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A systematic Analysis of Port Capacity Literature: Trends and Future Research Avenues

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Abstract
The continuous growth in the world economy, technology, and the population still shapes the industrialization patterns. This massive progress has also shaped the international transportation requirements. Ports, as the one of the important infrastructure in international transportation and supply chains, have been pushed by these changes in terms of structuring their capacities to satisfy the demand. This study aims to systematically analyze port capacity literature regarding the perspectives of researchers. To do this, this study adopted a systematic literature review and content analysis together. Keywords were determined in the study and searched in databases without time limit and the obtained studies classified and evaluated by content analysis to find out the advances of the port capacity domain. Also, the research streams were analyzed thematically and future research avenues were provided. The result of this study showed that the most attractive topics are service level and performance in performance main category; development and planning in "capacity planning" main category; cost and investment topic in "cost and economic analysis" main category; demand and forecasting subcategories in "forecasting and market analysis" main category. Besides, this study suggests future research avenues in port capacity literature.

1. Introduction

Ports are referred to as a strategic topic for both port users and operators. Technological advances and increasing integration of transportation modes have increased the planning requirements of ports (Frankel, 1987). Planning the ports draws several fields together such as policy, strategy, operations, port investment, design, and capacity. However, the main target of the port planning is to balance capacity shortage and excess capacity (Bichou, 2013). Despite the diversity in its definitions, final output (Gaur, Pundir and Sharma, 2011a), the total quantity of cargo of specific berths (Zenzerović, Vilke, and Jurjević 2011; Bassan 2007), the maximum utilization rate of infrastructure (Bichou, 2013) and amount of vessel call that the port can service while providing minimum service quality (Morales-Fusco, Saurí, and Spuch, 2010), port capacity shows the capability of infrastructure and superstructure (Bichou, 2013). Because maritime transport is a link between supply chain and trade flow, and regarding this link can be possible with the ports, any fluctuations in demand affect the ports' operations directly and rises excess or deficiency in capacity topics. Despite capacity topic gains attention in the practice, the reflection of this attention to the literature is considerably limited.

Port capacity is a multifaceted concept that involves several perspectives. As an important decision making in port investment/reinvestments, capacity development, and planning of the port capacity are associated fields because the logic behind these concepts are based on economies of scale applications and serving with adequate capacity. This also led to profit and cost associated considerations (Luo, Liu, and Gao, 2012). Also, capacity planning and expansion decisions require significant forecasting avoiding the future oversupply or undersupply conditions of

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port capacity (Souf-Aljen et al., 2016). This, of course, encompasses the capacity analysis of ports. Bassan (2007) focused on capacity analyses of ports regarding the functional activities of the terminals. One other subject in port capacity is developing a capacity measurement method but this approach is considerably limited. Park, Yoon, and Park (2014) developed a formula for measuring the berth capacity of general cargo ports. Similarly, Gulmez (2019) proposed a series of the capacity formula for dry bulk terminals. Unlike Park et al. (2014), Gulmez (2019) addressed the capacity within a holistic perspective considering the ports as systems which composed of subsystems such as berth, stockyard, equipment, and gate. Performance, on the other hand, is highly effective and highly affected by port capacity. This bilateral relationship has an impact on throughputs of the ports because building the capacity without performance issues results in excess or shortage in the capacity as well as in capacity planning issue. Also, capacity creation can possible with the increasing port performance (Gaur, Pundir, and Sharma, 2011).

Regarding its importance in both supply chain, and trade flow, the port capacity topic is needed to be researched in all its parts. Despite their significant contribution to port capacity literature, limited literature makes the port capacity domain open to study. As far as is known, there is no study addressing all aspects of ports and existing gaps that lead future research efforts. Therefore, this study aims to systematically analyze how the port capacity topic is addressed by different researches. In line with the research objective, the following research questions were determined to perform the related analysis:

R.Q. 1: To what extent does port capacity gain attention in current literature?
R.Q. 2: What are the main streams addressed in port capacity literature?
R.Q.3: How can the main streams be categorized and how those categories related to each other?
R.Q.4: What are the avenues for future researches in the port capacity topic?

