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The dynamics of port competition and efficiency in Vietnam amidst COVID-19: a decadal analysis

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Abstract: Vietnamese seaports play an important role as crossroads for import, export and transformation in delivery from maritime transport to rail, road and inland waterway transport. Over the last two decades, the seaport system has been reformed with the participation of private and foreign investors. Consequently, this issue enhances competition between seaports and brings changes to the seaports' operations. In this article, the relationship between seaport competition and efficiency is examined in the context of Vietnam, an emerging market economy. The longitudinal data from 2011 to 2022 is collected to quantify the competition degree of Vietnamese seaports and Data Envelopment Analysis is used to measure seaport efficiency. A number of measures are used to quantify the competition level of the seaport system over time, including concentration ratio, Gini index, and Hirschman-Herfindahl Index. Besides, market share at both national and regional levels and distance to the nearest competing seaport are criteria of port-level competition. The results advocate an increasing trend of seaport competition in Vietnam. Moreover, based on Tobit regression models, the competition among seaports relates positively to efficiency using both the 2021-2022 and 2015-2016 data sets. Under the COVID-19 pandemic, the impact of external factors on seaport efficiency is insignificant and inconsistent due to the disruption of logistics systems and disrupted links to the outside environment.

1 Introduction

The world has witnessed a rapid growth of international trade in goods over the last 15 years [1]. The commodity export in emerging countries has been almost doubled in spite of the global financial crisis since 2008 as a result of the globalisation of trade and increasing global production process. While more than 90% of the world's cargo is transported by ships [2], the development of seaport systems in emerging countries contributes significantly to the growth of export-import volume. For export-led and non-landlocked countries such as China and Vietnam, seaports are playing a role as transport hubs and contribute substantially in logistics supply chain operations [3].

In the context of the globalisation of production and logistics systems, substantial changes in cargo transportation forms and technological breakthroughs, in many countries the state-controlled port governance models were ended. Port reforms have been launched by governments in order to transform their port systems and adapt a new context and changing structures [4]. The contents of port reforms include a reduction of public roles, ownership structuring, and enhancement of the port quality and performance. As a result, the devolution of public sector from port operation and management has led to the increasing participation of the domestically private and foreign sectors. Depending on the roles taken by the private sector, there are five models of port governance [5], including public service ports, tool ports, landlord ports, corporatised ports and private service ports. While public service ports are totally operated and owned by the public sector, the private service ports are run by their corporation and individual investors. However, the dominate models include landlord ports and corporatised ports that support the major ownership of the states.

The participation of private investors leads to increasing competition between ports. Port competition can be unfolded at three levels [6,7]. At the first level, intra-competition occurs between terminal operators within a given port. The competition arena includes traffic routings, shippers and shipping lines. At the second level, terminal operators have to account for competition with terminal operators in other ports. The "inter-port competition" term can be displayed out at national and regional levels. At the highest level, inter-port competition can take place between terminal operators operating at different port ranges. A port range is defined as a geographical area with several ports that possess largely overlapping hinterlands and thus serve mostly the same customers.

Competition can turn ports into focal points for collection of cargo and distribution of hinterlands. On the other hand, ports extend their boundaries and deal with problems of the whole logistics chain. Furthermore, port competition generates efficiency gain for the comparative and competitive advantages of their hinterlands. In particular, modern ports with supports from competitive and reliable transport services can raise econo-socio benefits of the port community and transport users [8].

The competition among ports brings about considerable impact [9]. Increasing competition can change the transport hubs and widen the geographical range of hinterland. Yap, Lam and Notteboom [8] find that competition among East Asia ports increased as the cargo hubs shifted to mainland China. Port competition also has impacts on port performance and government policies. The participation of foreign and local investors in port infrastructure development results in better port performance. In terms of strategic decisions, competition makes traditional business models unviable in landlord ports [10]. While competition has been mentioned widely in the literature, the impact of competition on port efficiency, especially detailed and in-depth empirical research, are scarce. Many studies point out the importance of port efficiency to port competitiveness in particular, and to regional and national competitiveness in general. Thus, investigating the impact of competition on port efficiency is greatly significant in the increasing port competition context.

On the one hand, the impact of competition on port efficiency is diverse due to various factors, including market changes, hinterland influences, port strategies and management practices, etc. [11]. On the other hand, this relationship is different in the perspectives of specific countries or regions, resulting in inconsistent findings. Consequently, this limitation can be addressed by in-depth empirical studies on the impact of competition on the essence of port efficiency.

In Vietnam, seaports are playing a very important role as the hub of national transportation system when 90% of the country ‘s export-import cargoes is transported through its seaports. Moreover, seaport tariff contributes to 20% of national budget revenues. In the last two decades, the seaport system has undergone a substantial change in the ownership structures through a corporatisation process [12]. A number of state-owned enterprises were established to operate Vietnamese seaports. Overseas or domestic private investors can take part in port operations via venturing, acquiring or being minor shareholders of corporate seaports. As a result, ports can be owned and operated by public, private, foreign investors, and local/central government. Profit-based objectives of port corporations have fostered competition. In the aftermath of the WTO entry from 2007, a significant increase of FDI capital results in a surge of international trade mainly through the country’s seaport system [13]. Besides, provision of port services is a profitable business and attracts many potential investors. Port operators have invested heavily in berth construction, warehouse and handling equipment. These investments have raised considerable competitive advantages for the ports. In addition, issuance of Maritime Law in 2015, Law of Sea in 2012 and Master Plan for Seaport Development in 2021 have paved the way for developing Vietnamese seaports. Vietnam's seaport system currently has 286 ports, distributed in 5 groups of seaports, with a total length of more than 96 km, and infrastructure to meet the throughput of more than 733 million MT in 2022 [14]. Established gateway ports combining with international transshipment in the North and the South has received container ships up to 132,000 DWT at Lach Huyen Wharf (Hai Phong), up to 214,000 DWT at Cai Mep Wharf (Ba Ria - Vung Tau).

