

PAPER DETAILS

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AUTHORS: Coskan SEVGILI, Ali TÖZ

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BIBLIOMETRIC ANALYSIS OF THE LITERATURE ON PORT STATE CONTROL

Coşkan SEVGİLİ ^{*1,2}, Ali Cemal TÖZ ¹

¹ Dokuz Eylul University, Maritime Faculty, Department of Marine Transportation Engineering, Izmir, Turkey
ORCID ID 0000-0003-3929-079X
ORCID ID 0000-0001-5348-078X
coskansevgili@gmail.com
ali.toz@deu.edu.tr

² Zonguldak Bülent Ecevit University, Maritime Faculty, Department of Marine Transportation Engineering, Zonguldak, Turkey
ORCID ID 0000-0003-3929-079X
coskansevgili@gmail.com

* Corresponding Author

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ABSTRACT

Port state control (PSC) are one of the most important ship inspection applications for the marine safety. Therefore, these ship inspections are an area that researchers are working on intensely. This study aims to analyze the publications on port state control with bibliometric methods. A total of 110 studies were obtained from the Web of Science database which is one of the leading databases for academic literature. The authors, their countries, publishers, and citations of these publications were analyzed, as well as text mining method was utilized for keywords and abstract analyses by the VosViewer software. According to the results of the analysis, there has been an increase in the number of studies on port state control in recent years, and it is seen that the researchers who have done the most work in this field are Chinese researchers. In recent years, it is found that the publications especially focus on data mining approaches. It is thought that this study will guide researchers who will conduct research on port state control.

Keywords: *Bibliometric Analysis, Marine Safety, Port State Control, Ship Inspection*

1. INTRODUCTION

Maritime transport is the backbone of the transport sector, as it is the most used mode of transport in world trade, both in terms of volume and material value. Although it is a relatively safer mode of transportation, there is always the risk of accidents or casualties, and the consequences and effects of these events occurring in maritime transportation can be huge (Yan et al., 2021). Therefore, it is very important to constantly protect the safety of ships to prevent these cases. Over the years, comprehensive standards have been developed and procedures are in place to verify that ships and their equipment comply with and are operated in accordance with international regulations enforced by International Maritime Organization (IMO) and International Labour Organization (ILO). In fact, the flag state is the first official authority responsible for the safety and inspection of ships. The problems experienced in practice, such as the fact that a ship rarely visits the flag state during its service life, and that some authorities cannot inspect the safety of their ships in accordance with the standards due to their limited resources, necessitated a complementary control mechanism. Both for this reason and to prevent the use of maritime safety as a competitive tool by ship owners or operators, a control mechanism known as port state control (PSC) has been put into effect. While the flag state inspects the ships flying its own flag, PSC inspects the foreign flagged ships coming to the countries' own ports. In other words, PSC is the last line of defense for detecting substandard ships (Knapp and Frances, 2007; Cariou et al., 2009; Fu et al., 2020c).

PSC, which was initially implemented by some of the North Sea and European countries in the 1980s, has expanded and turned into regional memorandums of understanding due to the fact that its success in applications and its ability to detect substandard ships. Since the 2000s, almost all of the coastal states have been implementing port state control under 10 different memorandum of understandings (MoU) (Knapp and Frances, 2007). PSC has been a field of extensive scientific publications for researchers throughout its inception and expansion period. The fact that it is directly related to fields such as law, technical, commercial, and social sciences as well as maritime makes PSC an area that attracts the attention of different disciplines. In this context, this study aims to analyze the publications on port state control, which is an important control mechanism for maritime, with the bibliometric analysis method. In this study, publications in the Web of Science (WOS) database, one of the most important databases in the scientific world, were examined. VOSviewer software was used in the analysis, in which a total of 110 publications were analyzed. However, the limited number of maritime journals causes the number of publications in this field to be low and the literature to be relatively narrow. The study provides the authors, countries and journals of the studies in the field of PSC, and the interactions between them, and finds the links between the terms used by analyzing the keywords and abstracts with the text mining method. This study is important in terms of giving the density of the field of publications on PSC and determining which field the publications are directed towards. The fact that it is the first study in the field as the method used also increases the importance of the study. It is thought that this study will be a resource

for researchers who will publish in this field.

2. METHODOLOGY

Bibliometric methods are used extensively in situations that require data analysis and text mining, and to evaluate variables such as citations, authors, and publishers. Bibliometric analyzes can give more comprehensive and detailed results from the large data accumulated over time. The important advantages of bibliometric methods are that they provide a fairly general overview of the scientific literature and the potential to provide more objective results than traditional analysis methods. The general flow diagram of the bibliometric method is to extract the publication from the selected database, to determine the final studies to be evaluated by filtering the bibliometric data according to the research purpose, and to choose software program. In this process, there may be various different refining and content analysis. The fact that this is a very long and arduous process is one of the difficult aspects of this method (Maier et al, 2020).

