single author of a paper. For example, the top ranked Qiang Meng published 61 papers, either as an author or a coauthor. The second metric ranking is the impact score (column 6) that considers the journal impact factor. In terms of paper numbers, Qiang Meng is the top researcher and published 61 papers. Qiang Meng was followed by Shuaian Wang with 52 papers. After those two researchers, the differences between the subsequent authors are not substantial.

Considering the impact score, Meng and Wang still take the first and second places, but their ranks are reversed. The gap between the second and third is relatively large. A notable change can be seen. Among the top 10 authors, Metin Celik, Chung-Yee Lee, Dong-Ping Song, and Lu Zhen emerge. Celik's ranking increased from 16th to 7th. Lee's ranking increased from 24th to 8th. Song's ranking increased from 16th to 9th. Zhen's ranking increased from 35th to 10th.

Significant changes can be observed on the citation score: Nishimura, Etsuko, and Stahlbock, R are the first time appearing in the top 10. Compared with the rank of number of papers, Imai, Akio, Voss, Stefan, and Papadimitriou, Stratos's ranks up more than 25.

3.2.2. Ranking Dynamics of Authors. This section examines the changes in the author's performance over each five-year period. Table 3 shows the dynamics of the impact score ranking of authors. The columns next to the impact score indicate the change of the ranking relative to the previous period in 2001-2005, 2006-2010, and 2011-2015, respectively. Ranking changes of an author will not be shown if he/she was outside the top 100 in the previous period. Overall, the rise and decline of core authors are prominent in the port and maritime transport system field. A notable point is that K.H. Kim maintains a top 10 ranking in every period. Numerous top 50 authors from 1996 to 2000 do not make the rankings in the next period, while most of the top 50 authors in 2001-2005 are new authors. A similar pattern appeared between

2006 and 2010 and 2011 and 2015. This field also had a new strength among the top 5 from 2011 to 2015. A typical example is S.A. Wang. Since all of his articles are published after 2010, he did not appear in the ranking of first three-time periods. Nevertheless, his centrality for 2011-2015 is quite high. Other examples include J.S.L. Lam and L. Zhen. It can be expected that these authors will contribute more to the field in the coming years. Only Notteboom maintains a top 5 position over the entirety of the last decade. The changeable ranking means this field is full of competition and opportunity.

Another point worth noting is that the five-year impact scores of active authors have a significant raise. For example, the impact scores of the top 3 between period 3 and period 4 soared from 9.05, 8.73, and 7.79, respectively, to 34.45, 31.03, and 17.98, respectively. It may have been influenced by the growing number of publications and more publications being published in high-impact journals (impact score = $\sum_{y=2000}^{2017} \sum_i^N (1/I_j^i) \times IM_y^i$).

3.2.3. Core Authors and Collaboration Patterns. Derek Price prompted the celebrated "square root law" that states that half of the scientific papers are contributed by the top square root of the total number of scientific authors. The law was first proposed in Little Science-Big Science [23] and is heuristically based on Lotka's inverse square law. The Price's law is calculated from the following equation:

$$M = 0.749 \sqrt{N_{max}} \quad (3)$$

where N_{max} is the maximum number of the articles by one author. M is the minimum number of articles by a core author, which means the author whose published paper number is above M is the core author. In our data sample, N_{max} equals 61, and according to Price's law M equals 5.8. Thus, there are more than 190 authors who have published more than 6 papers in the field.

For further analysis, we also tried to analyze the cooperation pattern of the core authors. The cooperation pattern means different authors appearing in multiple joint articles frequently. Table 4 shows the results. An interesting observation is that the core authors (such as S.A. Wang, Q. Meng, E.P. Chew, L.H. Lee, and K. Fagerholt) in the container port and maritime field do frequently cooperate. This result indicates that most container port and maritime researchers are willing to cooperate with their familiar partners.

The top articles were considered as the lead articles of a research area [13]. The titles of core authors' top 10 articles in the container port and maritime research area are also shown in Table 5. All of the top 3 articles are the overview in the port and maritime research area which may help new comers to understand quickly about container port and maritime field. The rest of the top 10 articles are interested in specific topics, including economics, operations research, business, and planning.

3.3. Affiliation Ranking Analysis

3.3.1. Affiliation Ranking for 2000-2015. Table 6 displays affiliation rankings for 1996-2016. In paper counts, the National

TABLE 2: Rankings by author.