To answer these questions, this study adopts both systematic literature review and content analysis.
The remainder of this study is as follows: In the second section involves the details of the research protocol, descriptive statistics of sample researches obtained from the databases, and the analysis of main and subcategories. The third section analyses thematic findings, and finally section fourth suggests further research avenues.

2. Methodology

In this study, the port capacity topic was addressed through content analysis. Content analysis is a research technique that allows categorization of the text and can be repeated with the purpose of the research (Krippendorff, 2004). With this technique, words in a text can be categorized as more specific word groups (Weber, 2011). Thus, the data obtained through literature review can be well-understood and the concept can be investigated more comprehensively (Elo and Kyngäs, 2008).

Systematic literature review in this study adopts Seuring and Gold, (2011) approach which consists of four steps, namely (i) data collection, (ii) descriptive statistics, (iii) category selection, (iv) data evaluation. The data collection process explains the determination process of keywords, topics, and scope of the journal, descriptive statistics include the related statistics of the port capacity literature, category selection indicates the inductive and deductive category building that subjected to the analysis. Finally, the data analysis section includes the iterative codes and the sub-categorization of these codes (Seuring and Gold, 2012).

2.1. Data Collection

Port capacity related researches were obtained through Web of Science, Scopus, and Google Scholars regardless of the time and whether peer-reviewed to examine the topic with a broader perspective. In the initial process of the query, related keywords were set as "port capacity", "capacity calculation" and this query resulted in 236 pieces of research (See Table 1). However, once these researches were examined, it was noticed that the query had irrelevant researches in several fields. For this reason, keywords were narrowed to reach port capacity-related results and a new research string was formed. Direct results were obtained through this research string. However, to reach relatively all studies in the port capacity domain, different keyword combinations were tried within the narrowed context for the second query process and added to the research string. In this stage, duplicated studies were eliminated and new findings were included in the sample.

Table 1. Data collection procedure.

	Database	Research String	Query Limits		Result
			Search Field	Document Type	
Initial Step					
1	Scopus	"port capacity" AND "capacity calculation"	Heading, Abstract, Keyword, Full Text	Article, Proceeding Paper	63
2	Web of Science	"port capacity" AND "capacity calculation"	Heading or Topic	Article, Proceeding Paper	37
3	Google Scholar	"port capacity" AND "capacity calculation"	Article Heading, Abstract, Keywords, Full Text	Article, Proceeding Paper, Thesis	136
First Step					
1	Scopus	"port capacity" AND "capacity calculation" ("seaport" OR "terminal")	Heading, Abstract, Keyword, Full Text	Article, Proceeding Paper	45
2	Web of Science	"port capacity" OR "seaport capacity" OR "port terminal capacity"	Heading or Topic	Article, Proceeding Paper	13
3	Google Scholar	"port capacity" OR "capacity calculation"-"seaport" OR "terminal" OR "port"-NOT "airport"	Article Heading, Abstract, Keywords, Full Text	Article, Proceeding Paper, Thesis	10
Second Step					
4	Scopus	("capacity calculation" AND "berth capacity") OR ("capacity calculation" AND "storage yard capacity") OR ("capacity calculation" AND "yard capacity") OR ("capacity calculation" AND "stockyard capacity") OR ("capacity calculation" AND "gate capacity")-("seaport" OR "terminal")-NOT "airport"	Article Heading, Abstract, Keywords, Full Text	Article, Proceeding Paper	2 (Duplication)
5	Web of Science	"port capacity" OR "berth capacity" OR "storage yard capacity" OR "yard capacity" OR "stockyard capacity" OR "gate capacity"	Heading or Topic	Article, Proceeding Paper	15 (13 Duplication, 2 New)
6	Google Scholar	"port capacity" OR "berth capacity" OR "storage yard capacity" OR "yard capacity" OR "stockyard capacity" OR "gate capacity"	Article Heading, Abstract, Keywords, Full Text	Article, Proceeding Paper, Thesis	4 (Duplication)

Results were evaluated, the researches included related keywords, but not addressed the "port capacity" were excluded from the study. Additionally, total of 2 studies, 1 research in Scopus and 1 study in Web of Science, were excluded due to being non-English text, although abstract of these researches in English. Table 2 shows the final results.

