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Seaport Quality Score (SQS): a new direction for determining the competitiveness of seaports

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ABSTRACT

The seaport plays a crucial role in supply and demand chain operations, receiving inputs from supply sites to manufacturing facilities, redistributing inventory among different plants and distribution centers in the maritime cluster, and hub for delivering finished goods to consumers. Seaport operation is a major part of the costs incurred by most of the maritime supply chains. This research study aims to employ Seaport Quality Score (SQS) concept, which has been developed, validated, and established as a platform for measuring the competitiveness of seaports. The study is divided into three phases: defining seaport quality from the perspective of the Malaysian seaport system, measuring seaport performance indexes based on quality and measuring and revealing the seaport quality based on SQS concept. The results indicate that seaport effectiveness, reliability, and governance have a strong correlation with the seaport competitiveness and play a crucial role in the development of the Malaysian seaport system. This study demonstrates that improving seaport quality based on the SQS concept is crucial for the sustainability of the maritime industry and economic growth of Malaysia and helps the Malaysian seaport to face challenges in the maritime industry strategically and consistently to maintain economic growth and commercial value.

1. Introduction.

The development of seaports towards the 5th and 6th Generation Ports (5GP and 6GP) were studied and introduced by (Flynn, 2011: Kaliszewski, 2018: Lee & Lam, 2016). The 5GP criteria are based on a uniform system that combines infrastructure, superstructure, and information technologies to maximize convenience for seaport users. The Singapore Port in 2015 was identified as the closest port to fulfilling the 5GP criteria. The 6GP proposes handling ships with a capacity of 50 thousand TEUs. Seaports must consider user requirements and offer the best service, with infrastructure being a key factor reflecting the current development of seaport function. Seaport competitiveness is one of the leading research interests, with location, productivity, efficiency, resources, facilities, pricing, connectivity, and organization being among the elements related to the study of global seaport competitiveness. However, other researchers suggest that the perception of users is also important, and factors such as resistance to innovation, port reputation, and social and political tension can affect seaport governance, green strategies, and competitiveness. Table 1 summaries the development of fifth and sixth generation of seaport in the global perspective.

2. Review of the literature .

The COVID-19 pandemic, the war in Ukraine, climate change, and geopolitical tensions have disrupted maritime transport and logistics, causing delays, rising shipping costs, and port closures. As shipping accounts for over 90% of global trade, these disruptions affect the delivery of essential goods such as food, energy, and medicine, leading to price increases and supply chain disruptions (Review of maritime transport, 2022). To

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Table 1: The criteria of fifth and sixth seaport generation.

	Fifth seaport generation	Sixth seaport generation
1	Developing wholesale centres to reduce waiting time in cargo delivery	The ability on handling the capacity of fifty thousand (50) TEU on container volume with the maximum draughts of the 20 metres.
2	The connecting of the water and land passengers' streams	The capability in using full automation due to the significant volume of loading/unloading over the last 50 years. The development of existing space with new technologies for future developments.
3	The development as an industrial centre with comprehensive facilities and infrastructure for intermodals transports handling	The capability on handling the intermodals with the hinterland that allows the transport of containerized cargoes with low external costs (Eg: connected without congestion)
4	The developments of logistics centres as connecting points for multimodal cargo transports.	

Source: Flynn (2011); Lee and Lam (2016); Kaliszewski (2018).

meet this demand, the maritime industry must invest in improving its resilience to future crises and climate change by expanding capacity, renewing fleets and equipment, improving labour skills, reducing emissions, and safeguarding competition based on the performance and quality. By doing so, seaports can remain efficient and reliable even during times of crisis and continue to deliver essential goods to those in need.

The Malaysian seaports are often based on the performance and quality of Port Klang and Port of Tanjung Pelepas (PTP). As such, there is a need to study the issue and improve the quality of Malaysian seaports to enhance their competitiveness. Malaysian seaports are governed by the Malaysian government, with nine major seaports and eighty small ports controlled by the Ministry of Transport. Sabah and Sarawak Ports fall under the jurisdiction of their respective state governments and are managed by the Ministry of Infrastructure Development and Ministry of Industrial Development, respectively. The federal government has privatized the major seaport operations to various operators, while the state government manages their own seaport authorities.

From the Malaysian seaport systems structure perspective, it would be beneficial to improve the Malaysian seaport governance as one of the approaches to improve seaport quality which is a major concern of this research. The Malaysian seaport systems have good potential in the industry as they are governed by federal and state government. With the strategic geographical location, exploring the seaport quality will assist the Malaysian seaport in improving the seaport systems. The quality of seaport determines the overall level of service provided by the seaport.

The Malaysian seaport has a strategic geographical location and good infrastructure, but the effectiveness and efficiency of managing seaport facilities and services is vital in increasing the performance and maintaining the quality. Port Kelang and Port Tanjung Pelepas are major contributors to the Malaysian seaport system, but inter-seaport competition can negatively impact seaport performance. Maintaining timeliness is crucial for quality performance, and good infrastructure and services contribute to seaport quality and industry development in Malaysia.

