Competition, Market Concentration, and Relative Efficiency of Major Container Ports in Southeast Asia

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Abstract

This study aims at investigating the degree of market concentration of container ports in Southeast Asia and to associate the concentration tendency with efficient container operations. While Singapore is the busiest container port in the region, its premier position is threatened by the emergence of other container ports in neighbouring countries. Major top ten container ports in Southeast Asia are included in the analysis, and market concentration is evaluated using established measures and analytical techniques such as the Hirschman-Herfindahl Index (HHI), Gini coefficient, and shift-share analysis from 2007 to 2017. A super-efficiency model is then applied to the ports to investigate the association between shift effects and port efficiency. The HHI index indicates that the container port system in Southeast Asia has become 'moderately concentrated' with a score of 0.21 in 2017, contrasting with an index of 0.27 in 2007 suggesting it was 'highly concentrated' indicating a tendency towards de-concentration. 'Super efficiency DEA' results suggest that Laem Chabang and Singapore ports are 'efficient' exhibiting efficiency scores higher than one, while the other eight ports are 'less efficient'. It is also found from the association of the net-shift effects and efficiency scores that Laem Chabang is the only port that is efficient and gaining market share, and, more importantly, and perhaps surprisingly, the ports gaining market share are 'inefficient'. This study contributes to the literature not only by investigating the concentration tendency of the fast growing container port system of Southeast Asia, but also by associating efficiency evaluations with the market concentration.

Keywords: *Container port, Southeast Asia, Competition, Market concentration, Port Efficiency.*

1. Introduction

With more than 20 container ports handling a total container throughput of over 104.6 million twenty-foot equivalent units (TEUs) in 2017, Southeast Asia has emerged as one of the busiest container port systems in the world (UNCTAD, 2018). With the sharp increase in seaport development projects in Southeast Asia, countries in this region are competing to secure a leading position in the container transport system. This trend contributes towards reducing congestion at existing ports by improving capacity as well as enhancing the competitiveness of manufacturing companies by lowering transport costs and lead times associated with the import and export of goods. The period between 2007 and 2017 witnessed a noticeable increase in container throughput, mainly contributed by major ports in the region, and this trend is projected to continue into the future as shown in Figure 1.

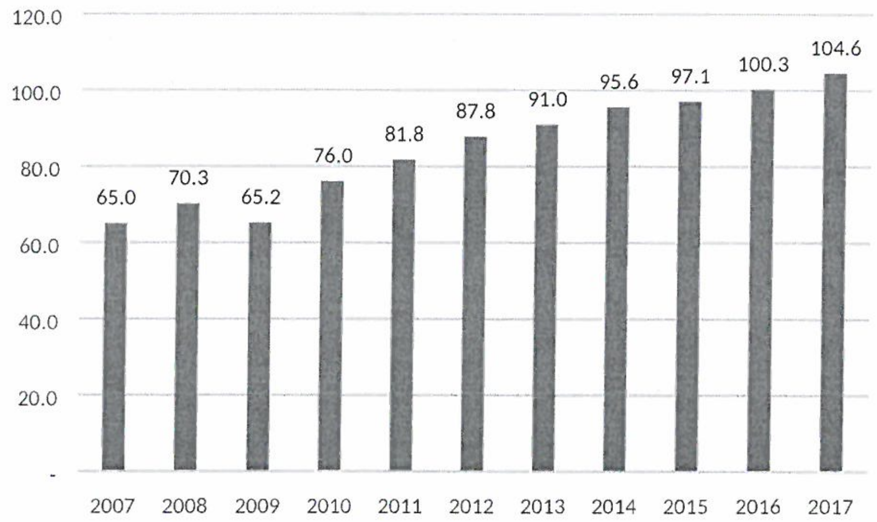

Figure 1. Container throughput of the Southeast Asian container port system between 2007 and 2017 (in million TEUs).
Source: UNCTAD (2017)

It is observed that the port system in the Southeast Asian region is evolving from a single-hub system to a multi-hub system to handle such a substantial and rapid increase in container volumes. Whilst Singapore port has played a key role of a single-hub which serves deep-sea container vessels in the single-hub system, there are also emerging ports that partly serve deep-sea vessels forming their feeder service networks. Since the early 2000s, Singapore port has lost some services of the main container carriers such as Maersk-Sealand and Evergreen Marine to Tanjung Pelepas in Malaysia. Due to the rapid development of infra- and supra-structure in the major ports in Southeast Asia, shipping companies now have more alternatives for their deep-sea routes. With this ongoing growth in container volumes and the scale of developments in the region, some existing ports will likely forfeit their monopolistic position with the formation and emergence of new deep-sea ports, and this is expected to create new dynamics in the pattern of inter-port competition in the region.

Singapore port is not only facing significant competition from Tanjung Pelepas port, but is also competing with the development of other ports such as Port Klang (Malaysia), Laem Chabang (Thailand), Saigon (southern Vietnam), and Haiphong (northern Vietnam). Table 1 shows the Southeast Asian ports which deep-sea services of main shipping alliances and shipping firms from/to Asia to/from North Europe and North America call at. Whereas a large number of container shipping services still call at Singapore port, there are an increasing number services that do not (e.g. services calling at Tanjung Pelepas only) or call at other ports in the region (e.g. Saigon, Haiphong, Port Klang, and Laem Chabang) along with Singapore. Therefore, the major ports in this region can be considered as emerging competitors, which invites the question of how spatial distribution of container cargoes is changing in a fast developing container port system as a market.

Table 1. Ports-of-calls for deep sea container routes in Southeast Asia

Operation	Service name	Destination /Origin	Ports of call in Southeast Asia	Ship size (TEUs)
2M	AE1, 2, 5, 6, 7, 10	Europe	Tanjung Pelepas	11,000-23,756
	TP7	America	Saigon, Laem Chabang	4,430 -6,760
	TP17	America	Saigon, Singapore, Tanjung Pelepas	6,600-10,000
THE Alliance	FE5	Europe	Saigon, Singapore, Laem Chabang	12,600-14,053
	PN2	America	Saigon, Haiphong, Singapore, Laem Chabang,	8,114-9,592
	PS3	America	Saigon, Port Klang, Singapore, Laem Chabang	11,075-13,800
	EC4	America	Saigon, Singapore	13,000-14,026
	EC5	America	Saigon, Singapore, Laem Chabang	4,924-7,510
Ocean Alliance	FAL1	Europe	Port Klang, Singapore	15,000-20,600
	FAL3	Europe	Port Klang, Singapore	13,000-20,000

	FAL6	Europe	Tanjung Pelepas	13,000-20,000
	FAL7	Europe	Port Klang, Saigon, Singapore	13,000-14,000
	FAL8	Europe	Port Klang	13,000-14,000
Wan Hai	CP1	America	Haipong	10,036-11,923
	CP5	America	Saigon	6,492-6,622

Note: The details of services are derived from websites of each shipping company as of October 2019. The list of services is not complete and inclusive of all the services.