Rank	Author	No. papers	Rank	Author	Impact Score	Rank	Author	Citation Score
1	Meng, Qiang	61	1	Wang, Shuaian	47.95	1	Kim, Kap Hwan	1713
2	Wang, Shuaian	52	2	Meng, Qiang	41.66	2	Imai, Akio	1214
3	Kim, Kap Hwan	47	3	Notteboom, Theo	25.63	3	Christiansen, Marielle	1189
4	Fagerholt, Kjetil	45	4	Lam, Jasmine Siu Lee	25.00	4	Fagerholt, Kjetil	1147
5	Lam, Jasmine Siu Lee	36	5	Kim, Kap Hwan	23.63	5	Meng, Qiang	1107
5	Notteboom, Theo	36	6	Fagerholt, Kjetil	23.06	6	Papadimitriou, Stratos	1083
7	Wang, Jin	31	7	Celik, Metin	20.41	7	Voss, Stefan	1030
8	Christiansen, Marielle	30	8	Lee, Chung-Yee	19.00	8	Nishimura, Etsuko	1021
9	Lee, Loo Hay	28	9	Song, Dong-Ping	17.44	9	Stahlbock, R	960
10	Parola, Francesco	26	10	Zhen, Lu	17.35	10	Wang, Shuaian	751
10	Lu, Chin-Shan	26	11	Monios, Jason	17.10	11	Cullinane, Kevin	744
10	Chew, Ek Peng	26	12	Ding, Ji-Feng	15.76	12	Laporte, Gilbert	680
10	Lee, Paul Tae-Woo	26	13	Ng, ManWo	14.41	13	Kozan, Erhan	659
14	Luo, Meifeng	25	14	Lu, Chin-Shan	13.99	14	Song, Dong-Wook	624
15	Lun, Y. H. Venus	24	15	Talley, Wayne K	13.45	15	Vis, Iris F. A.	614
16	Celik, Metin	23	16	Tovar, Beatriz	13.27	16	Notteboom, Theo	577
16	Lee, Der-Horng	23	17	Lee, Paul Tae-Woo	12.62	17	Meisel, Frank	562
16	Song, Dong-Ping	23	18	Thai, Vinh V	12.56	18	Park, YM	540
19	Cheng, T. C. Edwin	22	19	Ducruet, Cesar	12.56	19	Wang, Jin	522
19	Cullinane, Kevin	22	20	Christiansen, Marielle	12.15	20	Liu, JY	519
22	Ng, Adolf K. Y.	21	21	Lun, Y. H. Venus	11.75	21	Ronen, David	506
21	Thai, Vinh V	21	22	Lee, Loo Hay	11.65	22	Wan, YW	505
21	Yang, Zaili	21	23	Luo, Meifeng	11.61	23	Steenken, D	500
24	Chang, Young-Tae	20	24	Petering, Matthew E. H.	11.22	24	Bierwirth, Christian	484
24	Lee, Chung-Yee	20	25	Wilmsmeier, Gordon	11.18	25	Lee, Der-Horng	450
24	Li, Kevin X	20	26	Lee, Der-Horng	11.14	26	Lu, Chin-Shan	436
27	Lai, Kee-hung	19	27	Lai, Kee-hung	10.96	27	Tongzon, J	431
27	Laporte, Gilbert	19	28	Akyuz, Emre	10.91	28	de Koster, R	424
29	Huynh, Nathan	18	29	Cullinane, Kevin	10.76	29	Lee, Loo Hay	422
29	Papadimitriou, Stratos	18	30	Parola, Francesco	10.54	30	Linn, RJ	422
31	Ducruet, Cesar	17	31	Wang, Jin	10.17	31	Celik, Metin	411
31	Imai, Akio	17	32	Boysen, Nils	10.09	32	Andersson, Henrik	395
31	Tovar, Beatriz	17	33	Chou, Chien-Chang	10.08	33	Legato, Pasquale	391
31	Yip, Tsz Leung	17	34	Dong, Jing-Xin	9.88	34	Kujala, Pentti	389
35	Hu, Hao	16	35	Wang, Xinchang	9.83	35	Chew, Ek Peng	385
35	Kavussanos, Manolis G	16	36	Meisel, Frank	9.62	36	Song, Dong-Ping	375
35	Lim, Andrew	16	37	Ng, Adolf K. Y.	9.52	37	Murty, Katta G.	368
35	Monios, Jason	16	38	Chew, Ek Peng	9.47	38	Lam, Jasmine Siu Lee	360
35	Pisinger, David	16	39	Laporte, Gilbert	9.47	39	Ng, WC	320
35	Song, Dong-Wook	16	40	Yang, Yi-Chih	8.98	40	Wang, Teng-Fei	317
35	Talley, Wayne K	16	41	Yang, Zaili	8.90	41	Kavussanos, Manolis G.	312
35	Yang, Zhongzhen	16	42	Chang, Young-Tae	8.81	42	Zhang, CQ	291
35	Zhen, Lu	16	43	Kujala, Pentti	8.57	43	Hummels, David	286
44	Ferrari, Claudio	15	44	Psaraftis, Harilaos N.	8.56	44	Pisinger, David	282
44	Hvattum, Lars Magnus	15	45	Cheng, T. C. Edwin	8.44	45	Gue, KR	270
44	Kozan, Erhan	15	46	Cariou, Pierre	8.24	46	Lun, Y. H. Venus	269
44	Kujala, Pentti	15	47	Yip, Tsz Leung	8.20	47	Ng, Adolf K. Y.	249
44	Voss, Stefan	15	48	Pisinger, David	8.13	48	Cheng, T. C. Edwin	240
44	Wilmsmeier, Gordon	15	49	Sun, Zhuo	8.09	49	Er, I. Deha	237
44	Wilson, William W	15	50	Bell, Michael G. H.	7.90	50	Hasle, Geir	233

TABLE 3: Continued.

	Author	Impact Score (1996-2000)	Author	Impact Score (2001-2005)	Author	Impact Score (2006-2010)	Author	Impact Score (2011-2015)
23	Park, YM	0.82	Liu, Jiyin	0.89	Demaria, Federico	2.75	Yang, Yi-Chih	5.99
24	Ronen, D.	0.80	Wan, Yat-wah	0.89	Fagerholt, Kjetil	2.74	Cariou, Pierre	5.85
25	Jacobson, A	0.80	Krasnopolsky, VM	0.89	Kozan, Erhan	2.69	Monios, Jason	5.69
26	Farrell, JA	0.79	Schiller, H	0.89	Asteris, Michael	2.67	Rudd, Murray A.	5.68
27	Li, W	0.79	Tongzon, Jose	0.85	Meng, Qiang	2.67	Talley, Wayne K.	5.67
28	Lee, RM	0.78	Zhang, CQ	0.85	Paulauskas, Vytautas	2.67	Sun, Zhuo	5.65
29	Linn, RJ	0.76	Legato, Pasquale	0.84	Meisel, Frank	2.63	Laporte, Gilbert	5.65
30	Imai, Akio	0.76	Jetlund, AS	0.84	Ng, Adolf K. Y.	2.61	Pisinger, David	5.56
31	Nishimura, Etsuko	0.76	Karimi, IA	0.84	Vasiliauskas, Aidas Vasilis	2.55	Psaraffis, Harilaos N.	5.52
32	Papadimitriou, Stratos	0.76	Ronen, D.	0.80	Sharma, Mithun J.	2.53	Petering, Matthew E. H.	5.43
33	Ausloos, M	0.76	Jacobson, A	0.80	Yu, Song Jin	2.53	Lee, Paul Tae-Woo	5.37
34	Ivanova, K	0.76	Lu, Chin-Shan	0.79	Nishimura, Etsuko	2.51	Goerlandt, Floris	5.34
35	Fagerholt, Kjetil	0.75	Farrell, JA	0.79	Lee, Yusin	2.50	Wang, Hua	5.24
36	Fairlie, DP	0.73	Li, W	0.79	Konings, Rob	2.47	Hvattum, Lars Magnus	4.98
37	Lucke, AJ	0.73	Donderi, DC	0.78	Saeed, Naima	2.43	Yip, Tsz Leung	4.92
38	Singh, Y	0.73	McFadden, S	0.78	Merrick, Jason R. W.	2.43	Christiansen, Marielle	4.91
39	Tyndall, JDA	0.73	Lee, RM	0.78	Ramirez-Marquez, Jose Emmanuel	2.33	Hanninen, Maria	4.89
40	Fung, Michael K.	0.72	Bish, EK	0.77	Kahraman, Cengiz	2.29	Wang, Jin	4.83