The investments in seaport infrastructures and reform of ownership and governance have fostered competition. However, Vietnamese seaports have competed among others mainly through port service prices. Three rationales are behind this fact. First, the seaport system is moderately fragmented, including many small ports. For example, the port cluster in Haiphong city, the biggest cluster in the North of Vietnam, includes 60 ports operating along 10 km of Cam riverbank and they are operated by many port operators (Vinalines, New Port, Gemadept, Haiphong port corporation, Viconship…). With many port operators and short distance between ports have led to substantial competition through decreasing port service price. The same curriculum occurs in the South and the Central of Vietnam. Second, no significant difference of services providing to customers also intensifies the competition between ports. Last, port industry has hard barriers to exit. Due to the specification of seaports, their fixed assets and infrastructures cannot be moved to other places or reused by other industries. In the context of Vietnam, some may consider whether increasing competition can result in better performance of the seaport system.

This paper aims to investigate the seaport competition – efficiency relation in Vietnam. To measure seaport competition, this study uses several indexes including Hirschman-Herfindahl Index, Gini index and concentration ratio, with longitudinal data covering the 2011-2022 period. Port efficiency is estimated by Data Envelopment Analysis with the data of 44 seaports over the 2021-2022 period. The Tobit models are used to regress port competition on efficiency. Contributions of our research are twofold. First, this study is unique that investigates the impact of competition on seaports’ performance in an open, small and emerging market economy. Second, this is the first time that seaport efficiency is measured and analysed between pre- and during-COVID-19 periods.

The rest of this study is organised as follows. Section 2 presents the methods utilised to measure port competition and port efficiency. Section 3 provides details on inputs, outputs and environmental variables. Empirical analysis is included in Section 4 while concluding remarks are provided in Section 5.

2 Methodology

In this section, a number of competition measures and measures to port efficiency are presented.

2.1 Measures of port competition

(1) Market share

The market share of port i at time t (MS_{it}) (1) can be described as the ratio between the throughput volume of port i at time t (V_{it}) and the total throughput volume of the port system at time t ($\sum_{i=1}^{n} V_{it}$).

$$MS_{it} = \frac{V_{it}}{\sum_{i=1}^{n} V_{it}} \quad (1)$$

Due to the Vietnamese long coast from the North to the South, the country can be divided into three regions, including the southern, central and northern region [15]. Hence, market share at both national and regional level are included to present the competition degree. A port owned a higher proportion of market share is expected to have better contestability.

The market share of port i at time t of the region r can be identified as below (MS_{itr}) (2):

$$MS_{itr} = \frac{V_{itr}}{\sum_{i=1}^{m} V_{itr}} \quad (2)$$

where V_{itr} is the throughput volume of port i at time t of the region r and the total throughput of the region r at the time t is $\sum_{i=1}^{m} V_{itr}$.

(2) Concentration ratio (CR_K)

Concentration ratios reflect the level of competition within an industry and higher ratio value means more market entry barriers for new investors [16]. The CR_{Kt} (3) is presented for the market share of the K biggest ports in terms of throughput volume at the time t.

$$CR_{Kt} = \frac{\sum_{j=1}^{K} V_{jt}}{\sum_{i=1}^{n} V_{it}} \quad (3)$$

In this paper, K takes two values, including 4 and 8. The concentration ratio varies between 0 and 1.

(3) Gini index

Gini index can be defined as be low (4):

$$G_t = \frac{n-1}{n} - \frac{2\sum_{i=1}^{n}(n+1-i).X_{it}}{n.\sum_{i=1}^{n} X_{it}} \quad (4)$$

where X_{it} is the cumulative market share of the throughput volume of the port i at the time t in the condition that the throughput volume is sorted in increasing order. The Gini index's value ranges from 0 (perfect equality) to 1 (perfect inequality), reaching 1 when the market is dominated by only one port and is 'fully concentrated', and reaching 0 when there is no inequality between the throughput volumes at the respective ports. The higher value of Gini index demonstrates a lower level of equality among ports.

(4) Hirschman-Herfindahl Index (HHI)

The HHI (5) is calculated by summing the squared market share of all the ports in the port system.

$$HHI_t = \sum_{i=1}^{n} \left(\frac{V_{it}}{\sum_{i=1}^{n} V_{it}} \right)^2 \quad (5)$$

The HHI is among the best tools for determining the degree of concentration. The HHI ranges from 1/n to 1. In general, a HHI between 0.15 and 0.25 indicates moderate concentration, while above 0.25 indicates high concentration [17]. If the port system includes only one port, the HHI attains maximum value of 1. On the other hand, if the throughput of each of the ports in a given system is the same, then the HHI equals its minimum value of 1/n.