VOSviewer software, which is widely used in the bibliometric analysis, was used in this study. This software was developed for the creation and display of bibliometric maps and unlike most other programs it places more emphasis on the graphical display of bibliometric maps. VOSviewer uses distance-based maps in which the distance between two items represents the strength of the relationship with each other. A shorter distance usually means a stronger relationship. In addition, software creates maps based on co-occurrence matrixes (van Eck and Waltman, 2010). The maps, in other word networks, are consisted using bibliographic database files (i.e., WoS, Scopus and PubMed) or reference manager files (i.e., RIS, EndNote, and RefWorks) (Einecker and Kirby, 2020). The difficulty in analyzing files obtained from different databases at the same time is a disadvantage. VOSviewer's user-friendly interface, fast and easy to interpret analyzes are very important advantages.

By using this software, quite comprehensive bibliometric analyzes such as publications, citations, publishers, authors, institutions and countries of the authors making the publications can be made. In addition, bibliometric analyzes of co-authorship, co-occurrence of keywords, citation, bibliographic coupling and co-citation data can be performed (Shah et al., 2019). The size of the item on the map indicates its importance and popularity in the dataset. In other words, the larger an item, the more significant it is. As aforementioned, the close distance between the items indicates that the relationship between those items is strong or that the frequency of co-occurrence is high. Also, these items that are close in distance are often shown in the same color on the map. Each group of items with the same color is called a cluster. The curves between items show the link strength of two items. In a keyword analysis, for instance, the curve between two items means their co-occurrence in the same publication, and a thicker line represents a stronger link strength (Shah et al., 2019; Einecker and Kirby, 2020; Yu et al., 2020).

3. DATA DETAILS

In this study, Web of Science, one of the most

important databases in the world, was used to examine the literature on port state control. All index criteria (SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI, BKCI-SSH, BKCI-S) were included in the research in the literature review made in January 2022 from the database. In order to determine the publications related to port state control, the search in the database is performed as theme= ("port state") OR ("ship inspection") OR ("port state control (PSC)") in the topic that comprises title, abstract, author keywords, and keywords plus of a publication. A total of 305 publications were found as a result of the search without any time limit for the publication date. Information about all of the identified publications was extracted from the database as a text file (*.txt). Afterward, it was aimed to determine the studies that are not directly related to the subject by making content analysis of these studies. While doing this analysis, first of all, the abstracts of the articles were examined, then the full texts of some articles were examined and it was decided whether to include them in the data set. As a result of the examinations, it was determined that a total of 177 studies were not directly within the scope of the research and these studies were excluded from the dataset. 1 book chapter and 17 proceeding statements in the remaining 128 studies were removed from the database and finally, the analysis phase was started with 110 publications. The flowchart of the research methodology can be seen in Figure 1.

No publication date limitation was set for the 110

studies included in the analysis. It has already been determined that studies have been carried out since the 1990s when port state controls began to become widespread in practice. In addition, it is seen that there has been a significant increase in the number of studies, especially after 2007, and the trend curve continues upwards (Figure 2). Moreover, almost half of the publications were published in the last three years. When the publications conducted before 2007 and not included in Figure 2 are examined, it was found that 2 publications were published in 1994, and one publication each in 1993, 1997, 1999, 2000, 2001, and 2005 on port state control.

4. FINDINGS

The analyses made in this section were given under separate sub-topics. Within the scope of the study, the analysis of the authors, journals, publications, keywords, citations, and the countries of the authors were made. In addition, the abstract sections of the publications were analyzed by text mining method.

4.1. Author Analysis

In this analysis, the number of publications and citations of the authors who published on the PSC and their interactions with each other were analyzed. The authors with the most publications in the WOS database on the field are Knapp, S., Wang, S., and Yan, R. with