Table2. Number of publication.

Database	Number of researches	Final results
Scopus	45	26
Web of Science	15	14
Google Scholar	10	9
Total	**70**	**49**

2.2. Descriptive Statistics

In this stage, the classification of the researches was performed through NVIVO 12 software. Each research was appointed in NVIVO as individual cases, and name of the journal, type of publication (proceeding paper, article, book, book chapter, and thesis), year of publication, the category (empirical and theoretical), method, type of port (dry bulk, general cargo, container, Ro-Ro, liquid bulk, and all types of ports that disregard the port category), focused topic, focused part of the port (berth, yard, gate and all part that does not include in only part) and database were appointed to each case.

2.3. Category Selection

The categories subjected to content analysis were formed following the research questions. The main topics were determined and associated topics were coded under the same main category by analyzing each research manually. These topics were set as the themes for content analysis. Categories were re-evaluated in the "Material Evaluation" section, the categories in coding were re-formed.

2.4. Material Evaluation

Several categories were formed to perform a clear analysis of the port capacity literature with NVIVO software. A general overview of the researches performed to form categories of the literature and final categories were set namely "capacity planning", "economic and cost analysis", "performance", "forecasting and market analysis". To address the port capacity topic in a more comprehensive perspective, sub-categories were appointed to these main categories (See Table 3). Once the sub-categories were determined, keywords mostly associated with the related fields were selected.

Table 3. Main and sub-categories.

Main Categories	Sub-Categories
Capacity Planning	construction, expansion, design, inadequate, overcapacity, planning, development
Cost and Economic Analysis	cost, capital, investment, economic, depreciation
Performance	utilization, efficiency, effectiveness, service level, congestion, performance
Forecasting and Market Analysis	forecast, market, supply, demand, customer

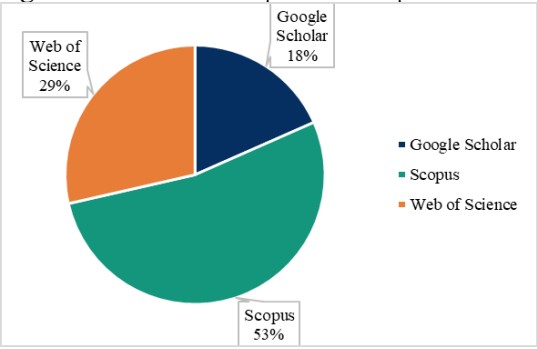
2.5. Descriptive Statistics

Port capacity literature was analyzed under the seven headings namely, distribution of publications per databases, distribution of publication types and categories, distribution of focal point of publications and databases, distribution of the focal point of the publications, distribution of the methods used in the publications, distribution of the focal points per port types, distribution of focal points and part of the port.

2.5.1. Distribution of publications per databases

Figure 1 shows the distribution of researches according to three different databases.

Figure 1. Distribution of publications per databases.

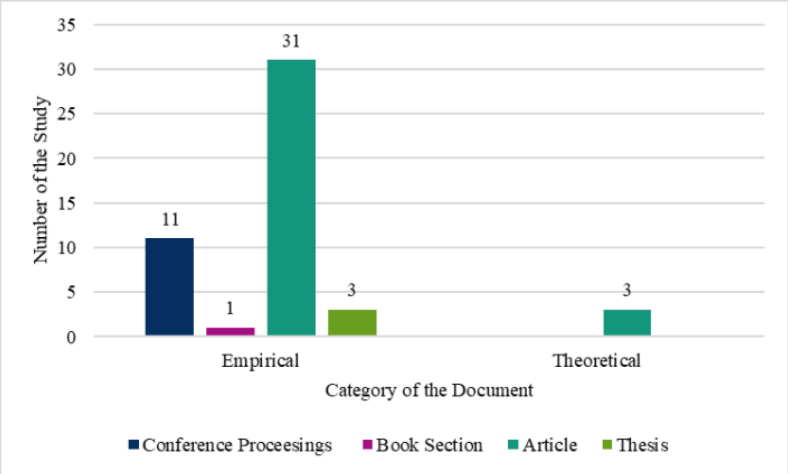


A majority of the port capacity researches were obtained from the Scopus database with a share of 53% share. Total of 29 percent. 29% of the studies were obtained from Web of Science, while Google Scholar constitutes 18% of this share.