TABLE 3: Continued.

	Author	Impact Score (1996-2000)	Author	Impact Score (2001-2005)	Author	Impact Score (2006-2010)	Author	Impact Score (2011-2015)
41	Bish, EK	0.67	Linn, RJ	0.76	Hastings, Justin V.	2.27	Featherstone, David	4.82
42	Yun, JE	0.67	Ausloos, M	0.76	Cebi, Selcuk	2.18	Lee, Der-Horng	4.77
43	Marin, PL	0.66	Ivanova, K	0.76	Panayides, Photis M	2.18	Hu, Zhi-Hua	4.77
44	Sicotte, R	0.66	Umemoto, K	0.76	Goulielmos, Alexander M.	2.11	Kontovas, Christos A.	4.76
45	Legato, Pasquale	0.66	Sciomachen, Anna	0.75	Cao, Jin Xin	2.10	Knapp, Sabine	4.52
46	Bhargava, HK	0.66	Koutsavdis, E	0.74	Park, Changkyu	2.09	Luo, Meifeng	4.51
47	Snoap, KJ	0.66	Rhee, SH	0.74	Seo, Junyong	2.09	Nathan Huynh	4.50
48	Altiok, T	0.64	Fairlie, DP	0.73	Wu, Wei-Ming	2.07	Yeo, Gi-Tae	4.43
49	Cullinane, Kevin	0.63	Lucke, AJ	0.73	Fossen, Thor I.	2.05	Meisel, Frank	4.41
50	Gold, C	0.62	Singh, Y	0.73	Low, Joyce M. W	2.03	Bell, Michael G. H.	4.40

TABLE 4: The most prolific paired authors.

Rank	Paired authors	Number of joint publications	Rank	Paired authors	Number of joint publications
1	Meng, Q, Wang, SA	34	11	Papadimitriou, S, Nishimura, E	12
2	Chew, EP, Lee, LH	25	12	Fagerholt, K, Christiansen, M	12
3	Lai, KH, Cheng, TCE	17	13	Tan, KC, Chew, EP	11
4	Cheng, TCE, Lun, YHV	15	14	Tan, KC, Lee, LH	11
5	Yang, ZL, Wang, J	15	15	Wang, SA, Liu, ZY	11
6	Boile, M, Theofanis, S	14	16	Monios, J, Wilmsmeier, G	10
7	Lai, KH, Lun, YHV	14	17	Parola, F, Satta, G	10
8	Lee, DH, Chen, JH	13	18	Lee, DH, Cao, JX	10
9	Papadimitriou, S, Imai, A	13	19	Lai, KH, Wong, CWY	9
10	Imai, A, Nishimura, E	12	20	Christiansen, M, Andersson, H	9

TABLE 5: The top 10 articles of port and maritime research area.

Author	Title	Citation
Steenken, D; Voss, S; Stahlbock, R	Container terminal operation and operations research - a classification and literature review	500
Stahlbock, Robert; Voss, Stefan	Operations research at container terminals: a literature update	423
Vis, IFA; de Koster, R	Transshipment of containers at a container terminal: An overview	290
Christiansen, M; Fagerholt, K; Ronen, D	Ship routing and scheduling: Status and perspectives	270
Hummels, David	Transportation costs and international trade in the second era of globalization	242
Bierwirth, Christian; Meisel, Frank	A survey of berth allocation and quay crane scheduling problems in container terminals	228
Imai, A; Nishimura, E; Papadimitriou, S	The dynamic berth allocation problem for a container port	222
Kim, KH; Park, YM	A crane scheduling method for port container terminals	200
Tongzon, J; Heng, W	Port privatization, efficiency and competitiveness: Some empirical evidence from container ports (terminals)	169
Cullinane, K; Wang, TF; Song, DW; Ji, P	The technical efficiency of container ports: Comparing data envelopment analysis and stochastic frontier analysis	168

University of Singapore (NUS), Hong Kong Polytechnic University (HKPU), Norwegian University of Science and Technology, Delft University of Technology, and the University of Antwerp (UA) are in the top 5. The top schools are all strong regardless of how they are ranked. The most productive school, NUS, published 184 papers and was followed by HKPU with 174 papers. As with the authors' ranking, the gap between the second and third in the affiliation rankings is also relatively large (60 papers). Below these schools, the gap between the subsequent affiliations is no longer substantial. The top ten affiliations for 1996-2016 published 986 papers, which equate to an annual average of 46.87 papers. The best performing schools is still NUS. Another notable point is the sudden increase of Nanyang Technological University (NTU) in the ranking. As for the rank of citation score, it is stable

and similar to the rank of impact score except for some slight fluctuations. But there is still some sudden increase that needs to be noteworthy. Univ Georgia Inst Technol's rank ups 16 places to 9th. Univ Hamburg is not among the top 50 in the impact score but places to 5th in citation score.