Above concentration-based measures do not take into account cross ownership where a firm owns shares in a competitor or common ownership where two rivals have shares in common. This type of ownership may reduce the incentives to compete for what seems independent firms.

2.2 Estimating port efficiency

Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) are the two dominating methods in measuring port efficiency [18]. DEA is a non-parametric linear programming approach. One of DEA's advantages is that it does not require any assumptions on the firm's production technology. However, DEA methods have difficulties in testing hypotheses, a problem which can be solved when using a stochastic approach. In SFA methods, the form of a cost or production function is assumed in an ad hoc manner and estimated with a two-part composite error term.

In this study, two-stage DEA is applied to measure and analyse the possible factors influencing seaport efficiency. At the first stage, DEA is used to measure port efficiency. When the inefficiency scores are estimated, they will be regressed again a set of environmental variables at the second stage. Under the assumption of free disposability of inputs and outputs, and variable returns to scale, the DEA estimate of the production set can be defined as (6):

$$\widehat{\wp} = \left\{ \begin{array}{c} (x,y) \in \mathbb{R}_+^p \times \mathbb{R}_+^q : \sum_{k=1}^{n} z_k y_k^i \geq y^i, i = \\ 1,\dots,q;\ \sum_{k=1}^{n} z_k x_k^j \leq x^j, j = \\ 1,\dots,p;\ \sum_{k=1}^{n} z_k = 1, z_k \geq 0 \end{array} \right\}, \quad (6)$$

where $x \in \mathbb{R}_+^p$ denotes a (1×p) vector of inputs and $y \in \mathbb{R}_+^q$ denotes a (1×q) vector of outputs. y_k^i is the quantity of output *i* of unit *k*. x_k^i is the quantity of input *i* of unit *k*. z_k is the respective weight of unit *k*. *n* is the total number of units.

Due to the fact that some inputs of seaports such as berth length or terminal area are quasi-fixed and cannot adjust for a better performance, assumption of output-orientation is applied in our DEA models [19]. The DEA output-oriented estimator of δ for variable returns to scale production can be written as (7):

$$\hat{\delta} = \delta(x, y \in \hat{\wp}) = max \begin{Bmatrix} \delta > 0: \sum_{k=1}^{n} z_k y_k^i \geq \delta y^i, i = \\ 1, \dots, q;\ \sum_{k=1}^{n} z_k x_k^j \leq x^j, j = \\ 1, \dots, p;\ \sum_{k=1}^{n} z_k = 1, z_k \geq 0 \end{Bmatrix}. \quad (7)$$

To investigate the impact of environmental variables on port efficiency, the Tobit regression model is utilised in this research at the second stage. Tobit is a widely used method to model the DEA (in)efficiency scores against exogenous factors, which is suitable when the dependent variables are either censored or corner solution outcomes [20]. In this paper, the dependent variable is output-oriented inefficiency scores, which is larger or equal to one at least. The higher score value indicates a lower level of efficiency and a seaport is considered to be efficient if its score is one.

3 Data

Input and output variables

The production process of ports demands capital, land and labour resources as inputs to produce outputs [21]. Capital is an important input of ports but also the most difficult to measure. The common monetary proxies of capital can be book value of assets or depreciation [22]. On the other hand, capital can be proxied by physical assets such as the total length of berths, number of berths, number of cranes or total number of pieces of equipment [23]. Land resource used by seaports is quantified by the size of terminal area or the size of warehouse area [24]. Labour resource is difficult to identify as port authority labour is often outsourced. Due to the fact that port industry is highly capital-intensive, port operators tend to substitute away from labour towards more mechanized or automated technology. The labour input is proxied by the number of port authority employees, or expenditure on salaries. In this research and based on the availability of data, four inputs is chosen including total berth length (BL), terminal area (TA), warehouse area (WA) and total pieces of equipment (Eq).

Regarding output variables, the most important output measure is the amount of cargo handled at the seaports [25]. Due to the multi-product nature of port production, a number of output variables can be utilised, including the volume of containers (in TEUs or MT), bulk cargo (in MT), general and rolling freight (in MT) [26]. Some studies use monetary measures including total revenue or net income as alternatives of port output [27]. Qualitative measure of output is also considered and can be obtained via user satisfactory survey [28].

While the above mentioned outputs of seaports are desirable, authorities and local communities also consider CO_2 emission from port operations. These negative externalities should be accounted as undesirable or bad outputs [29]. In the case of the Vietnamese port sector, most of seaports are multi-purpose ports, and only data for total cargo throughput is provided for all the ports. Thus, annual total throughput is chosen as the unique output of our DEA models.

Environmental variables

This research aims to examine the impact of inter-port competition on Vietnamese seaport efficiency. There are several measures for port competition. The distance to the nearest seaport is used for the proxy of inter-port competition [30]. Oliveira and Cariou [31] use HHI concentration index and market share to quantify the competition degree of container terminals. Adler et al. [28] develop a competition measure based on distance to and size of competing ports. In this study, market share is utilised as proxy of Vietnamese seaport competition. This proxy is measured at national and regional level. Furthermore, the distance to the nearest competing seaport is another proxy for port competition in Vietnam. It is assumed that the competitive pressure to a seaport is harder if the distance to the nearest seaport is shorter. Consequently, the seaport must operate efficiently to increase its competitiveness compared with its neighbouring seaports.

