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Article

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Original Article

Extension of the seaport life cycle (SLC) by utilising existing inland capacity for current and future trade preparation

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ABSTRACT

This paper explores the structure of the seaport life cycle (SLC) of Malaysian container seaports to restructure the seaport development plan. Quadratic regression analysis is proposed to stratify the life cycle stages of seaports through the quantification of throughput volume, and forecast future growth patterns of seaports. The findings show that Port Klang, Penang Port, PTP and Kuantan Port are experiencing the growth stage in their seaport life cycles, while Johor Port is standing at the decline stage of the seaport life cycle. Penang Port and Port Klang are expected to continue growing until 2050. Meanwhile, PTP, Johor Port and Kuantan Port have entered the maturity stage in 2018 and are expected to move into the declining stage by 2050. This paper provides significant evidence about the need to establish a link between seaports and dry ports, and develop a symbiotic strategy to prolong the life cycle of seaports. Academically, this paper provides significant literature on Malaysian seaport cycles, which may be utilised for seaport development plans to cater to the demands of the domestic and global market.

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1. Introduction

A recent study carried out by Ibrahim (2017) stated that both the seaport life cycle and seaport generation are relevant to seaport development, where the former recognises the evolution phases of any development or installation in a seaport area (Charlier, 1992). Moreover, a seaport life cycle represents the micro-economics model of the development of a seaport as a whole; while a seaport generation represents the micro-to-meso-economic model of time evolution through a functional and organisational development process (UNCTAD, 1992). Monios and Bergqvist (2016) argued that a seaport life cycle is more holistic, and encompasses the growth of its businesses rather than as a specific spatial. As containerisation is part of the seaports' processes, seaports will enter their life cycle introductory stage when operating their first container berth (Cullinane & Wilmsmeier, 2011). They then evolve from a 2nd generation seaport to a 3rd generation seaport when the seaports are fully containerised (UNCTAD, 1992).

The seaport generation concept describes the seaports' different operational ways throughout different eras. Among the transformations witnessed are those that have transformed seaports from

traditional to modern seaports; from isolated seaports to network seaports; from mere interface locations to commercial and logistic hubs; and from basic port services providers to customer-satisfaction oriented seaports. Accordingly, the seaport generation concept differs from the seaport life cycle concept as it does not describe the seaports' growth and prosperities periods, seaport throughput volume, and seaport competitiveness.

Therefore, seaports' life cycles need to be identified and explored to prepare significant strategies that will be adopted. Seaports need to ensure that they are ready to deal with future throughput loads to handle future and unknown high demands of container and cargo logistic services. By relying heavily on the knowledge of their life cycles, seaports can achieve this by continuing to invest and improve their handling capacity per their ability. This paper aims to reveal the current life cycle stages of Malaysian seaports; to forecast the life cycle stage in which the ports under study are expected to be in 2050; and to analyse the role of dry ports as a means to prolong their life cycles. Moreover, this paper recapitulates the importance of the theory of product life cycle in a seaport's context, and provides concrete justification for seaports to deal with upcoming challenges and prepare for future long-term planning.

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2. The scenario of seaport life cycles in seaport sectors

The application of the life cycle theory to seaports can be deemed as planning and evaluation tools for logistics administrators (Harrison, McCray, Henk, & Prozzi, 2002) as the predictable patterns produced from this theory can provide better insight for monitoring the industry's environment (Sletmo, 1999). As highlighted by Cullinane and Wilmsmeier (2011) and Monios and Bergqvist (2017), the main goals of applying a life cycle approach to the seaport sector are to settle operational issues, which prevent future growth, and to identify the signs as well as the competitive strategies linked with each stage of its life cycle. For example, the Port of Hong Kong overcame its congestion issues by expanding its seaport area and infrastructure to the hinterland at its development stage. Then, when it reached its maturity stage, the dry port concept was implemented after the intermodal transport infrastructure had been completed (Cullinane & Wilmsmeier, 2011).

Rytönen (1999) indicates that the development of a new seaport is the ultimate solution for seaport capacity issues. Cullinane and Wilmsmeier (2011) then pointed out that the establishment of a new port is attributed to the development stage of the seaport life cycle. However, in current dynamic trade systems, this concept has become inappropriate because external investment opportunities reduce the authority of local seaports. Thus, seaport development plans can be refused due to political agendas. In such cases, the development of a new seaport based on the feasibility studies may not be relevant (Habib, 2018). For example, the Hambantota seaport project in Sri Lanka highlights this issue. The development of this new seaport was driven by opportunities derived from the external environment. This project aimed to increase its throughput and profits. However, the project took place without considering the present condition of existing seaports, therefore neglecting the outcome of the feasibility studies which were not aligned with the objective of the project. This project indicates that expanding seaports based on their life cycles is the right strategy to initiate any seaport's development plans in any region. Hence, an analysis of the current seaports' situation/life cycle needs to be understood before presenting any development plans, restructuring existing policies, and initiating new seaport restructuring plans.

