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A longitudinal study of seaport selection: the perspective of container shipping companies

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Abstract

Purpose – Competition among seaports is rapidly increasing due to various factors such as the global recession, resurgence of COVID-19, tight environmental regulations of IMO, sharp rise in ocean freight charges, increasing global uncertainties and growth in ship sizes. It is essential to have precise knowledge of shipping companies' port selection factors to secure the competitive advantage of seaports. This study aims to empirically analyze recent changes in the importance of port selection factors.

Design/methodology/approach – By employing a longitudinal study, this study conducted the *t*-test analysis. The first survey was conducted from January 2005 to April 2005. Then, the second survey was conducted in May 2021.

Findings – First, the importance of port facilities (berth length and the number of berths, shed and terminal areas, possession of adequate equipment and maximum berth size) increased significantly. Second, while ship and cargo safety were the critical port service factors in previous studies, speed, flexibility and reliability for handling cargo and berthing schedule were found to be crucial in this study. Third, the importance of ship arrival/departure frequency, route diversity and ship arrival/departure information systems increased when shipping companies selected the port.

Originality/value – This study has academic significance in that it reveals the changing importance of port selection factors in the 2020s and has taken the form of a longitudinal study on the importance of port selection factors from 2005 to 2021, moving beyond the cross-sectional approach. This study can provide valuable insights into and implications for port policymakers and managers when developing and formulating port policies and strategies.

Keywords Seaport, Port selection, Port selection factors, *t*-test, Container shipping companies

Paper type Research paper

1. Introduction

Ports are crucial infrastructure for the development of international trade and play a significant role in supporting the development of maritime transport and trade connectivity (Oh *et al.*, 2018). After Malcom McLean developed its first shipping container in 1956, container terminals were built at New York Harbor in New Jersey in 1963, and containers

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began to be used worldwide. Indeed, the invention of container boxes has significantly improved the efficiency of waterway transportation (Lau *et al.*, 2013). The growing demand for containers led shipping companies to start ordering new ships, and when the supply of container ships exceeded demand, it resulted in their oversupply in the shipping market (Ha *et al.*, 2023; Park and Seo, 2016; Seo and Park, 2016, 2018; Park *et al.*, 2019). This led to fierce competition among shipping companies because of supply and demand mismatches. Furthermore, competition between seaports is gradually becoming fierce with the globalization of trade. Shipping companies began establishing various strategies to secure a competitive advantage, such as increasing ship sizes, performing mergers and acquisitions (M&As), securing dedicated terminals and diversifying portfolios. With the intensifying competition in the global shipping market, shipping companies are striving to hedge risks by securing stable cargo volumes and routes through M&As and reorganizing alliances.

Since the 1980s, when the relocation of production began, port facilities, port services, port operation policy, port safety and speed and flexibility of cargo handling have been considered important factors. However, there has been insufficient research on port selection factors since 2020 after the COVID-19 pandemic. Therefore, it is necessary to conduct a study on the port selection factors of shipping companies regarding their importance, as presented in previous studies (Murphy *et al.*, 1988, 1991; Kim, 2005; Zarei, 2015).

Moreover, although there have been various studies on port selection factors, most have been cross-sectional (Chang *et al.*, 2008; Wiegmans *et al.*, 2008; Kavirathna *et al.*, 2018; Onwuegbuchunam, 2013; Lirn *et al.*, 2004; De Langen, 2007; Zarei, 2015; Wang and Yeo, 2019; de Souza *et al.*, 2021; Baştuğ *et al.*, 2022; Munim *et al.*, 2022), while few are longitudinal. Cross-sectional analysis cannot account for the influence of time on the variables measured (Caruana *et al.*, 2015). In recent years, scholars have expressed increasing concerns about the validity of this approach (Rindfleisch *et al.*, 2008). Longitudinal research is commonly offered as a solution to these problems. As data are collected for individuals within a predefined group, statistical testing may be employed to analyze changes over time for the entire group or for individuals (Caruana *et al.*, 2015). Even if there are factors that are evaluated as somewhat low in importance among the port selection factors, their importance may change depending on time and environmental changes (Kim *et al.*, 2005).

The initial data were collected in 2005 before the global financial crisis, one of the predominant issues in the maritime industry. The events occurring between 2005 and 2021, such as larger shipping alliances, Hanjin shipping's bankruptcy, IMO (International Maritime Organization) regulation, the global financial crisis and COVID-19, warrant analysis regarding their impact on seaport selection factors. Therefore, this study aims to investigate longitudinal changes in the importance of various seaport selection factors from the perspective of container shipping companies by employing a longitudinal research design. More specifically, this study focuses on empirically re-evaluating the necessity of the evaluation results of a study of port selection factors of shipping companies conducted in 2005 (Kim, 2005), hereafter referred to as Study 1, as well as individual items comprising those factors at this point. In this context, this paper seeks to answer three research questions.

RQ1. Were there significant differences in shipping companies' seaport selection decisions between 2005 and 2021?

RQ2. If there were changes, which type of the seaport selection factors changed?

RQ3. Specifically, how did each seaport selection factor change?

Section 2 reviews the previous studies on port selection. Section 3 describes the research design and methodology. Section 4 shows the process of comparing Study 1 and a recent study (hereafter referred to as Study 2) through an independent sample *t*-test. Section 5 discusses the results of the empirical analysis and answers three key research questions.