The affiliation ranking shows a similar pattern to author rankings. NUS have an outstanding container port and maritime researcher; Meng and HKPU have Wang. The two authors publish in impact score journals in container port and maritime research. It seems to indicate a direct relationship between research infrastructure and researchers. The size of the research infrastructure and the number of researchers available in the field may impact the researchers' effectiveness and strength of knowledge conversion. In other words, the more the numerous researchers and knowledge, the higher

TABLE 6: Rankings by affiliations.

Rank	School	No. Paper	Rank	School	Impact Score	Rank	School	Citation Score
1	Natl Univ Singapore	184	1	Natl Univ Singapore	148.06	1	Natl Univ Singapore	3342
2	Hong Kong Polytech Univ	174	2	Hong Kong Polytech Univ	130.64	2	Norwegian Univ Sci & Technol	2525
3	Norwegian Univ Sci & Technol	114	3	Norwegian Univ Sci & Technol	69.67	3	Pusan Natl Univ	2179
4	Delft Univ Technol	93	4	Delft Univ Technol	64.03	4	Hong Kong Polytech Univ	1558
5	Univ Antwerp	84	5	Nanyang Technol Univ	59.83	5	Univ Hamburg	1075
6	Erasmus Univ	82	6	Erasmus Univ	58.04	6	Erasmus Univ	1052
7	Nanyang Technol Univ	73	7	Pusan Natl Univ	56.32	7	Istanbul Tech Univ	951
8	Shanghai Jiao Tong Univ	68	8	Dalian Maritime Univ	53.49	8	Univ Antwerp	934
9	Pusan Natl Univ	66	9	Istanbul Tech Univ	52.56	9	Georgia Inst Technol	868
10	Dalian Maritime Univ	62	10	Tech Univ Denmark	50.78	10	Hong Kong Univ Sci & Technol	802
11	Univ Genoa	61	11	Univ Antwerp	50.53	11	Univ Calif Berkeley	785
12	Univ Piraeus	58	12	Natl Taiwan Ocean Univ	47.26	12	Natl Cheng Kung Univ	777
13	Natl Taiwan Ocean Univ	55	13	Univ Genoa	46.33	13	Tech Univ Denmark	758
14	Istanbul Tech Univ	54	14	Hong Kong Univ Sci & Technol	43.11	14	Delft Univ Technol	719
15	Hong Kong Univ Sci & Technol	53	15	Natl Cheng Kung Univ	42.08	15	HEC Montreal	699
16	Tech Univ Denmark	52	16	Natl Kaohsiung Marine Univ	41.71	16	Kobe Univ	689
17	Univ Plymouth	51	17	Univ Plymouth	41.24	17	Univ Plymouth	645
18	Natl Cheng Kung Univ	47	18	Old Dominion Univ	39.36	18	Univ Hong Kong	635
18	Rutgers State Univ	47	19	Univ Piraeus	38.91	19	Univ Calabria	618
20	Cardiff Univ	43	20	Shanghai Jiao Tong Univ	38.59	20	Nanyang Technol Univ	574
21	Georgia Inst Technol	40	21	Cardiff Univ	32.64	21	Liverpool John Moores Univ	569
22	Natl Kaohsiung Marine Univ	39	22	Natl Tech Univ Athens	31.14	22	Norwegian Marine Technol Res Inst MARINTEK	559

TABLE 6: Continued.

Rank	School	No. Paper	Rank	School	Impact Score	Rank	School	Citation Score
23	Univ Rijeka	38	23	Vilnius Gediminas Tech Univ	31.00	23	Univ Genoa	559
24	Edinburgh Napier Univ	37	24	Edinburgh Napier Univ	30.94	24	Univ Halle Wittenberg	539
24	Liverpool John Moores Univ	37	25	Georgia Inst Technol	29.72	25	Univ Wisconsin	525
24	Natl Tech Univ Athens	37	26	Shanghai Univ	29.51	26	Univ London Imperial Coll Sci Technol & Med	513
27	Old Dominion Univ	36	27	Aalto Univ	29.35	27	Rutgers State Univ	492
27	Texas A&M Univ	36	28	Liverpool John Moores Univ	27.55	28	Univ Michigan	488
29	Univ Aegean	35	29	Inha Univ	26.71	29	Shanghai Jiao Tong Univ	461
30	Inha Univ	34	30	Univ Las Palmas Gran Canaria	26.42	30	Aalto Univ	458
30	Norwegian Marine Technol Res Inst MARINTEK	34	31	Univ Hong Kong	26.02	31	Univ Piraeus	421
30	Univ Hong Kong	34	32	Univ Calabria	24.92	32	Univ Elect Sci & Technol China	416
33	Univ Calif Berkeley	32	33	Norwegian Marine Technol Res Inst MARINTEK	24.05	33	Chalmers University of Technology	411
34	Chung Ang Univ	31	34	Univ Wollongong	24.02	34	Cardiff Univ	409
34	Univ Valencia	31	35	Shanghai Maritime Univ	23.97	35	Natl Tech Univ Athens	409
36	Shanghai Maritime Univ	30	36	Univ Aegean	23.03	36	Univ Tecn Lisboa	369
36	Shanghai Univ	30	37	Univ Belgrade	21.50	37	Queensland Univ Technol	363
38	HEC Montreal	29	38	Queensland Univ Technol	21.50	38	Kobe Univ Mercantile Marine	354
38	Univ Calabria	29	39	Univ Wisconsin	20.74	39	Univ Newcastle Upon Tyne	346
38	Univ Illinois	29	40	Chalmers	20.68	40	Univ Maryland	344
41	Eindhoven Univ Technol	28	41	Chang Jung Christian Univ	20.53	41	City Univ Hong Kong	342

TABLE 6: Continued.