Studies focusing on the concentration and consolidation of seaports in a region or country are important in order to better understand how a port system develops and evolves in terms of, for example, the distribution of cargo among ports and the level of competition in a particular region or country (Woo et al., 2011). Concentration and de-concentration of port systems have been widely studied in the European regions (Fageda, 2000; Notteboom, 1997; 2010), and in the United States (Hayuth, 1988). These studies analyse the factors causing port concentration or de-concentration such as containerization, technological changes, and trade patterns (Woo et al., 2012). It is observed that the container port system was first de-centralised in the US between 1970 and 1985 (Hayuth, 1988) and in China from 1998 to 2010 (Pan et al., 2014; Zhang et al., 2015) with the development of a mature container transportation system.

Since Southeast Asia is one of the world's fastest developing regions and with the dynamics of competition evolving, it is necessary to evaluate the concentration tendency of container port systems and the shift in market share associated with the changing concentration tendency in the region. Compared with other well-developed container systems such as those in Europe and the US, Southeast Asia has not been studied in detail in terms of the development of a container port system. Another question arising here is how the port investment and management approaches can interact with interport competition and concentration tendency. It has been suggested that port efficiency can be compromised when greater interport competition occurs at the regional level (De Oliveira and Cariou, 2015). Therefore, the purpose of this study is to investigate the concentration of container ports in Southeast Asia and to associate the concentration tendency with efficiency of container port management. To this end, the top ten major container ports in Southeast Asia are included in the analysis, and market concentration is evaluated using common measures and analytical techniques such as the Hirschman-Herfindahl

Index (HHI), Gini coefficient, and shift-share analysis. A super-efficiency model is then applied to the ports to investigate the association between shift effects and port efficiency.

The rest of the paper is structured as follows. Section 2 provides a brief review of the literature on market concentration and super efficiency models. Section 3 presents the methodology, where some indexes are used to calculate the market concentration level, and the outputs and inputs for the super-efficiency model are presented. Section 4 provides the results of the market concentration analysis and the shift-share analysis. Section 5 assesses port efficiency and presents 'efficiency' scores for the top ten container ports in the Southeast Asia region. Section 6 provides the findings and conclusion with the discussion on the contribution to the literature.

2. Literature Review

There are numerous studies evaluating market concentration levels of the container port systems (Hayuth, 1981, 1988; Notteboom, 1997, 2010; Ginevičius and Čirba, 2007; Le and Ieda, 2010; Lee *et al.*, 2014; Pham *et al.*, 2016, Zhang et al., 2015), and they mainly focus on container ports in developed countries. Notteboom (1997) investigated and analysed concentration and de-concentration tendencies and load centre development in the European continental container port system from 1980 to 1994 applying the HHI, Gini coefficient and shift-share analysis to the data. The study was then updated for the period 1985–2008 by applying the normalised HHI and Lorenz curve from Notteboom (2010). Hayuth (1981, 1988) analysed the de-concentration trend within the U.S. container port system by developing a five-phase model: the pre-container era, the introduction of containers, worldwide boost for containerization, concentration tendency, and load centres. The de-concentration trend in the container port market witnessed in Southern China, the U.S., European ports in the Hamburg-Le Havre range, and other regions points towards considerable efforts being made by leading container ports to maintain their regional and global position.

Over the years, several researchers have studied the development of Southeast Asia's container port system; however, most of these studies were primarily about the efficiency or competitiveness of container ports in the region, or the market concentration level in a specific country. Using different data analysis techniques, earlier studies focused on comparing the performance and efficiency of container ports in Southeast Asia and other similar container ports. Tongzon and Ganesalingam (1994), for example, showed that Southeast Asia's container ports achieved efficient utilization of resources such as berths, cranes, and total areas while recording inefficiency in terms of timeliness, and labour and tug utilization. Using the DEA model, Seo et al., (2012) compared the efficiency of 32 container ports in nine countries of Southeast Asia and only 2 out of these 32 ports in 2010 were shown to be efficient. Southeast Asia had 6 out of the 26 biggest container ports in 2015, but Singapore port was the only consistently efficient port in the area (Hlali, 2018). The results indicate that there are many potential container ports that can increase both their throughput and their performance by, for example, developing the infrastructure.

The competition and development witnessed in Southeast Asia's container port system has been highlighted in a number of studies (Yap *et al.*, 2006; Lam and Yap, 2008; Hung *et al.*, 2010; Yeo, 2010; Kim, 2011, 2015; Herrera Dappe and Suárez-Alemán, 2016; Dang and Yeo, 2017). Typically these papers point to the role of geographic location in influencing competition among ports in the region, and other factors such as operational capacity, infrastructure, information processing capacity and connectivity with inland areas. All these factors can significantly affect the level of competition between ports as well as the efficiency of the ports themselves. According to Huang *et al.*, (2008), Singapore port and Port Klang handle extremely high volumes of transhipment boxes which account for over 80% and 95% respectively of total throughput, respectively. It is suggested that competition from Port Klang and Tanjung Pelepas in particular has affected Singapore's transhipment performance negatively (Lam and Yap, 2008; Kang and Woo, 2017).

Ginevičius and Čirba (2007) suggested that market concentration and efficiency of firms contribute to corporate competitiveness (see Figure 2). Gaining a larger market share is a principal strategy to achieve competitiveness while a certain level of efficient operations is maintained. The association of efficiency analysis therefore would be able to provide additional value to market concentration analysis from the managerial perspective. De Oliveira and Cariou (2015) studied the efficiency of 200 container ports in terms of competition on three different scales (local, regional and global scale). The results indicate that the level of competition does not significantly affect the efficiency of the port when it is calculated on a global scale (over 800km) while interport competition lowers efficiency of ports at the regional level.