Applying the life cycle model on seaports and analysing the curve patterns of their life cycles will make demand forecasting possible, which would greatly assist policy makers in planning and recommending suitable strategies to be carried out during the early stages (Sletmo, 1999). The essence of the life cycle theory, which contains warning signs to be observed, is to predict the precise timing of growth or shocks (Norton, 1986). Similarly, Monios and Bergqvist (2016) found that the framework of the life cycle is advantageous to identify the key stakeholders, motivations, and strategies at each stage and knowledge gap. However, some professional knowledge related to advanced seaport systems and operations to be pursued in the future is needed. By having these inputs, seaports can ensure that they will be developed accordingly with their seaport life cycles, without missing and skipping any significant seaport development events or projects. However, this prerequisite has been neglected by the Malaysian seaport sector whereby the development plans, strategy recommendations and policy approvals have been made without referring to seaports' life cycles due to internal and external investment opportunities. If seaport strategies are not based on their life cycles, investments may cause overcapacity and/or underutilisation, or even promote the development of white elephants.

Besides developing new seaports, the development of dry ports also plays a potentially key role in solving seaport capacity, space and congestion issues (Rosso, Russell, Ruamsook, & Stefansson, 2013), and promotes the development of seaport-inland systems (Cullinane & Wilmsmeier, 2011). In order to deal with the incre-

Table 1

Container throughput and capacity (million) of Malaysian container seaports in 2018.

Ports	2018		
	Container volume (TEUs)	Seaport capacity (TEUs)	Utilisation rate (%)
Port Klang	12.3 million	17.6 million	70
PTP	8.9 million	12.5 million	71
Penang	1.5 million	2 million	75
Johor Port	0.900 million	1.2 million	75
Kuantan Port	0.149 million	0.600 million	25

TEUs: Twenty Equivalent Units.

Source: Authors.

asing container volumes in a limited seaport capacity, Malaysian seaport development is, undoubtedly, supported by four main dry ports. Even though these dry ports play an essential role in the logistic sector, these inland nodes still receive poor recognition from their respective stakeholders (Jeevan, Chen, & Pateman, 2016). This poor recognition is due to stakeholders having a lack of understanding on the role and importance of dry ports in prolonging seaports' life cycles, which results in the underutilisation of dry ports (Jeevan, 2016). These issues and the seaport life cycle theory should be a concern to the related parties to ensure that Malaysian dry ports can be fully utilised in the Malaysian seaport system.

Owing to the inadequate understanding of seaport life cycles among the local maritime-related policymakers, major Malaysian seaports' planning and strategies are not maximised. This situation may result in seaports being uncompetitive, or trapped by seaports' internal development factors without any early reminders, or are strongly affected by external environmental factors under unprepared conditions. Overall, a strong understanding of seaport life cycles is extremely crucial to ensure that Malaysian seaports are well developed with proper strategies in place. This is important so that seaports are more efficient in terms of their planning and strategies, ability to cope with challenges, and ability to seize opportunities for growth in the near future. Table 1 indicates the container throughput volume and port capacity of Malaysian container seaports, and presents the utilisation of each seaport capacity. As shown in Table 1, Kuantan Port has utilised 25 per cent of its designed capacity in the handling of containers. In general, a container seaport needs to find new investments as a solution when its utilisation exceeds 70 per cent as it implies that seaports are starting to become congested (Ilmer, 2018). Based on Table 1, the capacity utilisation of Penang and Johor ports exceed 75 per cent, and the capacity utilisation of Port Klang and PTP are close to optimum levels of utilisation.

The situation in Table 1 also shows that these seaports immediately require additional plans to improve their space capacity. However, this single indicator, which refers to seaport utilisation, is not sufficient or appropriate to determine the seaport's situation for present and future development, or to draw any policy measures related to seaport expansion. Seaports require additional information related to their activities, including container throughput, investment levels on facilities and infrastructure, services and service providers, core production factors, competition, market shares, and capacity, to plan and execute their development strategies (Cullinane & Wilmsmeier, 2011; Sánchez & Wilmsmeier, 2010).

3. Malaysian seaport system: an introduction

In general, Malaysia consists of 18 major seaports (see Fig. 1), where Port Klang, Port of Tanjung Pelepas (PTP), Penang Port, Johor Port, Kuantan Port, Kemaman Port and Bintulu Port are the main seaports. The remaining seaports are minor seaports owned by state and tourism organisations. Recently, the Malacca Port had

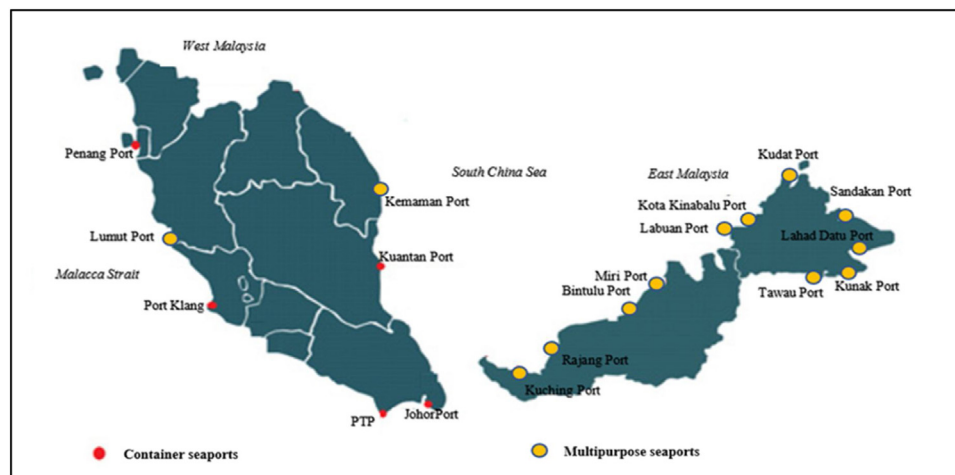


Fig. 1. Malaysian seaports.