Rank	School	No. Paper	Rank	School	Impact Score	Rank	School	Citation Score
41	MIT	28	42	Eindhoven Univ Technol	20.27	42	Dalian Maritime Univ	336
41	Univ Las Palmas Gran Canaria	28	43	Texas A&M Univ	20.09	43	Molde Univ Coll	336
44	Aalto Univ	27	44	Wuhan Univ Technol	19.05	44	Univ Las Palmas Gran Canaria	334
45	Univ Hamburg	26	45	Rutgers State Univ	18.60	45	Univ Southampton	332
45	Univ Oviedo	26	46	Chung Ang Univ	18.59	46	Natl Kaohsiung Marine Univ	329
45	Univ Wisconsin	26	47	Univ Illinois	18.49	47	Purdue Univ	324
45	Wuhan Univ Technol	26	48	Univ London Imperial Coll Sci Technol & Med	18.29	48	Antwerp Maritime Acad	318
49	Chalmers	25	49	Univ Seville	18.04	49	Chinese Acad Sci	305
49	City Univ Hong Kong	25	50	Univ Valencia	18.03	50	Ecole Polytech	303

the probability of the affiliation obtaining substantial knowledge conversion.

3.3.2. Ranking Dynamics for Affiliations. In Table 7, the change of dynamic ranking of affiliations is relatively small. HKPU, NUS, and EU are consistently high. As we mentioned above, there seems to be a direct relationship between the affiliations and researchers. According to Foray and Lundvall [24], human capital (including graduates, highly skilled personnel, and public and private researchers) somewhat tends to flow to have more of the benefits from positive spillovers. Conversely, if there is not too much of a brain drain, the dynamics of affiliation ranking will remain relatively stable. However, if affiliations seek to remain competitive, it will have to retain a positive welfare system and take care of its producers in order to stem a brain drain.

3.3.3. Collaboration Patterns. We also analyzed the cooperation pattern of affiliations. Table 8 shows the top ten paired affiliations. The result indicates that affiliations do not stay in static cliques. They are willing to cooperate with new partners in order to achieve diversity and novelty. Core affiliations in the maritime field play the role of spreading advanced research results and promoting the development of the field.

4. Analysis of the Countries/Regions

Table 9 displays country rankings from 1996 to 2016. USA, China, and England are the top 3 countries irrespective of the scoring method. Although none of the authors or affiliations

in the USA reached the top five, it still has dominant positions in these fields. It is true that local academic researchers could contribute to the competitiveness of the territory. However, in the context of world metropolis, the competition is no longer subject to natural geographical constraints, but more dependent on the territory itself to attract and retain human capital. The advantage of country competitiveness is actively built and not passively suffered. This may also indicate that the American government is good at attracting and promoting research.

Going further into country publications in the port and maritime transport system field, the top 20 countries ranking by the annual number of publications are discussed. Figure 2 shows the change among the top 20 countries over time. It can be seen that the general trend of annual journal publication has increased. Over the past decade, however, the publications of China have grown much faster than in the United States and other countries. In addition, China has kept up with the United States approximately with the same number of journal publications in the port and maritime transport system field since 2014, as indicated in Figure 2. Interestingly, the pioneers are not American or Chinese, even though they are the most influential countries in this field, since they did not publish papers from the beginning.

5. Analysis of Research Terms

In bibliometric analysis, it is useful to select several keywords as a representation of important research topics in this field if a researcher wants to explore every facet of a field's major

TABLE 7: Ranking dynamics of affiliations.

	school	impact score (1996-2000)	school	impact score (2001-2005)	school	impact score (2006-2010)	school	impact score (2011-2015)
1	Pusan Natl Univ	6.44	Pusan Natl Univ	7.12	Natl Univ Singapore	34.97	Natl Univ Singapore	98.16
2	Natl Univ Singapore	3.68	Natl Univ Singapore	4.33	Istanbul Tech Univ	24.40	Hong Kong Polytech Univ	42.30
3	Chinese Acad Sci	3.14	Hong Kong Polytech Univ	3.33	Hong Kong Polytech Univ	19.92	Norwegian Univ Sci & Technol	39.96
4	Univ Queensland	2.93	Univ Hawaii Manoa	3.30	Pusan Natl Univ	18.40	Nanyang Technol Univ	33.29
5	Hong Kong Polytech Univ	2.73	Chinese Acad Sci	3.14	Natl Kaohsiung Marine Univ	12.50	Dalian Maritime Univ	32.20
6	Univ Edinburgh	2.44	Univ Queensland	2.93	Univ Calabria	12.16	Pusan Natl Univ	31.76
7	Penn State Univ	2.39	Univ Hong Kong	2.60	Univ Genoa	10.31	Delft Univ Technol	29.53
8	Norwegian Univ Sci & Technol	2.36	Norwegian Univ Sci & Technol	2.56	Erasmus Univ	10.01	Univ Antwerp	29.44
9	Erasmus Univ	2.28	Erasmus Univ	2.52	Georgia Inst Technol	9.90	Erasmus Univ	28.32
10	Carnegie Mellon Univ	2.25	Univ Genoa	2.52	Univ Wisconsin	9.85	Shanghai Maritime Univ	27.10
11	Hong Kong Univ Sci & Technol	1.89	Univ Texas	2.44	Univ Hong Kong	9.64	Tech Univ Denmark	25.07
12	Univ Hawaii Manoa	1.78	Hong Kong Univ Sci & Technol	2.29	Norwegian Univ Sci & Technol	9.54	Old Dominion Univ	24.22
13	Univ So Calif	1.76	Carnegie Mellon Univ	2.25	Univ Piraeus	8.96	Univ Wollongong	22.55
14	World Bank	1.71	Univ Piraeus	2.02	Univ Antwerp	8.41	Univ Genoa	22.01
15	Univ Tennessee	1.52	Natl Tech Univ Athens	1.99	Natl Cheng Kung Univ	8.39	Aalto Univ	21.88
16	Univ Genoa	1.51	Natl Cheng Kung Univ	1.83	Delft Univ Technol	8.06	Univ Plymouth	21.64
17	Univ Calif Riverside	1.40	Univ So Calif	1.76	Univ Plymouth	7.70	Shanghai Univ	19.62
18	Georgia Inst Technol	1.38	World Bank	1.71	Shanghai Maritime Univ	7.62	Shanghai Jiao Tong Univ	19.36
19	Natl Tech Univ Athens	1.36	Univ Calabria	1.68	Univ So Calif	7.29	Natl Kaohsiung Marine Univ	18.79
20	Univ Calabria	1.32	Queensland Univ Technol	1.67	Vrije Univ Amsterdam	6.75	Natl Taiwan Ocean Univ	18.51