2.5.2. Distribution of publication types and categories

Findings achieved by classification of the publications as empirical and theoretical are illustrated in Figure 2.

Figure 2. Distribution of publication types and categories.

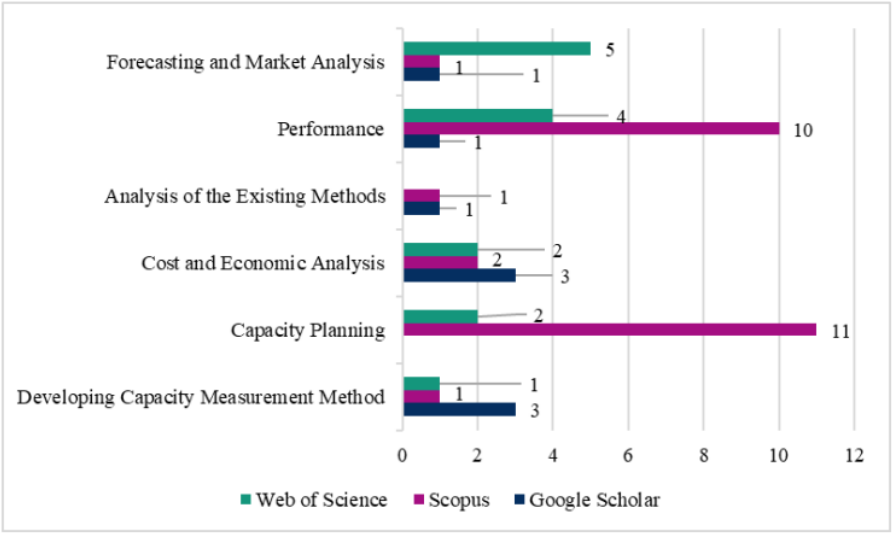


Classification yielded 46 empirical and 3 theoretical types of research. While the studies in the "article" category have the biggest share among the empirical studies, the study in the "book section" has only 1 study. In the theoretical category, types of studies are article types of research. Theoretical studies are considerably limited comparing the "empirical" publication category.

2.5.3. Distribution of focal point of publications and databases

Focal points of the studies were formed through the manual analysis of each study. Figure 3 shows the distribution of main topics over databases.

Figure 3. Distribution of main topics per databases.

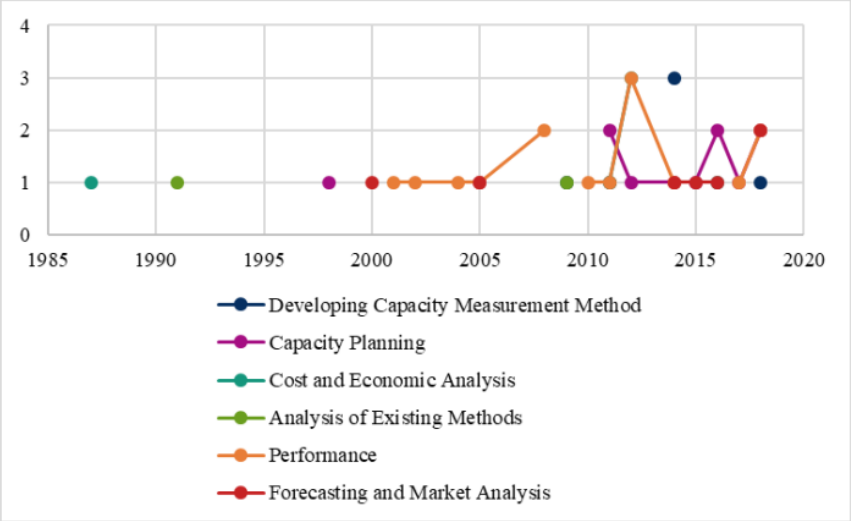


The studies in which capacity measurement methods were developed mostly in the Google Scholar database. Capacity planning-related studies were mostly achieved from Scopus, no study was recorded in Google Scholar. All databases included the studies on cost and economic analysis. Web of Science mostly focused on forecasting and market analysis, whereas no study was found related to testing the existing measurement methods. Significant attention was paid to the studies that mostly addressed the capacity planning and performance topics.