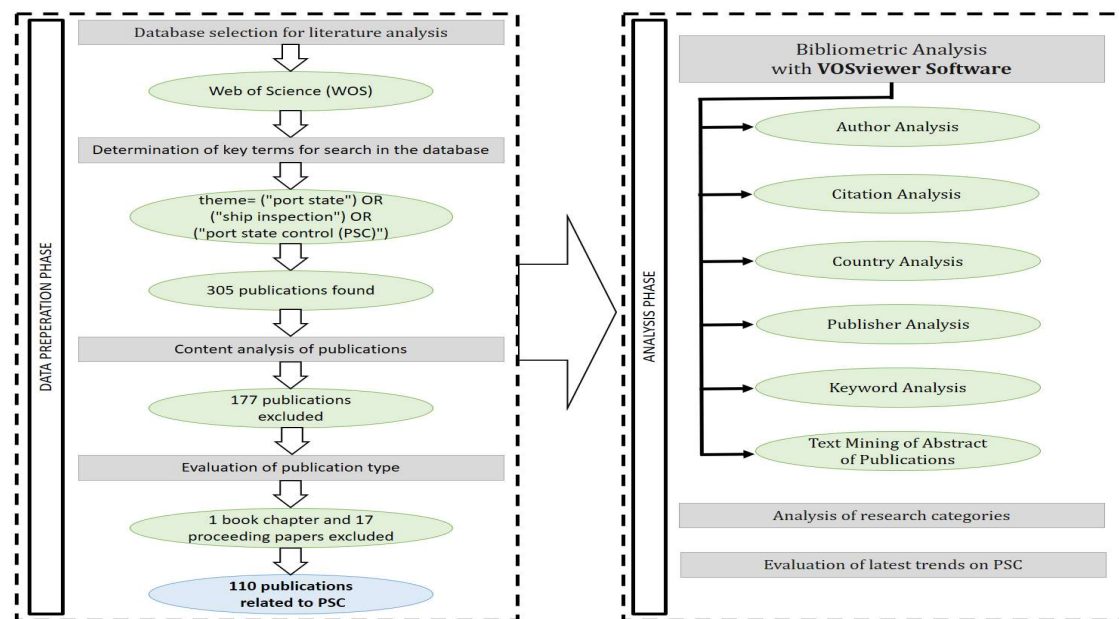


Fig. 1. Flowchart of the research methodology

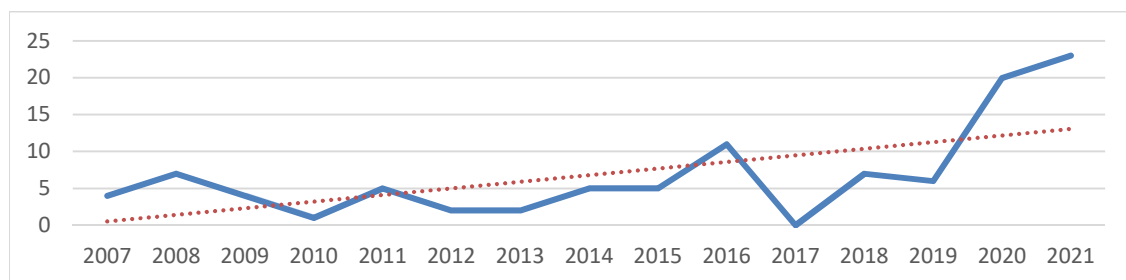


Fig. 2. Distribution of studies on PSC by years

eight, seven, and seven publications, respectively (Table 1). When the number of citations received by the authors is examined, Snapp, K. ranks first in the number of citations with 227 citations as well as in the number of publications. Other authors with high citation counts are Carriou, P. (181 citations), Hanninen, M. (140 citations), and Kujala, P. (140 citations). When the average number of citations per publication is examined, Hanninen, M and Kujala, P. are again the most prominent authors. These authors have an average of 70 citations per publication, with 140 citations for a total of 2 studies.

Table 1. Analysis results of authors

| Name of Author | Number of Publications | Number of Citations | Average Citations per Publication | Total Link Strength |
|-------------------------|------------------------|---------------------|-----------------------------------|---------------------|
| Knapp, Sabine | 8 | 227 | 28.38 | 8 |
| Wang, Shuaian | 7 | 37 | 5.29 | 11 |
| Yan, Ran | 7 | 37 | 5.29 | 11 |
| Yang, Zaili | 5 | 106 | 21.20 | 9 |
| Yang, Zhisen | 5 | 106 | 21.20 | 9 |
| Carriou, Pierre | 5 | 181 | 36.20 | 8 |
| Meija, Maximo Q. | 4 | 94 | 23.50 | 7 |
| Wolff, Francois-Charles | 4 | 120 | 30.00 | 7 |
| Heij, Christiaan | 4 | 101 | 25.25 | 4 |
| Yuan, Chien-Chung | 4 | 16 | 4.00 | 4 |

The network structure formed as a result of the co-authorship analysis of the authors is given in Figure 3. When the network structure is examined, it is seen that the 7 authors with the most interaction are under two clusters (red and green). In particular, it can be said that the connection strength between Yang, Zaili and Yang, Zhisen is high. In the interaction results between the countries of the authors in terms of co-authorship, a meaningful network structure could not be obtained.

4.2. Citation Analysis

In this section, the most cited publications and their interactions were analyzed. The minimum number of citations per publication was set to 20. In other words, studies with less than 20 citations in total were not included in the analysis. A total of 27 publications met this requirement, and the 10 most cited publications and their link values are given in Table 2. Hanninen (2014b) is the most cited publication with a total of 81 citations. Molenaar (2007), Yang (2018b), Knapp (2007), and Carriou (2008) are other publications with over 60 citations. When the network structure between the publications is examined, the studies are grouped under 4 clusters, as can be seen in Figure 4. In addition, it can be said that the studies are concentrated in green and red clusters.

