

A Systematic Review on Factors Influencing Container Terminal's Performance

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ABSTRACT

The container terminal is considered as a supply chain station where freight containers are transferred from the sea into the hinterland or vice versa. Port terminal operators have to brighten up their strategies for increasing port performance to compete with other rival marine ports. Technological advances in port operation have created a wide variety of study options for port designers, but little attention has been paid to the fully examine factor influence in port performance from both technical operation and management perspectives simultaneously. The paper aims to substantially review factors that influenced container terminal performances. The authors report a systematic literature review conducted using the method of Preferred Reporting Items for Systematic reviews and Meta-Analyses. 106 published articles have been gathered from Web of Sciences journal databases. The findings of the review classify the domain of the studies into eight main themes such as assignment, scheduling, optimization, strategic management, risk, performance evaluation, information system, and maintenance. The literature review also identified trends of those main themes. Furthermore, the studies found the highest performance cluster of container terminals focused on operation, facility, and equipment. In conclusion, operation time, container handling time, and quay crane productivity have been identified as the primary elements that influenced container terminal performance.

Keywords: *Container terminal, influenced factors, PRISMA, port performance, and systematic reviews.*

1. INTRODUCTION

Expansion of the manufacturing industry resulted in increased import-export traffic activities at marine ports. The scale of the worldwide manufacturing networks cultivates

impact on the role of transportation, typically marine transportation becomes more important (Huang *et al.*, 2020). Increasing container quantities also leads to competition among container terminal operators. While aiming for a high service level, port competition boosts the work of material handling in the port and indirectly enhances operator efficiency (Lu and Le, 2014). Competition among East Asian container terminals has become gradually more intense, each marine port is motivated to enlarge its investments to continue to preserve the competition (Lu and Wang, 2013). Container terminal operators are required to compete in the global market by accelerating port performance services. The most defying problem affecting the acceptable port presentation is determining the influencing factors that have a direct impact on container terminal performance.

Container terminals with limited resources are more likely to have delays and waiting times in their services. Otherwise, the COVID-19 pandemic is a complex crisis affecting all life systems including the business sector (Pinzaru *et al.*, 2020). Businesses around the world have experienced supply chain disruption due to the COVID-19 pandemic (Forehand *et al.*, 2021). The pandemic situation has had a significant influence on container terminal operations. Complex problems and relationships among those variables attempt to obtain favorable technical operation and management approaches for container terminal operators. This requires accurate input strategies in diverse backgrounds to discover the precise match for the application. However, to discover a precise match for answering those challenges, the container terminal must identify proper parameters influencing port performances. Improperly influenced factor selection leads to process

failures, undesirable idle time, and effects on the overall container terminal performances.

Examining performance in both technical operations and managerial categories is critical. Appropriate management practices will also result in improved terminal throughput and efficiency, as well as good performance achievement (Lun, 2011). Another factor considered in port performance is strategic operational performance (Budipriyanto *et al.*, 2015b). Elements that influence technical performance in the operations category are assignment, scheduling, optimization, maintenance, and information. Meanwhile, papers in the management category have been divided into three categories: strategic management, risk management, and performance evaluation. Technical operation factors consist of reviews regarding the utilization of equipment facilities, activity algorithm settings, and preventive maintenance in anticipation of various field constraints. In general, the overall technical operation and management performance factors presented will significantly improve the operation performances of a container terminal.

A lot of research has been done on container terminal activities. The most demanding problem affecting the achievement of ideal port performance is the systematic evaluation of factors that stimulate the improvement process. Meanwhile, only several studies have focused on the factor identification to execute port performance evaluation. Most factor identification studies examine risk themes in container terminals such as risk factor identification methods (Mokhtari *et al.*, 2011), risk attributes in decision making (Su *et al.*, 2014), insurance behavior evaluation (Tsai, 2017), port safety (Tseng and Pilcher, 2017), operational risk (Juliza and Anggiat, 2019), handling procedure High-Risk Cargo (HRC) (Saruchera, 2020b) and work accident assessment (Budiyanto and Fernanda, 2020). The majority of factor identification research focused on management strategy, with technical operations receiving less attention. Furthermore, Performance evaluation studies only look at technical operation or management separately without reviewing the overall perspective concurrently for the escalating performance of the container port. Despite a variety of container terminal research for developing performance services, there seems to be a lack of comprehensive acknowledgement of a factor that integrates technical operation and management prompting a scientific discussion through a systematic review. Therefore, this literature review can assist in providing direction for container port performance improvement through the integration of technical and management factor identification. Additionally, the condition coerced future researchers to conduct deep exploration that required time for enhancing the whole picture of the technical operation together with strategic management simultaneously. Moreover, this systematic literature review is necessary to offer structured information that could support the researcher in providing the most influential variable for raising port presentation. The background of the literature review is derived from the core of the research questions:

1. *What are the classifications of the article's main theme in the literature review?*
2. *What is the trend of the main themes for the last twelve years?*

3. *What are the categories factors in influencing the performance of container terminals being categorized?*
4. *What are the categories of container terminal performances examined in research articles?*

A systematic review is a method for evaluating data by combining a quantitative and qualitative recognition for answering the research question and illustrating a clear object of research (Shaffril *et al.*, 2018). The method encourages the researcher to produce meaningful review quality articles and provide a clearer and transparent illustration of a research topic. This article provides a systematic review directed by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) that supply a conceptual description for the identification, recognition, and discovery of factors increasing port performances. Following the methodology, this article presents the result and discussion on the factors that influence the container terminal performance. It will then discuss the influencing factors by their category.

The result of this literature review will present factors into several categories such as risk, environment, facility utilization, operation time, unproductive activity, stacking yard, productivity, maintenance, traffic, information, human factor, and cost. Meanwhile, this performance has been divided into numerous categories in this study, including operation, equipment, facility, port productivity, information sharing, strategic management, human resources, environmental quality, risk-safety, maintenance, and cost-efficiency. The remaining part of the article is classified as follows: The methodology for conducting a literature review was presented in section 2. The results would be highlighted in Section 3. In section 4, the topic was discussion, and in part 5, a conclusion was provided.

2. METHODOLOGY

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method is adopted in this literature review. PRISMA is often conducted using online databases such as Web of Science and SCOPUS with period and language perimeter (López-Santos *et al.*, 2020). The systematic literature review approach was chosen because of the contest of variety in the existing body of information in every article (Ahmed *et al.*, 2018). Many studies have been conducted on systematic reviews to obtain trends including precise activities investigation (Shaffril *et al.*, 2018) and evaluating how one aspect affects others (Garrote *et al.*, 2017). PRISMA methodology consists of structured steps such as identification, screening, and eligibility (Gillath and Karantzas, 2019), which will be implemented in this systematic literature review. The entire process is shown in **Figure 1**.

This literature review employs Web of Science (WoS) databases hosted by Clarivate Analytics. WoS was chosen because the authors believe that this database contains a wide range of trustworthy scientific publications, books, and proceedings. WoS collects more than 21,294 journals with coverage of over 76 million records. It has scientific journals of various aspects and it has allowed examining recognized publications with any of terminologies, phrases, titles, and keywords (Yeung *et al.*, 2020). Consequently, the purpose of this study is to explore the supply of databases from the Web of Science associated with the subject of research.

2.1. Identification

The first step of the review process is the identification step focusing on selecting appropriate articles through recognition of keywords tag along with exploration for linked terminology of the article topics. Thus, examine strings on the Web of science implemented on 5 April 2021. Search for topic terms in the title, abstract, author keywords, and keywords recognized as TS (Topic) in WOS. The search keywords used apply were (TS=("container* terminal* operation*" OR "container* terminal* perform*" OR operation* OR perform* "Container* movement*" OR variable* OR stack* OR berth* OR "custom* clearance*" OR "container* terminal* maintenance*" OR maintenance* OR "crane maintenance*" OR import* OR export* OR "dwell* time") AND ("influen* variab*" OR "influen factor*" OR "variab*" OR "factor*" OR "impact* variab*" OR "impact* factor*" OR "effect* variable*" OR "effect* factor*" OR "performan* indicator*" OR "performan* meter*") AND ("sea port" OR sea-port OR "container terminal" OR "marine port")). As a result, 307 articles were found based on these strings. At first, the title of "dwelling time" was not written into the string. The total number of articles obtained was 304. We elaborated that the terminology "dwelling time" is widely used in some articles connected with container terminal operation. Then the title "dwell time" has been decided to be included in the string, bringing the total number of articles to 307. The literature review began with 307 articles from the Web of Science database.