Finally, Section 6 presents policy implications based on the results and discusses the limitations of this study, including future directions.

2. Literature review

2.1 Impact of COVID-19 on the maritime industry

COVID-19 has had significant impacts on the maritime industry (Chua *et al.*, 2022), including severe supply chain disruptions that affected lead times, production performance and demand (Min, 2023; Nguyen and Kim, 2022; Wong, 2023). Moreover, shipping lines reduced services or changed the number of ports in each route (Nguyen and Kim, 2022). When shipping companies did not obtain sufficient bookings from ports of operation, they reduced port calls or announced blank sailing until demand increased (Toygar *et al.*, 2022). In addition, container throughput and connectivity in container ports in the region decreased significantly due to COVID-19 (Nguyen and Kim, 2022). Furthermore, seaports need to revisit their marketing strategies to align with the current trends (Jeevan *et al.*, 2023).

However, contrary to expectations, container throughput has increased rapidly since the end of 2020 (Zhou *et al.*, 2022); every major forecasting institution (e.g. IMF (International Monetary Fund), World Bank, OECD (Organisation for Economic Co-operation and Development)) revised their expectations for growth (Notteboom *et al.*, 2021). The reduced consumer demand and shortage of containership capacity triggered a collapse of global supply chains (Vukić and Lai, 2022), causing critical bottlenecks in workflow and inter-organizational business networks (Huang *et al.*, 2022). The lingering effects of the COVID-19 pandemic on the frequency and severity of port congestion notably challenged the stability of the global supply chain.

Congestion at major ports such as Long Beach and Los Angeles caused weeks of delays in docking due to significant labor shortages (Kent and Haralambides, 2022; Min, 2023) and caused backlogs of ships, leaving no places for incoming vessels to dock (Huang *et al.*, 2022) and supply chain disruptions across the US (Min, 2023). However, even though shipping companies faced these challenges (Wong, 2023), they benefited greatly from increased freight fares (Cullinane and Haralambides, 2021; Kent and Haralambides, 2022; Zhou *et al.*, 2022). Meanwhile, container terminals were unable to operate at full capacity because of the restrictions and lockdowns (Notteboom *et al.*, 2021; Zhou *et al.*, 2022).

There has been extensive research on the impact of COVID-19 on the maritime industry (Chua *et al.*, 2022; Wong, 2023). However, despite the substantial body of literature, sufficient attention has not been given to the effects of COVID-19 on selecting seaports. Seaport selection is an area that requires more attention because it is critical for policymakers, port operators and shipping companies (Bhatti and Hanjra, 2019; de Souza *et al.*, 2021; Hsu *et al.*, 2020; Tiwari *et al.*, 2003). Therefore, it is necessary to find recent changes in seaport selection factors during the COVID-19 pandemic.

2.2 Seaport selection

Seaport selection criteria have been extensively reviewed in previous studies by hub port selection, shipping lines, forwarders and shippers (Kavirathna *et al.*, 2018). Many ports need to consider redefining their corporate missions seriously (Murphy *et al.*, 1992), and port choice is a valid part of port transportation demand behavior (Nir *et al.*, 2003).

Regarding port selection, Slack (1985) verified the port selection factors considering exporters and freight forwarders in Europe and the Midwestern United States, for which price and service considerations of land and ocean carriers are considered to be the main criteria. Murphy *et al.* (1988) analyzed 236 worldwide ports engaged in international trade activities and indicated that service aspects, such as equipment availability and loss and damage

records, are the most important factors for choosing a port. Murphy *et al.* (1991) analyzed the decision-making behavior of international freight forwarders and revealed that low loss/damage frequency, equipment availability and low freight handling charges are significant port evaluation factors. Murphy *et al.* (1992) suggested that forwarders emphasize a port's freight handling capabilities. Cullinane and Toy (2000) investigated universal mode choice decisions and revealed that cost was considered the most important, followed by speed, transit time reliability, characteristics of goods and service. Nir *et al.* (2003) examined port choice behavior in Taiwan and suggested that travel time and cost are significant. Tiwari *et al.* (2003) modeled the port choice behavior of shippers in China and indicated that the distance of the shipper from the port and port congestion plays an important role. Lirn *et al.* (2003) identified the cost and port efficiency as the chief factors for transshipment port selection in Taiwan. Lirn *et al.* (2004) conducted an empirical analysis of 20 global shipping companies and showed that the geopolitical location of ports, ship navigation and port charges were the main port selection factors. Tai and Hwang (2005) highlighted that the prime factors are handling efficiency and drafts of a harbor that belongs to the internal factors, cargo source of the hinterland and frequency of routes belonging to the external factors of ports.

Wiegmans *et al.* (2008) examined the port selection factors of deep-sea container operators operating in Hamburg and Le Havre, indicating that client concentration, adequate cargo handling costs and hinterland connectivity, including feeder connectivity, environmental issues and the port's total portfolio, were considered important for shipping companies. Onwuegbuchunam (2013) surveyed shipping companies in Nigeria and revealed that crane efficiency, cargo handling speed, level and functionality of port facilities and ship-call frequency were influential port selection factors. Zarei (2015) conducted an exploratory factor analysis to verify the port selection factors of major shipping companies in Iran and showed that the important ones were those related to port management, such as service speed, ability to obtain special requirements, port operation policy, promptness in issuing documents, port safety and custom services. Kavirathna *et al.* (2018) surveyed shipping companies to assess the hub port selection factors among Colombo Port, Singapore Port, Kelang Port and Tanjung Pelepas and suggested that berth availability was the principal factor in both hub-and-spoke and relay networks.