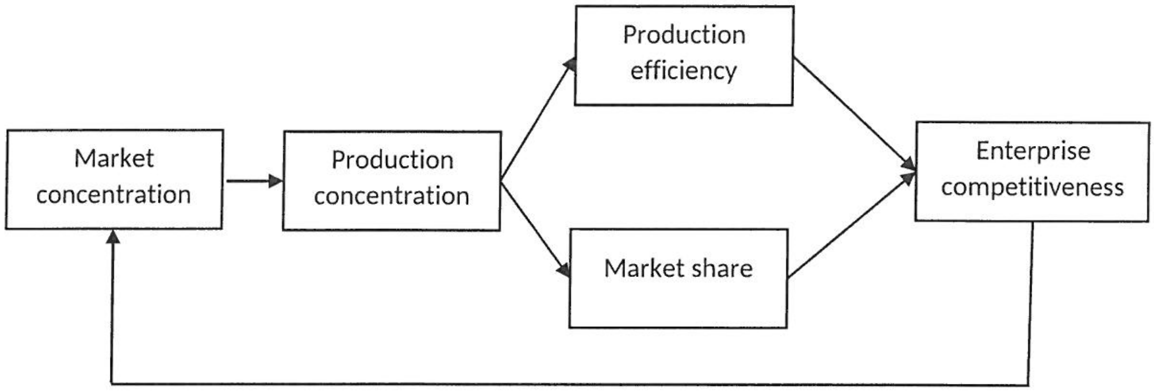

Figure 2. Relationship between market concentration and enterprise competitiveness.
Source: Ginevičius and Čirba (2007)

It is noteworthy that scholars have rarely studied the change in level of competition over time among container seaports in Southeast Asia; this would in turn lead to analysis of the tendency within concentration or de-concentration of container port systems in the region. In addition, there has not been a systematic evaluation and comparison of container port efficiency in association with concentration tendency in this region. Accordingly, this study addresses the following questions:

- how concentrated has the container port system become in Southeast Asia?;
- how has market share changed among the major ports in the system?;
- how efficiently are the ports operating?; and
- how do the changes in market share and efficiency of ports interact?

3. Methodology and Data

3.1. Concentration measures and shift-share analysis

In this section, several methods for measuring the level of concentration/de-concentration in the container port market are presented. Hayuth (1988) used the Lorenz Curve and Gini coefficient methods to analyse the concentration of the container port system in the U.S. Hanafy and Labib

(2017) used concentration ratio analysis, HHI technique, and shift-share analysis to study the container port market in the Eastern Mediterranean region for the period between 1995 and 2014. Notteboom (1997; 2010), meanwhile, used these indices and cumulative curves to study the relationship between concentration and load centre development in the European container port system.

3.1.1. Concentration curve

A concentration curve can be obtained by plotting the market players on the abscissa of the coordinate system in descending order of their magnitudes while laying off on the ordinate the respective cumulative values (Ginevičius and Čirba, 2007). A concentration curve reflects the contribution of each container port in the given region's total container throughput. Each plot in the concentration curve is measured as follows:

$$CI_j = \sum_{i=1}^{j} \frac{TEU_i}{\sum_{i=1}^{n} TEU_i}, \qquad (1)$$

where

CI_j: is the concentration index

j: represents the i^{th} attribute port

TEU_i: refers to the container throughput of the i^{th} container port where the container volume is standardised to twenty foot equivalent units (TEU)

n: represents the number of container ports in the system ($j \leq n$)

3.1.2. Concentration ratio (CR_K)

Concentration ratios express the degree of competition in an industry and high ratios may create market entry barriers for new investors (Varan and Cerit, 2014). Commonly, concentration ratios are measured by the market share of k, which represents the biggest container ports in terms of TEU. CR_K is expressed as:

$$CR_K = \frac{\sum_{i=1}^{k} TEU_i}{\sum_{i=1}^{n} TEU_i}, \qquad (2)$$

where

CR_K: is the concentration ratio of k, which represents the biggest container ports in the port system

K: represents the number of biggest container ports selected for measurement

TEU_i: refers to the container throughput of the i^{th} container port

n: represents the number of container ports in the system

In this study, CR_4 is applied to determine the degree of concentration of the biggest container ports in Southeast Asia. The concentration ratio ranges from 0 to 100%. A concentration ratio ranging from 0 to 40% indicates that the port system is close to perfectly competitive and is considered as 'low concentration'. When the concentration ratio is higher than 70%, the port system is called 'high concentration' (Notteboom, 1997), with the implication that a small number of operators hold a large level of power and inter-firm competition is limited.

3.1.3. Herfindahl-Hirschman Index (HHI)

The HHI is commonly applied to identify the level of concentration in a specific industry. Several scholars (e.g. Le and Ieda, 2010; Notteboom, 1997; 2010) used this index to study the level of concentration/de-concentration in the port industry. The HHI is calculated by summing the squared market share of all the ports in the port system.

$$HHI = \sum_{i=1}^{n}\left(\frac{TEU_i}{\sum_{i=1}^{n} TEU_i}\right)^2 \text{ and } \frac{1}{n} \leq HHI \leq 1\,, \qquad (3)$$

where

HHI: is the Herfindahl-Hirschman Index

TEU_i: represents the container throughput of the i^{th} container port

n: denotes the number of container ports in the system

The HHI is among the best tools for determining the degree of concentration. The HHI ranges from 1/n to 1. In general, an HHI between 0.15 to 0.25 indicates moderate concentration, while above 0.25 indicates high concentration (Notteboom et al., 2016). If the port system includes only one container port, the HHI attains maximum value of 1. On the other hand, if the container throughput of each of the container ports in a given system is the same, then the HHI equals its minimum value of 1/n.

3.1.4. Lorenz curve and Gini coefficient

These indexes are useful in measuring concentration levels in a system. The Lorenz curve represents variations in the container throughput of all container ports, while the Gini coefficient is the ratio of the area between the Lorenz curve and a diagonal line. The Gini coefficient's value ranges from 0 (perfect equality) to 1 (perfect inequality), reaching 1 when the market is dominated by only one terminal and is 'fully concentrated', and reaching 0 when there is no inequality between the container volumes at the respective ports, i.e. there is zero concentration; here the Lorenz curve matches the diagonal (Hayuth, 1988). The Gini coefficient is measured as follows:

$$G = \frac{n-1}{n} - \frac{2\sum_{i=1}^{n}(n+1-i)x_i}{n\sum_{i=1}^{n}xi}, \qquad (4)$$

where

n: denotes the number of container ports in the system

x_i: is the cumulative market share for the throughput of container ports from the lowest to the highest

3.1.5. Shift-share analysis

The shift-share analysis is commonly used to analyse regional economic growth, but Lombaerde and Verbeke (1989) applied it, for the first time, to the development of port systems. The shift-share analysis divides the change in container throughputs in a port into two components: shift effect and share effect. The growth rate of the reference port cluster is considered the 'share effect'. The 'share effect' reflects the expected growth of container traffic in each seaport calculated based on the growth rate of the seaport system (Notteboom, 1997). The difference between the performance of a port and a part of the total change in the port cluster is referred to as the 'shift effect'. The total shift reflects the total number of containers a port has actually lost or gained from competing ports in the same range, compared to expected container traffic (share effect) (Notteboom, 1997).