The effectiveness of strategy and advantages of location can be used to promote quality services and attract stakeholders to use Malaysian seaports. Improving seaport quality is a long-term investment that can be utilised to sustain the Malaysian seaport industry globally. Thus, the competitiveness of the seaport industry can be influenced by various factors, including technological advancements, regulatory framework, infrastructure development, global trade patterns, and market demand that related to the competitiveness of the maritime industry as and described below:

i. Technological advancements: The maritime industry has seen significant advancements in technology over the years, which have increased efficiency, reduced costs, and improved safety. Examples include automation, big data analytics, and blockchain technology;
ii. Regulatory framework: The maritime industry is subject to various regulations at the national, regional, and international levels. Compliance with these regulations can impact the industry's competitiveness, particularly with respect to safety, environmental protection, and labor standards;
iii. Infrastructure development: The quality and efficiency of ports, shipping lanes, and other maritime infrastructure can impact the industry's competitiveness. Investment in infrastructure can improve the speed, reliability, and cost-effectiveness of maritime transportation;
iv. Global trade patterns: The maritime industry is closely tied to global trade patterns. Changes in global demand for goods can impact shipping routes, vessel sizes, and cargo volumes, which in turn can impact the competitiveness of the industry; and,

v. Market demand: The competitiveness of the maritime industry is ultimately determined by market demand. Demand for maritime transportation is influenced by factors such as economic growth, consumer preferences, and supply chain trends. The ability of the industry to meet this demand in a cost-effective and efficient manner can determine its competitiveness.

The seaport performance refers to the achievement of the task of the seaport which measured by the standards of accuracy, completeness, cost, and speed. The seaport also monitored the performance based on operational parameters such as administrative and financial performance. (Vaggelas, 2018). Other research that has been studied on Malaysia seaport performance were the examination of the efficiency parameters, (Nguen et al., 2018), the correlation between port efficiency and the port's governance model (Notteboom et al., 2000), the relation between port privatization and/or deregulation policies and operational efficiency (Cullinane and Song, 2003), and participation in the ownership status of Chinese ports increases the container terminals' (Yuen et al., 2013). The performance of Malaysian seaports is evaluated through container handling and cargo handling, with timeliness being a main concern. The quality of infrastructure, equipment, manpower technology, and governance are important factors in improving the timeliness of seaport activities. Thus, the development of a Quality Score (SQC) concept, will guide the growth of Malaysian seaport performance in a sustainable manner, and help to identify weaknesses and improve seaport quality, rather than investing in costly seaport expansions.

3. Methodological design.

This study aims to measure the level of seaport performance in Malaysia based on seaport quality. The definition of seaport quality includes three categories: seaport effectiveness, seaport reliability, and seaport governance. The study examines the relationship between these categories and seaport competitiveness. The study developed elements of seaport competitiveness, and the SQS formula to study the percentage of seaport quality achievement stages as an indicator of the seaport's performance towards seaport competitiveness for sustainable development. The benefits of research on seaport quality, which fills a gap in the existing research that has focused primarily on technical approaches. The research will contribute to the understanding of seaport quality, which is important for sustaining the growth and development of seaport industries. The study aims to identify and categorize the determinants of seaport quality and will assist in the development of seaport performance in Malaysia. The research will reveal the causes of problems in seaport activities and provide a comprehensive benchmark for improving and monitoring seaport quality. The outcome of this research will create guidelines for addressing seaport quality issues and assist the seaport industry in developing strategies for competitive advantage and sustainability.

The research design consists of three (3) phases are shown below. The details on each phase of the Research Design are described in Fig. 1.

(i) Phase 1: Category that attributes to seaport quality.
(ii) Phase 2: Measure the seaport performance based on the quality perspective; and,
(iii) Phase 3: Measure the maritime economic index (MEI) based on the TEU/KM.

Figure 2 shows the development of the Quality Score (SQS) as a key performance indicator for measuring seaport quality. The SQS was developed in three phases, which involved defining the attributes of seaport quality, measuring seaport quality, and measuring the maritime economy for formulating the SQS. The development of the SQS can support the formulation of new policies and regulations to improve the seaport performance and sustainability in the Malaysian seaport industry. Ultimately, improving seaport quality can also improve economic factors.