Source: Adapted from Jeevan (2016).

been developed as a new deep-sea terminal to serve larger megavessels along the busiest maritime route of the Malacca Straits from 2019 (Aznam Shah, 2018). Owing to their geographical advantages, Port Klang, PTP and Penang Port have become the most attractive seaports along the west coast of Peninsular Malaysia.

The growth of international trade significantly influences the Malaysian seaport industry. Malaysian container seaports' volumes have increased to 23 million TEUs in 2017 compared to 12 million TEUs in 2005, and are expected to achieve 36 million TEUs in 2020. Table 2 shows the TEUs handled by the main seaports from 1973 to 2017.

Since 1989, Malaysian seaport development has been, undoubtedly, supported by dry ports in dealing with increasing container volumes within a limited seaport capacity. Ipoh Cargo Terminal (ICT) was the first dry port initially built to capture the growing container volume from Port Klang (Jeevan, 2016). As of today, Malaysia possesses four major dry ports that are operating to handle inland container movement to and from seaports. These four main dry ports are Ipoh Cargo Terminal (ICT), Padang Besar Cargo Terminal (PBCT), Segamat Inland Port (SIP) and Nilai Inland Port (NIP). Moreover, there are also three inland clearance depots at Sungai Way, Prai and Bukit Kayu Hitam (Jeevan, 2016).

Firstly, the capacity of the container yard in PBCT is approximately 800 TEUs. However, this dry port has no space for accommodating empty containers or land for future development. Secondly, ICT has a container yard capacity of 800 TEUs and space available to accommodate empty containers. However, it has no land for future expansion. Thirdly, the current yard capacity of NIP is approximately 1200 TEUs, but it has no space for empty containers. Finally, the total capacity of SIP's container yard is 3500 TEUs, and unlike the previous ones, it has ample space for empty containers and future development (see Table 3). Space for future development and empty container placement are critical advantages of dry ports to accommodate unpredictable container volumes, and to assist seaports in prolonging their competitiveness effectively.

An intermodal transport system supports the linkage between container seaports and dry ports. For example, in 2005, almost 5.5 million container volumes have been handled at Port Klang, and in 2007, the volume increased to 11 million TEUs (MAPA, 2017). As a hybrid seaport which executes the functions of a gateway and transshipment seaport, the support from inland components is required to accommodate the significant volume of containers between these years. Road and rail transport are both responsible for hinterland transport connections to Malaysian container seaports. However, due to limited rail infrastructure, road haulage became

the main transport link for container movement, either directly to or from seaports, dry ports, and hinterland (Chen, Jeevan, & Cahoon, 2016). The proportion of road freight to rail freight has reached 98:2, which indicates a significant domination of road freight in this region (Jeevan, Chen, & Cahoon, 2019).

Besides that, Malaysian seaports are also positioned at strategic regional transport and freight economic corridors along the region. However, the Malaysian economic corridors attempt to balance the urban and rural development with the promotion of logistics, education and other economic industries at the respective regional areas, and integrate the designated regions within the national and global economy by improving accessibility so that they will be connected efficiently with national and global trade (Athukorala & Narayanan, 2017). Among the six economic corridors, only three are implemented in Peninsular Malaysia. Iskandar Malaysia (2006–2025) is located at the southern tip of Malaysia; the Northern Corridor Economic Region – NCER (2007–2025) encompasses the state areas of Perlis, Kedah, Penang and Perak; and the East Coast Economics Region – ECER (2007–2020) covers the east coast states of Malaysia, namely Kelantan, Pahang, Terengganu, and Mersing in Johor (MIDA, 2018). Each economic corridor has a seaport, serving as a logistic gateway or hub, with high connectivity along the corresponding corridors (Athukorala & Narayanan, 2017).

On a similar note, many coastal countries wish to benefit from the One Belt One Road initiative (OBOR). Hence, they are actively developing their ports for future collaborative opportunities with China and other ASEAN countries. To become a port of choice in this international context, Malaysia should seize the opportunity to accelerate its seaport development by keeping pace with international demand and improving its port competitiveness. However, the lack of knowledge about Malaysian seaports' life cycles leaves them unlettered in strategies and critical requirements regarding future port capacity. This lack of understanding may cause Malaysia to be replaced by other peers (China Press, 2017) and be left behind in this international collaboration. Therefore, Malaysian seaports need to be guided to re-adjust its pace with strategies provided accordingly for each stage through a thorough understanding of the seaport life cycle.

