Received 7 July 2020
Revised 29 May 2021
28 December 2021
30 January 2022
23 March 2022
Accepted 26 April 2022

A hierarchical cluster analysis of port performance in Malaysia

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Abstract

Purpose – The term competitive has always been used as a comparison to provide a distinction between two or more things. Southeast Asia handles billions of tonnes of global seaborne trade annually. Thus, there is a necessity to look in detail at the performance indicators of port competitiveness on the basis of port performance.

Design/methodology/approach – This study has categorized 18 Malaysian bulk terminals into two different classes based on various performance indicators. The distinctions used a hierarchical cluster analysis by arranging the performance indicators. The technique is among the most popular techniques used to form homogeneous groups of entities or objects.

Findings – In this study, it was found that two classes were classified as being competitive from the homogeneous groups created. Based on the performance metrics chosen, Group 1 had the lowest score and Group 2 had the highest score. It was found that the Westport and Northport of Klang Port had the best performance of all.

Research limitations/implications – A major challenge for the study is the lack of variables relevant to other port competitiveness requirements, and a detailed research study is needed to gather information on the satisfaction of terminal customers, the paperwork involved, the accuracy and consistency of tariffs paid, the level of safety at sea and on land and environmental protection around the facility site.

Originality/value – The study on ports has been given less attention among researchers in this particular area. Therefore, this paper focuses on the port terminals in Malaysia and compares port performance metrics between ports to determine their competitiveness.

Keywords Port performance, Port competitiveness, Scheduling algorithms, Hierarchical cluster

Paper type Research paper

1. Introduction

Seaports are a component of the supply chain that serve as an important link in the transportation system, facilitating the flow of freight. Malaysia is a renowned nation with some of the world's busiest ports. Seaborne trade has grown to 10.7 billion tons and almost half of it

Funding: This research was conducted under the UMT/PPPI/55316). Universiti Malaysia Terengganu (UMT) provided the research fund.

Maritime Business Review
Vol. 8 No. 3, 2023
pp. 194-208
Emerald Publishing Limited
2397-3757
DOI 10.1108/MABR-07-2020-0040

passed through Southeast Asia (UNESCAP, 2019). In 2019, Malaysia recorded 2.9% transport service exports (84,384 million US$) and 4.33% GDP growth (366,828 million US$) from the maritime sectors (UNCTAD, 2021). Over decades ago, Malaysian ports had recorded an average growth of 3% in cargo throughput (Van der Heide, 2019). The strategic location and its good connectivity make Malaysia as a preferred entry point for Southeast Asian companies (Van der Heide, 2019; Chen *et al.*, 2016). Over the last couple of decades, the ports have seen a 400% increase in container traffic (Van der Heide, 2019). Currently, there are eight federally administered ports in Malaysia. They are Port Klang, the Port of Tanjung Pelepas, Johor Port, Penang Port, Bintulu Port, Malacca Port, Kuantan Port and Kemaman Port. In East Malaysia, there are ports administered under the state governments of Sabah and Sarawak. Besides these ports, there are several privately owned port facilities and jetties throughout Malaysia primarily for the oil and gas industry, such as in Port Dickson and Lumut (Ministry of Transport Malaysia, 2022). These seaports support Malaysia's economy by integrating the maritime and inland transportation networks (Chen *et al.*, 2016). The leading ports are the Klang Port and Tanjung Pelepas Port, which are responsible for 64% of Malaysia's total cargo throughput in 2018. These two ports contribute to a substantial part of Malaysian transshipment. Recently, the sustainable growth of Tanjung Pelepas port which cost RM 430 million in investment was highlighted as it prepared for the arrival of the P3 Network or Maersk Line, CMA CGM and Mediterranean Shipping Co (UNESCAP, 2019). In overall terms, the performance of other ports has been found to be much lower compared to the port mentioned. Additionally, port performance indicators are measuring the ports from their individual competitive advantage (Rezaei *et al.*, 2018).

Malaysia is located right at the heart of region where intercontinental and intra-Asian sea trade routes meet each other. Yet, Singapore claims the best port in the Southeast Asia and the world, but there is a very little space for the respective nation to expand and grow. Vice versa, there are thousands of opportunities for Malaysia ports to grow compared to their proximity neighbour. Ports have started to compete with one another to be the new node in cost reduction and performance; this was propelled by the improvements in ocean productivity over the past several decades (World Bank, 2007). It has led to an increase in port competition resulting from the liberalization of transportation markets and concentration in the shipping industry (De Langen, 2007). To support this assertion, De Langen (2007, p. 1) narrated that "port services are no longer provided in isolation, but need to fit in door-to-door supply chains." A port is in a competitive position when port users are presented with a competitive offering relative to other connected ports. Hence, the nature of competitiveness in a port is heavily dependent on its distinguishing factors and many other variables, such as policy-related, terminal-specific, chain-related or scope-related factors (Vanelslander, 2005). In a competitive port environment, it is crucial to identify the key factors guiding users in choosing a certain port, as this strategically employed expertise will help port growth and increase its market share.