$$ABSGR_i = TEU_{it1} - TEU_{it0} = SHARE_i + SHFT_i \qquad (5)$$

$$SHARE_i = \left(\frac{\sum_{i=1}^{n} TEU_{it1}}{\sum_{i=1}^{n} TEU_{it0}} - 1\right) * TEU_{it0} \tag{6}$$

$$SHFT_i = TEU_{it1} - \frac{\sum_{i=1}^{n} TEU_{it1}}{\sum_{i=1}^{n} TEU_{it0}} * TEU_{it0}, \tag{7}$$

where

$SHARE_i$: is the share effect in TEU of the i^{th} container port for the period t_1-t_0
$SHFT_i$: represents the shift effect in TEU of the i^{th} container port for the period t_1-t_0
$ABSGR_i$: is the absolute growth in TEU of the i^{th} container port for the period t_1 - t_0
TEU_i: refers to the throughput volume of the i^{th} container port
n: denotes the number of container ports in the port system

3.2. The DEA super-efficiency model

Data envelopment analysis (DEA) has been used widely as an effective linear programming technique for measuring the efficiency of decision-making units (DMUs) with multiple inputs and outputs. The DEA models most widely applied in practice are Charnes, Cooper, and Rhodes (CCR) model and Banker, Charnes, and Cooper (BCC) models. The CCR and BCC models divide the DMUs into inefficient and efficient ones. Because the CCR and BCC models give a value of 1 for all efficient DMUs, it is unable to distinguish between the efficient DMUs. Andersen and Petersen (1993) were among the first authors present the DEA super-efficiency model for ranking efficient DMUs. Formally, let inputs be $x_k = (x_{1k}, x_{2k}, x_{Mk}) \in R_+^M$ to produce outputs $y_k = (y_{1k}, y_{2k}, y_{Nk}) \in R_+^N$. The row vectors $x_k$and y_k forms the k_{th}rows of the data matrices X and Y, respectively. Let $\lambda_k = (\lambda_1, \lambda_2, \lambda_k) \in R_+^K$ be a non-negative vector, which forms the linear combinations of the *K* firms. Finally, let *e* = (1, 1 . . . 1) be a suitably dimensioned vector of unity values. This model shows a new score for the efficient DMU following in Equation 8, 9 10, and 11. The score of each efficient DMU in the super-efficiency model can be greater than 1 and DMUs with higher scores will be ranked higher.

$$Min\ U^{sup} \tag{8}$$

Subject to $$\sum_{\substack{i=1 \\ i \neq 0}}^{n} \lambda_i X_i - U^{sup} X_0 \leq 0 \tag{9}$$

$$\sum_{\substack{i=1 \\ i \neq 0}}^{n} Y_i \lambda_i - Y_0 \geq 0 \tag{10}$$

$$\lambda_i \geq 0 \; i = 1,2,3 \ldots n \text{ (DEA super-efficiency)} \tag{11}$$

3.3. Data

To identify the level of market concentration in a seaport system, previous studies invariably used the container throughput to calculate related indicators such as concentration curve, CR_4, HHI, Lorenz curve, and shift-share analysis (Hayuth, 1988; Le and Ieda, 2010; Notteboom, 2010; Varan and Cerit, 2014). The study data were collected from the ten largest container ports in terms of container throughput in Southeast Asia; they are located in Singapore, Malaysia, Thailand, Vietnam, the Philippines, and Indonesia. Table 2 provides an overview of the ten biggest container seaports in Southeast Asia. The port of Singapore is the busiest container port in Southeast Asia and is ranked the second largest in the world, after Shanghai port in China. Eight of the ten largest container ports in the region are among the top fifty container ports in the world. While Singapore port maintains the leading position in the region, although its growth rate is lower (1.7%) than that of several other ports with growth rates ranging from 3.8% to 8.4%. It is notable that the ports handling more than 5 million TEUs in 2017 (Port Klang, Tanjung Pelepas, Laem Chabang, Saigon, and Tanjung Priok) have been developing with a sound growth rate of 4.6% on average.

Table 2. Container throughput of major container ports in Southeast Asia (in thousand TEUs)

Port	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Rank	CAGR*
Singapore	27,935	29,918	25,867	28,431	29,938	31,649	32,579	33,869	30,922	30,904	33,667	2	1.7%
Port Klang	7,312	7,974	7,310	8,872	9,604	10,001	10,350	10,946	11,890	13,170	11,978	12	4.6%
Tanjung Pelepas	5,465	5,594	6,016	6,536	7,541	7,719	7,628	8,524	9,120	8,029	8,261	19	3.8%
Laem Chabang	4,642	5,134	4,622	5,068	5,658	5,830	5,974	6,583	6,780	7,227	7,670	20	4.7%
Saigon	2,532	3,100	3,563	4,100	4,674	5,060	5,542	6,334	5,788	5,987	6,156	25	4.7%
Tanjung Priok	3,690	3,984	3,805	4,715	5,620	6,214	6,590	5,900	5,201	5,515	6,090	26	5.2%
Tanjung Perak	2,042	2,213	2,270	3,030	2,640	2,850	3,020	3,106	3,121	3,327	3,553	45	8.4%
Manila	2,946	2,999	2,878	3,158	3,465	3,711	3,782	3,811	3,976	4,523	4,782	30	4.5%
Bangkok	1,582	1,377	1,335	1,501	1,305	1,397	1,505	1,519	1,538	1,498	1,496	-	-0.5%
Haiphong	684	808	816	954	1,019	964	1,040	1,003	1,020	1,087	1,110	-	4.5%

Note: CAGR-Compound Annual Growth Rate

Source: Data are from UNCTAD Reviews of Maritime Transportation from 2007 to 2017

Table 3 provides the data used for the super-efficiency DEA model. Berth length, the number of cranes and total area are used as input variables and the container throughput is used as the output variable following the convention in previous container port efficiency studies (see, for example, Cullinane et al., 2005). The data were collected from the websites of each port. While Singapore port is the largest in terms of overall input and output variables, the other ports in the sample exhibit notable variation. For example, Tanjung Priok benefits from the second largest overall total berth length and total area, whereas it is only 6th in terms of its container throughput.

Table 3. Input and output variables for super-efficiency model (2017)

DMU	Input			Output
	Berth length (m)	Number of cranes	Total area (m^2)	Container throughput (1,000 TEU)
Singapore	21,030	205	8,170	33,667
Port Klang	9,000	99	5500	11,978
Tanjung Pelepas	5,040	58	1,800	8,261
Laem Chabang	3,650	56	1,610	7,670
Saigon port	7,690	65	6,000	6,156
Tanjung Priok	11,260	95	6,040	6,090
Manila	7,780	35	2,310	4,782
Tanjung Perak	10,067	23	5,450	3,553
Bangkok	6,028	14	3,600	1,496
Haiphong	2,697	12	1,100	1,110

Source: The data are collected from websites of each port in Southeast Asia

4. Results of analysis

4.1. Concentration curve

The concentration curve, as shown in Figure 4, compares the cumulative market share of the top ten container ports in Southeast Asia in the three years (i.e. 2007, 2012, and 2017). It is observed that the level of concentration in the ten ports is high, which is 90% in 2007 and 80% in 2017. The port of Singapore alone – the biggest container port in the region – comprised over 40% of the region's total throughput during 2007 but only 30% in 2017, clearly suggesting a tendency towards de-concentration in the region.