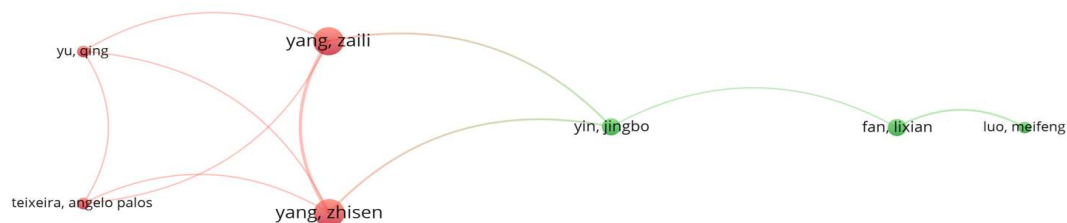


Fig. 3. Mapping the co-authorship on PSC

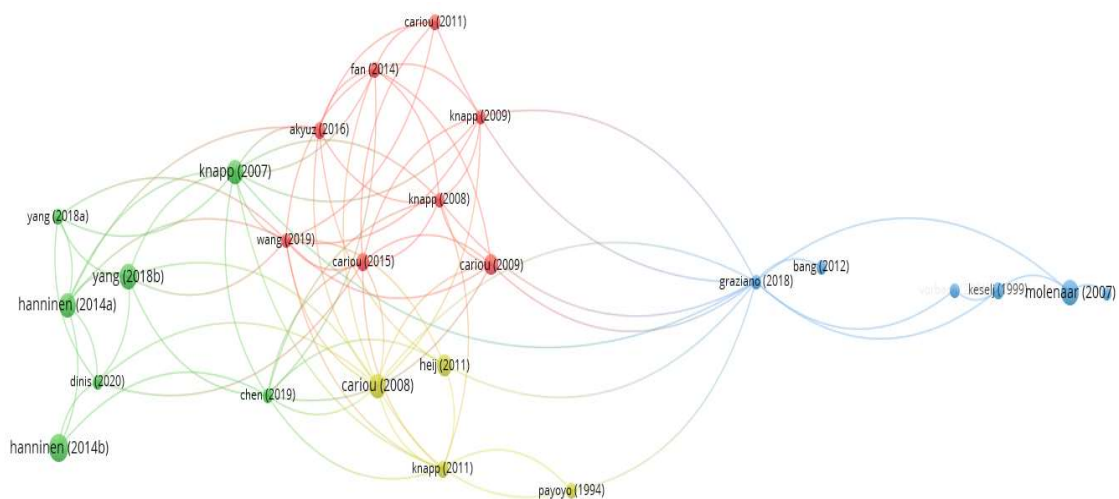


Fig. 4. Mapping on citations of publications

Table 2. Analysis results of citations of publications

| Publications | Citations | Links |
|-------------------------------|-----------|-------|
| Hanninen and Kujala (2014b) | 81 | 3 |
| Molenaar (2007) | 64 | 3 |
| Yang et al. (2018b) | 63 | 7 |
| Knapp and Franses (2007) | 62 | 11 |
| Cariou et al. (2008) | 61 | 12 |
| Hanninen and Kujala (2014a) | 59 | 7 |
| Heij et al. (2011) | 50 | 5 |
| Saengsupavanich et al. (2009) | 48 | 0 |
| Cariou et al. (2009) | 42 | 7 |
| Cariou et al. (2015) | 32 | 9 |

4.3. Country Analysis

The analysis in this section covers the interaction of citations by author's country. In Table 3., the total number of publications, citations and total link strength of the countries of the authors are shown. The countries with the highest number of publications are Peoples R. of China, Netherlands and, Turkey with 27, 12 and, 10 publications, respectively. When the total number of citations received by the publications of the countries is examined, it has been determined that Peoples R. of China and the Netherlands are the prominent countries. On the other hand, it is seen that France has the highest value in the average number of citations per publication. In the network structure, which shows the interaction of countries with each other, it is seen that especially People R. of China, France, Sweden, and Netherlands have high link strengths.

Table 3. Analysis results of countries of publications

| Country | Number of Publications | Number of Citations | Average Citations per Publication | Total Link Strength |
|---------------------------|------------------------|---------------------|-----------------------------------|---------------------|
| Peoples Republic of China | 27 | 207 | 7.67 | 295 |
| Netherlands | 12 | 313 | 26.08 | 147 |
| Turkey | 10 | 63 | 6.30 | 93 |
| Sweden | 9 | 183 | 20.33 | 176 |
| Taiwan | 9 | 63 | 7.00 | 78 |
| England | 8 | 144 | 18.00 | 112 |
| France | 6 | 189 | 31.50 | 164 |
| United States of America | 6 | 72 | 12.00 | 57 |
| Spain | 6 | 21 | 3.50 | 42 |
| South Korea | 5 | 33 | 6.60 | 53 |
| Croatia | 5 | 8 | 1.60 | 11 |

4.4. Publisher Analysis

There are a total of 10 journals with at least 3 publications on PSC. The number of publications published by these journals, the total number of citations received by these publications and the total link strength information can be seen in Table 4. With a total of 16 publications and 296 citations, Marine Policy is by far the most important journal in the field of port state control. Marine Policy is also the journal with the highest total