Additionally, Malaysia has a fair number of small ports on its coastline. The ports compete for cargo, especially volumes destined for the contestable hinterland of Malaysia. Aside from that, the ports are also competing to secure regional port status as the volume of cargo increases. VanDyck (2015) in their study found that ports have been modernizing and expanding their facilities, thus increasing their competitiveness and attracting more cargo as the hinterlands become increasingly contestable and less captive. Yet, it was revealed that most Malaysian ports lack of adequate infrastructure and amenities. This is proven by a low volume of freight handled by ports. It was added that Malaysian ports' services are also insufficient to meet consumers' needs (Jeevan *et al.*, 2015b; Nazery *et al.*, 2012). In a study by Jeevan *et al.* (2015b), insufficient railway tracks, unstructured container layout on the train deck, usage of a single mode of transportation, less acknowledgement from seaports concerning the credibility of ports, rivalry from seaports and location have all been explored as issues confronting port performance. Still, there is always room for improvement for Malaysia port performance. Therefore, the main objective of this paper is to investigate the competitiveness of ports in Malaysia. This study will categorize 18 Malaysian terminals into two different classes based on various performance indicators. This approach allows for an easy comparison of port terminals with different characteristics and constraints because similar terminals will be grouped together.

This study starts in Section 2 with a brief literature review on port competitiveness and efficiency. Next, Section 3 discusses the definition of the variables and the methodology used to classify the terminals in the sample. Section 4 reports the results. Finally, Section 5 concludes the paper.

2. Literature review

2.1 Port competitiveness background

As the overall performance of a port greatly affects its competitiveness, many previous works focused on the terms derived from port productivity and operational efficiency (Cabral and Ramos, 2014). In the case of Brazilian seaports, Cabral and Ramos (2014) used the average productivity at terminals/berths to measure port performance. Other than that, there are other indicators which are used as the proxy for efficiency: waiting time for mooring/loading (Cabral and Ramos, 2014); freight handling efficiency and port access waiting time and frequency of calling vessels and port congestion (Rozar *et al.*, 2018; Razik *et al.*, 2015). There are also additional elements used to determine the quality of port service (Yeo *et al.*, 2016; Kim and Lu, 2015; Scaramelli, 2010; Van Dyck and Ismael, 2015) and efficiency in documentation process (Scaramelli, 2010; Jeevan *et al.*, 2015a).

In the studies of Notteboom and Yap (2012) and Chang and Talley (2019), port competitiveness is defined by the researchers in several ways. The competition between ports has led to competitive advantage. This is because competitive advantage is attained through the provision of requirements for ship owners and shippers to choose a port across various functions. Thus, it can be used as an indicator which develops a countermeasure as it recognizes the opportunities and threats of the port (Kim and Lu, 2016). Other than that, Parola *et al.* (2016) stated that port competitiveness refers to the capabilities of ports that vary from rivals to achieve their strategic goals, similar to the capability of manufacturers to gain customers and dominate the markets. This kind of competitiveness evolves the market structure and also increases the competition from competitors. There are two meanings of port competitiveness: (a) the economic nature of the port with the intention of making profits and (b) the social nature of the port, which means that the port is a harbour city and a gateway to foreign trade in surrounding areas where resources can be reallocated, such as freight, transport vehicles, knowledge, funds and labour force and so on, in a proper and fair manner, through connections between ports.

A port therefore plays an important role in the pooling of a myriad of resources in the region and gradually becomes a key part of the harbour city. In this perspective, port competitiveness can be denoted as the ability to generate a variety of resources and some kind of competitive advantage over other ports by combining and maximizing key elements and engaging with the external environment in terms of market positioning and generating value and sustainable growth in the cycle of market competition. Yeo *et al.* (2011) mentioned that port competitiveness is on their port selection criteria. There are multifarious perspectives in a study of port competitiveness, and in order to evaluate the competitiveness of ports, it is important to define the components or factors that have or may have an effect on the study. It was emphasized that the capacity of facilities at the seaport terminals in Malaysia is a key competitiveness factor to differentiate the level of competitiveness between seaports in Malaysia.