Port Klang and PTP have been ranked as part of the top 20 container ports in the world. Their port performance has always drawn the academia to studying their port operation productivity (MIMA, 2012), region competition on capacity (Dang & Yeo, 2017), port growth and hinterland integration (Jeevan, Chen, & Lee, 2015), inland connectivity (Othman, Jeevan, & Rizal, 2016), and others. However, the literature and research works surveying Malaysian

Table 2
Container Throughput (TEUs) in major container seaports.

Year	Port Klang	PTP	Penang Port	Johor Port	Kuantan Port
1973	13,321	–	–	–	–
1974	41,887	–	2994	–	–
1975	56,940	–	N.A.	–	–
1976	68,728	–	N.A.	–	–
1977	82,273	–	N.A.	–	–
1978	98,914	–	24,000	–	–
1979	117,281	–	N.A.	–	–
1980	127,055	–	45,000	–	–
1981	148,305	–	N.A.	–	–
1982	157,231	–	65,000	–	–
1983	193,460	–	N.A.	–	–
1984	240,692	–	100,000	–	–
1985	244,120	–	N.A.	–	–
1986	241,182	–	132,000	–	–
1987	273,335	–	N.A.	–	–
1988	319,557	–	167,000	–	N.A.
1989	393,954	–	N.A.	–	N.A.
1990	496,526	–	222,440	66,083	2343
1991	607,626	–	251,849	96,931	4065
1992	677,678	–	303,367	128,558	6818
1993	771,901	–	330,922	168,315	9681
1994	943,846	–	386,182	235,659	12,192
1995	1,133,811	–	433,474	302,898	22,591
1996	1,409,594	–	454,765	377,890	40,821
1997	1,684,508	–	506,863	429,448	54,855
1998	1,820,018	–	510,307	439,661	50,989
1999	2,550,419	20,698	566,409	558,056	56,056
2000	3,206,753	413,844	635,780	659,181	62,783
2001	1,872,767	1,969,815	605,294	638,718	71,252
2002	4,533,212	2,550,836	632,042	683,816	87,795
2003	4,841,235	3,316,633	688,171	750,446	104,848
2004	5,243,593	3,835,893	772,024	805,689	122,745
2005	5,543,527	4,044,816	795,289	836,754	119,298
2006	6,326,295	4,637,418	849,730	880,611	124,834
2007	7,118,714	5,297,831	922,099	927,287	127,600
2008	7,973,579	5,466,191	929,639	935,037	127,061
2009	7,309,779	5,835,085	943,183	952,702	135,169
2010	8,871,745	6,298,734	956,185	953,286	141,894
2011	9,603,926	7,302,461	1,202,179	830,340	132,796
2012	10,001,495	7,493,806	1,165,733	801,058	136,101
2013	10,350,409	7,416,518	1,237,713	757,023	126,548
2014	10,945,804	8,231,752	1,265,712	792,501	131,244
2015	11,886,685	8,798,747	1,317,352	800,524	140,959
2016	13,209,577	8,029,093	1,437,120	827,013	128,897
2017	11,978,166	8,137,905	1,507,266	900,692	147,041
2018	12,316,003	8,960,865	1,510,376	941,589	149,912

N.A. – not available.
Source: Authors (Compiled from different sources).

seaport life cycles are limited, more so that which describes the current position of Malaysian seaports' structural growth trends. Without a clear picture to identify the current position of seaport life cycles of Malaysian container seaports, it will be difficult for port authorities to ensure that they are prepared for both the future demands of globalisation and the challenges of shipping liberalisation. The existence of dry ports does not make any significant impact on seaport life cycles (Jeevan, 2016). However, the nature of Malaysian dry ports is unique whereby these dry ports are competing with the seaports. Hence, having dry ports in the Malaysian seaport system does not capture the role of dry ports in expanding seaport capacity.

This case is similar to one that occurred in Brazil between its seaports and dry ports (Robles, 2013); in which the cooperation between these nodes need to be improved using a generating mutualistic-relationship. This strategy may reduce the competition between them, improve the awareness of dry ports in freight transport systems as well as increase the recognition of dry ports in Malaysian seaport systems. Moreover, the cooperation between these nodes is a prerequisite for dry ports to assist seaports in expanding their life cycles.

As new container ports, namely Malacca gateway deep-sea seaport, Kuantan seaport and Carey Island seaport (expansion of Westport), are still under construction, their future volume capacity and port demand are both unknown. Although having a new port is the ultimate solution to overcoming port capacity issues, previous studies have pointed out that the establishment of a new port is attributed to the development stage of the seaport life cycle (Cullinane & Wilmsmeier, 2011) without considering the purpose of new seaport establishment. Therefore, the life cycle model of a new port coupled with the analysis of the curve pattern of seaport life cycles will provide an idea to revisit the initial plan by the policy makers, especially regarding new seaport development.

As written by Norton (1986), through the life cycle theory, a seaport's future growth and shocks can be predicted, and any warning signals can be seen. Monios and Bergqvist (2016) also reiterated the same conclusion on the importance of implementing the life cycle theory. The life cycle theory will help seaport operators understand who the stakeholders are, what drives or motivates them, the strategies that have been or are being used, and if there are any knowledge gaps that must be addressed. Thus, by having learnt and applied the life cycle theory, these seaports can ensure that

Table 3

General information on Malaysian dry ports.