Recently, Bhatti and Hanjra (2019) verified the port selection factors that were most important to one belt–one road stakeholders, who selected port location and efficiency and intermodal connectivity as the main criteria. Ergin and Eker (2019) analyzed carriers at the four largest container ports in Turkey and identified port cost, efficiency, location and environmental impact as important selection factors. Khalid and Al-Mamery (2019) explored the factors attracting shippers to the port of Sohar, Oman, and highlighted that port competitiveness can be improved through strategic locations, improved hinterland conditions, port facilities, service cost, volume of cargo, connectivity to other ports and dwell time factors.

Hsu *et al.* (2020) analyzed the decision-making of liner carriers for ship calls and revealed that cargo volume is a significant port evaluation factor. Kaliszewski *et al.* (2020) collected quantitative data from a survey on the competitiveness of container ports perceived by global shipping lines. de Souza *et al.* (2021) investigated selection factors in Brazil for different port users and revealed that ship calls were the most important, while the concentration of cargo was essential for shipping lines. Fahim *et al.* (2022) examined port performance evaluation and selection in the future shipping environment of the physical Internet and found differences in intelligent agents' perspectives with the increased importance of the level of service, network interconnectivity and information systems. Munim *et al.* (2022) selected seven criteria (maritime connectivity, port facilities, port efficiency, cost factor, policy and management, information systems and green port management) to assess the competitiveness of four transshipment ports in the container shipping market in

Bangladesh. Baştuğ *et al.* (2022) argued that the most important criterion for port operators is port location, followed by service level, port tariffs and port facilities, whereas the most important criterion for carriers is operational efficiency.

Previous studies have shown that the port selection factors of shipping companies have changed along with environmental changes in the shipping and port industries. Before 2000, when ports were insufficiently developed, port facilities, tariffs and services were the key factors in port selection (Slack, 1985; Murphy *et al.*, 1988, 1991, 1992). However, as the competition among ports intensified after 2000, port reliability (Cullinane and Toy, 2000), geopolitical location (Nir *et al.*, 2003; Tiwari *et al.*, 2003; Lirn *et al.*, 2004), port efficiency (Lirn *et al.*, 2003; Tai and Hwang, 2005), hinterland connectivity (Wiegmans *et al.*, 2008), the scale of the hinterland economy (Tai and Hwang, 2005), along with port facilities, tariffs and services, are regarded as the key factors. In the 2010s, not only existing factors but also port operation policy (Zarei, 2015), ship-call frequency (Onwuegbuchunam, 2013) and port safety (Zarei, 2015; Kim *et al.*, 2021) were considered important.

After a thorough review of prior studies on port selection, it was found that port selection studies typically focused on cross-sectional analysis. However, the cross-sectional study is unable to grasp the impact of time on the port selection factors. To fill this gap, this study employs a longitudinal study to examine longitudinal changes in the importance of seaport selection factors from the perspective of container shipping companies.

3. Methodology

3.1 Sample design and data collection

Caruana *et al.* (2015) suggested three types of longitudinal study designs: first, repeated cross-sectional studies of largely different participants on each sampling occasion; second, prospective studies of the same participants over a period of time and third, retrospective studies of events that have already happened.

There are differences in the respondents between studies 1 and 2 because some left their jobs for diverse reasons, including Hanjin's bankruptcy in 2017; in addition, it was difficult to contact other respondents. Therefore, experts from 20 major container shipping companies who were expected to have sufficient knowledge regarding the overall processes of shipping and shipping company's port selection from Korea and overseas were newly selected for the repeated cross-sectional survey in Study 2.

Snowball sampling was used in studies 1 and 2 because there was no single directory for effectively identifying potential respondents. Nonetheless, a number of previous researchers have used similar methods to analyze seaport selection and have argued that the snowball sampling is reliable (Kaliszewski *et al.*, 2020, 2021; Kavirathna *et al.*, 2018).

After sufficiently explaining the research objectives and survey participation, the responses for studies 1 and 2 were obtained on-site by visiting the offices to increase objectivity and validity. Regarding ethical considerations, we received ethics approval from the university and all participants were volunteers. Additionally, all participants provided informed consent, and we guaranteed their anonymity and confidentiality.

Responses to the questionnaire for Study 2 were also collected online and by email, where visits were not feasible due to COVID-19. The first survey was conducted from January 31, 2005, to April 22, 2005, by distributing 140 questionnaires. A total of 131 copies were collected, showing a 93.6% return rate; 121 copies were used in the empirical analysis of this study, excluding 10 copies that appeared to comprise insincere and invalid responses.

The second survey was conducted from May 17 to 31, 2021, and involved distributing 133 copies of the questionnaire. All copies distributed were returned, showing a 100% return rate, and all 133 were used in the empirical analysis as they did not contain insincere responses.

The general results of the questionnaires collected from the two surveys and used in the final analysis are summarized in Table 1.