2.2 The key drivers of port competitiveness

First, there is unanimous agreement in a number of previous studies that port costs have emerged as relevant economic-related drivers of port competitiveness (VanDyck and Ismael, 2015; Yuen *et al.*, 2013; Scaramelli, 2010; Yeo *et al.*, 2016; Seo *et al.*, 2016). For most sectors, the quality of goods or services is an important consideration that consumers take into account, especially when choosing a selection of homogeneous items. The cost is among the main considerations before making a decision, and the lower the port cost, the greater the competitiveness. Typically, this happens when the port tariffs (a tax or duty to be paid to the port authority) and costs (i.e. port charges paid to the terminal) constitute a substantial proportion of the overall costs of transport for ocean and shipper companies. Similarly, most industries within the maritime sector are able to compare the cost and tariffs of competing ports and choose the most realistic one.

Second, other important drivers are port geographical position and maritime connectivity. This is critical especially for those players who are responsible for the supply of goods between manufacturing plants and the ports involved in cargo routing decisions (e.g. ocean carriers, freight forwarders, etc.). Thus, the strategic location of a port significantly increases its competitiveness. Specifically, position refers to the "diversion distance" concept where ships deviate from main trunk routes to the port. The centrality of shipping routes is vital not only because it acts as a port gateway but also as a hub for transshipment (Yuen *et al.*, 2012; Scaramelli, 2010).

Third, the endowment of port infrastructures and nautical accessibility are indicated as other relevant drivers (Burnson, 2020; VanDyck and Ismael, 2015; Razik *et al.*, 2015; Scaramelli, 2010; Yeo *et al.*, 2016). Commonly, it is accepted that nautical accessibility is closely connected with port infrastructures (e.g. berth length, water depth, yard spaces, etc.). In order to meet trade growth and delivering economies of scale in a highly competitive market, shipping firms have invested in building mega vessels to face unprecedented operational challenges. Particularly, these are expressed in deeper channel and terminal water depths, as well as in the search for longer quays and wider terminal areas. This is for the ports to maintain their competitiveness as it helps in speeding up the pace of the ports. Moreover, due to continuous expenditure on efficiency improvement in port terminal infrastructure, Malaysian ports have managed to achieve higher levels of efficiency in port operation (e.g. cargo handling technology and equipment and port information technology). Nonetheless, all ports have always been able to perform beyond their current capacity but at the high expense of capital spending on port facilities and services. Normally, huge quantities of port trade cause port management to take initiatives to expand port capacity.

Fourth, operational performance is a significant factor for port authorities and port operators in order to gain a competitive edge. VanDyck and Ismael (2015) evaluated the best performance maximization approach where the correct balance and compromise should be reached between the private sector involvement and the port authority's owners and regulatory functions. Also, it has been recognized by multiple authors that the quality of port services is a determinant of competitiveness (Yeo *et al.*, 2016; Kim and Lu, 2015; Scaramelli, 2010; Van Dyck and Ismael, 2015; Razik *et al.*, 2015; Yunan *et al.*, 2017; Puig *et al.*, 2015). Table 1 illustrates the key drivers of port competitiveness.

3. Research methodology

This research is conducted on 18 ports in the Northern, East Coast, Central and Southern regions of Malaysia. Since this study is extended from the study of Jeevan *et al.* (2015a), it is known that Malaysian ports have been positioned as the main extended gateways of major container seaports. Table 2 and Figure 1 depict the list of ports in Malaysia. These ports provide an idea of the size of Malaysia's ports to derive port performance indicators, including loading and unloading time, service quality, cost, material handling facility, stockpile location and trucking efficiency. These performance indicators will be measured for selection criteria through the data analysis.