Over the last two decades, many Vietnamese seaports have transformed their ownership structures from being totally owned by SOEs or government to corporations, in which domestically private and foreign investors can take part. To assess the impact of this process, the OWN dummy is included in the regression models, taking the value of one if the seaport is a corporation and zero if they are wholly SOEs or managed by governments.

Due to the different economic-social conditions among three Vietnamese regions, the location of seaport is an important factor influencing port efficiency and competition. The geographical character of seaports is proxied by two dummies. The dummy variables GS and GC are used for seaports located in the South and Central respectively, whereas seaports in the North are treated as the base group.

The increasing trend of exporting manufactured goods stimulates containerisation of Vietnamese logistics system. As a result, the impact of containerisation on Vietnamese seaport operation should be assessed. The environmental variable CNS is a dummy variable representing the operational setting of the port, i.e. whether it handles container cargo and ships or not. CNS is equal to one if seaports serve container ships and zero for others.

The data of 44 Vietnamese seaports in the 2021-2022 period has collected from the website of Vietnam Seaports

Association (www.vpa.org.vn). Table 1 provides descriptive statistics on inputs, output and environmental variables. Table 2 describes the correlation between environmental variables utilised in regression models.

Table 1 Inputs, output and environmental variables

Variables	Description	Unit	Min	Max	Mean	St. dev.
Output						
Throughput (O)	Annual total throughput	MT	21,931	30,424,620	5,268,133	6,659,365
Inputs						
Berth length (BL)	Total berth length in meter	Meter	104	3,213	598	532
Terminal area (TA)	Total terminal area in square meter	m2	1,200	796,979	143,872	151,030
Warehouse area (WA)	Total warehouse area in square meter	m2	900	50,000	12,826	12,927
Equipment (Eq)	Total number of cranes, tractors, trucks	Number	5	312	48	53
Environmental variables						
South location (GS)	Dummy variable for seaports locating in the southern area of Vietnam	1 or 0	0	1	0.3409	0.4740
Central location (GC)	Dummy variable for seaports locating in the central area of Vietnam	1 or 0	0	1	0.3750	0.4841
Container serving (CNS)	Dummy variable for seaports serving container lines	1 or 0	0	1	0.5682	0.4953
Ownership (OWN)	Dummy variable for seaports operating under the corporation model	1 or 0	0	1	0.7386	0.4394
National market share (NMS)	The proportion of the national total throughput is penetrated by a seaport.	Percentage	0.0001	0.0854	0.0144	0.0185
Regional market share (RMS)	The proportion of the regional total throughput is penetrated by a seaport. There are three regions, including the northern, central and southern region.	Percentage	0.0002	0.3149	0.0519	0.0687
Distance to the nearest seaport (D)	Measured in km from a seaport to its nearest rival.	km	1	130	32	40

Table 2 Correlation matrix of the environmental variables

	GC	GS	OWN	CNS	NMS	RMS	LogD
GC	1						
GS	-0.5571	1					
OWN	-0.5543	0.4278	1				
CNS	-0.1777	0.143	0.2124	1			
NMS	-0.3032	0.1507	0.2068	0.4602	1		
RMS	0.0435	-0.2293	-0.0033	0.4423	0.7881	1	
LogD	0.5406	-0.4354	-0.5392	-0.2376	-0.3767	-0.0956	1

Notes: GS: Southern area location; GC: Central area location; CNS: serving container ships; OWN: Ownership; NMS: market share at national level; RMS: market share at regional level; LogD: logarithm 10 form of the distance to the nearest port.

4 Empirical analysis

4.1 A longitudinal analysis of Vietnamese seaport competition

The 2011-2022 period has witnessed a significant increase of total cargo throughput in the Vietnam's seaport system. In 2011, the total throughput is about 157 million MT and this figure has been tripled in a decade when reaching 397.5 million MT in 2020. However, due to the impact of COVID-19 pandemic and disruption of global logistics system, the cargo throughput has slightly decreased to 356 million MT in 2021 and 369 million MT in 2022 (see Figure 1).

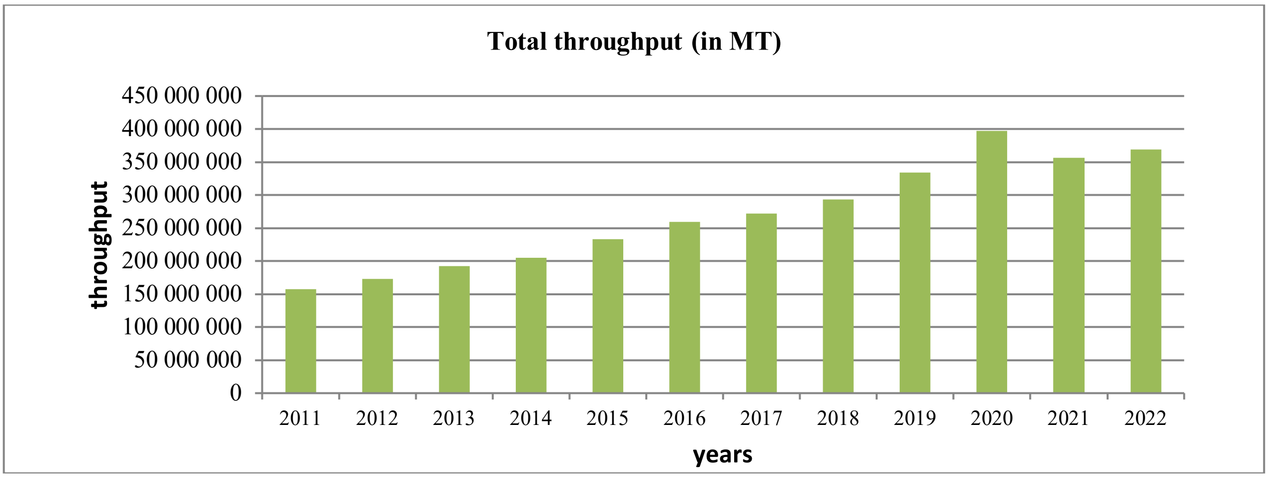

Figure 1 Annual total throughput of Vietnamese seaports from 2011 to 2022
Source: Vietnam Seaports Association