3.2 Questionnaire structure and research method

3.2.1 Questionnaire structure. Most factors were derived from previous research that had validated the instruments, ensuring their reliability (Kwak *et al.*, 2018). The questionnaire consisted of eight factors and sub-items for the port selection of container shipping companies from Study 1. Port selection factors were classified into internal and external factors. Internal factors included port facilities, port tariffs, port services and ship arrival/departure. The external factors included geopolitical location, the scale of the hinterland economy, social conditions and the hinterland connection system; the detailed survey components are shown in Table 2. Ensuring that each factor was understandable to participants and pertinent in Korea, we conducted in-depth interviews with Korean port and shipping managers in senior positions and conducted a pilot test with five participants; their feedback was used to improve the questionnaire structure. Each item must be considered in port selection, and its importance is rated on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree) to evaluate the importance of each seaport selection factor. Reliability analysis was conducted to verify the difference between port selection factors, followed by an independent-sample *t*-test.

3.2.2 t*-test analysis.* A *t*-test is a statistical method used to identify whether the mean difference between the two groups is statistically significant. It can be divided into independent samples: *t*-test and paired-samples *t*-test. An independent-samples *t*-test verifies whether there is a mean difference between two independent groups, and a paired-samples *t*-test verifies the mean difference between two samples from the same group.

The confidence level of the *t*-test is determined based on the research purpose and variable characteristics. It can be increased to 99% or higher if a significant decision must be made or lowered to 90% if not. In general, a 95% confidence level is commonly used, and the significance level is set at 5% (Yang *et al.*, 2016).

4. Result and analysis

4.1 Analyzing the characteristics of survey respondents and responding companies

The general characteristics of the second survey respondents showed that the first survey results were similar in terms of the average ship size and major sailing routes. The details of the general statistical analysis of the respondents are shown in Table 3.

4.2 Results of reliability analysis and t*-test by factors*

Reliability analysis was conducted to determine the consistency with which items were measured. The results showed that the reliability was mostly greater than 0.70, which is the threshold for considering items reliable. The reliability values of port facilities, port service, ship arrival/departure, the scale of the hinterland economy and social and political safety in Study 1 were lower than 0.70. However, since this study aimed to examine the differences in the importance of existing port selection factors, there is no problem in the analysis, given that the minimum reliability value is close to 0.70. The results of the reliability analysis are presented in Table 4.

Classification	Questionnaire	No. of subjects responded	No. of subjects analyzed
Study 1 (2005)	140	131	121
Study 2 (2021)	133	133	133

Source(s): Authors' own work based on survey results

Table 1.
Survey results

Survey components			Reference
Internal	Port facilities	Berth length and the number of berths, shed and terminal area, possession of adequate equipment (G/C, T/C, S/C, etc.), maximum berth size	Murphy *et al.* (1991, 1992) Tai and Hwang (2005) Wiegmans *et al.* (2008) Onwuegbuchunam (2013) Kavirathna *et al.* (2018)
	Port tariff	Ship and cargo arrival/departure costs, loading-unloading/transfer/storage costs, inland transport costs, incentives and discount system	Slack (1985) Murphy *et al.* (1988) Cullinane and Toy (2000) Nir *et al.* (2003) Lirn *et al.* (2003, 2004) Wiegmans *et al.* (2008)
	Port service	Ship and cargo safety, speed and flexibility of cargo handling, berthing schedule and reliability of cargo handling, subsidiary services such as water, oil and supplies for ships	Slack (1985) Murphy *et al.* (1988) Cullinane and Toy (2000) Onwuegbuchunam (2013) Zarei (2015)
	Ship arrival/departure	Ship arrival/departure frequency and route diversity, time in port and waiting time of ships, ship arrival/departure information system (VTS, etc.)	Tai and Hwang (2005) Onwuegbuchunam (2013) Mittal and McClung (2016)
External	Geopolitical location	Voyage and marine transport distance, location on the main line, port and route accessibility, the distance and accessibility to the place with main cargo	Tiwari *et al.* (2003) Lirn *et al.* (2004) Kim *et al.* (2005) Malchow and Kanafani (2001, 2004) Yeo *et al.* (2014)
	The scale of the hinterland economy	Handled and generated cargo volume, economic scale of hinterland city, port hinterland and FTZ (Free Trade Zones) size, utilization level and trade size among nations	Tai and Hwang (2005) Kim *et al.* (2005) De Langen (2007)
	Social conditions	Port labor and labor management safety, political safety, change in port and social environment	Kim *et al.* (2005) Wiegmans *et al.* (2008) Zarei (2015) Vega *et al.* (2019)
	Hinterland connection	Connectivity to the inland transport network, connectivity to hinterland city, diversity of transport modes (road, railway, canal, aviation, etc.)	Wiegmans *et al.* (2008) Yeo *et al.* (2014) Wang and Yeo (2019)

Table 2.
Survey components

Source(s): Authors' own work based on literature review

A *t*-test was conducted to empirically compare the evaluation results of the importance given to port selection factors presented in Study 1, including the individual items composing those factors. As a result of the *t*-test on internal factors such as port facilities, port tariffs, port services and ship arrival/departure, the *t*-values were 6.186, 1.973, 4.059 and 3.597, respectively, and were all accepted at a 95% significance level. It indicates that a difference existed between Study 1 and Study 2 in evaluating the importance given to internal factors for port selection by container shipping companies. In other words, the importance of the internal factors varied depending on the change in time and the port environment from the perspective of container shipping companies. The *t*-test results for the internal factors are shown in Table 5.