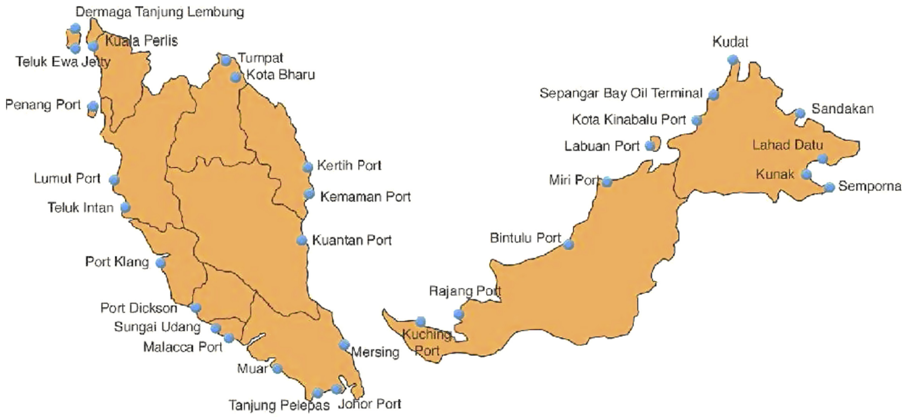
Key driver	Details	References
Port costs	The costs of the port's customers are based on direct port costs, including port, storage and indirect costs on long shutdown: towage, pilotage, mooring dues; cargo handling charges; dwell time fee; storage costs; terminal charges and fees; bunkering prices; waste processing dues; cold ironing costs and inland distribution costs	Yuen *et al.* (2013), Yeo *et al.* (2016), Scaramelli (2010)
Maritime/port (Infrastructure and superstructure	Infrastructure is basic physical and organizational structures needed for the operation of a society or enterprise *Basic port*: usually has a port entrance, sea locks, protective work (including breakwaters and shore protection) and can easily access the port for inland transport *Operation port infrastructure*: roads, tunnels, bridges and locks in the port area. operation port infrastructure also has quay walls, jetties and finger piers *Port superstructure*: paving and surfacing, terminal lighting, parking areas, sheds, warehouses and stacking areas, tank farm and silos, office and repair shops	Jeevan *et al.* (2015a), Scaramelli (2010)
Port service quality	Port service quality consists of items related to outcome, process, management, and image and social responsibility such as vessel turnaround time, vessel waiting time, speed of cargo, handling, frequency of sailings, quality management/policies; reputation for cargo damage/loss/theft/pilferage; delays in cargo; handling/customs inspections; port/terminal congestion; transhipment capabilities; bunkering-fresh wate-ship's product; services; waste management; terminal productivity	Yeo *et al.* (2016), Kim and Lu (2015), Scaramelli (2010), Puig *et al.* (2015)
Operational efficiency	The port's ability to effectively use all its resources for high outputs (e.g. turnaround time, ship waiting times due to congestion, the efficiency of cargo handling, etc.) *Labour quantity/productivity:* annual/daily operation, flexibility of working hours, power of trade unions, skills and professionalism of labour, provision of 24/7 service	Scaramelli (2010), Razik *et al.* (2015)
Authorities	Port authorities have statutory duties to meet social and environmental obligations whilst embedding the corporate social responsibility (CSR) concept in port management systems and undertaking routine operations and development projects commercially *Government policies:* government local/regional/national intervention, port authority intervention; management structure *Private sector involvement:* environmental responsibilities; environmental standards *Implementation*: relationship port-city, environmental compensation provisions	Scaramelli (2010), Puig *et al.*, (2015), Yeo *et al.* (2016)
Port geographical location	Geographical location has an expansive definition and refers to the port's geographical positioning in relation to transportation networks, inland markets, inland transport infrastructures and logistics centres	Yuen *et al.* (2013), Scaramelli (2010)
Other	Reputation, reliability, preferences of lines/shippers, promotion and marketing, customer relationships, fast and efficient problem-solving and reporting	Scaramelli (2010), Yeo *et al.* (2016)

Table 1.
The key drivers of port competitiveness

No.	Port	Region
1	Sandakan Port	Sabah
2	KK Port	
3	Kudat Port	
4	Labuan Port	
5	Bintulu Port	
6	Tawau	
7	Lahad Datu	
8	Tg Manis	Sarawak
9	Kuching	
10	Sarikei Port	
11	Sibu Port	
12	Kuantan	Central
13	Kemaman	East Coast
14	Johor Port	Southern
15	Penang Port	Northern
16	Lumut	
17	North Port	
18	Westport	Western

Source(s): Razik *et al.* (2015)

Table 2. The list of ports in Malaysia



Source(s): Ministry of Transport Malaysia (2022)

Figure 1. Ports in Malaysia

3.1 Cluster analysis

Cluster analysis is an exploratory analysis that tries to identify structures within the data. Cluster analysis is often referred to as segmentation analysis or taxonomy analysis. Specifically, it attempts to classify homogenous groups of cases if the classification is not previously identified. In an exploratory study, there is no distinction between dependent and independent variables. The different cluster analysis methods that SPSS offers can handle binary, nominal, ordinal and scale (interval or ratio) data. In addition, R statistical computing project or average is used to validate the clustering. Clustering analysis is commonly used together with other analyses, such as discriminant analysis (Shengrong *et al.*, 2010). Researchers must be able to interpret the cluster analysis on the basis of their interpretation of the data in order to assess whether the findings of the analysis are actually relevant.