2.5.4. Distribution of focal point of publications over years

Figure 4 indicates the distribution of focal points of studies over the years.

Figure 4. Distribution of focal point of publications over years.



In port capacity literature, the continuity was found in performance and capacity planning categories. As of 2000, there has been an increase in studies focused on performance. Moreover, performance has recorded a higher increase compared to other studies between the years of 2010 and 2015. Besides, discrete progress was recorded in developing capacity measurement. In recent years, in line with the findings, only one study was performed on this topic. The forecasting and marketing analysis topic was addressed in 2000 and 2005, despite it showed continuity between the years of 2014 and 2016.

2.5.5. Distribution of the focal point of the publications

Sampling researches were examined and classified according to the methods used in the research. Total 21 methods were determined. The methods used to analyze the main categories are shown in Table 4. Studies in port capacity literature preferred quantitative methods rather than qualitative. Optimization techniques, especially simulation methods and queuing theory were commonly used in these studies.

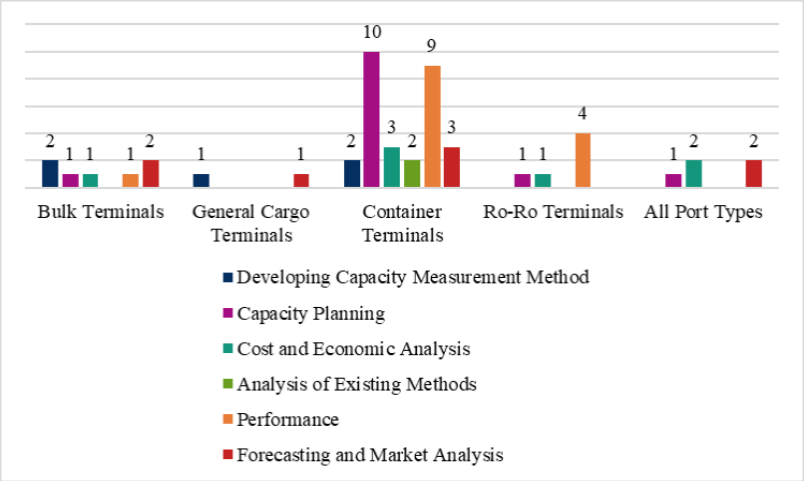
Table 4. Analysis of main categories according to methods.

Methods	Developing Capacity Measurement Method	Capacity Planning	Cost and Economic Analysis	Analysis of Existing Methods	**Performance**	**Forecasting and Market Analysis**	**Total**
Survey						1	1
Discrete Event Simulation		1			2	1	4
Computer-based Simulation Methods	1	2	1		4		8
Fuzzy Comprehensive Evaluation		1					1
Non-linear Programming			1				1
General Equilibrium Model			1				1
Genetic Algorithm	1	1			1		3
Goal Programming					1		1
Statistical Methods-Data Analysis		1	2	1		1	5
Queuing Approach		4	1		4		9
Literature Review		1					1
Mathematical Programming						1	1
Interview					1		1
Game Theory			1				1
Case Study	2			1			3
Regression Analysis						1	1
Heuristic Algorithm		1					1
Simulation-Markov Chain	1						1
Simulation-System Dynamics		1					1
Neural Artificial Network					1		1
Time Series Analysis					1	2	3
Total	5	13	7	2	15	7	**49**

2.5.6. Distribution of the focal points per port types

Regarding the research questions, the distribution of the focal points per port type was analyzed (Figure 5).