2.2. Screening

The second step of the literature review was to eliminate articles based on the writer's criteria. The writer's first criterion was to focus on articles published in English, with 8 articles being removed, leaving 299 records. The next criterion was articles published for the last 12 years (2010-2021). There were a total of 73 articles that were removed. There were 81 articles out of a total of 226 that were excluded based on those criteria. At the end of this stage, the download process was completed using the Endnotes X9 software, and 112 articles were successfully obtained. 114 articles were unsuccessfully downloaded and excluded from the list. The complete process for the step of the literature review is described in **Figure 1**.

2.3. Eligibility

This step was conducted a thorough review of the subjects covered by each article. Abstract, background, goals, method, result, and core of substance from all of those studied articles and selected papers that compatible with the main criteria of conducted literature review. The writer removed articles that have less affiliation with the technical operation and management aspects of container terminal performances. A total of six papers was eliminated in this step. Six items were removed in this level and will not be examined in the next step.

Lastly, 106 remaining articles were ready for the elaboration process. All of the articles' selected themes were classified in this study. Initially, the selection of articles that conduct research questions was established, and then all of the selected articles have been studied. The classification of article content was created based on the reading activities. The author obtained the categorization in this example through the article extraction technique. The core of the

articles are stored in Microsoft Excel spreadsheet format as a result of the extraction process. The author then separates the summary of the material into columns to facilitate categorizing the paper easier. The extraction column of the article consists of author, title, journal name, years, goals, method, tool, factors involved, background, the focus of improvement, impact, city location, country, continent, solution, the impact of the solution, research focus, main theme, method category, object category, department, main goals, goals category, factor, factor category, performance, performance category and type of paper.

The author's column, title, and journal name were placed to make it easier for identification and conduct searching of the full paper text within endnotes software. Writing goals in the column allow the writer to classify them based on the topic and object of the articles. The factors column is a column that could answer the research question regarding what factors are considered in improving the performance of the container terminal. A column of problems intended to categorize the problems faced by terminal ports. Based on the problem column, the author could fill in the background of a minor performance column using operational difficulties. The impact of minor performance is intended to identify the negative impacts caused by the minor performance of the container terminal. The author can also identify the research location of each article for easier understanding in the mapping of container terminals. The solution column is the core of the research result and conclusion, also equipped the impact of the solution, based on the entire filling of the column above. The author could conclude the overall discussion in each article and comprise it in the theme column. Themes have a very close relationship with writing keywords. In addition, the reviewer must be able to infer the main purpose of each piece.

The study categorized paper typology and grouped them into article types. Based on the results of the study, collected articles can be classified into a literature review, specific practical paper, and case study. Articles categorized as literature reviews became the basis of ideas in compiling the writing of this review. The basis for mapping difficulties faced by ports around the world is case study articles gathered through the search process. The number of article reviews in this study is dominated by partial practical papers. Those articles usually implement simulation, optimization, modeling, scheduling, and assignment of the specific method to solve the problem within the container terminal.

The review process obtained nine main themes from the literature study as follows: assignment, scheduling, optimization, strategic management, risk, performance evaluation, information system, maintenance, and environment. Furthermore, based on the method used by the researcher in solving problems, the authors classify these methods into modeling, assessment, simulation, system evaluation, expert systems, model implementation, operation research, measurement, and factor identification. Meanwhile, according to the paper category, the review produced several categories namely case study, technical, and literature review. Literature reviews also elaborate on the location of each article studied. We have received articles implementing research in 32 countries and spread across the five continents.

Based on the paper's elaboration in the context of answering the research questions, the related factors have been divided into several categories. Initially, the factors have been classified into twenty-seven categories. Then the classification was further reduced into twelve categories consisting of risk, environment, facility utilization, operation time, unproductive activities, stacking yards, productivity, maintenance, traffic, information, human factors, and costs. Those factors determine the performance of the terminal container. Based on a study of the 106 articles, the performance has been divided into eighteen categories as well as narrowed it down to eleven categories namely operation, equipment, facility, port productivity, information sharing, strategic management, human resources,

environmental quality, risk-safety, maintenance, and cost-efficiency.

Overall articles obtained refer to the context of terminal operation employed to facilitate the review process. Searching for articles related to the PRISMA methodology obtained and achieved 11 additional articles. To sharpen the review of the methodology and basic terminology used by several articles, the reviewer added two more additional articles. Overall, the writer affixed 11 additional articles. 106 articles were related to the prime subject and 11 articles related to the methodology in this literature review.

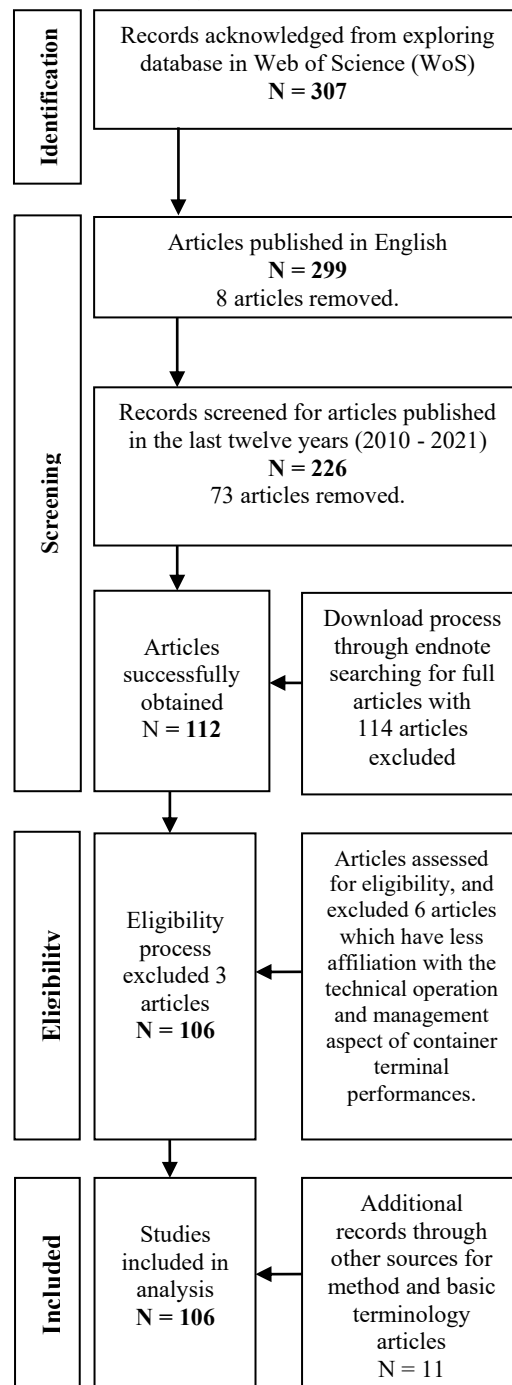


Figure 1 Flowchart of the Paper Selection Process (Adopted from (Shaffril *et al.*, 2018))

3. RESULTS

This study has identified nine main theme categories and elaborated on 106 articles for the last 12 years. The main theme categories are assignment, scheduling, optimization, strategic management, risk, performance evaluation, information system, maintenance, and environment. **Figure 2** illustrates the distribution of the main theme articles. Performance evaluation is the key theme category that has prompted a lot of discussions. They are 20% of all main theme categories. The second position was optimization (16%) followed by strategic management (13%). The highest study of the main theme paper which elaborates from 2010 up to 2021 is performance evaluation, followed by optimization and strategic management.