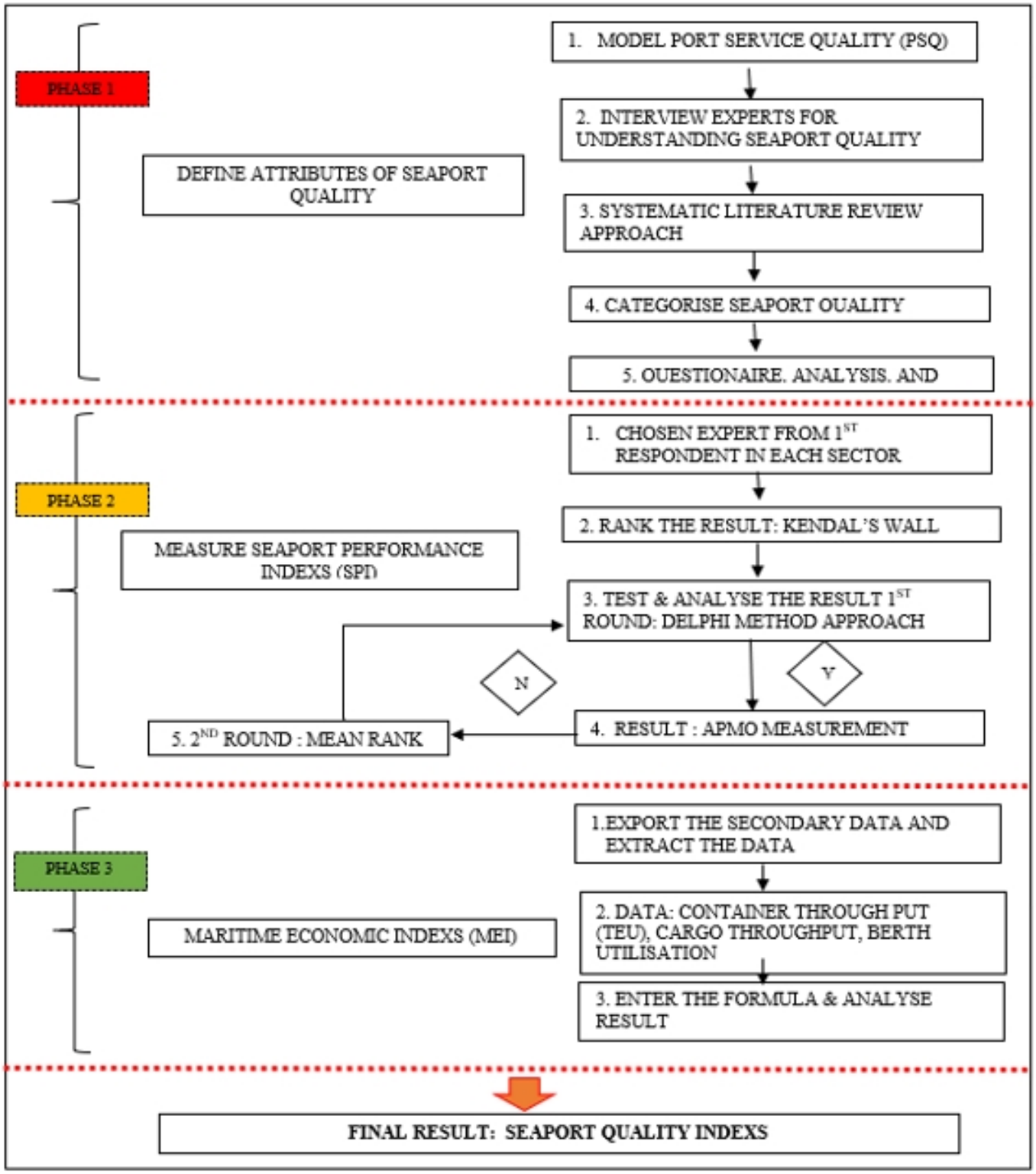
The SQC was developed to measure the performance of Malaysian seaports. Secondary data was collected from various sources to understand the challenges and performance determinants in the seaport systems. The SQS was formulated using the mean value of seaport quality indicators such as effectiveness, reliability, and governance, while the Port Performance Index (PPI) was chosen based on socio-economic performance, intermodal container connectivity, governance, and the environment. The Maritime Economy Index (MEI) prototype was based on the standardized variables container throughput and berth facilities, both of which were weighted with a factor of 0.5. The weightings were chosen based on their respective loading values in accordance with the principal component analysis. The final construction of the PQI was then generated by the related values of the SQI and MEI; the equation form is shown below:

$$SQS = (w1 * ((iv1/max1) * w11 + (iv2/max2) * w12)) + (w2 * (iv3/max3 * w2)) + (w3 * ((iv4/max4) * w31 + (iv5/max5) * w32))$$

Where:
SQS: Seaport System Quality Index.
iv1-5: Indicator values for each category.
max1-5: Maximum values for each indicator.
w1-3: Category weights.
w11-12: Indicator weights for Category 1.
w31-32: Indicator weights for Category 3.