Figure 5. Distribution of main categories per port types.

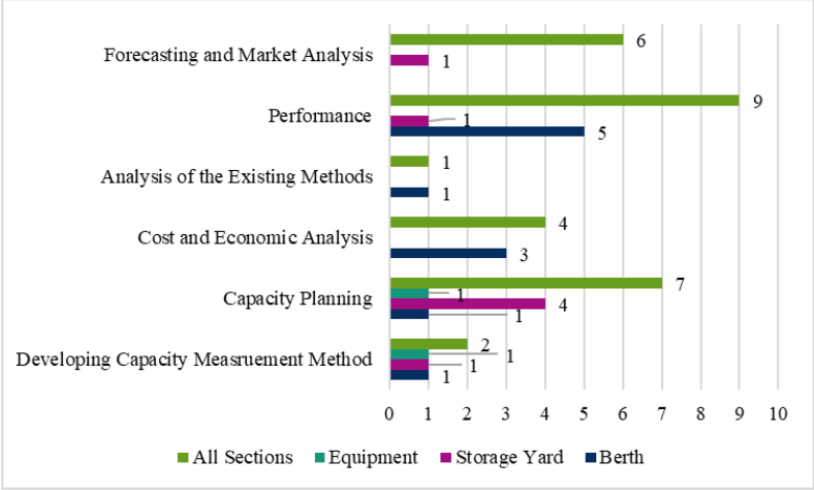


All the categories were mostly performed on container terminals. The least interesting terminal type is general cargo terminals. The studies in container terminals mostly addressed capacity planning and performance topics.

2.5.7. Distribution of Focal Points and Part of Port

Once analyzing the port capacity literature, it was determined which part of the port that main categories considered (Figure 6).

Figure 6. Distribution of focal points and part of port.



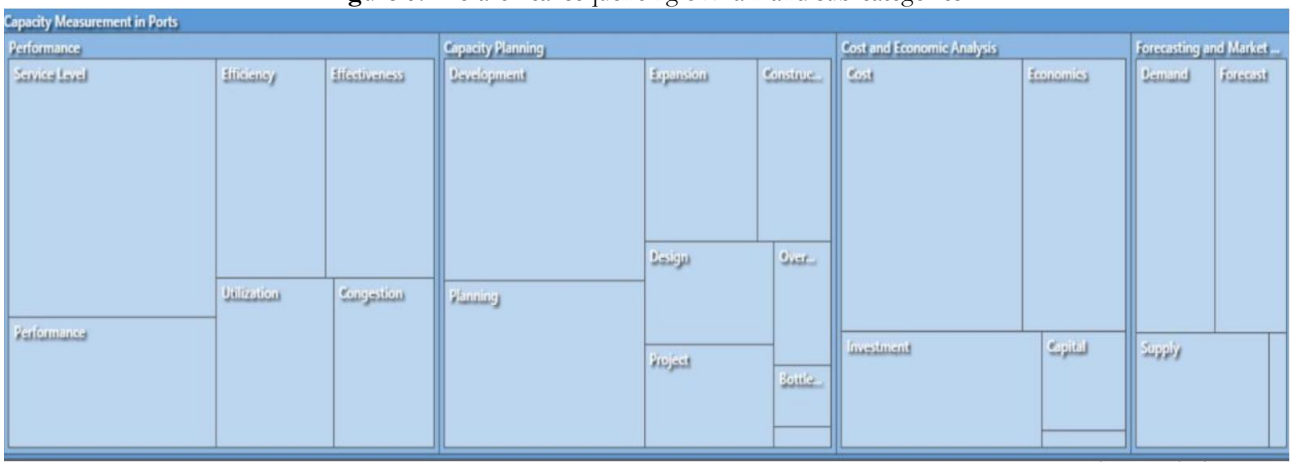
As shown in the figure, all categories did not discriminate the part of the port. Performance category mostly focused on berth following all sections, whereas planning addressed the stockyard following all sections of the port.