To quantity the degree of competition of Vietnamese seaport system, three measures of competition are utilised in this study, including Hirschman-Herfindahl Index (HHI), Gini index and two types of concentration ratio (CR_4 and CR_8). According to Notteboom, Ducruet and De Langen [17], if the HHI varies between 0.15 and 0.25 indicating moderate concentration, and the indexes with above 0.25 values indicates high concentration. The HHI is under 0.1 in the context of Vietnam, thus this result suggests a competitive and dispersed seaport market. The linear curve of HHI does not show a decreasing or increasing trend (see Figure 2). In contrast, the Gini index shows an increasing trend of competition in Vietnamese seaport system and this index has grown from around 0.6 in 2011 to about 0.7 in 2022 (see Table 3). Both two concentration ratios (CR_4 and CR_8) have decreased during the 2011-2022 period, indicating the lower level of seaport concentration or a higher level of competition. The CR_4 fluctuates between 0.43 and 0.47 during the 2011-2022 period and implies a low concentration level, following the standards suggested by Notteboom [32]. The mentioned standards reveal a competitive seaport market if the CR_4 is under 0.4, and a highly concentrated market if this measure is above 0.7. In general, an increasing trend of Vietnamese seaport competition can be observed via the empirical results of this research. This finding is in line with Pham et al. [33] when they point out a deconcentration trend of container terminals in Northern Vietnam.

Table 3 Measures of Vietnamese seaport competition from 2011 to 2022

Year	Herfindahl - Hirschman Index	Gini coefficient	CR4	CR8
2011	0.0697	0.6064	0.4655	0.6035
2012	0.0787	0.5973	0.4743	0.6131
2013	0.0865	0.5976	0.4696	0.6087
2014	0.0775	0.6082	0.4286	0.5656
2015	0.0764	0.6238	0.4290	0.5665
2016	0.0828	0.6497	0.4381	0.5856
2017	0.0875	0.6535	0.4474	0.5895
2018	0.0846	0.6396	0.4468	0.5701
2019	0.0814	0.6386	0.4443	0.5629
2020	0.0773	0.6589	0.4683	0.5880
2021	0.0781	0.6549	0.4311	0.5545
2022	0.0757	0.6856	0.4299	0.5546

(Source: Authors' calculations)