In the literature, the hierarchical cluster is among the most common methods in research. It generates a series of models with cluster solutions from 1 (all cases in one cluster) to *n* (each case is an individual cluster). The hierarchical cluster deals with variables instead of cases; in a manner that is similar to factor analysis where it can cluster variables together. In addition, hierarchical cluster analysis can handle nominal, ordinal and scale data; however, it is not recommended to mix different levels of measurement. Moreover, clustering is done in two steps where grouping is done by running preclustering first and then by running hierarchical methods. As it uses a quick cluster algorithm upfront, huge sets of data can be managed where it would take longer for hierarchical cluster methods to compute. In a two-stage cluster, scale and ordinal data can be treated in the same way, and the number of clusters can be automatically selected. As in Table 2, the main objective is to classify 18 Malaysian terminals into different groups according to competitive criteria available for ports.

In comparison, Cabral and Ramos (2014) in their study on 18 Brazilian ports employed three distinct groups according to nine competitiveness criteria, including port tariffs, berth depth and delay time for mooring using cluster analysis. In another study in China, the competitiveness of ten coastal ports in China was assessed by Shengrong *et al.* (2010) using a combined cluster and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) test model in the classification of seaports by their competitiveness. Similarly, Sayareh and Alizmini (2014) also used TOPSIS and analytic hierarchy process (AHP) where they found that the working time, stevedoring rate, safety, port entrance, sufficient draft, capacity of port facilities, operating cost, number of berths, ship channelizing and international policies are critical factors for selecting a container seaport in the Persian Gulf.

In this study, the ports were classified into different groups (inter-group) according to some competitive criteria selection forming clusters of ports with similar characteristics (intra-group) using clValid package, and it was a validation measure for clustering results by a statistical method.

3.2 Selection criteria for port competitiveness

The available selection criteria and their definitions are shown in Table 1. However, only four out of seven key drivers were selected for this study. Each key driver's details were surveyed using quantitative data collection. Also, the statistics related to the sample are summarized in Table 3. Table 4 lists the top ten (out of 39) drivers in competitiveness criteria: Loading/unloading cost reduction; material handling facility efficiency improvement; flexibility (loading) improvement; labour improvement; stockpile location improvement, trucking efficiency improvement, loading/unloading processing time reduction; loading/unloading lead time reduction; loading work-in-process reduction and service quality (loading)

Variable	
Input	Output
Port cost	Loading/unloading cost reduction
Port infrastructures	Material handling facility efficiency improvement
	Flexibility (loading) improvement
Operational efficiency	Labour improvement
	Stockpile location improvement
	Trucking efficiency improvement (less than 15 min)
	Loading/unloading processing time reduction
	Loading/unloading lead time reduction
	Loading work-in-process reduction
Port service quality	Service quality (loading) improvement

Table 3. Variables used for measuring Malaysian port competitiveness

Variable	Description	Mean	Std. deviation	N
	Descriptive statistics			
BS	Berth size (m)	524.7222	341.02593	18
BB	Bulk berth multipurpose)	43.6111	29.79368	18
CB	Container berth	29.1667	25.90991	18
LCB	Liquid chemical berth	24.7222	31.55165	18
PB	Passenger berth	2.5000	7.71744	18
LV	Loading (to vessel)	57.7778	13.95605	18
UV	Unloading (from vessel)	42.2222	13.95605	18
Iron	Iron ore	17.5000	16.47190	18
Fertilizer	Fertilizer	6.1111	3.23381	18
Coal	Coal	5.0000	3.42997	18
Maize	Maize	5.0000	3.42997	18
Wheat	Wheat	5.0000	3.42997	18
SP	Steel pipes	5.8333	6.47393	18
ISP	Iron and steel products	6.3889	5.37028	18
CKDV	Completely knocked down (CKD) vehicles	6.9444	8.76807	18
HC	Heavy cargo	7.7778	7.90053	18
ST	Sawn timber	24.4444	25.14013	18
LNG	Liquefied natural gas (LNG)	6.3889	18.21486	18
PO	Palm oil	4.7222	18.82366	18
L	Labour	52.5000	17.84327	18
M	Machines	47.5000	17.84327	18
BWL	Bucket wheel loading	7.5000	6.00245	18
CG	Clamshell grabs	8.0556	5.18450	18
LS	Loading spouts	9.4444	5.91332	18
MHC	Mobile harbour cranes	21.9444	7.88500	18
CVY	Conveyor	26.1111	7.77544	18
CLO	Conventional labour oriented	19.7222	15.76222	18
PG	Pipeline grabs	5.5556	16.52884	18
H	Hooper	1.1111	3.23381	18
CRA	Cranes	0.5556	2.35702	18
Lorry	Lorry	50.0000	5.94089	18
Truck	Truck	46.6667	4.85071	18
Railway	Railway	3.3333	7.66965	18
Less than 15	Trucking efficiency <15 min	40.8333	22.63846	18
From 15 to 30	Trucking efficiency 15–30 min	43.6111	22.01641	18
More than 30	Trucking efficiency >30 min	15.5556	8.20489	18
Less than 1	Stockpile locations < 1 km	18.8889	13.12335	18
From 1 to 3	Stockpile locations 1–3 km	15.5556	13.81484	18
From 3 to 5	Stockpile locations 3–5 km	13.0556	15.15982	18
From 5 to 10	Stockpile locations 5–10 km	6.9444	4.89264	18
More than 10	Stockpile locations >10 km	5.0000	3.83482	18