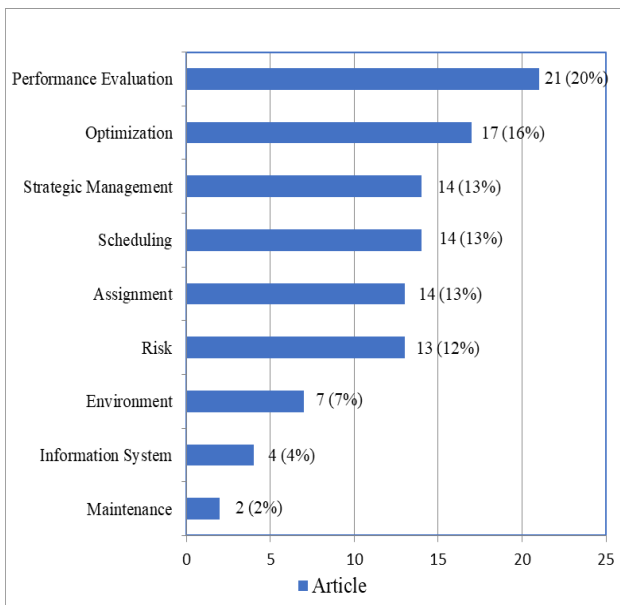


Figure 2 Distribution of main theme categories

The study categorized a group of articles according to research goals categories. Overall research goals are classified into 25 categories which have been represented in **Figure 3**. The most research goal category is to improve overall port performance (12%). The second position is reducing waiting time (8%) and followed by increased risk management quality (7%). Minimizing congestion and reducing ship service time are the least quantity of research goals categories.

Literature review clustered method utilized by each article. Methods categories are modeling assessment, simulation, system evaluation expert system, model implementation, operation research, factor identification, and measurement. All the method categories were represented in **Figure 4**. The top method category utilized by the researcher evaluated in the last 12 years is performance evaluation. They are 27% from the overall method categories. A researcher is less interested in elaborating on the category of operation research.

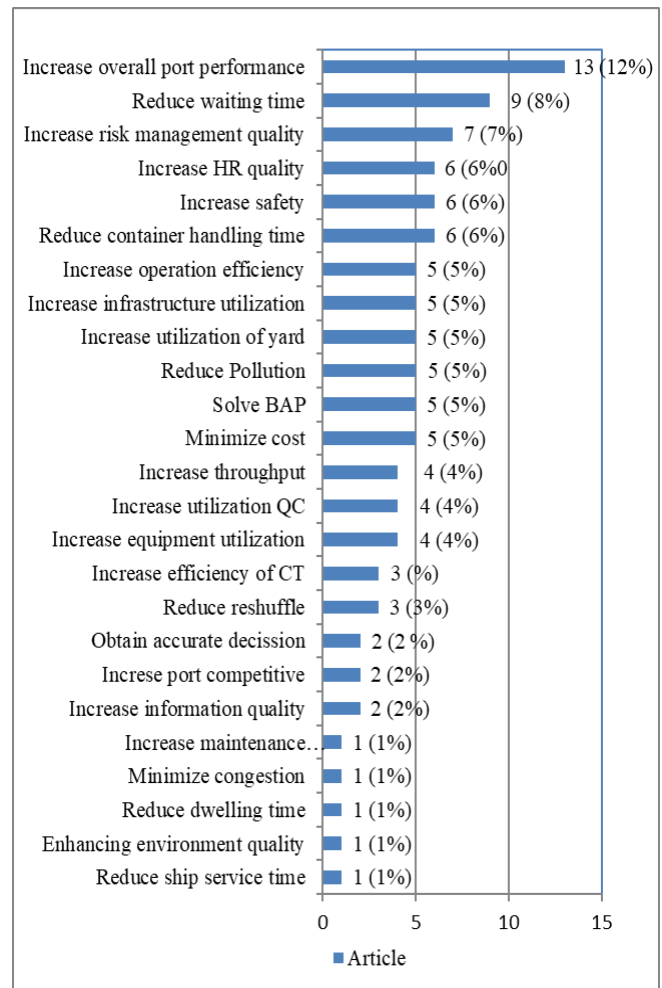


Figure 3 Research goal categories.

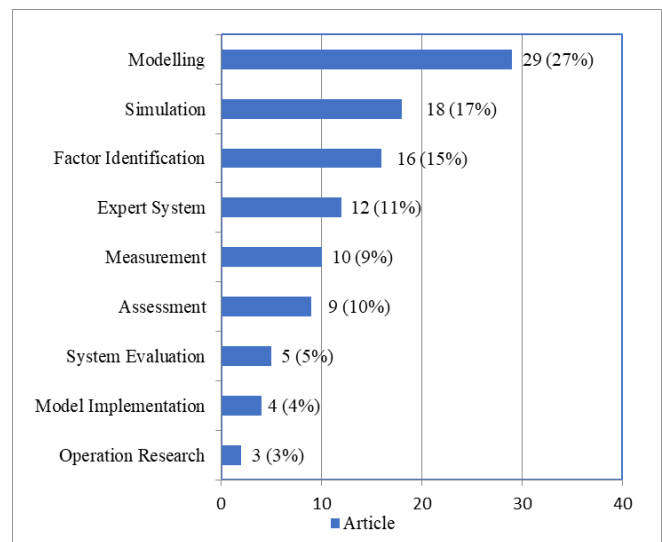


Figure 4 Distribution of article method categories.

The performance of the container terminal operator involves a working section which collaborates for obtaining a smooth operation process. Therefore, container terminal has several working sections which carry out their functions as part of the entire operating system. Every research article will select the working section to be the object focus of the research. The section has been categorized as the focus study in every article. **Figure 5** shows the section categories that

are the focus of the research. The most research article involves overall container terminal sections (60%). The second position was stacking yard section (15%).

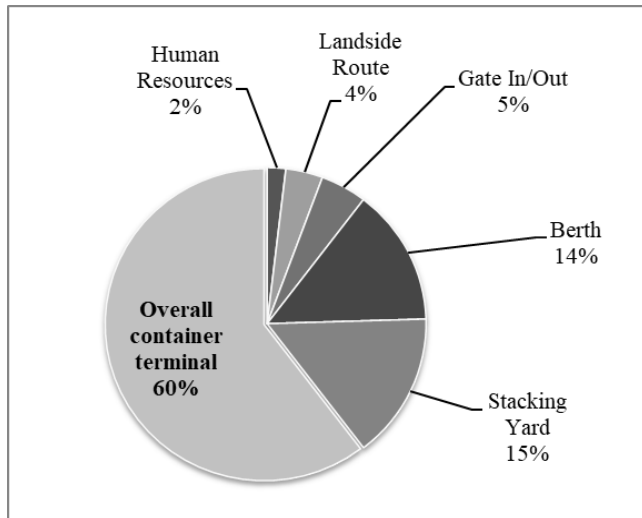


Figure 5 Research focuses according to section category

A literature review cluster derived from the location of the research which indicates the interest and frequency in the elaboration of container terminal performance based on countries and continents. **Figure 6** demonstrates the article cluster based on research location. Asia has the highest study (57%) on this research topic. Most studies in Asia came from China. The second position of the research location cluster is in Europe (29%), with the Netherlands occupying the top position in Europe. **Table 1** shows a more detailed record of overall papers reviewed based on countries, and appendix 1 contains a detailed distribution of articles depending on country and continent. This literature review elaborates on all factors that influence the goal performance in every paper in order to answer the third question of the literature review. Then the factor has been categorized into two steps. In the first step, we categorize into 27 categories and continue with the second step into twelve categories. **Figure 7** represents the factor category of the literature review. The most influenced factor category in container terminal research is operation time, followed by productivity and risk.