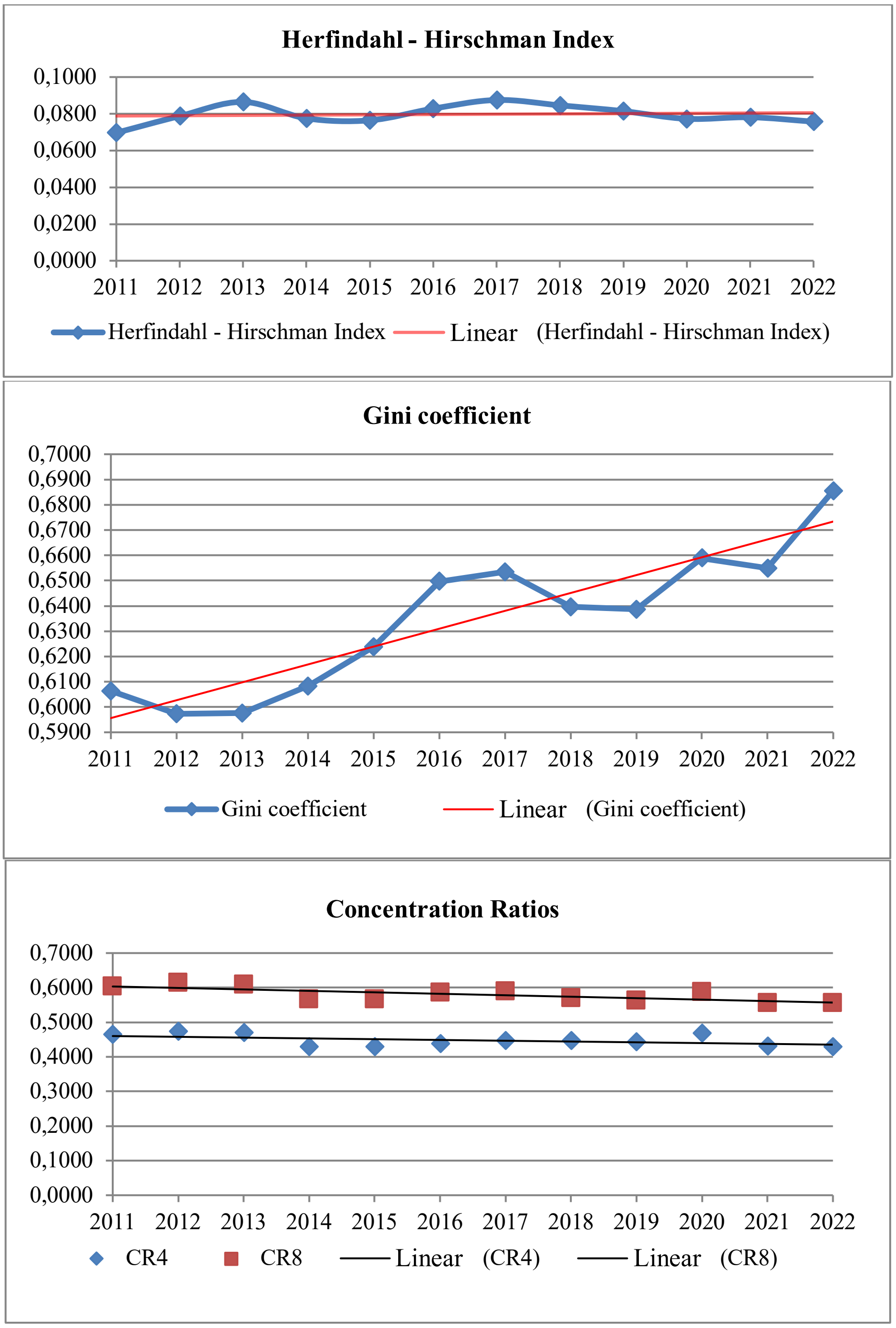

Figure 2 Measures of seaport competition in Vietnam

4.2 Estimating seaport efficiency

Estimates of Vietnamese seaport efficiency is presented in Table 4. The range of inefficiency scores is between 2.5 and 3.9, indicating that port operators can extend their output from 2.5 to 3.9 times to achieve the optimal level. Southern seaports having the highest inefficiency scores are the least efficient when compared to their competitors in the central and the north of Vietnam.

Table 4 Estimates of Vietnamese seaport efficiency using output-oriented DEA

Year	Northern seaports	Central seaports	Southern seaports	All seaports
2021	2.5674	3.5421	3.9377	3.4081
2022	3.1521	3.2888	3.5989	3.3527

4.3 The impact of competition on seaport efficiency in Vietnam

Table 5 demonstrates regression results on the impact of environmental variables on seaport efficiency with the data of Vietnamese seaports over the years 2021-2022. All models show that a higher level of market penetration leads to a lower inefficiency score or a better efficiency performance of Vietnamese seaports using both national and regional market share as proxies of competition. Accordingly, seaports with higher degree of competition can operate more efficiently when generating more output with a given level of inputs in a comparison with other rivals. Oliveira and Cariou [31] also found a positive relation between market share and port efficiency when using the data of international container terminals.

The results also point that the location of seaports is not important in determining seaport efficiency. The coefficients of GC and GS variable are insignificant in all different models. Moreover, the coefficient of OWN variable is insignificant, indicating that owning to a corporate or a government body does not make changes to the performance of seaports. The outcomes relating to CNS variable reveals an inconsistent impact of container service provision on seaport efficiency. While models 1 and 4 show a negative and significant impact of CNS, models 5 and 8 provide insignificant results.

It is worth to note that the results presented in Table 5 is based on the data of the 2021-2022 period. Consequently, the COVID-19 pandemic can distort the results when the supply chain is disrupted and the operation of seaports is influenced by the pandemic. To eliminate the possible impact of COVID-19 on the seaport competition – efficiency relationship, the data of Vietnamese seaports between 2015 and 2016 (the data of Vietnamese seaports between 2015 – 2016 is chosen due to its availability) was used in the paper (see Subsection 4.4).

Table 5 Tobit regression results on the impact of competition on Vietnamese seaport efficiency using the 2021-2022 data

	Competition at national level				Competition at regional level			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Intercept	3.491842***	4.345569***	3.527112***	3.770339***	3.095387***	3.897906***	3.723422***	3.647804***
	(.9671533)	(.6781914)	(.6266528)	(.4817341)	(1.019437)	(.7066052)	(.688728)	(.5039701)
GC	-.3492276	-.5410136			.5403358	.2299541		
	(.8514633)	(.7990061)			(.8798798)	(.8152777)		
GS	.4746387	.6869272			-.2328084	.0903776		
	(.7916445)	(.7907802)			(.8756124)	(.8571717)		
OWN	.550408		1.123657		.5892393		.3957192	
	(.8451623)		(.7211491)		(.8980055)		(.7441298)	
CNS	1.175607*			1.319926*	.9637398			.9101956
	(.7028189)			(.7071907)	(.7625448)			(.7279153)
NMS	-104.5891***	-88.80059***	-87.74217***	-99.726***				
	(20.53404)	(18.59801)	(18.21191)	(20.23346)				
RMS					-20.9711***	-17.3714***	-17.38379***	-20.26743***
					(5.522699)	(4.894584)	4.730448	(5.218391)
No of Ports	44	44	44	44	44	44	44	44
Observations	88	88	88	88	88	88	88	88
LR χ^2	25.27	21.77	21.56	22.60	14.73	12.50	21.56	13.97
Pro>χ^2	0.0001	0.0001	0.0000	0.0000	0.0116	0.0059	0.0000	0.0009
Log likelihood	-195.25571	-197.00521	-197.11119	-196.58977	-200.52399	-201.64076	-197.11119	-200.90546
Pseudo R^2	0.0608	0.0524	0.0518	0.0544	0.0354	0.0301	0.0518	0.0336

Notes: GS: Southern area location; GC: Central area location; CNS: serving container ships; OWN: Ownership; NMS: market share at national level; RMS: market share at regional level. The coefficients with * and *** are significant at 10 and 1 percent, respectively. Standard errors are included in parentheses.