Factors		Frequency (ratio)				
Average ship size		10,000 tons or less	10,001–30,000 tons	30,001–50,000 tons	50,001 tons or more	Others and missing values
	Study 1	9 (7.4%)	18 (14.9%)	46 (38.0%)	39 (32.2%)	9 (7.4%)
	Study 2	22 (16.5%)	31 (23.3%)	10 (7.5%)	63 (47.4%)	7 (5.3%)
Major sailing routes (multiple responses)		American routes	European routes	Korean/ Chinese/ Japanese routes	Southeast Asian routes	Others and missing values
	Study 1	74 (27.2%)	92 (33.8%)	50 (18.4%)	45 (16.5%)	11 (4.0%)
	Study 2	60 (36.8%)	33 (17.3%)	38 (21.1%)	22 (9.0%)	7 (15.8%)
Years of service by respondents		Less than 10 years	11–15 years	16–20 years	21 years or more	Others and missing values
	Study 1	4 (3.3%)	26 (21.5%)	50 (41.3%)	32 (26.4%)	9 (7.4%)
	Study 2	47 (35.3%)	19 (14.3%)	30 (22.6%)	33 (24.8%)	4 (3.0%)
Field of business of respondents		Sales	Operations	Customer Service	Document, etc.	Others and missing values
	Study 1	76 (62.8%)	26 (21.5%)	10 (8.3%)	9 (7.4%)	0 (0.0%)
	Study 2	32 (24.1%)	57 (42.9%)	32 (24.1%)	11 (8.3%)	1 (0.8%)

Source(s): Authors' own work based on survey results

Table 3. General characteristics of survey respondents

As a result of conducting a *t*-test on external factors such as geopolitical location, the scale of hinterland economy, social conditions and hinterland connection, the *t*-values were 1.964, 1.611, 0.688 and 0.426, respectively, and all were rejected at the 95% significance level. It indicates that there was no difference between Study 1 and Study 2 in evaluating the importance of internal factors in port selection by container shipping companies. The *t*-test results for the external factors are shown in Table 6.

There are various reasons for the significant increase in the importance of internal factors compared with Study 1 among the container port selection factors of shipping companies. The biggest reasons for this are the growth in ship size and the alliance reorganization of shipping companies. This is because it is essential to have a sufficient water level, cargo handling equipment, berth length and the number of berths for 24,000 TEU (Twenty-foot equivalent unit) ships to enter ports. Moreover, given that the volume of cargo loaded and unloaded increased owing to the growth in ship sizes and the sharing of capacity within the alliance, the importance of internal factors increased to handle a greater volume simultaneously.

4.3 t-*test results by component*

The *t*-test proved a significant difference in internal factors such as port facilities, port tariffs, port services and ship arrival/departure. This section describes the *t*-test conducted on the components of each factor to specifically verify those components that showed changes.

4.3.1 t-*test on port facilities components.* Port facilities comprised berth length and the number of berths, sheds and terminal area, possession of adequate equipment (e.g. gantry crane, transfer crane and straddle carrier) and maximum berth size. The *t*-test results showed that the importance of berth length and the number of berths increased from 4.025 (Study 1) to 4.414 (Study 2), showing a statistically significant result (t-value = 4.499, p-value = 0.000). It can be attributed to the fact that shipping companies have recently been seeking cost

Factor		Sub- factors	Cronbach's α	
Internal	Port facilities	Berth length and the number of berths, shed and terminal area Possession of adequate equipment (G/C, T/C, S/C, etc.) Maximum berth size	Study 1 Study 2	0.662 0.861
	Port tariff	Ship and cargo arrival/departure costs, loading-unloading/transfer/storage costs, inland transport costs, incentives and discount system	Study 1 Study 2	0.829 0.815
	Port service	Ship and cargo safety, speed and flexibility of cargo handling, berthing schedule and reliability of cargo handling, subsidiary services such as water, oil and supplies for ships	Study 1 Study 2	0.686 0.798
	Ship arrival/departure	Ship arrival/departure frequency and route diversity Time in port and waiting time of ships Ship arrival/departure information system (VTS, etc.)	Study 1 Study 2	0.626 0.711
External	Geopolitical location	Voyage and marine transport distance, location on the main line Port and route accessibility Distance and accessibility to the place with main cargo	Study 1 Study 2	0.837 0.873
	The scale of the hinterland economy	Handled and generated cargo volume, economic scale of hinterland city Port hinterland and FTZ size Utilization level, trade size among nations	Study 1 Study 2	0.656 0.895
	Social conditions	Port labor and labor management safety, political safety Change in port and social environment	Study 1 Study 2	0.656 0.851
	Hinterland connection	Connectivity to the inland transport network, connectivity to hinterland city, diversity of transport modes (road, railway, canal, aviation, etc.)	Study 1 Study 2	0.819 0.876

Source(s): Authors' own work based on survey results

Table 4.
Reliability analysis results

Factors		No. of samples	Mean	Standard deviation	*t*-value	*p*> |t|	Acceptance
Port facilities	Study 1	121	3.977	0.503	6.186	0.000	o
	Study 2	133	4.400	0.586			
Port tariff	Study 1	121	3.979	0.690	1.973	0.050	o
	Study 2	133	4.139	0.607			
Port service	Study 1	121	4.118	0.493	4.059	0.000	o
	Study 2	133	4.376	0.518			
Ship arrival/ departure	Study 1	121	3.993	0.527	3.597	0.000	o
	Study 2	133	4.233	0.537			

Source(s): Authors' own work based on survey results

Table 5.
Internal factors *t*-test results

reduction strategies through economies of scale, making sufficient berth length and the number of berths important factors to consider in accommodating large ships.