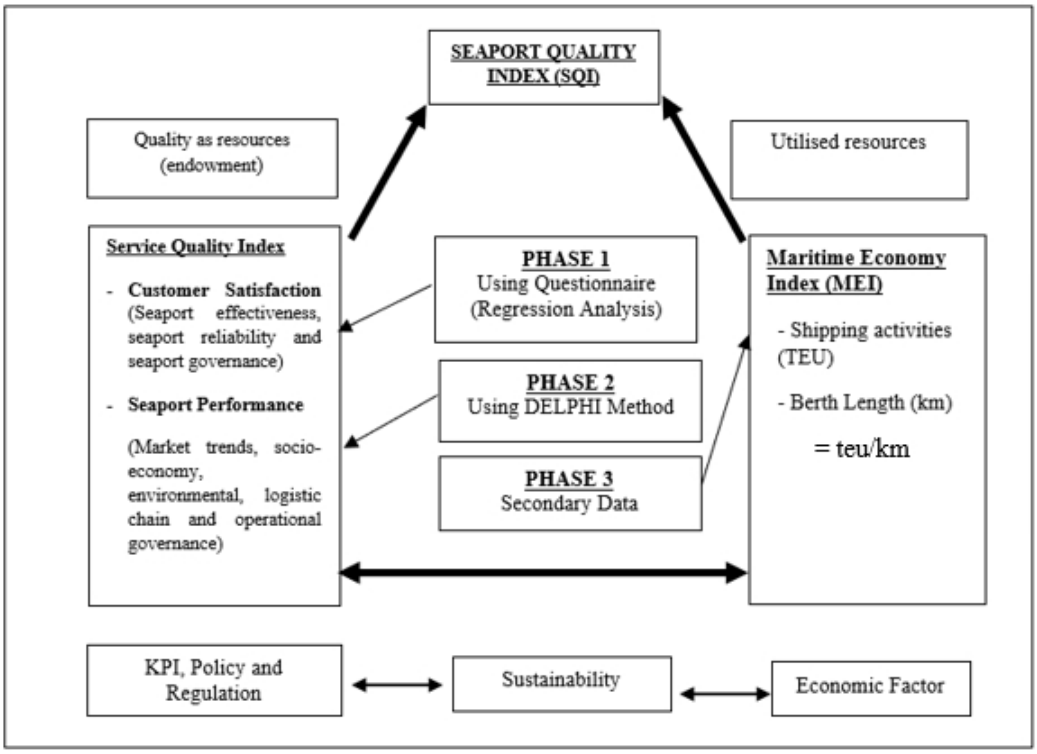
To use this formula, first identify the indicators that they will use to measure their performance across the three categories: Effectiveness, Reliability, and Governance, then assign weights to each category and indicator based on the relative importance to the overall performance of the seaport. Finally, plug in the actual indicator values and maximum values into the formula to calculate the Quality Score for the seaport. The Quality Score thus measures how far a seaport has made use of its quality endowment; the higher the index, the more a seaport has made use of its quality endowment and the expected seaport Key Performance Indicator (KPI) has been achieved.

Figure 1: The proposed research design.



Source: Authors.

Figure 2: Key Performance Indicator for Seaport Quality.



Source: Authors.

4. Findings and Results.

4.1. The category of the seaport quality.

This section presents the findings and results of a study on seaport quality and competitiveness in Malaysia. The study utilized a Systematic Literature Review (SLR) approach and conducted analysis on the personal and business characteristics of the expert community of the seaport cluster in Malaysia. This section also includes the results of hypotheses testing on the relationship and influence between seaport effectiveness, reliability, and governance on seaport competitiveness. The Delphi analysis is explained in detail, and the maritime economic index is formulated as the benchmark of the seaport System quality index.

The Systematic Literature Review (SLR) approach with three sequential stages, including planning, execution, and reporting. The first stage focused on academic literature review to identify 110 journals from 1990 to 2016 using the Scopus search engine. The journals were classified based on the development and understanding of the keyword's "quality" and "seaport" over 16 years. The classification was used to identify research trends and changing directions of studies. One journal related to seaport competitiveness took 32 years, starting from 1983 until 2014, and focused on academic reputation and relevance in the transportation and logistics domain. This method helped in identifying the category of seaport quality by determining its definition. Based on a review of 30 journals, the study identified three categories of seaport quality: seaport effectiveness, seaport reliability, and seaport governance.

The main criteria on searching keywords classification was divided into two broad perspective which were quality and seaport. The element criteria in quality and seaport were summarized in recent 70 journal for literature research and applications as referred in Table 2:

Seaport quality can be defined as the overall ability of a seaport to meet the needs of its users in terms of effectiveness, reliability, and governance. It encompasses various elements of seaport operations, including infrastructure, equipment, processes, and services, with the aim of providing a high level of satisfaction to port users while ensuring efficiency and safety. Seaport quality is crucial for the competitiveness and sustainability of seaports in the global logistics chain.