Table 6 provides Tobit regression models on the relation between the distance to the nearest seaport and efficiency. Using the data in the pre-COVID-19 period (2015-2016) and COVID-19 period (2021-2022), the findings show that the distance to the nearest seaport relates negatively to the seaport efficiency. Thus, the seaport with a shorter distance to the nearest port and facing more competitive forces possesses a higher level of efficiency. This finding is also in line with Yuen, Zhang and Cheung [30] when they find that the inter-port competition as proxied by the distance to the nearest port has a positive impact on the efficiency of Chinese container terminals. The variables indicating seaport location (GS, GC) and ownership (OWN) are insignificant. The CNS variable is significant in models 1 and 4, demonstrating a positive relation between container service provision and seaport efficiency.

Table 6 Tobit regression results on the impact of competition on Vietnamese seaport efficiency with the distance to the nearest seaport variable

	2015-2016				2021-2022 (under COVID-19 impact)			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Intercept	1.730233*	.6373331	1.412006*	1.831922**	.3284799	1.113903	.7718357	2.421013***
	(.8884652)	(.7073094)	(.8425226)	(.7428049)	(1.398771)	(.9513935)	(1.304851)	(.923741)
GC	.4330764	1.236196			-1.74427	-1.939886		
	(1.141743)	(1.15071)			(1.419763)	(1.412929)		
GS	.72245	.7626338			.5828419	.7340653		
	(.8102989)	(.8410144)			(.8802677)	(.8692992)		
OWN	-.1720162		-.83825		.9498761		1.343519	
	(.6853605)		(.6499916)		(.9603989)		(.9389326)	
CNS	-1.552313**			-1.559867***	-.1767619			-.1188945
	(.6666371)			(.5871411)	(.7125713)			(.7327407)
LogD	1.511993**	1.487716**	1.761753***	1.705618***	2.338564**	2.193207**	1.182603*	.6560174
	(.6855239)	(.6991718)	(.4883697)	(.4422821)	(1.038698)	(1.015664)	(.6588138)	(.5803379)
No of Ports	41	41	41	41	44	44	44	44
Observations	82	82	82	82	88	88	88	88
LR χ^2	26.66	20.09	20.51	25.68	6.34	5.34	3.44	1.45
Pro>χ^2	0.0001	0.0002	0.0000	0.0000	0.2749	0.1483	0.1786	0.4845
Log likelihood	-175.61413	-178.90014	-178.68939	-176.10558	-204.72197	-205.21842	-206.16744	-207.16529
Pseudo R^2	0.0706	0.0532	0.0543	0.0680	0.0152	0.0129	0.0083	0.0035

Notes: GS: Southern area location; GC: Central area location; CNS: serving container ships; OWN: Ownership; LogD: logarithm 10 form of the distance to the nearest port. The coefficients with *, ** and *** are significant at 10, 5 and 1 percent, respectively. Standard errors are included in parentheses.

4.4 Robustness analysis

*** COVID-19 impact**

To exclude the possible impact of COVID-19 pandemic on the relationship between seaport competition and efficiency, the data of Vietnamese seaport system in the 2015-2016 period is employed. Table 7 provides regression results and they again support a positive relation between seaport efficiency and competition. The coefficients of national and regional market share are significant. Other variables including GS, GC, and CNS relate to seaport efficiency. The coefficients of GS and GC are positive and significant and this result indicates an impact of geographical location on seaport performance. Specifically, the northern seaports are more efficient than their counterparts in the southern and central regions of Vietnam. Besides, the seaports serving container cargo are more efficient. A comparison of regression results based on the COVID-19 period data (2021-2022) and pre-COVID-19 period data (2015-2016) reveals that the impact of environmental factors can be changed in the context of COVID-19 pandemic. For example, seaports providing container services are more efficient in the pre-COVID-19 period (see Table 7) but they are less efficient in the COVID-19 period in a comparison with other seaports (see Table 5). Furthermore, geographical variables (GS, GC) and ownership (OWN) are significant in the pre-COVID period but they are insignificant in the COVID-19 period. The pandemic disrupted external links and forced port operators to conduct internal solutions on governance, operations and usage of inputs etc., to adapt with the new situation.

Table 7 Tobit regression results on the impact of competition on Vietnamese seaport efficiency using the 2015-2016 data