The importance of the shed and terminal areas increased from 4.050 (Study 1) to 4.436 (Study 2), showing a statistically significant result (t-value = 5.015, p-value = 0.000). As the shipping market was expected to stagnate due to COVID-19 in the first quarter of 2020,

Factors		No. of samples	Mean	Standard deviation	*t*-value	*p*> |t|	Acceptance
Geopolitical location	Study 1	121	4.017	0.664	1.964	0.051	x
	Study 2	133	4.171	0.582			
The scale of the hinterland economy	Study 1	121	3.896	0.501	1.611	0.109	x
	Study 2	133	4.015	0.668			
Social conditions	Study 1	121	3.884	0.622	0.688	0.492	x
	Study 2	133	3.940	0.661			
Hinterland connection	Study 1	121	4.118	0.613	0.426	0.671	x
	Study 2	133	4.085	0.629			

Source(s): Authors' own work based on survey results

Table 6. External factors *t*-test results

shipping companies adjusted their tonnage by delaying new orders, laying up ships or abandoning them. However, contrary to expectations, the container ship market improved significantly, leading to unexpected growth in cargo volume due to the prevailing contact-free social trend. The limited shipping volume due to insufficient tonnage led to an increase in average container installation days and container yard installation rates, causing sheds and terminal areas to become important elements in reducing the time of ships in ports.

The importance of possession of adequate equipment (e.g. G/C, T/C, S/C) increased from 4.008 (Study 1) to 4.398 (Study 2), showing a statistically significant result (t-value = 4.407, p-value = 0.000). Shipping companies pursue high turnover rates of ships to reduce the immense initial capital of managing mega-ships and the transport cost per unit. Therefore, the importance of owning equipment that can handle large volumes simultaneously when large ships enter ports has increased.

The importance of maximum berth size increased from 3.827 (Study 1) to 4.353 (Study 2), showing a statistically significant result (t-value = 5.199, p-value = 0.000). That is because the maximum berth size that can be accommodated by certain ports gained importance owing to the growth in ship sizes. The t-results for each port facility component are listed in Table 7.

4.3.2 t-*test on port tariff components.* Port tariffs include ship and cargo arrival/departure costs, loading-unloading/transfer/storage costs, inland transport costs and incentive and discount systems.

The t-test results showed that the importance of the ship and cargo arrival/departure costs did not show a statistically significant difference. They increased from 4.223 (Study 1) to 4.248 (Study 2) (t-value = 0.273, p-value = 0.785). Likewise, the importance of loading,

Port facilities component		No. of samples	Mean	Standard deviation	*t*-value	*p*> |t|	Acceptance
Berth length and the number of berths	Study 1	121	4.025	0.713	4.499	0.000	o
	Study 2	133	4.414	0.664			
Shed and terminal areas	Study 1	121	4.050	0.561	5.015	0.000	o
	Study 2	133	4.436	0.667			
Possession of adequate equipment (G/C, T/C, S/C, etc.)	Study 1	121	4.008	0.713	4.407	0.000	o
	Study 2	133	4.398	0.696			
Maximum berth size	Study 1	121	3.827	0.853	5.199	0.000	o
	Study 2	133	4.353	0.761			

Source(s): Authors' own work based on survey results

Table 7. *t*-test results of each port facility component

unloading, transfer and storage costs did not show a statistically significant difference, increasing from 4.132 (Study 1) to 4.286 (Study 2) (t-value = 1.508, p-value = 0.133).

In contrast, the importance of inland transport costs increased from 3.669 (Study 1) to 3.917 (Study 2), showing a statistically significant difference (t-value = 2.433, p-value = 0.016). This is because the port and port hinterland space are integrated, and the port is functionalized as a place for industrial convergence, such as cargo handling, logistics, manufacturing and research and development, increasing the importance of inland transport costs.

The importance of the incentive and discount systems increased from 3.889 (Study 1) to 4.105 (Study 2), showing a statistically significant difference (t-value = 1.979, p-value = 0.049). This is due to the increasing importance of the discount system of ports, which have become a key national industry, in maintaining a competitive advantage over other ports. Table 8 lists the t-results for each port tariff component.

4.3.3 t-*test on port service components.* Port services include ship and cargo safety, speed and flexibility of cargo handling, berthing schedule, reliability of cargo handling and subsidiary services such as water, oil and supplies for ships.

The t-test results showed that the importance of ship and cargo safety did not show a statistically significant difference, increasing from 4.405 (Study 1) to 4.481 (Study 2) (t-value = 0.925, p-value = 0.356).

The importance of speed and flexibility in cargo handling increased from 4.364 (Study 1) to 4.519 (Study 2), showing a statistically significant difference (t-value = 2.009, p-value = 0.046). In addition, the importance of the berthing schedule and cargo handling increased from 4.314 (Study 1) to 4.624 (Study 2), showing a statistically significant difference (t-value = 3.818, p-value = 0.000). There was insufficient tonnage as the container market, which had been stagnant due to COVID-19, began to recover in the third quarter of 2020. As the limited shipping volume decreased global schedule reliability and increased global average delay for late vessel arrivals, the importance of speed and flexibility in cargo handling increased.

Finally, the importance of subsidiary services, such as water, oil and supplies for ships, increased from 3.388 (Study 1) to 3.880 (Study 2), showing a statistically significant difference (t-value = 4.962, p-value = 0.000). This is because the number of arrivals and departures of large ships increased due to the recent growth in ship sizes, increasing the demand for subsidiary services such as water, oil and ship supplies. Table 9 presents the t-test results for each port service component.