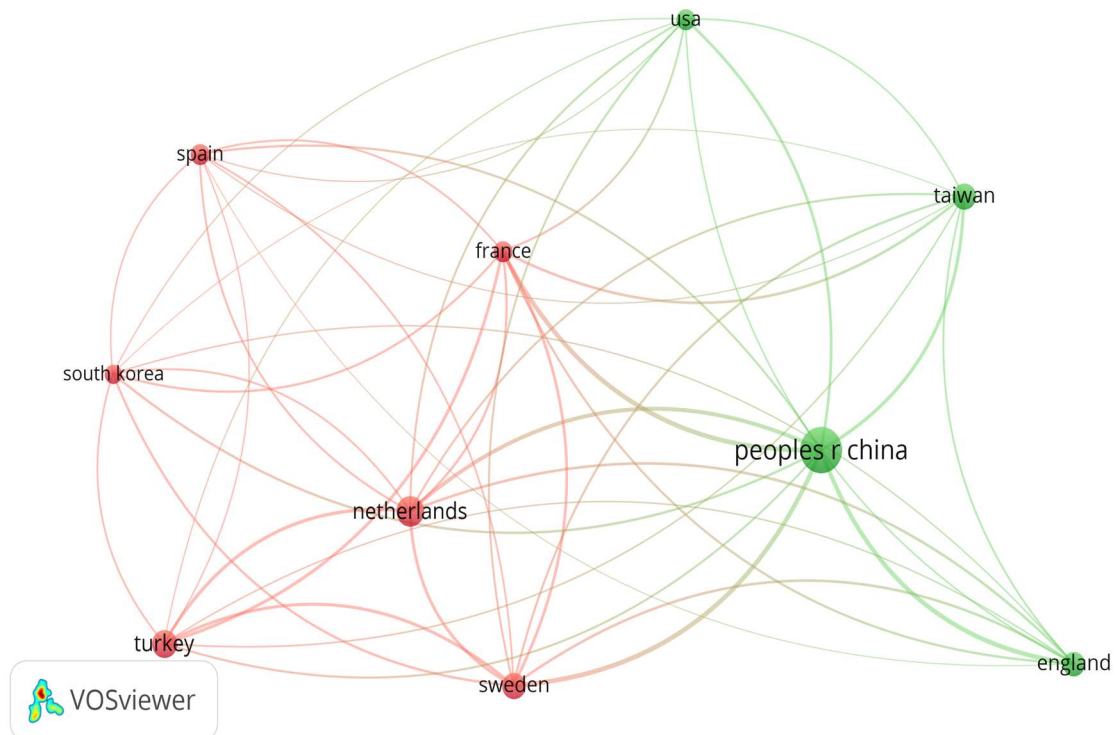


Fig. 5. Mapping on citations of countries

link strength. Ocean Development and International Law, Maritime Policy & Management and International Journal of Marine and Coastal Law are the other journals with the highest number of publications with eight articles each. It is seen that the map (Figure 6) showing the interaction of the journals consists of 3 clusters. The red one of these clusters covers half of the magazines including Marine Policy. Additionally, the strongest links are among the journals in the red cluster.

Table 4. Analysis results of publisher of publications

| Publisher | Number of Publication | Number of Citations | Total Link Strength |
|---|-----------------------|---------------------|---------------------|
| Marine Policy | 16 | 296 | 88 |
| Ocean Development and International Law | 8 | 156 | 29 |
| Maritime Policy & Management | 8 | 66 | 39 |
| International Journal of Marine and Coastal Law | 8 | 57 | 17 |
| Transport Policy | 4 | 49 | 47 |
| Transportation Research Part B- Methodological | 3 | 28 | 22 |
| WMU Journal of Maritime Affairs | 5 | 27 | 21 |
| Reliability Engineering & System Safety | 4 | 27 | 16 |
| Sustainability | 3 | 22 | 7 |
| Journal of Marine Science and Engineering | 3 | 3 | 16 |

4.5. Keyword Analysis

When 110 publications were analyzed, a total of 308 different keywords were found. For keyword analysis, the minimum number of occurrences of a keyword was set to 3. The number of keywords used at least 3 times were determined as 19. The most frequently used keyword "port state control" was used in 50 publications. "Maritime safety" was also used as a keyword in 18

different publications. These two keywords have the highest value in total link strength. "Bayesian network" keyword also gives an idea about the most used method in studies in this field of port state control. Similarly, the keyword "Paris MoU" indicates the regional port state control regime where the studies are concentrated. When the map of the keywords was examined, it was found that the keywords formed 7 different clusters, so it can be said that the keywords are scattered. "Detention", "port state", "jurisdiction", "MoU" and "port state jurisdiction" formed the red cluster, which is the largest cluster in number, although their total connection strengths are low.

Table 5. Analysis results of keywords

| Keyword | Occurrences | Total Link Strength |
|--------------------|-------------|---------------------|
| Port State Control | 50 | 50 |
| Maritime Safety | 18 | 29 |
| Bayesian Network | 6 | 13 |
| Deficiencies | 5 | 7 |
| Paris MoU | 5 | 7 |
| Port State | 5 | 4 |

4.6. Text Mining of Abstract of Publications

In the text mining analysis, the most frequently used terms and the interactions between them were analyzed by analyzing the abstracts of 110 publications. The minimum number of occurrences of a term was set to 10, and a total of 40 terms was found. 13 terms containing general expressions such as analysis, case, study, article, paper, and for which evaluation would not be appropriate were excluded from the analysis. The most frequently used term in abstracts was "port state control" with 62 occurrences. This was followed by the terms inspection, ship, PSC, deficiency respectively. When the map formed as a result of the text mining analysis is examined, it is seen that 27 terms form two almost equal clusters (Figure 8). All of the terms are in Table 6. were linked with all the words in the network. The terms with a high relevance score tend to represent specific topics covered by the data, while terms with a low relevance score can be assumed to be general and not representative of any particular topic.