	Competition at national level				Competition at regional level			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Intercept	2.877933***	2.414741***	4.410217***	4.826678 ***	3.018323***	2.051379***	4.264588***	4.743954***
	(.731202)	(.5903089)	(.4126503)	(.4190193)	(.7438031)	(.5931552)	(.4066154)	(.4099356)
GC	2.586826***	2.888623***			2.087018***	2.744787***		
	(.7796546)	(.69916)			(.7825903)	(.7332053)		
GS	1.536023**	1.399261*			1.863897**	1.751137**		
	(.720336)	(.7183158)			(.7436855)	(.7479163)		
OWN	.5136508		-1.108422*		.3050046		-1.294344**	
	(.7098311)		(.6623631)		(.704762)		(.6509998)	
CNS	-1.346571**			-1.857677***	-1.796554***			-2.081349***
	(.6379366)			(.5847175)	(.6612211)			(.5768092)
NMS	-10.45095***	-10.45973***	-9.054386***	-9.707252***				
	(3.009804)	(2.761567)	(3.273983)	(2.904694)				
RMS					-21.36098***	-19.18033***	-17.81096**	-21.46776***
					(6.855164)	(6.647129)	(7.195512)	(6.396309)
No of Ports	41	41	41	41	41	41	41	41
Observations	82	82	82	82	82	82	82	82
LR χ^2	33.38	29.00	15.78	22.61	31.23	23.65	14.34	22.66
Pro>χ^2	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0008	0.0000

Log likelihood	-172.25596	-174.44712	-181.05414	-177.64045	-173.32988	-177.11896	-181.77622	-177.61705
Pseudo R^2	0.0883	0.0767	0.0418	0.0598	0.0826	0.0626	0.0379	0.0600

Notes: GS: Southern area location; GC: Central area location; CNS: serving container ships; OWN: Ownership; NMS: market share at national level; RMS: market share at regional level. The coefficients with *, ** and *** are significant at 10, 5 and 1 percent, respectively. Standard errors are included in parentheses.

*** Scale impact**

Some may wonder the rational of using market share as a proxy of competition. They argue that seaports with bigger size are more advantageous in competing with the others [34], and consequently have a larger market share. On the other hand, when having a larger size the port can utilise the scale effect and achieve a higher level of efficiency. Hence, port size is included in the models to investigate its possible impact on port efficiency. In this study, total berth length is used as a proxy of port size. Table 8 provides results on the relationship between port efficiency and port size with two data sets. Using the data of 2015-2016 period, a positive and significant relationship between port size and efficiency is recorded, while the results show no relation if the 2021-2022 data is used. The results show a different impact of port size when ports operate in the COVID-19 context.

Table 8 Tobit regression results on the impact of scale on Vietnamese seaport efficiency

	2015-2016				2021-2022 (under COVID-19 impact)			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Intercept	3.377061*** (.6598382)	2.280911*** (.6598382)	4.494009*** (.4458762)	5.042054*** (.4638999)	2.748701** (1.10303)	3.341933*** (.8000883)	3.28941*** (.7476718)	3.660315*** (.5893021)
GC	2.022192** (.8027142)	2.760294*** (.7513227)			.6136133 (.9427169)	.3206855 (.8697431)		
GS	1.559101** (.747316)	1.524966** (.7589981)			.5676554 (.9021091)	.7091928 (.8854958)		
OWN	.1029868 (.7100382)		-1.406195** (.6519162)		.7480463 (.9677855)		.6630465 (.8027142)	
CNS	-1.725276** (.674257)			-2.145455*** (.5833928)	.0735537 (.7840481)			.1946218 (.775974)
BL	-.0010342** (.0004144)	-.0009367** (.0004035)	-.0009142** (.0004295)	-.0011792*** (.0003897)	-.0011108 (.000721)	-.0010065 (.0006544)	-.0011353* (.0006575)	-.0011236 (.0007175)
No of Ports	41	41	41	41	44	44	44	44
Observations	82	82	82	82	88	88	88	88
LR χ^2	28.17	21.04	12.91	21.00	3.79	3.17	3.20	2.58
Pro>χ^2	0.0000	0.0001	0.0016	0.0000	0.5807	0.3668	0.2021	0.2751
Log likelihood	-174.86029	-178.42353	-182.49067	-178.44534	-205.99723	-206.30718	-206.29071	-206.59924
Pseudo R^2	0.0745	0.0557	0.0342	0.0556	0.0091	0.0076	0.0077	0.0062

Notes: GS: Southern area location; GC: Central area location; CNS: serving container ships; OWN: Ownership; BL: Berth length. The coefficients with *, ** and *** are significant at 10, 5 and 1 percent, respectively. Standard errors are included in parentheses.

5 Conclusion

This research examines the relationship between port competition and efficiency in Vietnam. The results find that port competition relates positively to port efficiency when the market share at both national and regional level and the distance to the nearest port are used as proxies for port competition. With the use of various measures of competition, an increasing trend of seaport competition is recorded over the 2011-2022 period.

To eliminate the possible impact of COVID-19 pandemic on the port competition-efficiency relation, the data of 2015-2016 period is employed and the results also support the positive impact of competition on Vietnamese seaport efficiency. Moreover, the scale effect on port efficiency is proven to be inconsistent; thus, this effect cannot substitute the impact of competition on seaports. The results show a change in the impact of environmental variables on seaport efficiency under the context of COVID-19. Specifically, while location of seaports, ownership and container service provision significantly impact seaport efficiency in the pre-COVID-19 period, they are insignificant in the COVID-19 period.

Based on the empirical evidence of this paper, a number of solutions are proposed to foster competition among Vietnamese seaports and increase their efficiency. First, investments in larger and deeper seaports are encouraged to exploit the scale effect in the port sector. Second, transferring ownership of seaports from government bodies to corporations can attract more capital and advanced technology from private and foreign investors. Third, the government should support the mergers and acquisitions between neighbouring port operators. It is well-known that the Vietnam has many small ports and they are located very closely. Subsequently, they are inefficient as proven by the average inefficiency scores.

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