4.3.4 t-*test on ship arrival/departure components.* Ship arrival/departure comprises ship arrival/departure frequency and route diversity, time in port and waiting time of ships and ship arrival/departure information systems, such as vessel traffic services (VTS).

Port tariff component		No. of samples	Mean	Standard deviation	t-value	p> |t|	Acceptance
Ship and cargo arrival/departure costs	Study 1	121	4.223	0.747	0.273	0.785	x
	Study 2	133	4.248	0.711			
Loading-unloading/ transfer/storage costs	Study 1	121	4.132	0.912	1.508	0.133	x
	Study 2	133	4.286	0.681			
Inland transport costs	Study 1	121	3.669	0.831	2.433	0.016	o
	Study 2	133	3.917	0.789			
Incentive and discount system	Study 1	121	3.889	0.902	1.979	0.049	o
	Study 2	133	4.105	0.837			

Source(s): Authors' own work based on survey results

Table 8.
t-test results of each port tariff component

Port service component		No. of samples	Mean	Standard deviation	*t*-value	*p*> |t|	Acceptance
Ship and cargo safety	Study 1	121	4.405	0.653	0.925	0.356	x
	Study 2	133	4.481	0.658			
Speed and flexibility of cargo handling	Study 1	121	4.364	0.606	2.009	0.046	o
	Study 2	133	4.519	0.623			
Berthing schedule and reliability of cargo handling	Study 1	121	4.314	0.696	3.818	0.000	o
	Study 2	133	4.624	0.598			
Subsidiary services such as water, oil and supplies for ships	Study 1	121	3.388	0.830	4.962	0.000	o
	Study 2	133	3.880	0.739			

Source(s): Authors' own work based on survey results

Table 9. *t*-test results of each port service component

The *t*-test results showed that the importance of the ship arrival/departure frequency and route diversity increased from 3.876 (Study 1) to 4.203 (Study 2), showing a statistically significant difference (*t*-value = 3.587, *p*-value = 0.000). This increase can be attributed to risk hedging due to the growing uncertainties of the external environment, such as COVID-19 and the Suez Canal accident in March 2021. Shipping companies are increasing their ship arrival/departure frequency and securing various routes through M&As and alliance reorganization within the global shipping market.

However, the importance of port time and waiting time of ships did not show a statistically significant difference, increasing from 4.392 (Study 1) to 4.414 (Study 2).

Finally, the importance of the ship arrival/departure information system (i.e. VTS) increased from 3.711 (Study 1) to 4.083 (Study 2), showing a statistically significant difference (*t*-value = 4.094, *p*-value = 0.000). This is because the importance of information sharing has increased between ports and shipping companies owing to the digitalization and platform creation of ports. The *t*-test results for each ship's arrival/departure component are presented in Table 10.

5. Discussion

The results of the *t*-test by factors clearly clarified the change of importance in several seaport selection decisions. This means that request question 1 is acceptable and we need to review the next step that distinguishes which type of seaport selection factors have changed during

Ship arrival/departure component		No. of samples	Mean	Standard deviation	*t*-value	*p*> |t|	Acceptance
Ship arrival/departure frequency and route diversity	Previous studies	121	3.876	0.781	3.587	0.000	o
	This study	133	4.203	0.672			
Time in port and waiting time of ships	Previous studies	121	4.392	0.610	0.275	0.783	x
	This study	133	4.414	0.653			
Ship arrival/departure information system (VTS, etc.)	Previous studies	121	3.711	0.747	4.094	0.000	o
	This study	133	4.083	0.697			

Source(s): Authors' own work based on survey results

Table 10. *t*-test results of each ship's arrival/departure component

the period. These results support the discovery of Kim *et al.* (2005), pointing out the change in the importance of the port selection factors over the course of time.

As an answer to the research question 2, all internal factors (port facilities, port tariff, port service, ship arrival/departure) of the port selection of container shipping companies showed statistically significant differences between Study 1 and Study 2. On the contrary, all external factors (geopolitical location, scale of hinterland economy, social conditions and hinterland connection) showed no major discrepancy between studies 1 and 2. These results imply that the affairs taking place between 2005 and 2021 affected the importance of the internal factors. In other words, as observed by Caruana *et al.* (2015), we have found the degree of change over time by accepting longitudinal methods.

The results of the *t*-test by the components of internal factors (port facilities, port tariff, port service, ship arrival/departure), as a discussion of the research question 3, indicate an important gap between Study 1 and Study 2. Most of the components reveal the change of importance. Especially, the importance of all components of port facilities (berth length and the number of berths, shed and terminal area, possession of adequate equipment and maximum berth size) is only advanced out of the internal factors. That indicates that port facilities have gained prominence because they are required to accommodate large ships, given the recent growth in ship sizes. This result is unsurprising because some researchers recently highlighted port facilities' importance (Kavirathna *et al.*, 2018; Khalid and Al-Mamery, 2019); for instance, Tchang (2020) noted that larger ships need stronger quays, more solid mooring facilities and deeper channels. In addition, this result is consistent with the findings of Baştuğ *et al.* (2022) regarding the importance of port infrastructure and facilities for competitiveness. Therefore, ports must review policy measures that improve cargo handling productivity, such as reinforcing adequate cargo handling equipment, securing a wide hinterland site and obtaining sufficient berth length and the number of berths.