Table 1 Articles based on country research location

No	Country	References
1	ASIA	
	- China	(Hu, 2010), (Yu <i>et al.</i> , 2017), (Li <i>et al.</i> , 2012b), (Guo <i>et al.</i> , 2013a), (Zheng <i>et al.</i> , 2019), (Tan <i>et al.</i> , 2019), (Zhang and Liu, 2020), (Peng <i>et al.</i> , 2016), (Tao and Qiu, 2015), (Chen and Jiang, 2016), (Hu, 2020), (Ding <i>et al.</i> , 2012), (Lu and Le, 2014), (Fan <i>et al.</i> , 2019), (Chang <i>et al.</i> , 2016b), (Lu and Wang, 2013), (Yuen <i>et al.</i> , 2013), (Chen, Yang, <i>et al.</i> , 2020), (Li <i>et al.</i> , 2018), (An <i>et al.</i> , 2010)
	- Taiwan	(Hu, 2015), (Chao and Lin, 2011), (Lupi <i>et al.</i> , 2019), (Lu and Yang, 2010), (Hsu <i>et al.</i> , 2019), (Hsu, 2016), (Yang and Shen, 2013), (Ding and Tseng, 2013), (Tsai, 2017), (Tseng and Pilcher, 2017), (Chiu <i>et al.</i> , 2015)
	- South Korea	(Zheng and Park, 2016), (Lu and Park, 2013), (Yoon <i>et al.</i> , 2015), (Jo and Kim, 2020), (Park <i>et al.</i> , 2019), (Park and Lee, 2020), (Zhou and Kim, 2020)
	- Indonesia	(Budipriyanto <i>et al.</i> , 2015a), (Buchari <i>et al.</i> , 2017), (Rum and Iop, 2018), (Sirajuddin <i>et al.</i> , 2018), (Rusgiyanto <i>et al.</i> , 2018), (Juliza and Anggiat, 2019), (Budiyanto and Fernanda, 2020)
	- Iran	(Mokhtari <i>et al.</i> , 2011), (Fereidoonian and Mirzazadeh, 2012), (Behjat and Nahavandi, 2019), (Mokhtari <i>et al.</i> , 2012)
	- UAE	(Li, Hathaway, <i>et al.</i> , 2015), (de Oliveira <i>et al.</i> , 2016)
	- India	(Dwarakish and Salim, 2015), (Dhingra <i>et al.</i> , 2018), (De <i>et al.</i> , 2020)
	- Hong Kong	(Lun, 2011), (Lau <i>et al.</i> , 2010)
	- Russia	(Kirichenko <i>et al.</i> , 2017)
	- Singapore	(Su, Lai, Lee, <i>et al.</i> , 2014)
	- Vietnam	(Pham and Yeo, 2019)
	- Japan	(Agboola <i>et al.</i> , 2010)
2	EUROPE	
	- Netherland	(Angeloudis and Bell, 2010), (Exposito-Izquierdo <i>et al.</i> , 2019), (van Asperen <i>et al.</i> , 2010), (Dhingra <i>et al.</i> , 2018), (Reniers and van de Mortel-Fronczak, 2018)
	- Poland	(Swieboda and Ltd, 2016), (Zwoln and Czaplewski, 2018), (Kotowska, 2013), (Kustra <i>et al.</i> , 2019)
	- Spain	(Frojan <i>et al.</i> , 2015), (Martinez-Moya <i>et al.</i> , 2019), (Sarabia-Jacome <i>et al.</i> , 2020)
	- Denmark	(Iris <i>et al.</i> , 2015), (Beskovnik and Golnar, 2020b)
	- France	(Munduteguy, 2012), (Rouky <i>et al.</i> , 2019)
	- Lithuania	(Barysiene, 2012), (Abrutyte <i>et al.</i> , 2014)
	- United Kingdom	(Li, Negenborn, <i>et al.</i> , 2015), (Alyami <i>et al.</i> , 2014a)
	- Turkey	(Güven and Eliiyi, 2014), (Dkhil <i>et al.</i> , 2018)
	- Italy	(Legato <i>et al.</i> , 2014), (Parola <i>et al.</i> , 2013)
	- Croatia	(Hess and Hess, 2010), (Krcum <i>et al.</i> , 2015)
	- Norway	(Sahin and Soylu, 2020)
	- Serbia	(Kovac <i>et al.</i> , 2018)
	- Rumania	(Bocanete and Dragomir, 2011)
	- Germany	(Borgman <i>et al.</i> , 2010)
	- Greece	(Pallis, 2017)
3	AMERICA	
	- USA	(Walker, 2016), (Kayeshgar <i>et al.</i> , 2012), (Caballini <i>et al.</i> , 2018), (van Asperen <i>et al.</i> , 2013), (Borgman <i>et al.</i> , 2010), (Gharehgozli <i>et al.</i> , 2017), (Petering and Hussein, 2013), (Dulebenets, 2017), (Dulebenets <i>et al.</i> , 2018)
	- Mexico	(Gracia <i>et al.</i> , 2019)
	- Brazil	(Rios and de Sousa, 2014)

Table 1 Articles based on country research location (Con't)

No	COUNTRY	References
4	AUSTRALIA	(Yuan <i>et al.</i> , 2011), (Yuan <i>et al.</i> , 2010), (Irannezhad <i>et al.</i> , 2019)
5	AFRICA	
	- Namibia	(Saruchera, 2020)
	- Egypt	(Elentably, 2016)

Regarding the fourth question of this research, we examine performance container terminal categories. A lot of performances were identified, and those performances were also classified into 11 categories. Prior to being clustered to 11 categories actually, it is found that they have 18

performance categories. **Figure 8** displays the distribution of performance categories in a container terminal. The highest research of literature review based on performance category was operation and followed by facility and equipment performance.

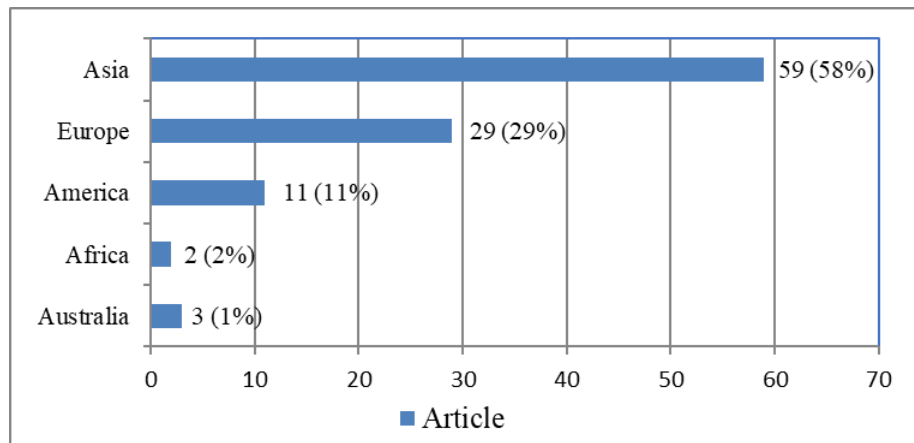


Figure 6 Distribution of article based on continent

This study also observes articles based on its types namely practical, literature review, and case study. The most article type in our observation from 106 articles is case study articles that have reached 58 papers. The middle position is a practical article reaching 38 articles. Only five literature review articles were found from 106 articles. Literature review discusses container terminal quite rare. The distribution of the article type category represents in **Figure 9**.

operation article is higher than the management perspective article. The literature review also elaborates the result of the evaluation process according to the main theme categories in the next sub-section.