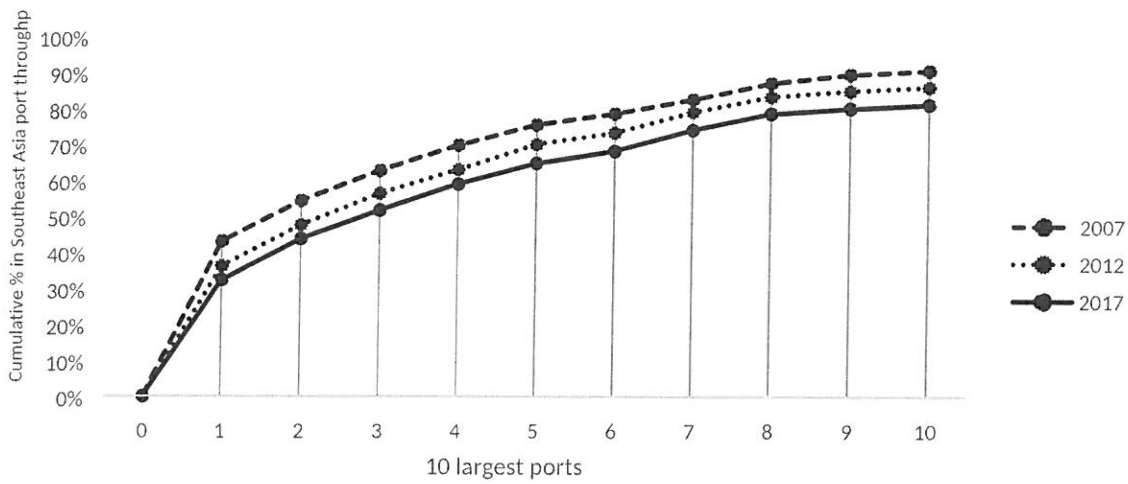

Figure 4. Cumulative market share of top ten container ports in Southeast Asia

4.2. Concentration Ratio (CR_4)

Figure 5 presents the statistical measures for the concentration ratio (CR_4) in the ten biggest ports in Southeast Asia over the period 2007–2017. If the CR_4 is always higher than 70%, it indicates that over 70% of all the containers are handled by the top four largest seaports, and the seaport market in Southeast Asia is highly concentrated. A slight tendency towards de-concentration was witnessed in the region when the CR_4 decreased from 77.1% to 72.6% between 2007 and 2017. The growth of other container ports in Southeast Asia has reduced the dominance of the top four container ports, but the market share is still heavily concentrated in Singapore port, largely because the geographic location still provides a comparative advantage over other container ports, especially for Pacific / Indian Ocean pendulum flows and regional transhipment.

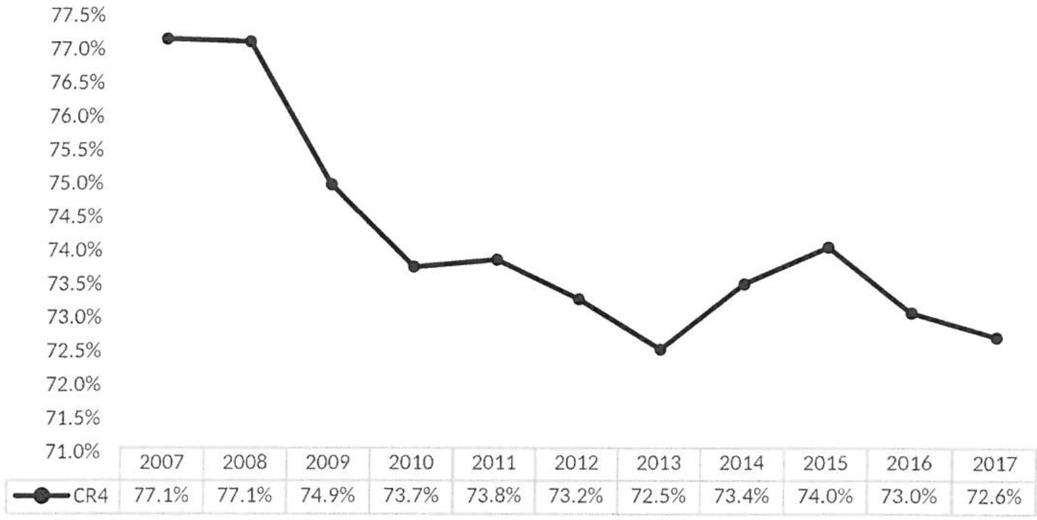

Figure 5. Concentration ratio (CR4) for top ten container ports in Southeast Asia

4.3. Herfindahl-Hirschman Index (HHI)

Figure 6 presents the Herfindahl-Hirschman Index (HHI) for the top ten container ports in Southeast Asia from 2007 to 2017. The results, once again, demonstrate that the level of concentration for the biggest container ports decreased steadily, but the degree of decline is limited (from 0.27 to 0.21) over the period 2007-2017. Since 2010, the HHI for the ten biggest container ports has almost flattened out with annual values at 0.20 to 0.23, indicating persistent moderate market concentration over the past 8 years or so.

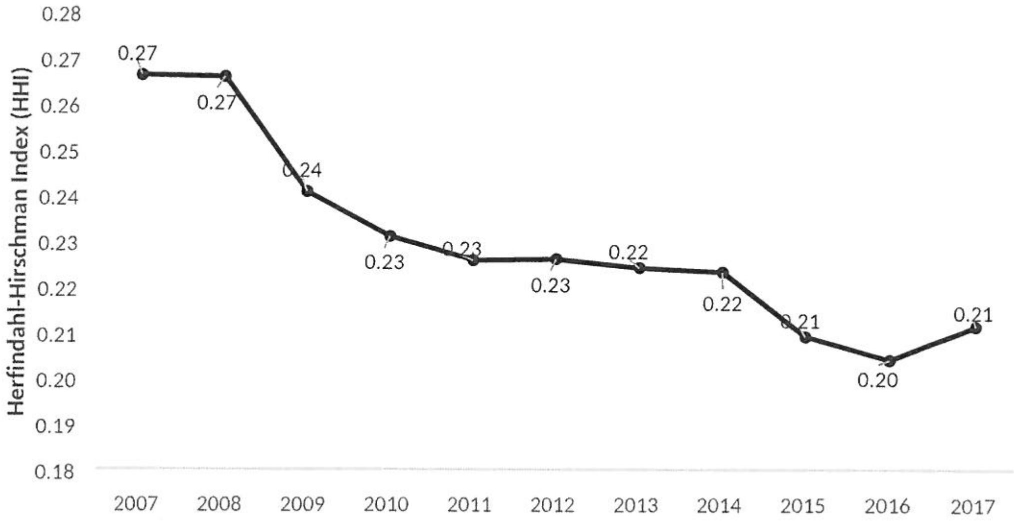

Figure 6. Herfindahl–Hirschman Index (HHI) for top ten container ports in Southeast Asia