Table 4. Criteria selection for measuring port competitiveness and summary of statistics for the sample

improvement. The key for selecting these factors is based on the weight of percentage and shown as in Table 4 and Figure 2.

4. Results

This technique enables us to construct a cluster hierarchy where the results presented in a dendrogram can easily be displayed to show which ports are part of what group as in Figure 3. By using a hierarchical algorithm, the number of clusters was first calculated to be three. To achieve the desired number of clusters, the dendrogram obtained can be terminated at a specified height. Nevertheless, the methods of agglomeration have also been tested (see Figure 4).

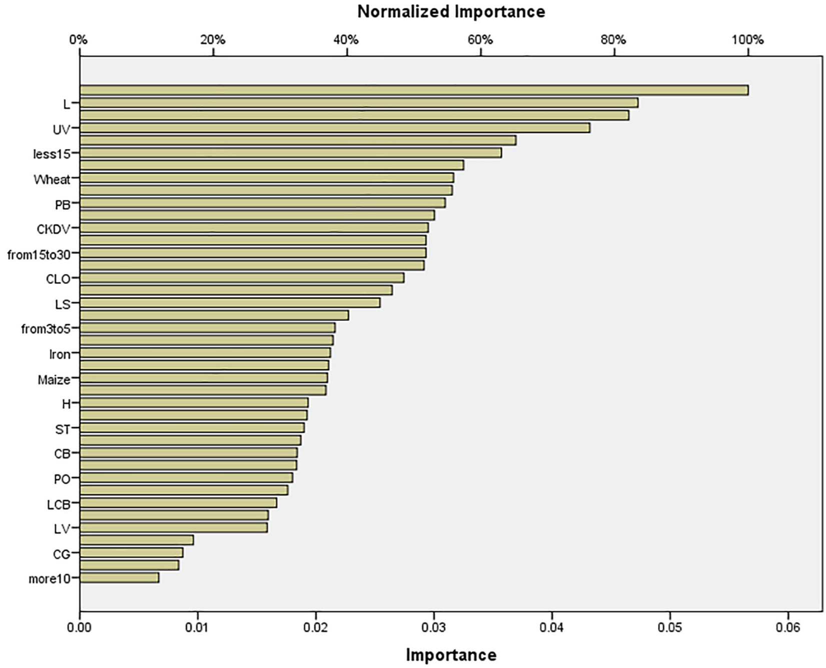


Figure 2. Percentage of total gross for criteria selection in measuring port competitiveness

5. Discussion

The goal of a cluster analysis is to identify groups in which there are large similarities among individuals within each group formed (intra-group) but large differences from the other groups of individuals (inter-group). Thus, several routines were run in R using the *clValid* package applying K-means, the hierarchical algorithm, all of them varying from three to four groups each time. The hierarchical average is composed of nine variables and 18 port terminals. The results showed us that the best algorithm is Hierarchical 2, i.e. it identified two distinct groups of terminals. Within each cluster, the terminals are similar to one another or have similar port competitiveness. In comparison, the terminals in the other groups have differences in competitiveness.

The hierarchical cluster analysis uses average or single agglomeration in the dendrogram (that provides the same clustering groups). The groups formed by this approach are shown in Figure 3. Table 5 shows the numbering used for each group suggested by the dendrogram, while Table 6 presents the mean values for the competitive selection criteria in each of the two groups. Next, we present an analysis of the results for the components of competitiveness in each group.

5.1 Group 1

Group 1 consists of 16 terminals as shown in Table 7. Among these terminals are the lowest values for six of the competitive criteria: material handling facility efficiency; loading/unloading time reduction; trucking efficiency improvement and service quality (loading). It was also found that the ports are still conventional labour oriented, and some of the ports are still taking more than 30 min in trucking efficiency.