TABLE 7: Continued.

	school	impact score (1996-2000)	school	impact score (2001-2005)	school	impact score (2006-2010)	school	impact score (2011-2015)
21	Florida Int Univ	1.28	Georgia Inst Technol	1.61	Chinese Acad Sci	6.66	Hong Kong Univ Sci & Technol	18.46
22	Univ Piraeus	1.25	Florida Int Univ	1.60	Chalmers Univ	6.46	Istanbul Tech Univ	17.41
23	USN	1.24	Univ Tennessee	1.52	Washington Chang Jung Christian Univ	6.16	Cardiff Univ	16.12
24	Swedish Univ Agr Sci	1.23	Fluent Inc	1.48	Cardiff Univ	5.86	Liverpool John Moores Univ	15.03
25	Kobe Univ	1.19	Univ Calif Riverside	1.40	Cardiff Univ	5.46	Tongji Univ	13.87
26	Liverpool John Moores Univ	1.17	Penn State Univ	1.32	Shanghai Jiao Tong Univ	5.19	Norwegian Marine Technol Res Inst	13.81
27	Univ Hong Kong	1.03	Univ Adelaide	1.29	Univ Western Australia	5.17	MARINTEK	13.19
28	Univ Liege	1.00	Liverpool John Moores Univ	1.27	Univ London Imperial Coll Sci Technol & Med	5.14	Edinburgh Napier Univ	13.16
29	Calif State Univ Bakersfield	0.96	Univ Missouri	1.25	Vilnius Gediminas Tech Univ	5.10	Univ La Laguna	13.12
30	Univ Sydney	0.93	Swedish Univ Agr Sci	1.23	Rutgers State Univ	5.10	Natl Tech Univ Athens	13.06
31	Rutgers State Univ	0.92	Kobe Univ	1.19	Univ Portsmouth	5.08	Univ Las Palmas Gran Canaria	12.88
32	Univ Glamorgan	0.92	World Maritime Univ	1.16	Natl Taiwan Ocean Univ	5.04	Imperial Coll Sci Technol & Med	12.08
33	Univ Ottawa	0.90	Natl Taiwan Ocean Univ	1.05	Queensland Univ Technol	4.69	Univ Calabria	12.06
34	Korea Adv Inst Sci & Technol	0.90	Texas A&M Univ	1.04	Kobe Univ	4.63	Univ Aegean	11.41

TABLE 7: Continued.

school	impact score (1996-2000)	school	impact score (2001-2005)	school	impact score (2006-2010)	school	impact score (2011-2015)
35 Univ Missouri GKSS	0.90	Univ Delaware	1.02	Nanyang Technol Univ	4.29	ExxonMobil Res & Engrn Co	11.34
36 Forschungszentrum Geesthacht GmbH	0.89	Univ Liege	1.00	Univ Halle Wittenberg	4.24	Eindhoven Univ Technol	11.33
37 NOAA	0.89	Newcastle Univ	0.98	Univ Politecn Cataluna	4.19	Chung Ang Univ	11.11
38 Cornell Univ	0.88	Calif State Univ Bakersfield	0.96	Natl Tech Univ Athens	4.19	Univ Seville	11.07
39 Univ Delaware	0.88	Univ Sydney	0.93	Univ Ulsan	4.18	Inha Univ	10.97
40 Univ Illinois	0.81	Kobe Univ	0.91	Scottish Agr Coll	4.13	Univ Piraeus	10.66
41 Univ E Anglia	0.80	Univ Ottawa	0.90	Univ N Carolina	4.10	Univ S Carolina	10.35
42 Queensland Univ Technol	0.76	Univ Michigan	0.89	Molde Univ Coll	3.96	Univ British Columbia	10.18
43 Aplus Flash Technol Inc	0.75	GKSS Forschungszentrum Geesthacht GmbH	0.89	Dalian Maritime Univ	3.82	Univ Bergen	10.18
44 Kyungnung Univ	0.74	NOAA	0.89	Univ Calif Berkeley	3.77	Newcastle Univ	9.76
45 Univ Carlos III Madrid	0.73	Cornell Univ	0.88	Stevens Inst Technol	3.76	Univ Sydney	9.50
46 Natl Cheng Kung Univ	0.73	Fern Univ Hagen	0.82	CNR	3.56	Georgia Inst Technol	9.47
47 Univ Pittsburgh	0.72	Univ Illinois	0.81	Hanyang Univ	3.48	Univ Valencia	9.27
48 Korea Maritime Inst	0.72	Univ E Anglia	0.80	Purdue Univ	3.43	Univ Politecn Valencia	9.08
49 Tech Univ Berlin	0.72	McGill Univ	0.78	Tsinghua Univ	3.36	Wuhan Univ Technol	9.04
50 Univ Wales Coll Cardiff	0.72	CNRS ULP	0.78	Univ Sci & Technol China	3.29	Univ Wisconsin	8.81

TABLE 8: The most prolific paired affiliations.