Dry Ports	PBCT	ICT	NIP	SIP
Location	Border-based	City-based	City-based	Border-based
Distant	Mid-range to Penang Port Distant to Port Klang	Mid-range to Penang Port Distant to Port Klang and PTP	Short-range to Port Klang Distant to PTP	Mid-range to Port Klang and PTP
Seaport connection	Penang Port Port Klang	Penang Port Port Klang PTP	Port Klang PTP	Port Klang PTP
Container to seaports (%)	40% to Penang Port 10% to Port Klang	35% to Port Klang 10% to Penang Port 5% to PTP	60% to Port Klang 10% to PTP	10% to PTP 10% to Port Klang
Transport connection	Rail Road	Rail Road	Road 1200 TEUs	Rail Road
Capacity of container yard	800TEUs	800 TEUs		3500 TEUs
Space for empty container	None	Available	None	Available
Type of cargo	Perishable goods Rubber Timber	Raw materials Manufacturing goods	Raw materials Manufacturing goods	Agricultural product Raw material
Land for future development	None	None	Available	Available

Source: Adapted from Jeevan et al. (2015).

they will be developed according to their seaport life cycle, without ever missing and skipping any critical port development events or projects.

Besides developing new ports, the development of dry ports also plays a potentially crucial role in solving issues on port capacity, space and congestion (Roso et al., 2013), as well as promoting seaport-inland systems (Cullinane & Wilmsmeier, 2011). In facing the increasing container volumes in a limited seaport capacity, Malaysia seaport development has, undoubtedly, been supported by the four leading dry ports. These dry ports play an essential role in the logistics sector, and are well-connected by rail and road systems. However, the underestimation of dry ports' functionalities and the seaport life cycle theory should be a concern for all related parties to ensure that Malaysian dry ports can be utilised in the Malaysia seaport system.

4. Methodological design

In order to identify the life cycle stages in which a seaport finds itself, the identification of stage boundaries in PLC must be carried out first as there must be boundaries, namely transitional points, to indicate the point where a seaport shifts from one stage to the next. To identify these boundaries between stages, Chang and Chang (2003) suggested the Short-Term Moving Average method, which involves a combination of simple moving average and linear regression. Quadratic regression, also called a second-order regression model or polynomial regression analysis, explains the nonlinear relationship between the dependent variables and the independent variables. It is advantageous as an approximating function to assess unknown and possible high complexity nonlinear relationships, and helpful in situations where the analyst knows that curvilinear effects are presented in the right response function.

Therefore, a quadratic regression analysis is proposed to identify the life cycle stages of a seaport through the observation of the throughput volume curve; the forecast of the future growth patterns of throughput; and the corresponding transition points of the seaport life cycle stages from the seaport life cycle curve as indicated by Feng (2005). Moreover, this quadratic regression analysis will help to discover the forecast trend of the seaport life cycle of each Malaysian container seaport for the next three decades. The timeframe for forecasting will be expanded over to the year 2050

as National Transformation 2050 is a new aspiration for Malaysia to achieve, and the prediction of shipping demand is expected to double in 2050 from that of 2030 as well as 2020 respectively.

In this case, the quadratic regression analysis aims to model the expected value of a dependent variable Y in terms of the value of an independent variable X , where the highest power on the term X is 2. Thus, the quadratic regression model, which expresses Y as a function of X_1 and X_2 , includes linear and squared terms for each of these variables. The outcome can be generalised by using the same model to determine the seaport life cycle to develop new policies, and new and innovating strategies according to global trade requirements. In order to estimate the regression parameters, $\pi(x)$ is transformed using logit transformation (Hosmer & Lemeshow, 2000). Logit transformation in the quadratic regression model is shown in Eq. (1). Owing to a continued character of Y as an independent variable in quadratic regression and TEUs as an application of the standardised measurement for containers (Zuhri, Sentia, Lubis, & Permai, 2019), this non-bulk cargo has been used as the main indicator to analyse the SLC.

The quadratic regression equation is:

$$Y = \beta_0 x + \beta_1 x + \beta_2 x^2 + \varepsilon \quad (1)$$

where, Y = dependent variable

x = independent variable

β_0 = the mean response of Y when $x = 0$

β_1 = linear effect parameter

β_2 = quadratic (squared) effect parameter

Therefore, the container volume is required from each seaport (as indicated in Table 2) to forecast the SLC. Data concerning the container volume was extracted from each selected Malaysian seaport's official website, including Kuantan Port, Penang Port, Johor Port, PTP, and Port Klang. The data reflects port activity, port investment, hinterland accessibility, port services and services provider, production factor, and competition level of each seaport. A content analysis approach was used to analyse the container volume data to identify the seaport life cycle stage. The content analysis indicated that Port Klang, Port of Tanjung Pelepas, Penang Port, and Kuantan Port are currently experiencing the growth stage; while Johor Port has passed through its growth stage after 2007, having entered the maturity stage from 2008 to 2010, and the decline stage from 2011 onwards.