It is already clear that the terminals of this category have similar characteristics to those of the competitiveness criteria chosen in this study. Despite the variations between the types of

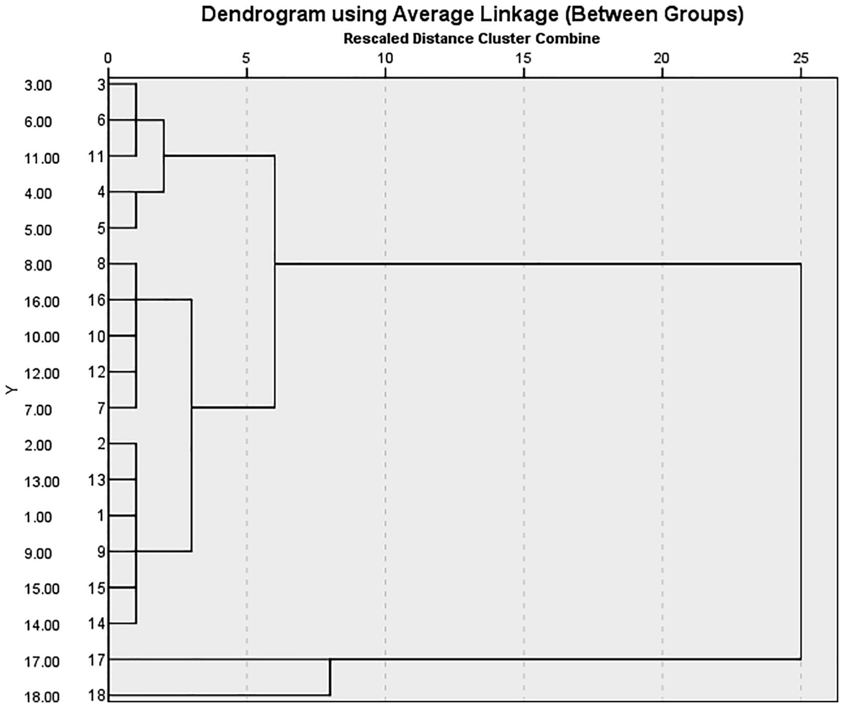


Figure 3.
Dendrogram using average linkage (between groups)

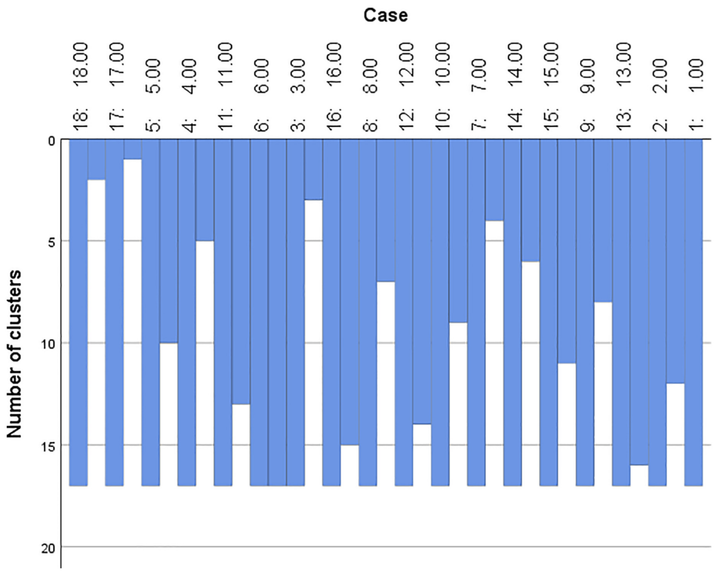


Figure 4.
Percentage of total gross weight in bulk terminal

Table 5.
Agglomeration schedule

Stage	Cluster combined		Coefficients	Stage cluster first appears		Next stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	3	6	6000.000	0	0	5
2	2	13	7150.000	0	0	6
3	8	16	9500.000	0	0	11
4	10	12	11101.000	0	0	9
5	3	11	12016.000	1	0	13
6	1	2	13325.000	0	2	10
7	9	15	13600.000	0	0	10
8	4	5	13800.000	0	0	13
9	7	10	15890.500	0	4	11
10	1	9	19741.667	6	7	12
11	7	8	26419.000	9	3	14
12	1	14	28500.000	10	0	14
13	3	4	38408.667	5	8	15
14	1	7	76182.733	12	11	15
15	1	3	177058.000	14	13	17
16	17	18	243831.000	0	0	17
17	1	17	780998.875	15	16	0