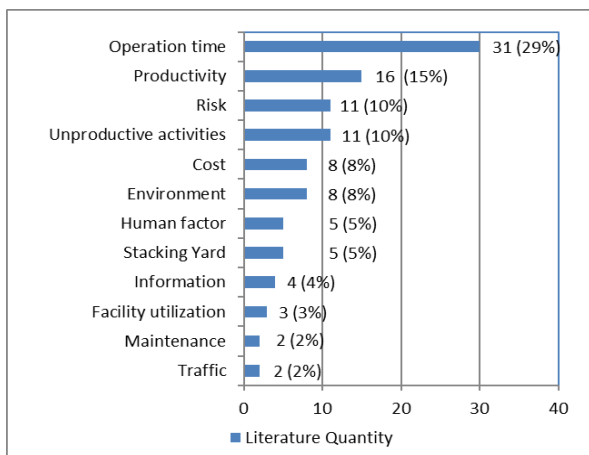


Figure 7 Factor influenced container terminal performance

Finally, a literature review was examined all articles according to two categories of perspective, such as technical operation and management. **Figure 10** shows the distribution of the article perspective category. Most of the articles discuss about technical operation (62%). The technical

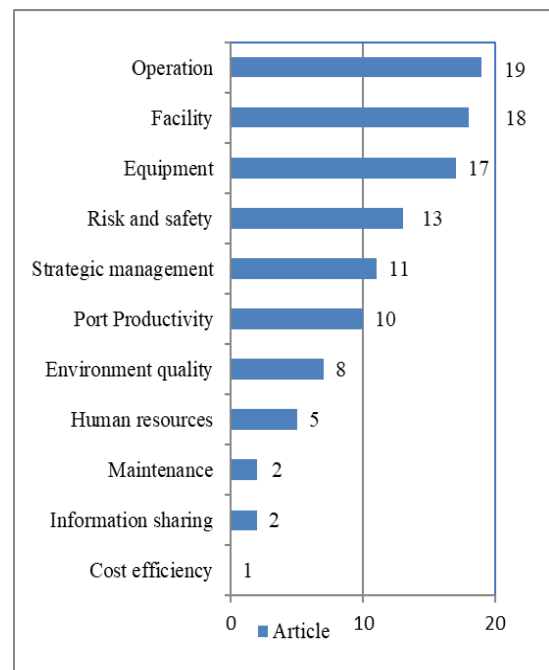


Figure 8 Performance category of container terminal research

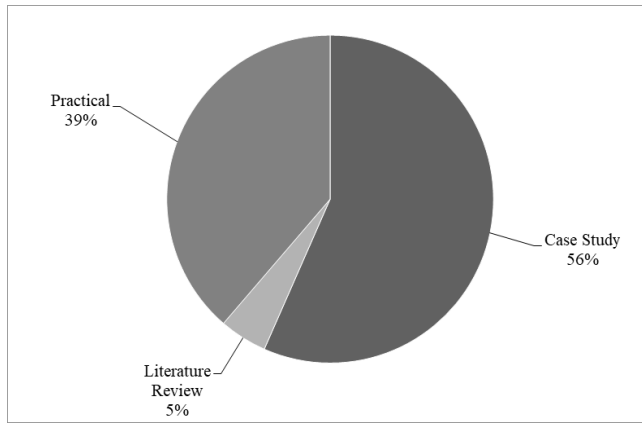


Figure 9 Distribution of article type

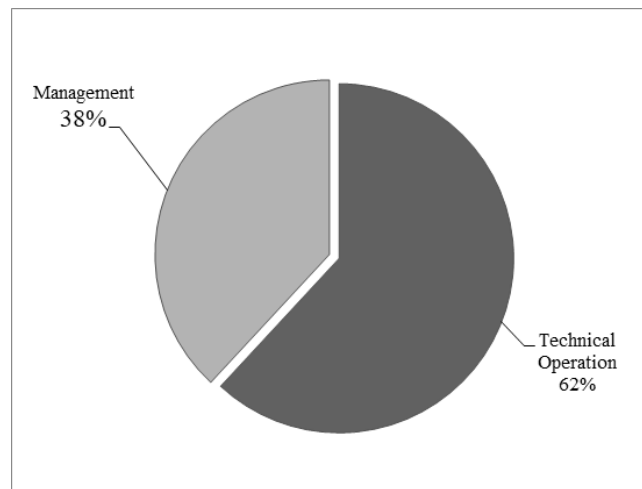


Figure 10 Distribution of perspective category.

3.1. Assignment

Papers elaborate assignment theme category reaching 13% from overall paper reviewed. Angeloudis and Bell (2010) discovered equipment assignment for facing uncertain conditions in port enables to reach significant operational benefit. Reviews obtained 14 articles focusing on exploring the assignment approach in solving problems faced by container ports. Assignment topics have been classified into four sub-topics, such as crane assignment, Automated Guide Vehicle (AGV) algorithm, straddle carrier deployment, and solve berth problem. Reducing operation time is one significant goal that indicates the assignment performance of container terminals. Several studies reveal that the duration of operation time is one factor that is required to reduce (Barysiene, 2012; Frojan *et al.*, 2015; Tao & Qiu, 2015; Yuan *et al.*, 2011). Faster operation time demonstrates the good performance of operation originated from the assignment accuracy.

The effective assignment is the answer to many difficulties arising in the daily operation of a container terminal. We noticed a variety of port problems as follows: unplanned delays (Angeloudis and Bell, 2010), assignment problems that affect the additional cost (Iris *et al.*, 2015), high carbon emission (Peng *et al.*, 2016), and berth problem (Iris *et al.*, 2015). Two papers designated that port performances depend on the improvement on the assignment of quay cranes (De *et al.*, 2020; de Oliveira *et al.*, 2016). Meanwhile, some studies have found that other types of equipment should be considered regarding the effective

assignment such as Automatic Guided Vehicle (AGV) (Angeloudis and Bell, 2010) and straddle carrier (Dkhil *et al.*, 2018). Those articles concerned assignments for reducing waiting time. Three other articles (de Oliveira *et al.*, 2016; Dkhil *et al.*, 2018; Iris *et al.*, 2015) explore assignment roles to solve the berth problem.

Some research related to assignments concentrates on stacking yards (Angeloudis and Bell, 2010; Barysiene, 2012; Peng *et al.*, 2016; Yuan *et al.*, 2011). Meanwhile, other research sees activities that are closely related to the series of processes. Trojan *et al.* (2015) and Hsu *et al.* (2019) implement a genetic algorithm for improving port activities, meanwhile, Hu (2010) and Petering and Hussein (2013) uses linear programming methods for increasing quay crane utilization and Berth Allocation Problem (BAP). Applied simulation in obtaining an optimal allocation of resources for yard crane network affected on reducing carbon emission. Mostly, assignments have been applied to increase the effectivity of equipment and resources. Another paradigm, the assignment was used for improvement in berth activity. Hu (2010) solved BAP in container terminal through quay crane assignment approach using integer linear programming. Meanwhile, mixed-integer programs were implemented for Berth Relocation Problem (BRP) using CPLEX for obtaining better runtime performance (Petering and Hussein, 2013).

3.2. Scheduling

A total of 14 articles categories as scheduling main theme observed in this literature review. This main theme has three sub-theme categories such as discharged loading algorithm, simulation, stacking yard, and operation schedule. Discharge loading algorithm was found in six articles. Three articles have similarities in solving scheduling problems through genetic algorithms. They have differences in the research object such as crane activity (Fereidoonian and Mirzazadeh, 2012; Guo *et al.*, 2013b) and truck appointment system (Caballini *et al.*, 2018; Fan *et al.*, 2019). Apart from genetic algorithms, there are other algorithms applied by researchers as self-adaptive evolutionary algorithms (Dulebenets *et al.*, 2018) and bee colony algorithms (Guo *et al.*, 2013a).

Two papers are interest in crane performance through simulation. Rouky *et al.* (2019) implement discrete event simulation using Anylogic software for port in Normandy to overcome uncertain quay crane scheduling problems and practice simulation-optimization approach. Meanwhile, Gharehgozli *et al.* (2017) utilized Matlab for the simulation. Only one article was discovered as a container yard sub-theme category. Sirajuddin *et al.* (2018) look at the analysis of container yard capacity using an autoregressive integrated moving average method to forecast throughput for maximizing utilization of yard capacity.

Operation schedule category found in five articles. The mathematical model is a choice to decrease completion time and obtained an optimal schedule (Behjat and Nahavandi, 2019; W. Li *et al.*, 2012). Ineffective schedule arrangement allows the emergence of equipment waiting time. Another article concerned about waiting time which used math modeling for coordinated scheduling (Ding *et al.*, 2012b). Meanwhile, other research utilized various methods such as particle swarm optimization (Lu and Le, 2014), and multi-stage approach (Exposito-Izquierdo *et al.*, 2019).