The finding reveals the importance of quality in various sectors of the economy, including the seaport industry. It presents different perspectives and definitions of quality, highlighting components such as customer satisfaction, functionality, reliability, and performance. The article emphasizes the need to broaden the concept of quality to manage customer feedback and improve knowledge about products or services. The seaport quality is defined as the overall level of excellence and effectiveness of seaport operations, encompassing various attributes related to service delivery processes, maritime transport, and port service quality. The seaport quality is a key performance indicator that reflects the degree of excellence and effectiveness of seaports in terms of their operations, productivity, and policies, and is crucial for the competitiveness and sustainability of seaports in the global logistics chain.

Table 2: Summary on Execute Process on 70 journals that related on definition of seaport quality.

Classification Criteria	Publications
	(i) Quality Perspective
Definition of Quality	Jan (1990); Thomas (1992); (Kailash, 1991); (Lynne, 1992); (John, 1993; Fred, 1993; David, 1993); (Kaj, 1994; Ann *et al.,* 1994; Anthony & Kwok, 1994; Philipa, 1994); (Allan *et al*., 1997; Steven, 1997; Sivakumar & Raj,1997); (James, 1998 ; Wen, 1998); (Dianne, 1999; Ashok *et al*., 1999; Jillian *et al*., 1999; Hellofs & Jacobson, 1999); (Lloyd, 2000; Raghunathan, 2000; Dwayne *et al*., 2000; Richard & John, 2000); (Rust *et al*., 2002); (Thomas, 2005); (Charles, 2006); (Jeroen & Albert, 2007); (Christina, 2010); (Olavur, 2011); (Willis, 2012; Golder, 2012); (Richard & Suman, 2013); (Macdonald *et al*.,2016);
Element of Quality Improvement	(Sujan, 1991); (Barbara, 1993); (Wen, 1996); (Michael & John, 1997); (Nicholas, 1999; Satish, 1999); (V. Roshan, & Wu, 2002); (Harriet & Rene, 2003); (Jeroen & Albert, 2007); (Jye *et al*., 2009); (William *et al*., 2013)
Quality Improvement	(Ravi & Elizabeth, 1999)
Total Quality Management	(Wolfgang, 1990); (Manus, 1999; Robert, 1999); (Patrick & Thomas, 2000); (Christina, 2010)
Service Quality	(Marjorie *et al*., 2001; Mary *et al*. 2001)
	(ii) Seaport Perspective
Seaport	(Hugh, 2000); (Ballis & Stathopoulos, 2002); (Lewis *et al*., 2003, 2006; Elvira *et al*., 2006; James, 2006); (Panayides and Song, 2008); (*Loyd et al*. 2009; Photis *et al*., 2009, Knatz *et al*., 2009); (Montwill (2011, 2014; Su *et al*., 2011); (Meng & Anthony, 2012); (Marcella *et al*., 2013; Rosa *et al*., 2013); (Halkos *et al*., 2015); (Fernando et al., 2016)
Seaport Management	(Peter, 2004); (Shy, 2007); (Cheon & Deakinm, 2010; Hercules, 2010; Cimen and A. Guldem, 2010; Chen *et al*., 2010; Christophe et al., 2010; K. Das and S. Sengupta, 2010; Pedro and Rui, 2010); (Mathew, 2011; Gordon *et al*., 2011; Hai *et al*., 2011; Michael & Melewar, 2011); (Rosa *et al*., 2013; Michael *et al*., 2013; Antonio *et al*., 2013); (Bo *et al*., 2015); (Claudia, 2016; Tony & Mary, 2016; Shu *et al*., 2016)
Seaport Competitiveness	(Daniel, 2002; Robert, 2002); (Bratteland & Netter, 2005); (Yeo *et al*., 2011); (Chi *et al*., 2012); (Wan and Zhang, 2013; Wan and Zhang, 2013); (Tsz *et al*., 2014); (Maria and Joao, 2015)
Seaport Safety and Security	(Kit et al.,2003); (Eski, 2011); (J. Rengamani and V. Venkatraman, 2015)

Source: Authors.

4.2. Seaport effectiveness.

The category of seaport quality has been identified and the importance of seaport effectiveness in achieving it. Seaport effectiveness is defined as the measurement of doing the right things to achieve objectives and goals and includes ship and cargo-related activities such as berth operation, cargo handling, and yard operation. This research emphasizes the importance of minimizing vessel delay and the quality of time in seaport stay in achieving seaport effectiveness. The factors that influence seaport effectiveness include service quality, cost, time, sustainability, and supply chain partner performance. This study identified a lack of recent studies on seaport effectiveness from different perspectives (see Table 3).

We explore the sub-elements of seaport effectiveness. The first sub-element is timeliness, which is important for reducing container time, increasing seaport capacity, and improving the efficiency of maritime services. The second sub-element is price acceptability, which focuses on attracting stakeholders and increasing customer satisfaction and loyalty by offering flexible pricing for services. The third sub-element is safety and security, which is essential for ensuring consistent improvement of seaport quality. It involves minimizing the risk of security threats such as terrorism attacks, surveillance system failures, and arson.