The next paragraphs show the steps used in the identification of seaport life cycle stages (development, introduction, growth, maturity and decline). According to the original Product Life Cycle, the shape of the curve is determined by the unit sales over time (Osland, 1991). Thereby, a similar application has been implemented in the seaport curve of the seaport life cycle by determining unit throughput (TEUs) over time. The life cycle curve is not a straight line but one with a bell shape which justifies the use of the quadratic regression model in the analyses of the container throughput of each Malaysian container seaport under study from 1973 to 2017 (a 44-year time frame).

The four steps to complete the quadratic regression are as follows:

Step 1: Run the quadratic regression by using container throughput.

The following is the equation of quadratic regression analysis,

$$Y = \beta_0 x + \beta_1 x + \beta_2 x^2 + \varepsilon \quad (1)$$

In this case, Y is Total Container Throughput (TEU), and x is the year (t). So, the equation of this research is shown below,

$$TEU = \beta_0 t + \beta_1 t + \beta_2 t^2 + \varepsilon, \quad (2)$$

Step 2: Forecast future container throughput by substituting the value of 1, 2, 3, ..., n , into t , to produce the forecasted seaport life cycle curve.

Step 3: Draw the result of Step 2 into a graph line to show the trend of forecasted container throughput curve.

Step 4: Consider the transitional point (k_{iji}) between stages, based on observation of each seaport characteristic and throughput curve pattern. In this case, the SPSS (version 22.0) programme was used to complete the regression analysis.

The following section discusses the proper strategy that should be applied to assist each container port in future preparations to cater to future challenges, according to its respective forecasted seaport life cycle.

5. Result and discussion: trend of Malaysian seaport life cycles

5.1. Port Klang: a growing trend in SLC

The quadratic regression analysis result for Port Klang's container throughput data shows that R -squared is 0.985, which means that 98.5 per cent variations in the dependent variable Y are explained by the independent variables present in this model. The significant value of this model is 0.000. The estimated quadratic regression equation that was used to develop Port Klang's seaport life cycle curve is $Y = 11224.342x^2 - 230283.025x + 926355.85$. Port Klang's growth stage started from 1986 to 2017, after this seaport was privatised in 1986. After its privatisation, its capacity grew from 3.6 million TEUs in 1993 to 17.6 million TEUs in 2017. The growth in capacity was a result of continuous private investments that took place during the period of its expansion and construction, infrastructure and facilities, standardisation and innovation of its operational processes. As the port has served as the hub and cargo transshipment centre of Peninsular Malaysia since 1988, continuous increase in the number of shipping lines from international shipping lines calling at the seaport has led Port Klang's container volume to grow significantly from 1986 to 2017.

Hinterland accessibility of Port Klang has been expanded to many non-adjacent cities like the Thailand and Singapore border while being well-connected to several dry ports by rail connections and expressways. Fig. 2 presents the seaport life cycle curve of Port Klang and its forecasted seaport life cycle curve until 2050. Port Klang is the top-ranked container port in Malaysia and is ranked

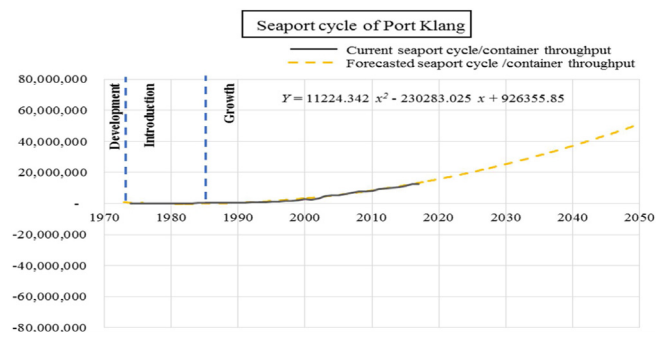


Fig. 2. Port Klang SLC from 1973 to 2050.

Source: Authors.

12th in the 2017 World Top Container Port List. Port Klang is predicted to continue its growth trend and serve more containers in the next 30 years. Even though the Port of Singapore Authority has out-paced Port Klang's latest performance, its performance is expected to grow based on the inferred and forecasted result. Port Klang is currently in the growth stage. This seaport is expected to continue to become a leading gateway and transshipment hub on the Maritime Silk Road of the One Belt One Road Initiative (Jeevan, Chen, & Cahoon, 2018). By extending the length of its growth stage period, Port Klang's container handling capacity will increase, which would be the most appropriate plan for future preparations.

Recently, Port Klang encountered capacity utilisation levels of up to 70 per cent, which leads to spatial constraint. However, the new seaport construction in Carey Island (Port City), with an annual throughput capacity of 30 million containers, manages to provide the additional space for this seaport even though this new port city will take between 10 and 15 years to complete and begin port operations. Hence, at this point, an existing capacity, such as dry ports, needs to be utilised to cater to additional containers at the growing stage. At this stage, Port Klang has reached economies of scale, and seaport activities are increasing rapidly. Therefore, an improvement in connectivity to and from the hinterland and seaport activities is expected to be expanded to many non-adjacent cities. Instead of waiting for Port City to be ready, as an immediate solution, Port Klang may materialise all dry ports in Malaysia including Padang Besar Cargo Terminal (PBCT), Ipoh Cargo Terminal (ICT), Nilai Inland Port (NIP) and Segamat Inland Port (SIP) as indicated in Fig. 3. Port Klang is the only seaport, which is connected to all dry ports, compared to the other Malaysian seaports. As a result, when bringing all dry ports together, this seaport owns an additional external space of about 171,200 sq., which will be an advantage to Port Klang in sustaining its growing stage. They may even assist Port Klang in improving its competitiveness by reducing congestion, which affects schedule reliability, timeliness in freight movement, as well as develop a symbiosis network between seaports and dry ports.