3. Thematic Findings

In this study, thematic analysis was conducted to explore the patterns of the main categories through NVIVO 12. Nvivo is a useful tool that allows making sense of the data. With this tool, the relationship between the texts can become more visible through the text formatting. Also, it can establish a nexus between documents and categories. As mentioned in "1.2. Descriptive Statistics", 49 documents imported to the program in 3 databases categories, and the main and sub-categories shown in Table 3 were appointed as free nodes and tree nodes respectively. With the text query function, sub-categories were searched in 49 files. In the query, the "With Stemmed Words" function

of the tool was used to acquire the synonym words within the "Broad Context". The paragraphs containing the words were coded at the relevant nodes. The frequency of sub-categories that were determined by content analysis and the number of files that were used to obtain data were determined. Service level (1603 words) and performance (807 words) sub-categories are the most repeated words in the "Performance" main category. Besides, the usage of development (1331 words), and planning (1000 words) are more than the other sub-categories in the "Capacity Planning" category. The sub-categories, cost (1492 words) and economic (855 words), are more than the remaining sub-categories, whereas demand (668 words) and forecasting (612 words) in "Forecasting and Market Analysis" are more than the other sub-categories in this category. Figure 7 shows the hierarchical sequencing of main and sub-categories depending on their frequencies.

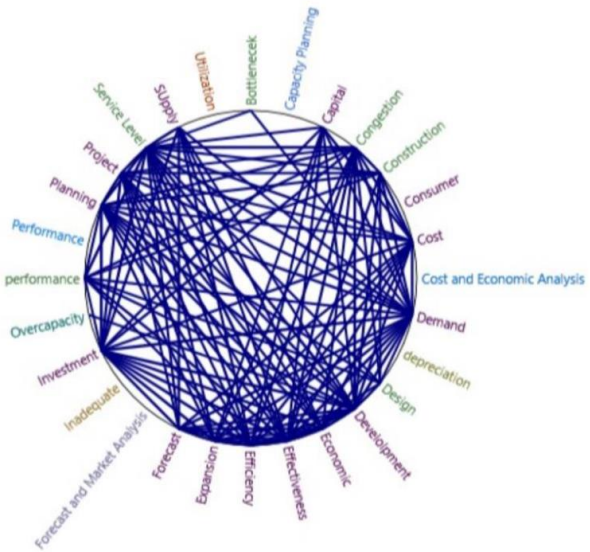
Figure 7. Hierarchical sequencing of main and sub-categories.



Hierarchical chart shows allow researchers to analyze patterns, see the patterns of nodes, codes, and attributes (QSR International, 2021). With the hierarchy chart, the pattern of the port capacity categories, the shares of the categories can be seen. Among the categories nested in the main rectangles performance and capacity planning dominate the port capacity literature. In these categories, service level code has a big share in the performance rectangle, whereas development in capacity planning has the biggest rectangle size comparing the other sub-categories.

Cluster analysis, besides, was conducted for the determination of the relationships of main categories. Cluster analysis provides identifying the discrete groups and grouping the similar sources into groups, and similarities between the nodes can be determined with this analysis. The similarity is a statistical technique that calculates the correlation between the nodes and it is measured by "Pearson", "Jaccard" and "Sorensen" coefficients (QSR International, 2021). Figure 8 illustrates the relationships between the categories.

Figure 8. Similarity analysis of nodes.



In circle graph visualization, blue arcs stand for the strong similarity between the nodes. According to Figure 8, many of the categories and subcategories show the similarity between them. The most intensive network was found between "investment", "performance", "demand", "congestion", "planning", "cost", "service level", "development" and "expansion" subcategories. Pearson correlation coefficient was used to determine the similarity level between the categories. A high correlation level was found between "service level", "performance", "congestion", "construction", project" subcategories. Additionally, "demand", "effectiveness", "investment", "expansion", "project" categories highly correlated, while "performance", "economic", "forecasting" and "analysis are highly correlated with each other.

4. Future Research Avenues

According to the content analysis result of this study, port capacity literature can be evaluated under the four main streams namely capacity planning, performance, cost and economic analysis, forecasting, and market analysis. Considering the scanty of literature, port capacity remains an unexplored research domain.