Table 6.
Mean values of competitiveness criteria by groups

Selection criteria of competitiveness	Group 1	Group 2
Loading/unloading cost reduction	4	5
Material handling facility efficiency improvement	3	8
Flexibility (loading) improvement	6	7
Labour improvement	5	4
Stockpile location improvement	4	8
Trucking efficiency improvement	5	8
Less than 15 min		
Loading/unloading processing time reduction	4	5
Loading/unloading lead time reduction	4	5
Loading work-in-process reduction	4	5
Service quality (loading) improvement	5	7

loads that multi-use terminals have compared to specialized terminals, it should not be assumed that such terminals are more effective and have superior efficiency inside or outside this category. It is likely that a specific terminal is productive even though it is not advanced and/or makes demand for containerized cargo. But it cannot be concluded that small terminals, even with higher port tariffs, are less profitable than large terminals. Small terminals do not have much opportunity for competitiveness as a limited number of container ships are being shipped and their infrastructure is only adequate to provide good service to other cargo.

5.2 Group 2

As shown in Table 7, two ports are part of this group: the Westport and Northport of Port Klang. These ports have intermediate values for competitiveness criteria (Table 5), and they are noteworthy for the number of containers moved in 2009, taking first place in the Malaysian rankings (Figure 3). In addition, this group also has higher values than terminals from Group 1 for all competitive parameters. The waiting time for trucking has contributed to

Group	Port/Terminal
1	Kudat Port
	Tg.Manis
	Sarikei Port
	Labuan Port
	Bintulu Port
	Kuantan
	Lumut
	Johor Port
	Sibu Port
	Kuching
	KK Port
	Tawau
	Sandakan Port
	Kemaman
	Penang Port
	Lahad Datu
2	Northport
	Westport

Table 7. The name of ports categorized into Group 1 and Group 2

a substantial score for efficiency with less than 15 min, and the stockpile location is less than 3 km compared with the other ports. It is also a fact that the Westport terminal (the Port of Klang) is the best performing compared with all the terminals in Malaysia. It has also been predicted that the Port Klang will be an attractive alternative hub in the future. During the first seven months of 2017, the port's overall trade value reached RM 1 trillion. This is the highest pace ever compared with RM 1.48 trillion in 2016. Also, during the first eight months of 2017, Port Klang's total indigenous production rose by 5.5% from 2.70 million Teus in 2016 to 2.85 million Teus (News Straits Times, 2017).

6. Conclusions

This study categorized 18 ports in Malaysia into three distinct classes using the hierarchical cluster framework based on competitiveness criteria. Among the attributes of each group created, we note that the competitive requirements of the 16 terminals in Group 1 are not much lower than the two other ports. Particularly, there are numerous terminals specialized in container handling, and they also have a heterogeneous cargo profile. Therefore, the average criteria for competition in the group are also higher than in Group 1. Group 2 consists of three midrange terminals only with higher values than Group 1 but lower than Group 2. Finally, Group 2 provides the largest terminals in Malaysia, which have specialized in all requirements and have excellent output.

Additionally, it is often unnecessary to make major investments in equipment for small terminals to make them more efficient or even to increase productivity as they receive low demand for container lots, i.e. the terminals have their own unique characteristics and freight profile to maximize their performance and charge lower tariffs.

Another challenge is the lack of variables relevant to other port competitiveness requirements, and a detailed research study is needed to gather information on the satisfaction of terminal customers, the paperwork involved, the accuracy and consistency of tariffs paid, the level of safety at sea and on land and environmental protection around the facility site. Another factor that deserves special consideration is the number of variables involved in our research.

At this point, it is also important to emphasize that any cluster solution is likely to be matched to other port databases if one has a group of terminals whose performance is compared to other terminals with similar characteristics and performance limitations. In this case, it is highly recommended that this technique to be replicated in many ports around the world. As competitiveness is associated with a sustained ability to maintain production at increasing rates, it is expected that both the emphasis on containerized freight transport and the investments announced by the PAC (growth acceleration program) in the Malaysian transport sector would contribute to the achievement of the best indicators of port productivity.

In terms of competitiveness, Westport and Northport have the highest ratings for port services and infrastructures. The ports also concentrate on attracting cargo from the Southeast Asia area. Therefore, Malaysian ports are anticipated to remain rapidly increasing in competitiveness with a steady increase in overall trade. The Malaysia Shipping Council has also been established to revitalize the Malaysian shipping industry (New Strait Times, 2017).

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Further reading

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