From the seaport generation perspective, Port Klang is heading towards its 5th generation, and will remain at this stage for the next 30 years. At this stage, this seaport is customer-oriented, and strong focus is given to customer services. On the other hand, this seaport will be facing severe competition from other seaports, which might affect its competitiveness. Hence, the integration of dry ports in the seaport system is required to improve seaport competitiveness to enhance seaport performance, increase service variations, improve seaport-hinterland proximity, increase seaport trade volume, and enhance seaport capacity (Jeevan, 2016). Due to these impacts, the incorporation of Port Klang with dry ports needs to be executed to ensure that the performance of this seaport will be improved along with its growing trend. At the current stage, these nodes are both competing rather than co-operating, which limits the performance

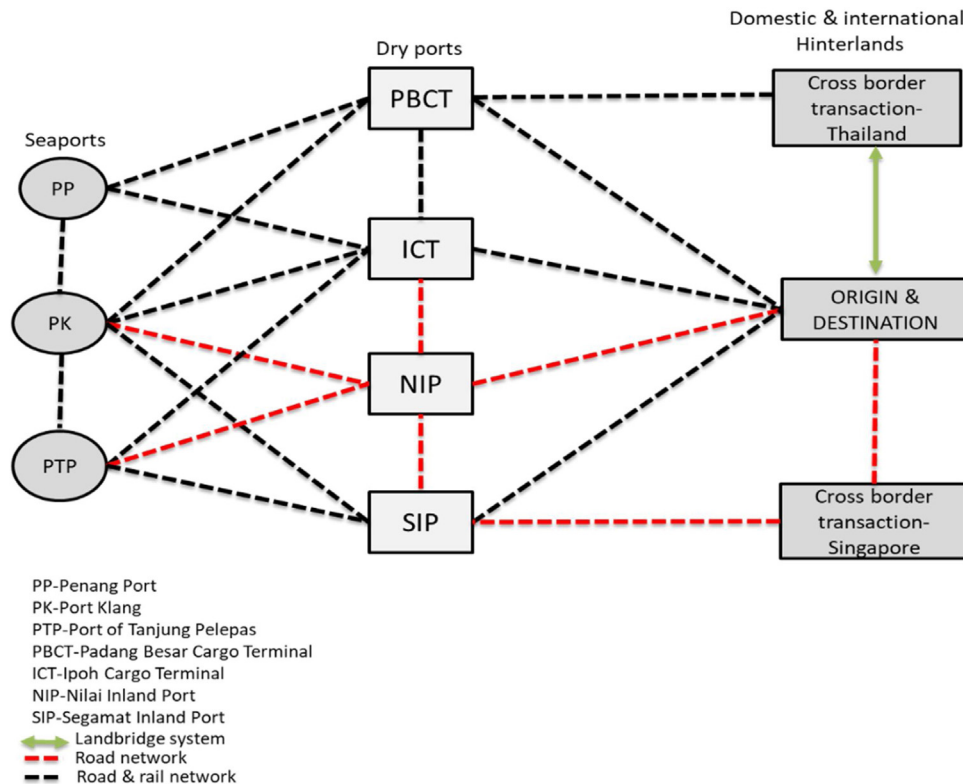


Fig. 3. Seaport-dry port-city network.

Source: Authors.

of seaports and dry ports in the seaport system. Hence, the integration with dry ports is an essential agenda for Port Klang to remain competent in the next few decades.

5.2. PTP: a declining trend in SLC

The quadratic regression analysis result for PTP's container throughput data shows that R -squared is 0.986, which means that 98.6 per cent variations in the dependent variable Y are explained by the independent variables present in this model. Meanwhile, the significant value of this model is 0.000, and the estimated quadratic regression equation that is used to develop to the PTP seaport life cycle curve is $Y = -18377x^2 + 831808x - 713339.7$. PTP's development as a container seaport started from 1996 to 1998, and it was evident in the investment towards the construction of six container terminals and container handling equipment. The introduction stage of PTP began in 1999 after the seaport infrastructure was ready to begin operations. This seaport handled its first batch of containers in 1999, and container throughput volume experienced good performance in the first introduction year by recording 20,698 TEUs. During the introduction stage, the seaport focused on the investment in hinterland accessibility between Kempas city to PTP in the southern region of peninsular Malaysia.

PTP's growth stage occurred between 2000 and 2017, and the container volume grew significantly from the year 2000 to 2017 as the seaport served as a hub and cargo transshipment centre by handling the busiest transshipment traffic during this period. In this period, seaport activity grew as a result of the continuous increment in the number of seaport and seaport investments on berth construction, infrastructure and facilities. The seaport standardisation and innovation process has increased the seaport capacity considerably from 6 million TEUs to 10.5 million TEUs.