4.4. Lorenz and Gini Coefficients

The values for the HHI and Lorenz curve for the ten biggest ports in Southeast Asia confirm the tendency towards de-concentration in the region. When the Lorenz curve is closer to the absolute equality line, a balance between large and medium-sized ports is being achieved amongst the ports in the region. Figure 7 illustrates the growth of smaller ports amongst the ten biggest container ports while the other major ports in this group are tending to lose their dominant position. This is most clearly visible in the average annual growth rates in container volumes at the respective ports. Volumes at Singapore have been growing at only 1.7% per annum, whereas throughput over the period has been growing rapidly at Saigon (northern Vietnam) with an annual average growth rate of 8.4%. Bangkok port, however, witnessed an annual average decline in throughput of 0.5% (see Table 2).

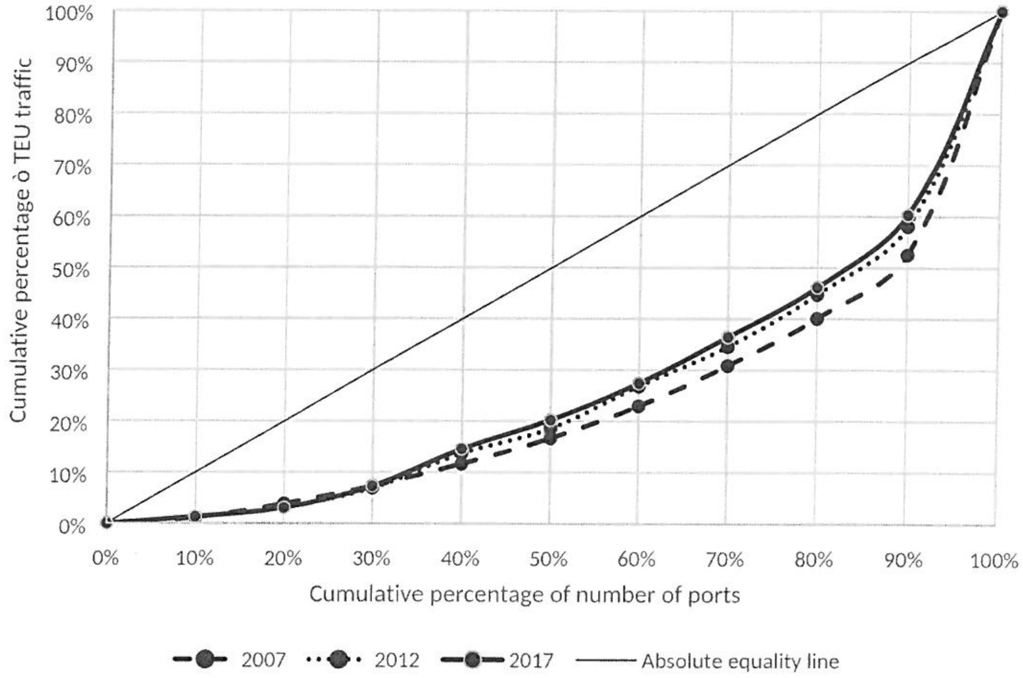

Figure 7. Lorenz curves for top ten container ports in Southeast Asia

4.5. Shift–share analysis

Shift-share analysis is a convenient way of explaining the time-related dynamics within a business system. Table 4 shows the difference between expected growth based on the growth rate of the seaport system and absolute growth in Southeast Asia's seaport system. The actual growth witnessed in container traffic of Singapore and Bangkok ports was less than the expected growth. In particular, between 2007 and 2017, an additional volume of over 12,314 thousand TEUs was expected to pass through Singapore port, compared to the actual additional throughput of a little over 5,731 thousand TEUs. Moreover, Singapore and Bangkok ports experienced significant competition and they lost around 6,583 thousand and 783 thousand TEU shifts, respectively, over the period in question. The other container seaports in the region gained from competition with Saigon port expanding by over 2,507 thousand TEU shifts and Port Klang with over 1,442 thousand TEU shifts.

Table 4. Share effects for ten biggest container ports in Southeast Asia

Port	Share Effects				Absolute Growth				Net shift
	07-09	10-13	14-17	07-17	07-09	10-13	14-17	07-17	07-17
Singapore	-165.9	4,989.2	1,315.3	12,314.5	-2,069	4,147	-203	5,731	-6,583.5
Port Klang	-43.4	1,556.8	425.1	3,223.3	-2	1,479	1,033	4,666	1,442.7
Tanjung Pelepas	-32.5	1,147.0	331.0	2,409.1	551	1,092	-263	2,796	386.9
Laem Chabang	-27.6	889.3	255.6	2,046.3	-20	906	1,087	3,028	981.7
Tanjung Priok	-21.9	827.4	229.1	1,626.6	115	1,875	190	2,400	773.4
Tanjung Perak	-12.1	531.7	120.6	900.2	228	-10	448	1,511	610.8
Saigon port	-15.0	719.5	246.0	1,116.2	1,031	1,442	-178	3,624	2,507.8
Manila	-17.5	554.2	148.0	1,298.6	-68	624	971	1,836	537.4
Bangkok Port	-9.4	263.3	59.0	697.5	-247	4	-23	-86	-783.5
Haiphong Port	-4.1	167.3	39.0	301.4	132	86	107	427	125.6

Source: author's calculations

5. Assessing the efficiency of ports

In the short term, growth of container throughput or gaining market share from other direct competitors is a top priority for a container port. However, if it does not work efficiently compared to other container ports, the port will eventually lose its competitive advantage. Alternatively, the less dominant container ports may be better candidates for growth and development because of their competitive efficiency. Shift-share analysis is widely applied to demonstrate the adjustment in container throughput among ports, but it cannot specifically compare the level of efficiency of these ports (Liu et al., 2016; Theodore, 2019). By contrast, data envelopment analysis (DEA) can be used as a tool for assessing the efficiency level, although it does not show if the container throughput of these ports is growing or decreasing (Chao et al., 2018). Therefore, combining these two methods allows us to provide comprehensive information about the growth and efficiency of container ports.