3.3. Optimization

Several studies reported on the optimization concept category in technical operation and management for increasing the performance of container terminals. Various problems arise in container ports that require optimization solutions from decision-makers. Otherwise, robust optimization has been drawing attention recently as an alternative way to deal with inventory control problems (Ohmori *et al.*, 2020). Optimization is the answer to various problems that arise within container terminals such as difficulties in deciding for selecting container terminals based on dwelling time (Irannezhad *et al.*, 2019). Furthermore, optimization gives a solution to dilemma with the interval of the loading and unloading process (Buchari *et al.*, 2017) and difficulties in planning short-term operation (Hess and Hess, 2010).

Optimization could be a solution for improving the performance of container terminals through an effort to anticipate problems and bring out many alternative solutions that could upgrade container port performance. Those alternatives are possible to conduct several methods including simulation, statistical analysis, optimization approach, modeling, and expert system. To solve the problem, some methods implemented in the literature review are categorized as optimization. Four articles are interest in the simulation method for performing optimization. Discrete-event simulation became a selected method for optimizing the stacking rules in the container terminal (Borgman *et al.*, 2010; van Asperen *et al.*, 2010). Other researchers carry out a discrete-event simulation on handling equipment (Elentably, 2016) and berth allocation (Legato *et al.*, 2014). Three articles were found using expert systems, such as fuzzy analytical (Park *et al.*, 2019; Sahin and Soylu, 2020) and genetic algorithms (Kayeshgar *et al.*, 2012). Other researchers are interested in queuing models for optimization, especially in determining equipment quantity and handling systems (Dhingra *et al.*, 2018; Yu *et al.*, 2017). The rest articles utilized math models and statistics.

Seventeen articles have been categorized in optimization and classified into six sub-themes. The first sub-theme is articles that elaborate stacking rules (Borgman *et al.*, 2010; van Asperen *et al.*, 2010; Zheng *et al.*, 2013). The second sub-theme that has been discussed on the port performance optimization is equipment handling (Chen and Jiang, 2016; Dhingra *et al.*, 2018; Elentably, 2016; Kayeshgar *et al.*, 2012; Yu *et al.*, 2017; Yuan *et al.*, 2010). For example, Elentably (2016) developed optimization models based on data in the red sea container terminal affecting the port performance, especially in reducing handling equipment time duration. Legato *et al.* (2014) and Hu (2020) are the articles categorized in the third sub-theme, elaborating berth allocation. The fifth sub-theme is quay crane utilization (Hsu, 2016; Kayeshgar *et al.*, 2012). The last sub-theme classification is a model selection that could be found in six articles (Buchari *et al.*, 2017; Hess and Hess, 2010; Hsu, 2016; Irannezhad *et al.*, 2019; Park *et al.*, 2019; Reniers and van de Mortel-Fronczak, 2018).

3.4. Strategic Management

There are 14 articles categorized as strategic management which are part of the main theme classification. Problems related to strategic management that arise are usually related to productivity, equipment utilization, and

service time. Therefore, it is necessary to choose the right strategic management to anticipate these various issues. Strategic management has been included in the management perspective group when compared to other prime main themes. The sub-themes of the strategic management category consist of allocation of resources, operation policies, and decision support systems.

Allocation of resources is the first sub-theme categorized. Many studies are taken by researchers in this sub-theme category. Even though these two articles have a concept for allocating resources, they have different goals for research, including overcoming uncertainty berth arrival time (Zheng *et al.*, 2013) and reducing energy consumption (Chang *et al.*, 2016). Some researchers use different approaches to maximize storage utilization. Rusgiyanto *et al.* (2018) apply discrete-event simulation and others make use of fuzzy theory (Tan *et al.*, 2019).

Operation policy is a second sub-theme that is included in management strategy. Guven and Eliyi (2014) and Gracia, M. D. *et al.* (2019) make use of a simulation model for operation policy to reduce reshuffle moves, dwelling time, and vessel handling time. Chen, Liu, *et al.* (2020) elaborates operation performance. Furthermore, Krcum *et al.* (2015) investigate management strategy in sea and river ports policy. Meanwhile, other researchers implement operation policy in a variety of research focus such as operation investment (An *et al.*, 2010), transshipment mode policy (Swieboda and Ltd, 2016), and concession contract policy (Zhou and Kim, 2020).

In addition, the last sub-theme of strategic management is the decision support system. Researchers have used various tools in solving problems related to decision-making. Kovac *et al.*, (2018) utilize Variable Neighborhood Search (VNS) methods to anticipate decision making. Meanwhile, Chao (2011) uses fuzzy theory. Other researchers Chiu *et al.* (2015) used the Analytical Hierarchy Process (AHP) method. In principle, all these methods have been taken in an effort to obtain optimal decisions in anticipating problems that might arise in container terminal operations.

3.5. Risk

Sub-themes appear beneath the risk theme category such as factor identification, risk control, and safety. Container terminal operators that could identify risks earlier would have a better chance of achieving better performance. Nowadays, the aspects of managing risks are crucial for maintaining the continuity of business processes (Wieteska and Journal, 2020). Factor identification sub-theme grouped articles concerned with recognizing variables that influenced risk performance in a container terminal. Identification of risk factors in the port is necessary to anticipate uncertainty factors that will reduce port performance (Juliza and Anggiat, 2019). Deeper research is carried out to uncover the effect of the risk factors on container terminal management (Lai and Lee, 2014). Although they researched intending to identify risk factors, the methods employed were different. Alyami *et al.* (2014a) evaluate the criticality of the Hazardous Events (HEs) in a container terminal through Failure Mode and Effects Analysis (FMEA) approach combined with Fuzzy Rule-Based Bayesian Networks (FRBN). Other researchers utilized Fault Tree Analysis (FTA), Event Tree Analysis (ETA), and expert systems to trace risk factor identification (Mokhtari *et al.*, 2011). Meanwhile, Saruchera (2020a)

determining factors influencing the effectiveness of High-Risk Cargo (HRC) handling procedures through the statistical qualitative method. Some articles grouped in risk control sub-themes interest with an effort to manage the unexpected condition in port. Risk control is utilized to controlled unexpected occasions (Musa, 2012). For example, Mokhtari *et al.* (2012) evaluated a decision support framework for risk management through an expert system using fuzzy set theory.

The last sub-themes are papers that concern safety topics. Researchers conducted a study in the effort for improving port performance through evaluation of safety factors (Ding and Tseng, 2013; Tseng and Pilcher, 2017) and reducing obstacles in operation caused by injury and inappropriate defining factors (Mokhtari *et al.*, 2011; Pallis, 2017; Tsai, 2017). Some researchers have special attention to the same subject, especially those related to safety topics. Even though they have different points of view on efforts to improve safety through the way in improving quality of performance risk assessment (Pallis, 2017), safety leadership and behavior (Lu and Yang, 2010) increase safety in public road utilization (Kustra *et al.*, 2019) and reducing work accidents (Budiyanto and Fernanda, 2020).

3.6. Performance Evaluation

Container terminal performance evaluation has been divided into three sub-theme categories as follows: comparison of performance, performance monitoring, factors identification, and correlation. Comparing the performance between ports could identify the strength and weaknesses of the ports to face global competition. Four articles conducted comparison research, even though they still have differences in the comparison coverage of the research such as overall port performance (Rios and de Sousa, 2014), usage of technology (Yang and Shen, 2013), favorable rail links facility (Lupi *et al.*, 2019), cost efficiency (Rum and Iop, 2018), and resource utilization (Zheng and Park, 2016). In addition to comparing performance in a container terminal, activities for performance monitoring are the concern of several researchers. Five articles show similarity to the interest in performance monitoring, even though they exploit different tools, such as Key Performance Indicators (KPIs) (Jo and Kim, 2020), Proof of Concept (PoC) (Park and Lee, 2020a), statistical analysis (Wiegmans *et al.*, 2015a), 3D laser trigonometry (Zhang and Liu, 2020) and simulation (Beskovnik and Golnar, 2020a).