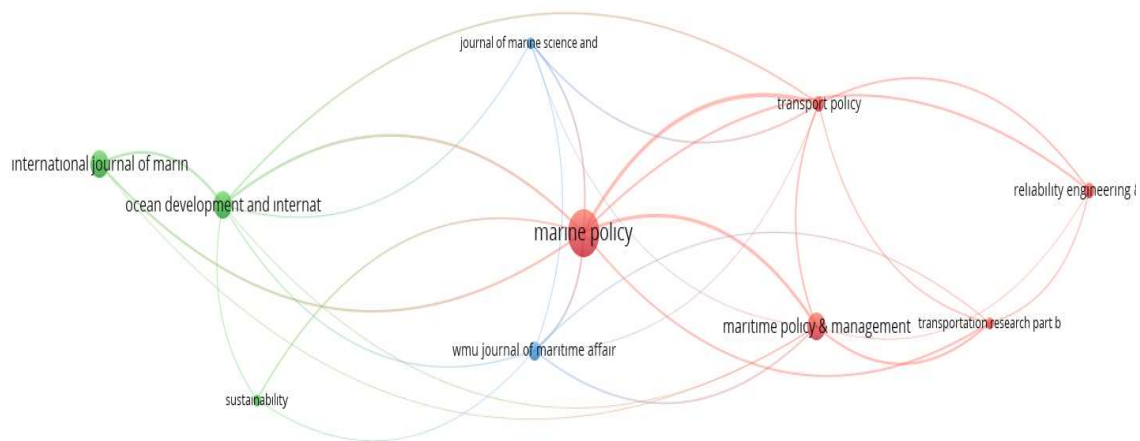


Fig. 6. Mapping on citations of publishers

Table 6. Text mining results of abstracts

| Term | Occurrences | Relevance |
|--------------------|-------------|-----------|
| Port State Control | 62 | 0.39 |
| Inspection | 53 | 0.31 |
| Ship | 52 | 0.32 |
| PSC | 46 | 0.39 |
| Deficiency | 44 | 0.31 |
| Vessel | 36 | 0.41 |
| Port | 34 | 0.40 |
| Detention | 27 | 0.18 |

4.7. Analysis of Research Categories

In the Web of Science (WOS) database, there is also information showing which category the publications are in. These categories state on which field the publications mainly focus on. Some publications can be classified into more than one category. A total of 143 research categories, 26 of which are in different categories, were identified for 110 publications on port state control (Figure 9). The research categories with the highest frequency were transportation, environmental studies, international relations, marine engineering, economics, and law. In