With the market concentration indicators suggesting an overall tendency towards de-concentration in Southeast Asia's container ports system, the shift-share analysis method shows that Singapore and Bangkok ports are losing their market share via competition, while the other ports are gaining market share. This section compares the efficiency of container ports in the region and links the results of shift-share analysis with performance in order to show more clearly the development pattern in Southeast Asia's container port system. By applying the DEA super-efficiency model, a full rank of major container ports from the most efficient to the least efficient is presented. The result from the output oriented CCR model with inputs consisting of length of berths, number of cranes, and total area, and output comprising container throughput are presented in Table 5.

Table 5. Efficiency scores of containers ports in Southeast Asia using super-efficiency model

DMU	Score	(I) Berth length		(I) Number of cranes		(I) Total area		(O) Container throughput	
		Projection	Gap (%)	Projection	Gap (%)	Projection	Gap (%)	Projection	Gap (%)
Laem Chabang	1.282	3650.0	0.0%	42	25.0%	1303.6	19.0%	5982.7	22.0%
Singapore	1.149	20893.7	0.7%	205	0.0%	8170.0	0.0%	29304.1	13.0%
Tanjung Pelepas	0.999	4226.7	16.1%	58	0.0%	1800.0	0.0%	8269.3	-0.1%
Tanjung Perak	0.941	2359.5	76.6%	23	0.0%	916.6	83.2%	3777.3	-6.3%
Manila	0.832	3590.5	53.9%	35	0.0%	1394.9	39.6%	5748.0	-20.2%
Port Klang	0.777	9000.0	0.0%	99	0.0%	3602.4	34.5%	15416.2	-28.7%
Bangkok	0.651	1436.2	76.2%	14	0.0%	558.0	84.5%	2299.2	-53.7%
Saigon	0.577	6668.0	13.3%	65	0.0%	2590.5	56.8%	10674.9	-73.4%
Haiphong	0.563	1231.0	54.4%	12	0.0%	478.2	56.5%	1970.8	-77.6%
Tanjung Priok	0.390	9745.6	13.5%	95	0.0%	3786.1	37.3%	15601.8	-156.2%

Judged by its super-efficiency score of 1.282, Laem Chabang port is the most efficient container port, compared to others in the region. In 2017, the container throughput of Laem Chabang port was 22% higher than the projected throughput, which is the designated nearest point on the production-possibility line. Although the market share of Singapore port is reducing with volumes shifting to other container ports at a macro level due to competition, berth length issues, crane numbers, total container handling areas, the actual container throughput of Singapore port still exceeds the projected throughput by 13%. Although container ports such as Saigon port and port Klang gained maximum market share from this competition, they are 'inefficient' with super-efficiency scores of 0.577 and 0.777 respectively. With the current facilities, all other things being equal, these ports can increase volumes by around 4,519 thousand TEU (73.4%) and 3,438 thousand TEU (28.7%) respectively. In the case of Tanjung Priok, which shows the lowest score of 0.390, its container throughput must increase by 4,341 thousand TEU (156.2%) or total area needs to reach about 2,254 km^2 (37.3%) to reach 100% efficiency.

Table 5 shows that most container ports in this group are considered to be heavy on inputs. The projection values are the reference set for a container port to achieve optimal operation. If the container throughput of the port is higher than the projected value the port performs better, using the facilities more effectively than the reference point. Thus, a positive value exists between actual performance and projected performance. By contrast, given the outputs of the ports, the positive values between projection and actual inputs may indicate over-capacity. For example, with about 2,570 thousand TEU shifts, Saigon port captures the largest market share compared to other ports in the group; however, the super-efficiency of this port is only 0.577, ranking it seventh among the top ten container ports. However, Saigon port can increase its container throughput by 73.4% if it takes advantage of the current inputs.

By combining the shift-share analysis with DEA methods, the top ten container ports in Southeast Asia can be divided into four groups as shown in Figure 8: the market share-gained and efficient group (Quadrant 1), the market share-gained but inefficient group (Quadrant 2), the market share-lost and inefficient group (Quadrant 3), and the market share-lost but efficient group (Quadrant 4). Laem Chang, in Quadrant 1, is the only container port in the region that achieved both market share gain and efficiency in using input facilities, with 982 thousand TEU shifts and a super-efficiency score of 1.282. In Quadrant 2, there are container ports that have gained market share but are evaluated to be operationally inefficient. It is worth noting that Tanjung Pelepas is in a marginal position, indicating it has gained market share and operates marginally efficiently. Bangkok port is positioned in Quadrant 3 being the most inefficient with a super-efficiency score of 0.651. Although losing 6,583 thousand TEU shifts to competitors, Singapore port, in Quadrant 4, is still the second most efficient port with a super-efficiency score of 1.149. It is shown that of the 8 ports with a positive net-shift effect, 7 ports are classed as 'not efficient'.

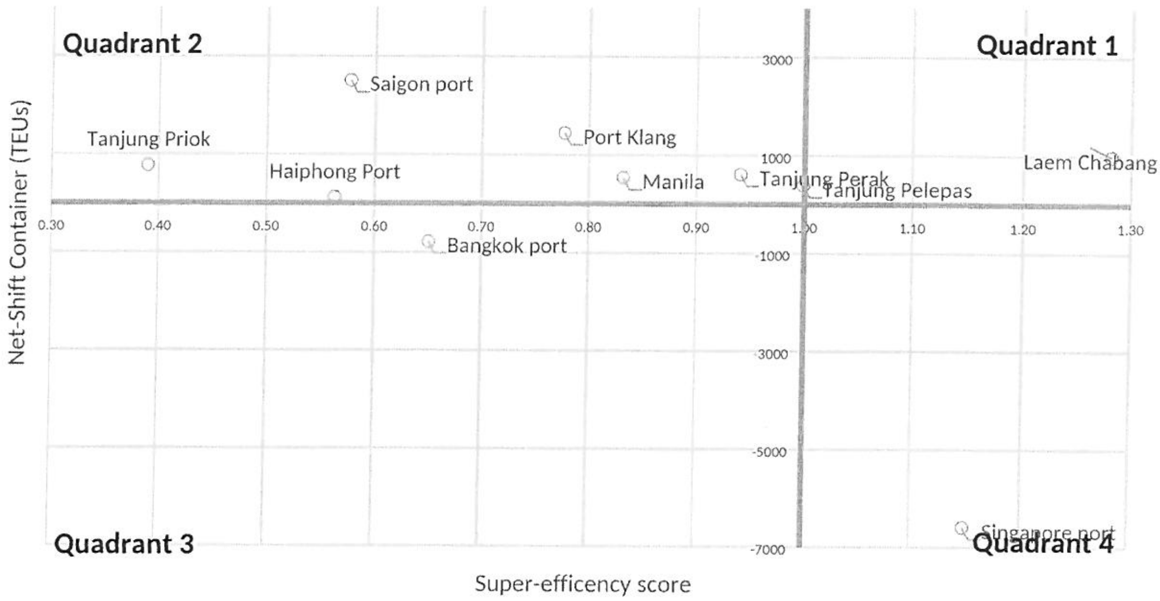

Figure 8. Net shift effect and efficiency scores in the major ports in Southeast Asia

The correlation between market share, net shift and efficiency are provided for both all the ports and for the eight ports which have gained in market share and which are positioned in Quadrants 1 and 2 (see Table 6).