The initial step to trace influenced factors that affected port performance is factor identification. A lot of studies have a similar format to carry out factor identification within container terminals despite their different way of classifying those factors. Factor detection clusters are the following: waste factors (Lu and Wang, 2013), competitive factor (Yoon *et al.*, 2015), container terminal efficiency (Yuen *et al.*, 2013), service quality factor (Pham and Yeo, 2019), time-space factor (Munduteguy, 2012), factor affecting dwelling time (Kourouniotti *et al.*, 2016), factor for the optimization of maritime Supply Chain Management (SCM) (Sahin and Soylyu, 2020), factors underlying foreign entry strategies (Parola *et al.*, 2013), and critical productivity factors of container terminals (Lu and Park, 2013).

The fourth sub-themes recognized in the performance evaluation category is the correlation among factors. Relationships among factors can be identified as positive

correlation or negative correlation. By expanding factor identification, a researcher could perform studies to identify the structure of relations that can directly influence the performance of the system (Orenstein and Tang, 2021). Lun (2011) investigated the correlation between Green Management Practices (GMP) and firm performance. Dwarakish and Salim (2015) studied the correlation role of ports with national development.

3.7. Maintenance

Research on maintenance topics within the container terminal seems to be very rare. From 106 articles reviewed, only two articles were addressed the maintenance problems. Maintenance activities are planned to implement the restoration of equipment to a specific state guaranteeing the desired service level (Moghaddam, 2020). Two articles attempt to identify factors that influenced preventive maintenance performance. Merely they have a different method to recognize those factors. Bocanete and Dragomir (2011) use Finite Element Analysis (FEA) to see factors in equipment accidents. Meanwhile, Li *et al.* (2015) employ a simulation model for factor detection in straddle carrier maintenance.

3.8. Environment

The container terminal's main theme has been divided into two sub-themes to measure environment quality and green management. We found six papers focused on the measure environmental quality. One paper investigated green management. Articles of environment measurement category have the same pattern, namely measuring the content of an element which influenced port environment quality, merely the object being measured is different such as Volatile Organic Compounds (VOC) (Lau *et al.*, 2010), nutrient concentration (Agboola *et al.*, 2010), CO₂ emission (Kotowska, 2013; Martinez-Moya *et al.*, 2019), NO_x emission (Abrutyte *et al.*, 2014), and dust pollution (Kirichenko *et al.*, 2017). Another category discusses environment management which is referred to as Green Marine Environmental Program (GMPEP) for enhancing port sustainability (Walker, 2016).

4. DISCUSSION

The factors affecting the performance of container terminals are systematically analyzed in this article. The source of the literature review has been taken from the Web of Science database, and the 106 articles that have been collected are certainly related to the topic in this research. The results showed that the performance of the container terminal is highly dependent on various factors. The output of this literature review is the grouping of articles into nine main themes. In addition, there are other categories in the form of factors affecting the performance of container terminals, which are divided into 12 groups (clusters). The main themes of articles published in the last 12 years were evaluated and grouped into two periods. The first period has a range of 2010-2015 while the second period is 2015-2021. Consequently, based on the results of the investigation depicted in **Figure 11**, it could be seen that there is a movement in the main themes of these categories during these two periods.

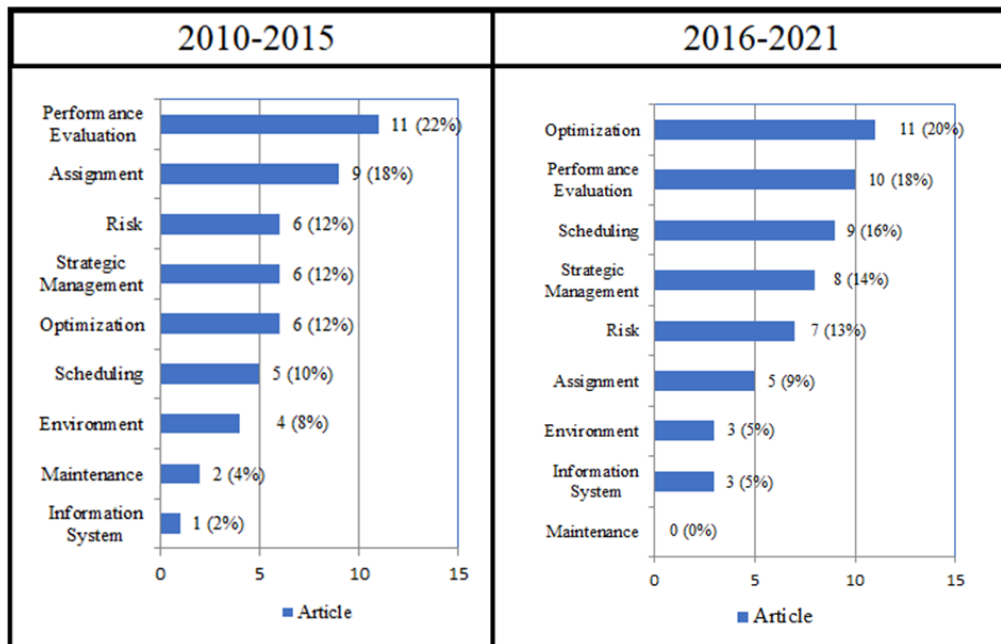


Figure 11. The rank of main theme article categories in two periods

It is found that from the comparison of the first to the second period, performance evaluation remains on the two highest themes in this domain of research. Even though in the first period 22% performance evaluation placed at the top position and in the second period it is in the second position with the smaller percentage (18%) because they are interested in other fields that are also being studied. Performance evaluation's main theme is sharing the position with other main themes. Performance evaluation is continuing to be the main area of the research due to many things that are being discussed within this main theme such as environment, human resources, port efficiency, port productivity, container terminal performances, service quality, maintenance, monitoring system, transportation connection and dwelling time. Among those areas of research, the environment would still be relevant for further studies, because of the increasing of the operation activities, changes in shipment technology, and the reliability of the global market for raw material and finished goods products. The other topics are optimization (12%) and scheduling (10%) in the first period. There is an increase in the number of studies related to optimization and scheduling main theme category. Furthermore, optimization topic placed at the top position in the second period. The emergence of research in Asia, due to container traffic in the second period began to increase. This gives rise to several studies on scheduling and optimization increases.

Research trend has been changing where more emphasis has been put on the optimization, and then we also observe that the interest in assignment research has dropped from the second position into the sixth position in the second period as presented in Figure 11. The decline occurred because in the first period, many of the research with assignment category was directed to anticipate Berth Allocation Problem (BAP) and Quay Crane Allocation Problem (CAP), which continued to the second period. Therefore, this topic had been answered by many studies conducted during the first period. In addition, the focus of

research for two periods has not changed, where they are still interested in the improvement of quay crane performances.

During the two observation periods, the main theme maintenance and information system were alternately at the lowest position. We also notice that the attention in maintenance research has dropped from the eighth ranking into the last position in the second period. Most of the research focused on problems directly related to performance and waiting time, thereby reducing the motivation to conduct research associated to maintenance. Problems related to breakdown and equipment failure do not appear to be a major variable determining the performance improvement of the terminal container, so they do not attract the attention of researchers in solving these problems. On the contrary, trend information systems research was in the last position in the first period, and experienced a slight increase in the second period. We project that the information system's main theme will continue to increase and remain relevant for future research, due to the restriction policy of Covid-19 pandemic situation.

We conducted an analysis of the performance category and each factor involved in those performances were conducted. Article based on the performance and factor category represents in table 2. Container terminal performance that most researchers have been interested in over the past 12 years is operation performance. The second position is facility performance. The most influential factor in operation performance is container handling time because it has close connectivity to the quay crane activity. The majority of operation container terminal research in Asia focused on quay cranes, and it has been discovered that Asia has the greatest number of researchers interested in container terminals. Meanwhile, we observed that the container handling time factor involved in almost all performance categories, such as operation, facility, strategic management, and port productivity. Other factors that are considered to influence operation performance are berthing time and waiting time. Meanwhile, the largest part influenced the

performance of the facility costs. It is assumed that the availability of the facility depends on the capability of a container terminal in handling the cost problem. Port competency in managing cost enables to increase saving for

providing acceptable facilities to the customer. Meanwhile, there were other factors deliberated in facility performance such as reshuffle moves and waiting time.