The importance of infrastructure and management in seaport operations. Various studies highlight the significance of infrastructure in providing effective and efficient services in seaports, and the need for continuous monitoring and improvement. Management is also an important element in seaport operations, which involves effective communication, understanding of client requirements, and technological application to achieve success. From the finding concludes that establishing and fo-

Table 3: Summary on element seaport effectiveness.

Influential element	Sub-element	Author
Seaport Effectiveness (SE)	• Timeliness	Kotowska (2019); Toukan and Chan (2018); Tony and Brooks (2016); Mirzabeiki et al. (2016), Grzelakowski (2015); Arvis et al. (2014);
	• Price Acceptability	Adonye et al. (2019); Nyenno et al. (2019); Wang and Yan (2019); Hailu (2017); Lee et al. (2017); Yapicioglu (2017) Brooks and Tony (2015); Meyiwa (2015); Meersman et al., (2003); (Bennathan & Wishart, 1983)
	• Safety and security	Zhang and Roe (2020:2019); Lauri et al. (2019); Jeevan (2019;2017); Plachkova (2019); Cho et al. (2018); Bauk et al. (2018;2016); Osnin (2018); Pahala et al. (2018); Kivalov (2018); Edet (2017); Tadic (2017); Peter (2016); Viet (2015); Manual Cudrado et al.,2004)
	• Infrastructure	Olkhovik (2019); Fernandez et al. (2018; 2016); Kotowska et al. (2018); Zhang et al. (2017); Rymanas (2016); Bentaleb (2015);
	• Management	Acciaro et al. (2018); Fernández et al. (2018); Cimpeanu et al. (2017); Yeo et al. (2016); Jacobsson et al. (2016); Viet (2015); Loh et al. (2015); Park and De (2015)

Source: Authors.

cusing on seaport effectiveness will improve the quality level in the seaport industry.

4.3. Seaport reliability.

The article discusses the concept of reliability in the seaport industry, which refers to consistently good performance and satisfying the quality expectations of customers. Reliability plays an important role in seaport operations and productivity, and has been measured through various approaches, including transport infrastructure and vessel capabilities. The article also highlights the importance of maintaining a stable labor relationship to maintain seaport reliability and improve efficiency. Additionally, seaport reliability is linked to factors such as transport network capacity, information sharing, harmonized working timetables, and seaport networking. The article summarizes previous studies on sub-element seaport reliability from 2015 to 2020 in Table 4.

The importance of reliability in the seaport industry and its various factors such as infrastructure transportation, vessel reliability, labor relations, and information sharing and highlight how seaport reliability affects seaport quality, productivity growth, and inbound and outbound traffic. The article concludes by emphasizing the need for seaport networking to improve network management and continuous seaport operation.

In addition, the seaport reliability, elaborated regarding the importance of resources, responsiveness, and cooperation in seaport productivity perspectives. The reliability of resources, such as human resources and infrastructure, is vital in improving the quality and productivity of seaports. Meanwhile, responsiveness, which is how the seaport community responds to clients, is an essential element of customer satisfaction. On the other hand, cooperation is necessary to improve seaport performance, with stakeholders working together to reduce congestion and improve the handling of cargo. These elements play a significant role in achieving sustainability and competitiveness in the seaport industry.

4.4. Seaport Governance.

Most of the articles explore the concept of governance and its evolution over time, with a focus on seaport governance. Kaufmann's (1999; 2007; 2009 and 2010) research defines governance dimensions such as voice and accountability, political stability, government effectiveness, regular quality, rule of law, and control of corruption. Network governance is a new approach that combines social network analysis with governance research. Seaport governance is distinct from Port Authority governance and relates to ownership, management, and control of seaport operations. The greater autonomy of the seaport authority results in greater responsibility for seaport management performance. The text also notes the importance of institutions, mechanisms, and processes in seaport governance (see Table 5).

The articles discuss three sub-elements of seaport governance: implementation of regulatory framework, degree of coordination among seaport cluster, and efficiency in the flows of giving information. The implementation of regulatory framework focuses on the impact of planning, strategies changing of rules and regulations, and networking between seaport stakeholders for facing up the challenges of the seaport policy and structure. The degree of coordination among seaport cluster is key to success for seaport governance perspectives, and the

Table 4: Summary on seaport reliability indicator.