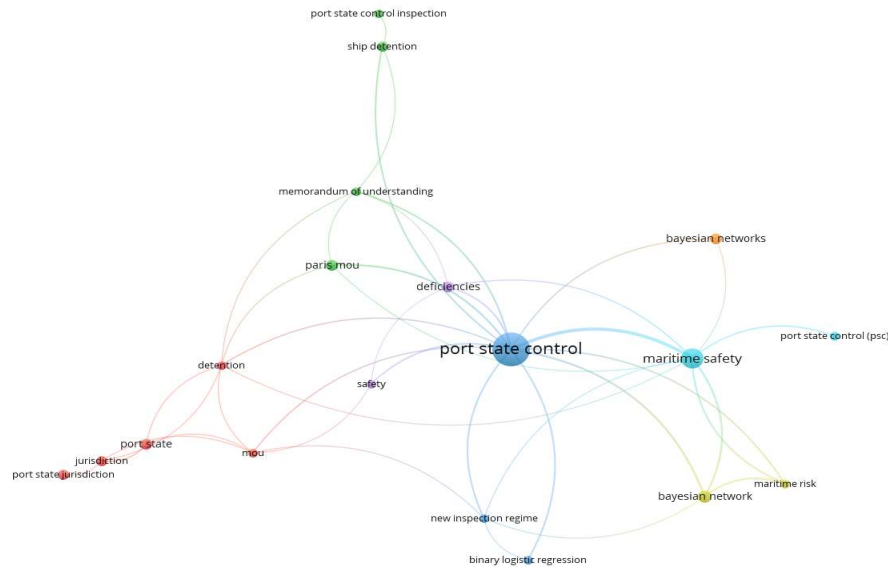


Fig. 7. Mapping on the co-occurrence of keywords related to PSC

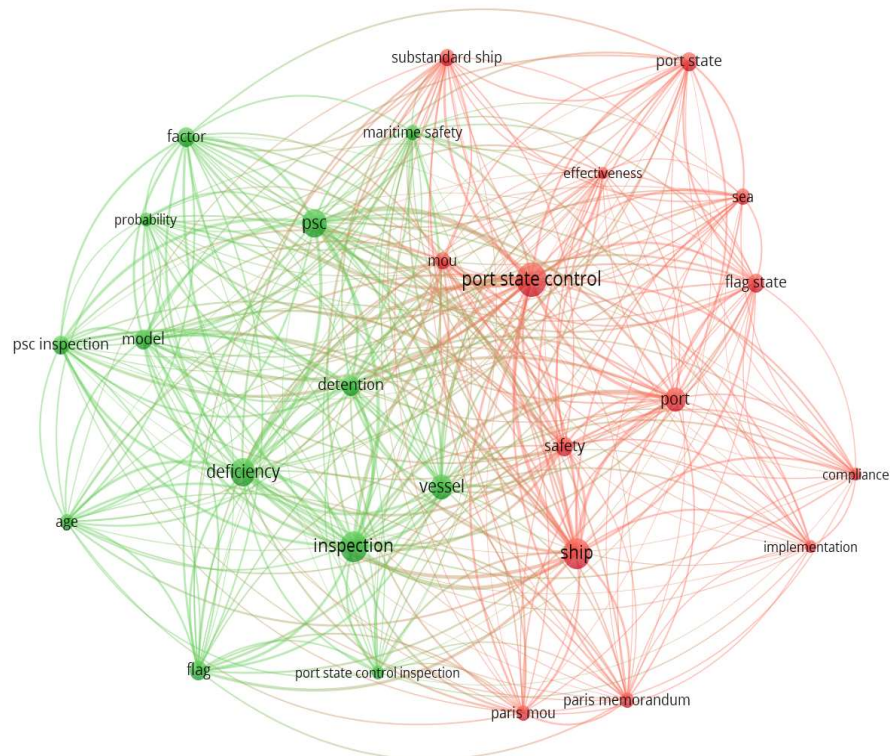


Fig. 8. Mapping on co-occurrence of terms in abstracts

addition, these categories account for almost three-quarters of the sum of number of categories. Considering the scope of PSC, it is quite expected that these categories are intensive research areas.

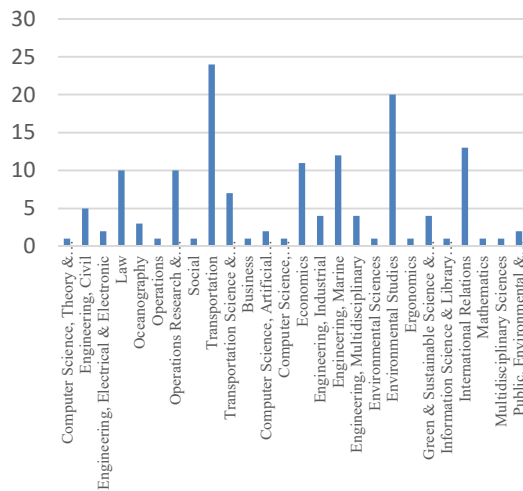


Fig. 9. Research categories of publications on PSC

4.8. Latest Publication Trends on Port State Control

When publications on PSC are examined, it is seen that the first studies are on the concept of PSC and its legal framework. It can be said that after these studies were carried out in the 1990s and early 2000s, the publications shifted to the implementation of PSC. In the late 2000s, publications generally focused on the factors affecting the ship inspection result. It has been determined that there has been a significant increase in the number of studies on PSC in the last four years. Moreover, more than half of the publications on the WOS (56 publications) have been published in the past four years. When these studies are examined, it is seen that the use of data mining algorithms to predict the inspection result in studies is a popular research area. It has been determined that almost one-third of the publications carried out in the last four years have been done in this field. The inspection results accumulated over the years in the databases of MoUs constitute quite a large amount of data. These big data are very useful inputs for data mining methods. In addition, with the use of different target factor systems developed by MoUs to detect risky ships, data mining algorithms are used for the evaluation and development of these systems.

The publications using data mining algorithms are shown in Table 7. When this table is examined, it is seen that most of the publications were made by Asian-Far Eastern authors. In addition, the Tokyo MoU inspection reports have been the data source in most of the publications. It is an expected result that these two results are related. Another MoU on which work has been done in the Paris MoU. Interestingly, there is no data mining publication on MoUs other than Tokyo and Paris MoU. Various data mining algorithms have been used in publications. However, the more commonly used algorithms have been the Association Rule (Apriori Algorithm) that gives descriptive analysis with data

mining, and Bayesian Networks one of the heuristic methods of data mining. Random Forest, Support Vector Machine, Logistic Regression and Decision Tree Algorithms are other algorithms used in publications. The journals in which publications are published also vary.

When the scope of the journals is examined, there are journals publishing in the fields of mathematics, computer science, and various engineering, as well as journals related to maritime. From this, it can be deduced that the studies on the subject arouse interest from different disciplines.

5. CONCLUSIONS

Port state control (PSC) are an important control mechanism that ensures the safety of the sea and ships. This inspection mechanism, which aims to detect and punish substandard ships, has been one of the most important applications of the maritime industry since its inception. Nowadays, PSC are actively implemented on almost all coasts of the world with memorandums of understanding (MoU). The spread of PSCs and their success in practice have led researchers to carry out intensive academic studies in this field. In this context, this study aims to analyze the trend of research on port state control from past to present, and to analyze publications and their interactions with each other using bibliometric methods. A total of 110 publications on port state control in the Web of Science (WOS) database were analyzed with the VOSviewer program.