Port is a system that involves several sub-systems. Any disruption in the sub-systems affects the whole port mechanism. Therefore port capacity needs to be discussed within a holistic perspective regarding berths, stockyards, gates, intermodal transport capacity, etc. Performance trend in of ports, as the most compelling subject in the port capacity related literature, was generally addressed the performance topics focusing on a limited section of the port while performance topic needs to be addressed in a holistic perspective. Further researches can discuss the performance from a holistic perspective. This can also allow for conducting process integrated performance studies. Additionally, connectivity is another up to date concern in port performance. The impact of connectivity levels of the ports, which depends on several parameters, namely number of called ships, number of service providers, number of services, size of the ships, and annually deployed container carrying capacity, on both port capacity and performance can be analyzed in the future studies.

Regarding the function of ports in global supply chains, capacity planning is essential in the realization of port services and production planning. Capacity planning has the second biggest share in port capacity literature. Capacity planning mostly focuses on overcapacity and capacity deficiency, on the other hand, the installation of new infrastructures, and optimization of port's extant resources specific to berth, stockyard, and gate sections of ports. Existing researches addressed the capacity planning in the static base which does not affect by internal, or external factors such as crisis, wars, pandemics, etc. Even though studies focused on capacity planning, current literature mostly ignores the managing of the capacity. Thus, considering the continuous changes in globalization trends, and supply chains, future researches may focus on dynamic capacity planning and capacity management concerning supply chain vulnerabilities and changing patterns of economy and globalization.

As for that cost and economic analysis, existing studies overwhelmingly addressed port development, economic analysis, and cost of port expansion. As well as the capacity investments, the number of services, and the cost of these services to the port investor are important decision parameters to investing in port projects. Future studies may address the transaction costs based analysis of the invested services or capacity that can be used as a decision support system in the evaluation of the efficiency of investment and following new investments.

Forecasting and market perspective is the least interesting stream in port capacity literature. This topic generally addressed the forecasting demand-sided (amount of throughput) of the port services. However, there is room for supply-sided forecasting that regards new entrants in the market, how much TEU or ton basis capacity will be supplied by the port operators in the future, and the effects of these entrants on market and the existing competition structure of the ports located within the same range. Future researches may consider these issues.

5. Conclusion

This study systematically analyses port capacity literature within three selected databases, namely Scopus, Google Scholar, and Web of Science by determining keywords without time limits. Following the query procedure, 49 studies were obtained. Regarding the number of studies, port capacity literature is quite limited. Once the distribution of the number of the studies according to databases, Scopus has the highest percentage among the other databases. In general, papers can be characterized as articles that are empirically conducted. Port capacity literature has advanced within the key areas; capacity measurement, capacity planning, cost and economic analysis, evaluation of the existing measurement methods, performance, and forecasting and market analysis. While the studies in the performance category showed continuity over the years, the studies in the remaining categories showed discrete progress. Descriptive statistics results showed that there was an increase as of 2000. These studies were mostly employed optimization techniques and mostly focused on container terminals rather than others.

Results also showed that these studies involved all the subsystems of ports (stockyard, equipment, berths, and gate). The most attractive topics are service level and performance in performance main category; development and planning in the "capacity planning" main category; cost and investment topic in the "cost and economic analysis" main category; demand and forecasting subcategories in "forecasting and market analysis" main category. Besides, cluster analysis showed that a high correlation was found between performance and capacity planning topics.

Also, this study suggests future research avenues in port capacity literature. With the analysis employed in this study, main categories and sub-categories in port capacity were determined and this was also led to the determination of streams in port capacity literature. For instance, studies commonly focused on capacity planning. Future studies may go beyond the planning topic and study the capacity planning within the management perspectives. Such perspective provides port service providers or port authorities to manage port capacity supply against vulnerabilities in supply ad transport chain in their dynamic environment.

This study, of course, has some limitations. One of the limitations is the analysis of the limited number of databases. Different databases may be included in further studies to obtain more papers. Besides, different research string combinations may be used and the keyword used in string formation may be extended in future studies.

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