Table 6. Correlation between market share, net shift and efficiency

		Market share	Net shift	Efficiency
Market share	All the ports			
	Share-gaining ports			
Net shift	All the ports	-0.835**		
	Share-gaining ports	0.141		
Efficiency	All the ports	0.532	-0.396	
	Share-gaining ports	0.421	-0.166	

Note: ** indicates significance at the 1% significance level

Due to the sample size, the statistical examination is limited, however, and interpretation should therefore be carried out with caution. In the correlation analysis with all the ports, market share and net-shift effect have a negative significant relationship (-0.835, p=0.003). Market share and efficiency have a positive relationship, and net shift and efficiency have a negative relationship although both relationships are not statistically significant. In the analysis involving the share-gaining ports, while the relationships are not statistically significant, efficiency has a positive relationship with market share (0.421) and a negative relationship with net shift (-0.166) respectively.

6. Conclusion and discussion

This paper has investigated the concentration tendency of the major ten container ports in Southeast Asia using several relevant measures such as the Hirschman-Herfindahl Index (HHI), Gini coefficient, and shift-share analysis during the period of 2007 to 2017. In addition, a super-efficiency model is applied to the ports to investigate the association between shift effects and port efficiency. The analysis shows that the container port system in Southeast Asia has become more competitive and less concentrated over the eleven year period. The HHI index indicates that the container port system in Southeast Asia has become moderate concentrated with 0.21 in 2017 from highly concentrated with 0.27 in 2007. The shift-share analysis shows that Singapore and Bangkok ports have lost market share and the other 8 ports have gained market share compared to their expected market share. Super efficiency DEA results suggest that Laem Chabang and Singapore ports are 'efficient' with efficiency scores higher than one while the other 8 ports are statistically less efficient. It is also found from the association of the net-shift effects and efficiency scores that Laem Chabang is the only port that is efficient and gaining market share, and, probably more importantly, the ports gaining market share are 'inefficient'.

Previously, geographic location along with investment were the favourable factors to position Singapore as the largest seaport in the region. Recently, Singapore's container throughput showed signs of slower growth while ports in Malaysia, Indonesia, Thailand, and Vietnam signalled increasing growth. A possible reason is that from the perspective of the global value chain, multinational corporations have diversified their manufacturing facilities across the region; this makes these ports more integrated into global supply chains (Woo et al., 2013; 2018). The value of goods transported in Southeast Asia has increased by more than 11% after many corporations shifted their production from China to Southeast Asia to cut labour costs (Tomiyama and Nakano, 2017). Some ports from neighbouring countries located near Singapore are also emerging as alternatives to many shipping companies. In addition to the expansion, these ports have upgraded their facilities regularly and modernised their equipment to improve transport and handling capacity. In addition, China's investment in Indonesia, Thailand, and Malaysia through the "One Belt One Road" initiative also threatens to undermine the strategic position of the dominant port. Another possible reason for Singapore's reduced attractiveness is institutional as suggested by Slack and Wang (2002). By not allowing any single carrier to monopolize a berth, Singapore tends to retain exclusive control over port planning and management. This strict policy combined with high port charges may have made several customers of Singapore port move their business to Tanjung Pelepas – its main competitor – or elsewhere.

It is apparent that the DEA super-efficiency model provides meaningful insights about the association between port investment, market share and efficiency in the developing and competitive market situation. In general, it is found that the assumed relationship between efficiency of ports and market share or market share gains is not verified in a developing market. Rather it is suggested that ports gaining market share are often 'not efficient', which is in line with the findings of De Oliveira and Cariou (2015). Under circumstances of intense interport competition, ports seeking growth tends to make considerable investment in infrastructure to attract shipping lines that operate deep-sea route services. Employment of large container vessels in the container services requires even more investment in infrastructure and equipment in the ports which may lead to over-investment in the short term until the expanded capacity is met by demand sometime in the future. Therefore, whereas efficiency studies tend to be undertaken in the region where interport competition is prevalent, efficiency analysis may not be a valid approach to evaluate performance or competitiveness of ports or terminals since operations in growing ports and terminals are not necessarily efficient.

Countries in Southeast Asia are racing to upgrade and expand their container ports to maintain their position in the regional market. Indonesia, which currently accounts for 40% of ASEAN's GDP, is Singapore's toughest competitor in the port industry (The ASEAN Secretariat, 2018). A president decree issued in 2012 declared that the port development project invested in by Pelindo II, which is Indonesia's largest port operator, will be implemented with two phases: phase 1 financed to the tune of US$ 2.47 billion and phase 2 with US $1.5 billion (Carruthers, 2016). When this whole project is completed in 2023, New Tanjung Priok Port will be able to handle over

18 million TEU per year and will be able to accommodate containerships with an 18,000 TEU capacity. In addition, the Ministry of Transport of Indonesia granted an estimated US$ 3 billion investment in developing a seaport in West Java, just 100 kilometres away from Jakarta (World Bank, 2018). Indonesia's ambitious goal is set to create a new transit hub, surpassing Singapore.

Thailand is also planning to spend more than US$ 2.5 billion through public-private partnerships to expand Laem Chabang port, expecting to raise capacity to 130 percent of the current capacity by 2022 (EEC, 2019). In Vietnam, a US$ 1.06 billion port project in Hai Phong, supported by Japan, is being completed on a priority basis. This port, which has a water depth of 14 meters, is twice as deep as the other major ports in Vietnam, allowing large-sized ships to dock (Vinamarine, 2019). The port of Tanjung Pelepas, which is the second biggest container port in Malaysia, will be expanded gradually annually to increase the port's throughput capacity to 30 million TEUs by 2030 (Van der Heide, 2019). However, it should be noted that Singapore port also has taken measures to combat the competition presented by the Tuas Mega Port project which will add a capacity of 65 million TEUs to the current capacity of 50 million TEUs when the whole project is completed targeting at 2040 (Singapore Maritime Connect, 2019). The aggressive expansion of Singapore port may neutralize or reverse the de-concentration tendency evident over the last decade, and which suggests that the implementation of expansion plans by emerging ports should be approached with caution.

This study contributes significantly to the literature by not only investigating the concentration tendency within the fast growing container port system of Southeast Asia but also by associating efficiency evaluations with the market concentration. However, the analysis of market concentration and relative efficiency may yield different results depending on the level and unit of analysis. Therefore, future research may be extended and broadened to encompass national and regional levels of analysis to investigate the interaction of market concentration within regional markets and individual national markets within which the major ports are located.

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