Influential element	Sub-element	Author
Seaport Reliability (SR)	• Resources	Balbi et al. (2020); Haezendonck and Langenus (2019); Tijan et al. (2019); Yoshitani (2018); Fernandez et al. (2017); Kadochinikov and Fedyunina (2017); Kumtong et al. (2017); Rymaniak and Piotrowski (2017); Wahed et al. (2017); Yeo et al. (2016); John et al. (2016); Ezzat (2016); Viet (2015); Halkos and Tzeremes (2015).
	• Responsiveness	Hossain et al. (2020); Rucha (2018); Hussein and Song (2018); Shadi et al. (2018); Yang et al. (2017); Rasidi et al. (2017); Loh & Thai (2016); Asfour (2016); Busa (2016); Yeo et al. (2016); Viet (2015); Kounopas and Pardali (2015)
	• Cooperation	Roso et al., (2019); Hintjens (2019); Haezendonck and Langenus (2019); Dias et. al. (2019); Shobayo and Van (2019);6 Nguyen et al., (2019); Ignasiak et al. (2018); Remzina (2016); Echeverry et al., (2015); Saha (2015);
	• Outcome	Khaslavskaya and Roso (2019); Schoyen et al. (2018); Gambo et al. (2017); Yeo et al. (2016); Pallis and Vaggelas (2015)

Source: Authors.

Table 5: Summary of seaport governance.

Influential element	Sub-element	Author
Seaport Governance (SG)	• Structure: Implementation Regular Framework	O'Keeffe et al. (2020); Fernandez et al. (2020) Di Vaio and Varriale, (2018); Geiger et al. (2011; 2014);
	• Element: Degree of coordination of seaport users	Di Vaio et al. (2019); Kotowska et al. (2018); Shinohara and Saika (2018); Lu et al. (2017); Xi et al. (2017); Nguyen and Notteboom (2016); Beatriz et al. (2015);
	• Action: The efficiency in the flows of giving information	Tijan et al. (2019); Kotowska et al. (2018); Knatz (2017); Van De Voorde and Verhoeven (2017); Wagner (2017); Becker et al. (2015); Geiger et al. (2011; 2014)

Source: Authors.

seaport users should act in coordination in implementing the seaport devolution process. The efficiency in the flows of giving information involves the matter of implementation of policy to consider such as coordination of seaport interest, joint viewpoint on federal policy issues, joint position on seaport issues, and modernization nautical chain management.

From the SLR, the research hypothesis was developed to identify the relationship of each variable. The seaport reliability elements were resources, responsiveness, cooperation and outcome. The seaport governance element consisted of the structure, action, and element. Meanwhile, the dependent variables consisted of the seaport competitiveness. The element of seaport competitiveness included hinterland geographical shipping network, enough capacity to accommodate large vessel at any time, an extension port area, quality of terminal layouts and common space.

Pearson's Correlation Coefficient was used to determine the linear relationship between the variables, with values ranging from -1 to 1, where 0 indicates no correlation. The analysis revealed that a positive sign (+) indicates a positive correlation, while a negative sign (-) indicates a negative correlation. The results showed that a correlation coefficient of ± 0.01 to ± 0.20 indicates a very low relationship, ± 0.21 to ± 0.40 a low relationship, ± 0.41 to ± 0.70 a moderate relationship, ± 0.71 to ± 0.90 a high relationship, and ± 0.91 to ± 1.00 a very high/strong relationship.

The study used Pearson's correlation coefficient to examine the correlation strength of the independent and mediating variables with the dependent variable. The results showed that all independent variables had a significant relationship with seaport competitiveness. Seaport effectiveness had a moderate positive relationship (0.685), while seaport reliability and seaport governance had a strong positive relationship (0.768 and 0.718, respectively) with seaport competitiveness. The findings indicate that workers with high levels of seaport reliability and governance tend to have strong levels of seaport competitiveness.

The results of the multiple linear regression analysis conducted in this research show that there is a strong positive correlation (R = 0.781) between seaport effectiveness, seaport reliability, seaport governance, and seaport competitiveness. The coefficient of determination (R2) is 0.610, indicating that 61.0 percent of the total variation in seaport competitiveness is explained by these independent variables. The remaining 39 percent is explained by other factors. The model is significant ($p = 0.00 < \alpha = 0.05$), indicating that at least one of the independent variables can be used to predict seaport competitiveness.

Further analysis reveals that seaport reliability and seaport governance significantly influenced seaport competitiveness (p-value $< \alpha = 0.05$), while seaport effectiveness did not have a significant effect on the model (p-value $> \alpha = 0.05$). The coefficient values show that for every one unit increase in seaport reliability, seaport competitiveness will increase by 0.496, while seaport governance remains constant. Similarly, for every one unit increase in seaport governance, seaport competitiveness will increase by 0.238, whereas seaport reliability remains constant.

Overall, this research shows that seaport reliability and seaport governance are crucial factors in predicting seaport competitiveness, while seaport effectiveness has no significant effect on the model.