Notably, while ship and cargo safety turned out to be the most important items of port service in Study 1, the speed and flexibility of cargo handling, berthing schedule and reliability of cargo handling became predominant in Study 2. There was insufficient tonnage due to the sudden growth in cargo volume with the prevailing contact-free social trend of the shipping and logistics market, along with the tonnage adjustment by shipping companies during the initial stage of COVID-19 in 2020 (Notteboom *et al.*, 2021; Gavalas *et al.*, 2022). According to Sea-Intelligence, global schedule reliability has been decreasing since 2020, whereas the global average delay for late vessel arrivals is increasing. This result seems to support Russell *et al.* (2022) in their emphasis on the importance of infrastructure flexibility for efficient port operations. Accordingly, shipping companies consider port flexibility and reliability important in port selection, and ports must attract shipping companies by establishing development policies and operating plans, such as establishing terminal facilities, reinforcing cargo handling equipment, building an efficient port operating system and securing a wide hinterland site.

Finally, the ship arrival/departure frequency, route diversity and ship arrival/departure information systems (e.g. VTS) have become more important in port selection by shipping companies. Currently, shipping companies compete by forming alliances in the global shipping market, indicating that they consider it vital to secure stable routes and cargo volumes by obtaining route diversity through the alliance (Chen *et al.*, 2022). Global shipping companies are expected to continue M&As and alliance reorganization to secure routes and cargo volumes. This implies that policy measures must be taken for ports and shipping companies to share ship arrival/departure information, with the digitalization and platform creation of ports to optimize port operations and enhance efficiency. Moreover, this research supports Paik and Gharehgozli's (2022) investigation of the importance of information systems related to port operations from the perspective of shipping companies.

6. Conclusions

This study empirically compares the results of the evaluation of the importance given to port selection factors and their components, as presented in Study 1 conducted in 2005. There has been insufficient research on port selection factors since 2020 when COVID-19 occurred, and this study has academic significance in organizing the changes in the importance of port selection factors in the 2020s. Moreover, previous studies were cross-sectional studies of the same period (Wiegmans *et al.*, 2008; Kavirathna *et al.*, 2018; Onwuegbuchunam, 2013; Lirn *et al.*, 2004; De Langen, 2007; Zarei, 2015; Wang and Yeo, 2019; Chang *et al.*, 2008), failing to identify changes in the importance of the same port selection factors over time. Therefore, this study can be differentiated from previous studies as it was a longitudinal study on the importance of port selection from 2005 to 2021 during the COVID-19 pandemic.

This study may provide various policy implications for port operators, developers and managers. The results increase awareness of the importance of longitudinal studies as theoretical contributions for seaport selection. Studies related to seaport selection typically have focused on cross-sectional analysis, which cannot account for the impact of time, and we found no studies in the literature that filled this gap. This study contributes to filling this gap by estimating longitudinal changes in the importance of seaport selection factors over the 2005–2021 period. To the best of our knowledge, this research is the first exploration of longitudinal changes in the importance of seaport selection factors. The results support Kim *et al.* (2005), who argued that the importance of selection factors may change depending on time and environment.

Furthermore, the study findings can aid managers and policymakers in devising strategies to secure container throughput from shipping companies. Port operators must be sensitive to the changes in the maritime industry to enhance port competitiveness.

Although this study verifies the changes in the importance of key port selection factors in the 2020s, it is limited in that it does not reflect new factors such as port automation, which have recently occurred in ports. However, since shipping companies consider such new factors while selecting ports, further research must comprehensively consider additional factors in port selection that have not been covered in this study to deal with the constantly changing logistics environment. Moreover, for a better understanding of the impact of port selection on other variables (e.g. customer satisfaction or loyalty), conducting structural equation modeling is needed to analyze the relationship in the future.

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Appendix
Questionnaire items

		Very important	Important	Neural	Not important	Not important at all
Port facilities	Berth length and the number of berths	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Shed and terminal areas	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Possession of adequate equipment (G/C, T/C, S/C, etc.)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Maximum berth size	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
Port tariff	Ship and cargo arrival/departure costs	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Loading-unloading/ transfer/storage costs	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Inland transport costs	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Incentives and discount system	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
Port service	Ship and cargo safety	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Speed and flexibility of cargo handling	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Berthing schedule and reliability of cargo handling	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Subsidiary services such as water, oil and supplies for ships	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
Ship arrival/ departure	Ship arrival/departure frequency and route diversity	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Time in port and waiting time of ships	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Ship arrival/departure information system (VTS, etc.)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
Geopolitical location	Voyage and marine transport distance	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Location on the main line	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Port and route accessibility	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Distance and accessibility to the place with main cargo	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)

(*continued*)

Table A1.
The following are detailed factors on seaport selection criteria in questionnaires. The respondents were asked to reveal the level of importance on each item

		Very important	Important	Neural	Not important	Not important at all
The scale of the hinterland economy	Handled and generated cargo volume	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Economic scale of the hinterland city	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Port hinterland and FTZ size, utilization level	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Trade size among nations	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
Social conditions	Port labor and labor management safety	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Political safety	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Change in port and social environment	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
Hinterland connection	Connectivity to the inland transport network	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Connectivity to the hinterland city	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)
	Diversity of transport modes (road, railway, canal, aviation, etc.)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)	(. . .. . .)

Table A1.

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