Rank	Paired affiliations	Number of joint publications
1	Norwegian Marine Technol Res Inst MARINTEK, Norwegian Univ Sci & Technol	27
2	Univ Naples Parthenope, Univ Genoa	19
3	Natl Univ Singapore, Univ Wollongong	14
4	Antwerp Maritime Acad, Univ Antwerp	14
5	HEC Montreal, Norwegian Univ Sci & Technol	11
6	Nanyang Technol Univ, RMIT Univ	11
7	Hong Kong Polytech Univ, Shanghai Univ	11
8	Hong Kong Polytech Univ, Chung Ang Univ	8
9	Nanyang Technol Univ, Univ Antwerp	8
10	Dalian Maritime Univ, Univ Antwerp	8

research topics and their relationships down to the finest detail. Term Frequency-Inverse Document Frequency (TF-IDF) promoted by Salton and Buckley [25] is a typical method of identifying important terms by combining their popularity and discrimination. The TF-IDF method can also be applied to bibliometric analysis. For example, Jaboska-Sabuka et al. [26] used TF-IDF to identify informative words from publication keywords of the research domain in order to predict research trends. Roche [27] used TF-IDF to select publication keywords of scientific fields and categorized them into unusual terms, established terms, and cross-sectional terms. $(tf - idf_t)$ is calculated for each word. Salton et al. [28] from the following equation:

$$tfidf_t = \sum_d tf_{t,d} \times \log \frac{N}{df_t} \quad (4)$$

where $tf_{t,d}$ is frequency of the word t in the document d , N is number of the articles, and df_t is the number of articles where word t existed.

5.1. Overall Analysis. Various research terms are observed in articles published in the time period from 1996 to 2016. Table 10 shows the top 60 research terms of these fields. From Table 10, we can indicate that port and maritime transport system field have been classified in the literature in terms of shipping or port research and their respective methodologies applied in the research. We also built the word cooccurrence table to create highly cooccurring word sets. The input words in the table satisfy the following two limitations. First, the $tf-idf$ factor of these words is greater than the A threshold value. Second, the number of publications which contained a candidate word is within the specified range by the B threshold. An analysis of Table 11 reveals that the specific shipping topics include seafarers, short sea shipping, shipping performance/management, shipping finance, and shipping safety. Specific port topics include port governance/privatization, port performance, port state control, port competition, and port choice.

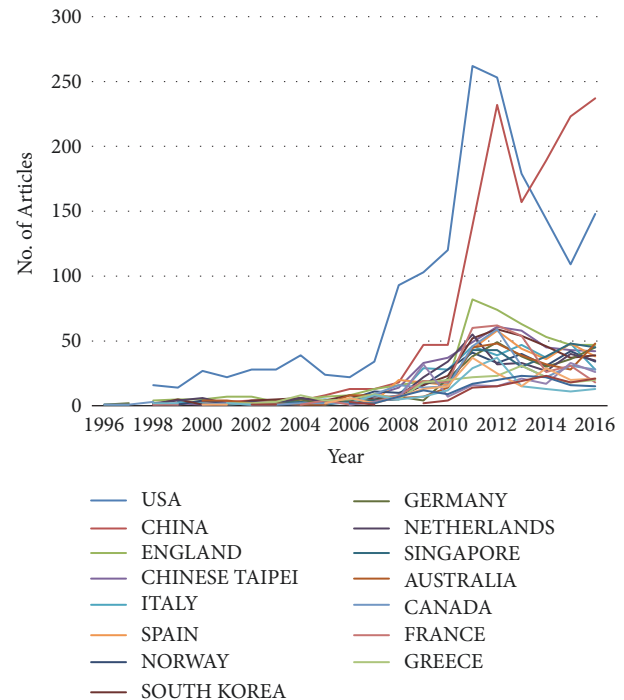


FIGURE 2: Trend of the countries/regions.

Table 12 shows the dynamics of the research terms. Although there are several new words that arise throughout time, the rise and fall of research terms are prominent in the port and maritime transport system field. In 2006-2010, some new words such as berth and vessel turned up as new research objects. In 2001-2015, the word emission turned up as a new research topic and reached the top 5. This may be caused by some environment protection policy such as Regulation 14 of the IMO that required ships to switch to low sulfur fuels in ECA areas. Another notable point is the rank change of the words risk and liner. Risk was a top 8 word in 1996-2000, but fell to 18th in 2011-2015. By inspecting

TABLE 9: The ranking of the countries/regions.

Rank	Country	No. papers	Rank	Country	Impact Score
1	USA	993	1	USA	1170.25
2	PEOPLES R CHINA	714	2	PEOPLES R CHINA	972.35
3	ENGLAND	305	3	ENGLAND	384.71
4	CHINESE TAIPEI	263	4	CHINESE TAIPEI	354.65
5	SOUTH KOREA	205	5	SPAIN	269.14
6	ITALY	196	6	NORWAY	265.79
7	SPAIN	194	7	SINGAPORE	263.14
8	NORWAY	189	8	ITALY	263.10
9	GERMANY	183	9	NETHERLANDS	246.82
10	NETHERLANDS	182	10	GERMANY	246.18
11	SINGAPORE	172	11	SOUTH KOREA	244.03
12	AUSTRALIA	154	12	AUSTRALIA	212.31
13	CANADA	141	13	FRANCE	212.21
14	FRANCE	141	14	CANADA	197.57
15	GREECE	131	15	TURKEY	166.71
16	TURKEY	107	16	GREECE	161.82
17	JAPAN	99	17	BELGIUM	117.86
18	BELGIUM	87	18	DENMARK	113.96
19	SWEDEN	78	19	SWEDEN	108.00
20	DENMARK	74	20	JAPAN	107.91
21	CROATIA	69	21	PORTUGAL	76.12
23	PORTUGAL	56	22	INDIA	69.68
24	SCOTLAND	52	23	SCOTLAND	67.00
25	IRAN	51	24	FINLAND	64.27
26	INDIA	49	25	IRAN	61.00
27	RUSSIA	49	26	BRAZIL	58.16
28	POLAND	40	27	SWITZERLAND	44.00
29	BRAZIL	39	29	WALES	40.62
30	FINLAND	38	30	POLAND	39.64
31	WALES	36	31	CROATIA	36.24
32	LITHUANIA	33	32	LITHUANIA	34.05
33	SWITZERLAND	26	33	SERBIA	27.93
34	CHILE	24	34	ISRAEL	24.99
35	ISRAEL	23	35	CYPRUS	21.23
36	SLOVENIA	23	36	NEW ZEALAND	21.16
37	SERBIA	20	37	RUSSIA	21.15
38	MALAYSIA	18	38	AUSTRIA	20.00
39	NEW ZEALAND	16	39	CHILE	19.75
40	SOUTH AFRICA	16	40	MALAYSIA	19.25
41	AUSTRIA	14	41	SLOVENIA	17.52
42	CYPRUS	12	42	U ARAB EMIRATES	16.55
43	MEXICO	12	43	SOUTH AFRICA	14.76
44	U ARAB EMIRATES	12	44	MEXICO	13.88
45	UKRAINE	11	45	THAILAND	12.11
46	MONTENEGRO	10	46	LEBANON	10.98
47	IRELAND	8	47	IRELAND	9.59
48	LEBANON	8	48	CZECH REPUBLIC	9.18
49	THAILAND	8	49	NIGERIA	6.83
50	ARGENTINA	6	50	MONTENEGRO	6.49

TABLE 10: The top 60 research terms.