The main findings obtained according to the analysis results, it is seen that the publications have focused on the last 4 years and these studies are the applications of data mining methods on the result of the inspection or the detention situation of the ships. It is foreseen that studies will be similar in the coming years since both data mining methods are one of the most important fields of study today and PSCs are a very convenient field for providing big data. It has been determined that especially the publications in this field have been made on Paris and Tokyo MoU, and there is no study on other MoUs. In addition, these studies have been published in a wide variety of journals in different disciplines.

When the journals in which the studies are published are examined, Marine Policy is far ahead of other journals in terms of both the number of publications and the number of citations. Marine Policy has twice the number of publications than the next journal, there is almost twice the difference in the number of citations. It was found that the publications were mostly made by Chinese researchers, and Chinese authors were dominant in the co-authorship map. In addition, the keywords and abstracts of the publications were analyzed with the text mining method and the interactions between the terms were determined. Aforementioned, the results of the analyses show that the Paris MoU has been a frequently used MoU in publications. In addition, it can be said that statistical methods such as logistic regression and Bayesian networks are also used on PSC. When the publications are examined in terms of research categories, it has been determined that there are 26 different categories, and it can be said that this is due to the multidisciplinary nature of PSC.

It is thought that this study will be a guide for researchers who want to publish in this field or seek information about port state control literature. The

limitation of this study is that only the studies in the Web of Science (WOS) database were examined. It is suggested that future studies can be carried out using different databases.

Table 7. Publications on PSC using data mining algorithms

| Publication Name | Authors | Year | Journal | Method | Data Sources |
|---|--------------|-------|---|------------------------------------|--------------|
| An artificial intelligence model considering data imbalance for ship selection in port state control based on detention probabilities | Yan et al. | 2021 | Journal of Computational Science | Random Forest | Tokyo MoU |
| An integrated dynamic ship risk model based on Bayesian Networks and Evidential Reasoning | Yu et al. | 2021 | Reliability Engineering & System Safety | Bayesian Network | Paris MoU |
| Incorporation of deficiency data into the analysis of the dependency and interdependency among the risk factors influencing port state control inspection | Wang et al. | 2021 | Reliability Engineering & System Safety | Bayesian Network | Tokyo MoU |
| Ship detention prediction via feature selection scheme and support vector machine (SVM) | Wu et al. | 2021 | Maritime Policy & Management | Support Vector Machine | Tokyo MoU |
| Using Bayesian network-based TOPSIS to aid dynamic port state control detention risk control decision | Yang et al. | 2021 | Reliability Engineering & System Safety | Bayesian Network | Paris MoU |
| Association rule mining for identification of port state control patterns in Malaysian ports | Osman et al. | 2021 | Maritime Policy & Management | Association Rule (Apriori) | Tokyo MoU |
| Development of two highly-efficient and innovative inspection schemes for PSC inspection | Yan et al. | 2021 | Asia-Pacific Journal of Operational Research | Association Rule (Apriori) | Tokyo MoU |
| A semi-“smart predict then optimize” (semi-SPO) method for efficient ship inspection | Yan et al. | 2020 | Transportation Research Part B: Methodological | Random Forest | Tokyo MoU |
| Comparative analysis of the impact of new inspection regime on port state control inspection | Yang et al. | 2020 | Transport Policy | Bayesian Network | Paris MoU |
| Mining ship deficiency correlations from historical port state control (PSC) inspection data | Fu et al. | 2020 | PLoS ONE | Association Rule (Apriori) | Tokyo MoU |
| Ship detention situation prediction via Optimized Analytic Hierarchy Process and Naïve Bayes Model | Fu et al. | 2020 | Mathematical Problems in Engineering | Naive Bayes | Tokyo MoU |
| The effectiveness of the New Inspection Regime for port state control: Application of the Tokyo MoU | Xiao et al. | 2020 | Marine Policy | Logistic Regression, Decision Tree | Tokyo MoU |
| Effectiveness of port state control inspection using Bayesian network modelling | Fan et al. | 2020 | Maritime Policy & Management | Bayesian Network | Tokyo MoU |
| Association rule learning to improve deficiency inspection in port state control | Chung et al. | 2019 | Maritime Policy & Management | Association Rule (Apriori) | Tokyo MoU |
| Big data analysis of port state control ship detention database | Tsou | 2019 | Journal of Marine Engineering & Technology | Association Rule (Apriori) | Tokyo MoU |
| Development of a non-parametric classifier: Effective identification, algorithm, and applications in port state control for maritime transportation | Wang et al. | 2019 | Transportation Research Part B: Methodological | Tree Augmented Naive Bayes | Tokyo MoU |
| A risk-based game model for rational inspections in port state control | Yang et al. | 2018b | Transportation Research Part E: Logistics and Transportation Review | Bayesian Network | Paris MoU |
| Realising advanced risk-based port state control inspection using data-driven Bayesian networks | Yang et al. | 2018 | Transportation Research Part A: Policy and Practice | Bayesian Network | Paris MoU |

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