Table 2 Articles based on performance and factor category

Performance	Factor	References
Operation	Container handling time	(Buchari <i>et al.</i> , 2017), (Yang and Shen, 2013), (Fereidoonian and Mirzazadeh, 2012), (Dkhil <i>et al.</i> , 2018), (Hsu <i>et al.</i> , 2019), (Kourouniotti <i>et al.</i> , 2016), (Lu and Le, 2014), (Dulebenets, 2017), (Fan <i>et al.</i> , 2019), (Rouky <i>et al.</i> , 2019), (Pham and Yeo, 2019), (Lu and Le, 2014), (Legato <i>et al.</i> , 2014)
	Berthing Time	(Petering and Hussein, 2013), (Tao and Qiu, 2015), (Frojan <i>et al.</i> , 2015), (Hsu, 2016)
	Waiting time	(Chen and Jiang, 2016), (Ding <i>et al.</i> , 2012), (Hu, 2020)
	Uncertainty events	(Hess and Hess, 2010)
	Energy consumption	(Chang <i>et al.</i> , 2016a)
	Cost	(Dulebenets <i>et al.</i> , 2018)
Facility	Cost	(Tan <i>et al.</i> , 2019), (Park <i>et al.</i> , 2019), (Sahin and Soylu, 2020), (Lupi <i>et al.</i> , 2019)
	Reshuffle moves	(Borgman <i>et al.</i> , 2010), (Zheng and Sha, 2019), (Güven and Eliiyi, 2014)
	Waiting time	(Yuan <i>et al.</i> , 2011), (Exposito-Izquierdo <i>et al.</i> , 2019), (Dhingra <i>et al.</i> , 2018)
	Infrastructure availability	(Beskovnik and Golnar, 2020a), (Krcum <i>et al.</i> , 2015), (van Asperen <i>et al.</i> , 2010)
	Yard Occupancy	(Yuan <i>et al.</i> , 2010), (Gharehgozli <i>et al.</i> , 2017)
	Information	(van Asperen <i>et al.</i> , 2013)
	Handling time	(Budipriyanto <i>et al.</i> , 2015a)
	Traffic	(Kustra <i>et al.</i> , 2019)
Equipment	Operation time	(Angeloudis and Bell, 2010), (Iris <i>et al.</i> , 2015), (de Oliveira <i>et al.</i> , 2016), (Kayeshgar <i>et al.</i> , 2012), (Li <i>et al.</i> , 2012a), (Guo <i>et al.</i> , 2013b), (Caballini <i>et al.</i> , 2018), (Behjat and Nahavandi, 2019)
	Quay Crane Productivity	(Hu, 2010), (Hu, 2015), (De <i>et al.</i> , 2020), (Chao and Lin, 2011), (Hu, 2010)
	Maintenance	(Jo and Kim, 2020)
	Cost	(Yu <i>et al.</i> , 2017)
Risk and safety	Safety	(Tseng and Pilcher, 2017), (Pallis, 2017), (Mokhtari <i>et al.</i> , 2011), (Mokhtari <i>et al.</i> , 2012)
	Accident	(Alyami <i>et al.</i> , 2014b), (Ding and Tseng, 2013), (Tsai, 2017), (Budiyanto and Fernanda, 2020)
	System failure	(Bocanete and Dragomir, 2011), (Juliza and Anggiat, 2019)
	Information	(Swieboda and Ltd, 2016)
	Response time	(Su, Lai, and Lee, 2014)
	HRC handling	(Saruchera, 2020)
Strategic management	Container handling time	(Elentably, 2016), (Kovac <i>et al.</i> , 2018), (Gracia <i>et al.</i> , 2019), (Li <i>et al.</i> , 2018)
	Information	(Sarabia-Jacome <i>et al.</i> , 2020), (Zhou and Kim, 2020)
	Facility	(Dwarakish and Salim, 2015), (Yoon <i>et al.</i> , 2015)
	Throughput	(An <i>et al.</i> , 2010)
	Cost	(Chiu <i>et al.</i> , 2015)
	Market condition	(Parola <i>et al.</i> , 2013)
Port productivity	Throughput	(Lu and Wang, 2013), (Lu and Park, 2013), (Zheng and Park, 2016), (Wiegman <i>et al.</i> , 2015)
	Container Handling time	(Chen, Yang, <i>et al.</i> , 2020), (Sirajuddin <i>et al.</i> , 2018), (Rios and de Sousa, 2014)
	Yard Occupancy	(Park and Lee, 2020), (Rusgiyanto <i>et al.</i> , 2018)
	Port efficiency	(Yuen <i>et al.</i> , 2013)
Environment Quality	Pollution	(Lau <i>et al.</i> , 2010), (Agboola <i>et al.</i> , 2010), (Abrutyte <i>et al.</i> , 2014), (Walker, 2016), (Kirichenko <i>et al.</i> , 2017)
	Throughput	(Lun, 2011)
	Energy consumption	(Martinez-Moya <i>et al.</i> , 2019)
	Cost	(Kotowska, 2013)
Human Resources	Container handling time	(Barysiene, 2012), (Munduteguy, 2012)
	Human factor	(Lu and Yang, 2010), (Reniers and van de Mortel-Fronczak, 2018)
	Equipment availability	(Zwolan and Czaplewski, 2018)
Information Sharing	Dwelling time	(Irannezhad <i>et al.</i> , 2019)
	Human factor	(Zhang and Liu, 2020)
Maintenance	Energy	(Peng <i>et al.</i> , 2016)
	Reliability	(Li, Hathaway, <i>et al.</i> , 2015)
Cost efficiency	Cost	(Rum and Iop, 2018)

5. CONCLUSION

This systematic review has been conducted to highlight the importance of identifying the factors that affect the performance of a container terminal. From 106 papers published in the last 12 years, it has been identified categories of articles that could be classified into nine main themes. The performance evaluation category has still been the top main theme in the two periods. The second position is occupied by the optimization category. Furthermore, it has been identified that there has been a significant increase in research topics related to optimization due to the increasing demand for system modeling which can eliminate unproductive activities and also reduce operating time.

This study answers several research questions regarding the challenges of the limited number of studies specifically discussing the identification of factors that affect the performance of container terminals. Studies have succeeded in uncovering these factors and have been grouped into twelve clusters. The most influential factor identified by researchers is the container handling time factor. The second position is the risk factor, and the next one is the cost factor. Research has focused on container handling time, mostly using simulation and modeling methods, with the main themes being optimization selection, performance evaluation, and scheduling. This could be quite reasonable due to the factor that is also an indicator of success that makes container terminals competitive globally.

We have expanded the review process to the performance category to include technical operations and management studies for container terminal operations. This supports the performance identification process involving technical factors, to anticipate the scarcity of research that pays attention to technical operation aspects. The performance category of the container terminal has been classified into eleven groups. The performance of the container terminal that is most commonly found in the field focuses on operation performance. The second position is facility followed by equipment performance. The performance operations described in the article are mostly aimed at reducing container handling time and waiting time, which is currently the biggest demands from customers related to container terminal services. Another essential part of this study is the performance category review, which includes technical and management studies for container terminal operations.

Identification of the right factors in the container terminal could be a major contribution in developing research involving model development and simulation methods. This research also combines the identification of factors integrating management and technical themes, as an answer to the scarcity of comprehensive research on this combination. Furthermore, the performance category would be useful for future researchers who have an interest in improving port performance. In the future, it is necessary to conduct research to reveal the factors affecting port performance, especially with traffic restrictions, people distancing, security, massive quantities, and online activities compatible with pandemic issues.

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