Word	TF-IDF	Word	TF-IDF
port	201.99	management	58.21
container	171.73	simulation	57.80
terminal	130.71	supply	57.59
shipping	121.37	dynamic	56.89
ship	120.68	liner	56.88
cost	100.25	company	56.76
transport	97.69	logistics	56.56
control	92.95	cargo	56.49
network	90.09	factor	56.44
service	86.66	impact	56.28
algorithm	85.17	route	55.70
maritime	82.58	rate	55.62
vessel	77.78	planning	55.03
market	75.80	development	54.87
transportation	74.55	optimization	54.57
risk	73.53	safety	54.32
freight	72.68	yard	54.17
approach	72.35	truck	53.48
operation	71.54	price	52.32
optimal	70.83	trade	52.11
data	67.46	traffic	51.59
efficiency	64.82	heuristic	51.58
crane	64.69	marine	51.10
scheduling	63.60	capacity	51.04
process	63.14	level	50.22
policy	61.66	economic	50.06
strategy	60.64	flow	48.94
emission	59.64	sea	48.66
chain	59.52	condition	47.73
industry	58.51	function	47.45

TABLE 11: The top 6 words cooccurrence table for port and shipping.

Cooccurrence word	Frequent	Cooccurrence word	Frequent
shipping management	603	port perform	824
shipping perform	354	port state control	383
shipping network	232	port governance/government	209
shipping short-term	168	port choice	188
shipping safety	157	port competition	183
shipping finance	91	port private(privatization)	135

the papers that include the word risk, we determined that the author Jin Wang published numerous papers examining maritime risk in 1996-2000, but he did not publish as much from 2011 to 2015, and his rank fell from 10 to 40. We can draw

an obvious conclusion that Shuaian Wang is a specialized researcher investigating liners, and he is the top author in 2011-2015. This finding indicates that a specific research may be influenced by one or two authors.

TABLE 12: Ranking dynamics of research terms.

	Word	TF-IDF (1996-2000)	Word	TF-IDF (2001-2005)		Word	TF-IDF (2006-2010)		Word	TF-IDF (2011-2015)	
1	freight	2.88	container	3.46	▲	port	16.37	▲	port	20.67	-
2	network	2.34	port	3.24	▲	container	14.64	▼	container	18.52	-
3	science	2.11	yard	2.45	-	shipping	8.27	▲	shipping	14.50	-
4	container	2.09	cost	2.28	▲	terminal	8.07	▲	ship	13.86	▲
5	carrier	2.00	truck	2.19	▲	cost	7.86	▼	emission	12.10	-
6	intermodal	1.99	heuristic	1.98	-	maritime	7.45	-	terminal	11.02	▼
7	transportation	1.83	ship	1.90	▲	transport	7.42	▲	cost	9.75	▼
8	risk	1.82	terminal	1.86	▲	market	7.09	▲	network	9.46	▲
9	port	1.76	vehicle	1.76	-	crane	6.94	▲	transport	9.29	▼
10	policy	1.65	safety	1.76	▲	transportation	6.85	▲	service	8.69	▲
11	terminal	1.56	policy	1.73	▼	yard	6.27	▼	freight	8.48	▼
12	truck	1.56	transport	1.71	▲	berth	6.17	-	control	8.47	-
13	ocean	1.54	crane	1.67	-	scheduling	5.97	-	algorithm	8.43	▲
14	service	1.51	transportation	1.65	▼	ship	5.94	▲	approach	8.16	▲
15	market	1.50	algorithm	1.62	-	network	5.87	▼	liner	7.93	-
16	operation	1.49	capacity	1.61	-	operation	5.79	-	crane	7.91	▼
17	ship	1.45	market	1.57	▼	service	5.61	▲	maritime	7.73	▼
18	transport	1.44	shipping	1.48	-	approach	5.43	-	risk	7.66	▼
19	cost	1.41	service	1.48	▼	vessel	5.36	-	optimal	7.61	-
20	safety	1.31	product	1.44	-	algorithm	5.34	-	cargo	7.48	-

6. Conclusions

In this paper, we have analyzed maritime-related academic research. We utilized bibliometric analysis method to illustrate the evolution of this field. The two criteria used in ranking were the number of published papers and the impact score (reflecting the prestige of the journals). We focused on the papers published in journals included in the Science Citation Index and Social Science Citation Index.

Ranking criteria influences the overall rankings for authors and affiliations sensitively. In terms of the impact score, the most active researchers are S.A. Wang, Q. Meng, T. Notteboom, J.S.L. Lam, and K.H. Kim. The most active affiliations were the National University of Singapore, Hong Kong Polytechnic University, the Norwegian University of Science and Technology, Delft University of Technology, and the Nanyang Technology University. Affiliations rankings seem to have been affected by authors ranking. For example, the top affiliation has the top author. However, the network features of authors and affiliations are quite different. At the microlevel, overall research terms in the container port and maritime field are identified by the TF-IDF algorithm.

This paper has limitations. In terms of the scoring method, especially impact score, the impact factor does not reflect a journals quality perfectly. For instance, several highly respected journals have a low impact factor. There are several other indicators that can measure the impact, such as the H index and the number of citations for authors.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they are no conflicts of interest regarding the publication of this paper.

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