4.5. Development of Seaport Quality Score (SQS).

To create a Seaport System Quality Index, one needs to determine relevant indicators, assign weights to each indicator, collect data on the indicators, normalize the data, calculate the Seaport System Quality Index by multiplying normalized value with assigned weight and then ranking the seaports based on their scores. The indicators are categorized into three categories - Seaport Effectiveness, Seaport Reliability and Seaport Governance, and each category has specific indicators. Normalizing data is essential to ensure equal weight to each indicator. Finally, ranking the seaports based on their scores would give an idea about the performance of each seaport. Then we can use this SQS formula to identify the seaport performance.

Here, we utilised the SQS formula how to calculate the performance of the Seaport Quality for two different seaports, Port A and Port B. Fig. 3 shows the indicator values and weights for each seaport, along with the maximum values for each indicator.

Using these values, we can calculate the Seaport Quality Score (SQS) for each seaport base on the SQS formula as follows:

SQS = (w1 * ((iv1/max1) * w11 + (iv2/max2) * w12)) + (w2 * (iv3/max3 * w2)) + (w3 * ((iv4/max4) * w31 + (iv5/max5) * w32))

Port A

Category 1 score = (2,000,000 / 5,000,000) x 0.4 + (65 / 100) x 0.2 = 0.32

Category 2 score = (24 / 36) x 0.5 = 0.33

Category 3 score = (2 / 3) x 0.6 + (95 / 100) x 0.4 = 0.73

Seaport Quality Score (SQS) for Port A = (0.25 x 0.32) + (0.35 x 0.33) + (0.4 x 0.73) = 0.52

Port B

Category 1 score = (3,500,000 / 5,000,000) x 0.4 + (80 / 100) x 0.2 = 0.44

Category 2 score = (28 / 36) x 0.5 = 0.39

Category 3 score = (1.5 / 3) x 0.6 + (98 / 100) x 0.4 = **0.8**

Seaport Quality Score (SQS) Port B = (0.25 x 0.44) + (0.35 x 0.39) + (0.4 x 0.8) = **0.62**

Based on these calculations, we can see that Port B has a higher SQS than Port A, indicating that it is performing better across the various categories and indicators we have considered.

The SQS can be used as a tool for benchmarking and improving seaport performance, but it's important to involve stakeholders and use reliable and up-to-date data. It's also important to regularly update and revise the SQS to ensure its relevance and effectiveness. The SQS is a tool for measuring the overall quality and performance of seaports. The SQS is calculated using a set of indicators that are relevant to seaport effectiveness, reliability, and governance, and these indicators are assigned weights to reflect their relative importance. Data is collected

Figure 3: Indicator value and weights for Port A dan Port B.

Port A

Category	Indicator	Indicator Value	Indicator Weight	Maximum Value
Effectiveness	TEU Handled	2,000,000	0.4	5,000,000
Effectiveness	Utilization of Berth	65 km	0.2	100 km
Reliability	Vessel Turnaround Time	24 hours	0.5	36 hours
Governance	Customs Clearance Time	2 days	0.6	3 days
Governance	Regulatory Compliance	95%	0.4	100%

Port B

Category	Indicator	Indicator Value	Indicator Weight	Maximum Value
Effectiveness	TEU Handled	3,500,000	0.4	5,000,000
Effectiveness	Utilization of Berth	80 km	0.2	100 km
Reliability	Vessel Turnaround Time	28 hours	0.5	36 hours
Governance	Customs Clearance Time	1.5 days	0.6	3 days
Governance	Regulatory Compliance	98%	0.4	100%

Source: Authors.

and normalized, and then the SQS is calculated by multiplying the normalized value of each indicator by its assigned weight and summing the products across all indicators.

The SQS is a valuable tool for assessing the quality of seaports and identifying areas for improvement. By using the SQS, port authorities, shipping companies, and government agencies can gain insights into the strengths and weaknesses of different seaports and make informed decisions about investment and resource allocation. However, it's important to note that the SQS is just one tool among many that can be used to assess seaport performance, and it should be used in conjunction with other measures and metrics to get a more complete picture of seaport quality.

Conclusion and implication.

This study reveals the importance of seaport competitiveness, which is determined by factors such as effectiveness, reliability, and governance. The quality of a seaport can be evaluated based on infrastructure, operations, logistics, and customer service. Effective and reliable seaports are able to handle cargo efficiently and on time, while strong governance practices make seaports more trustworthy and reliable partners for customers. Seaport competitiveness is also closely linked to environmental and energy issues, as ports that prioritize sustainability, environmental compliance, and energy efficiency tend to be more attractive to customers.

The seaport effectiveness, reliability, and governance are strongly correlated with seaport competitiveness and support the overall quality of a seaport. To remain competitive in a rapidly changing global economy, seaport managers and stakeholders need to prioritize sustainable infrastructure, environmental regulations compliance, energy efficiency, green logistics, and collaboration. By doing so, they can ensure that their seaports remain efficient, reliable, and environmentally responsible, and that they attract and retain customers in a highly competitive market.

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