The hinterland accessibility of PTP has also expanded to many non-adjacent cities like the Thailand and Singapore border, well-

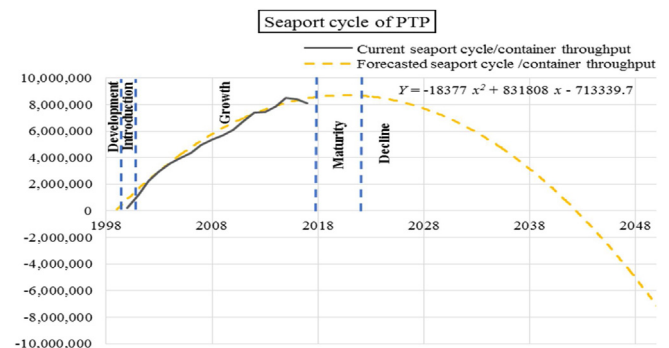


Fig. 4. PTP SLC from 1999 to 2050.

Source: Authors.

connected rails and roads, dry ports including the Johor Port, and access to the nearby Changi and Senai airports.

Fig. 4 indicates the PTP seaport life cycle curve and its forecasted seaport life cycle curve up until 2050. PTP is the Top 2 container seaport in Malaysia and is ranked 19th in the 2017 World Top Container Port List. PTP has been positioned in the growth stage since 2017, and the growth rate has become slower in recent years. The seaport is estimated to achieve a matured growth rate between 1 and 2 per cent on container throughput volume from 2018 to 2021. PTP is expected to fall into the decline stage and serve less containers in 2022 if no action is taken to prevent this declining phase.

PTP has entered the maturity stage and placed in the growth stage in 2018, which could be extended by carrying out the right strategic plans to gain the most optimal seaport growth. In the Malacca Straits region, extending the growth stage is possible via an expansion of the port area, berth construction, land infrastructure investment, standardisation and process innovation. This matches with what PTP has planned in its long-term port development

master plan until 2045. Besides, PTP is well connected to NIP and SIP, and the use of these dry ports can prolong the life cycle of this seaport and prevent it from entering the decline stage after 2021. During its decline stage, this seaport will face congestion issues and the saturation of its capacity, because there is a need to maintain its competitiveness despite no further investment in area expansion.

Currently, SIP is only contributing around 10 per cent of its container volume to PTP and remains underutilised in the southern region of Peninsular Malaysia. Furthermore, it is spacious enough for future development and is classified as a mid-range dry port for PTP. SIP is providing additional opportunities for this seaport to explore and utilise the potential benefits. This situation indicates that a dry port is essential for PTP to improve its performance in the next few decades. Although PTP is a transshipment hub in this region, the utilisation of dry ports is possible to enhance its performance. For example, the dry ports can be utilised to store transshipment containers which are listed at the end of the transshipment schedule, while the space in PTP can be used to place containers which will be transited ahead as listed in the transit schedule. This coordination between seaport and dry ports promises efficiency in container transshipment activities by prioritising the containers that need to be transited immediately to/from the seaport and dry ports.

5.3. Penang Port: a growing trend in SLC

The quadratic regression analysis result for Penang Port's container throughput data shows that R-squared is 0.994, which means that 99.4 per cent variations in the dependent variable Y are explained by the independent variables present in this model. Meanwhile, the significant value of this model is 0.000, and the estimated quadratic regression equation that is used to develop Penang Port's seaport life cycle curve is $Y = 691.8x^2 + 3247.6x - 9847.9$. The development of Penang Port as a container seaport began in late 1960 to 1977. Penang Port began to operate as a traditional seaport in 1786, and accommodated liquid bulk and bulk cargoes during its development stage. In 1974, this seaport served its first container with a minimum number of quay cranes, prime movers and gantry cranes. Between 1966 and 1977, the seaport witnessed a capital investment in port expansion, resulting in the construction of deep-water wharves, conversion of berths into container berths, and modern container-handling equipment.

Penang Port's introduction stage began when the dedicated container terminal was completed in 1978, and the seaport activities and container throughput volume increased considerably after the introduction of berthing space for container transactions. The seaport recorded 36 per cent of annual growth in throughput volume from 1974 to 1993. During the period of introduction, there were several vital investments, which included modern container-handling equipment, dredging of the North Channel, and construction of a new container terminal in Butterworth. Penang Port's growth stage started from 1994 to 2017 after it was fully privatised in 1994.

The seaport activity and capacity grew during this period as a result of continuous investment towards seaport expansion and construction, infrastructure and facilities, and standardisation and innovation of the operation processes. A new container terminal at Butterworth, called North Butterworth Container Terminal (NBCT), started in 2004, and the investment in seaport standardisation and innovation processes have considerably increased its capacity, and Penang Port's container volume grew significantly. During this period, Penang Port's hinterland accessibility has also been expanded to many non-adjacent inter- and intra-cities, as well as connected to the dry ports by rail and road links.

Fig. 5 represents the seaport life cycle curve of Penang Port, and its forecasted seaport life cycle curves upwards from 2018 to

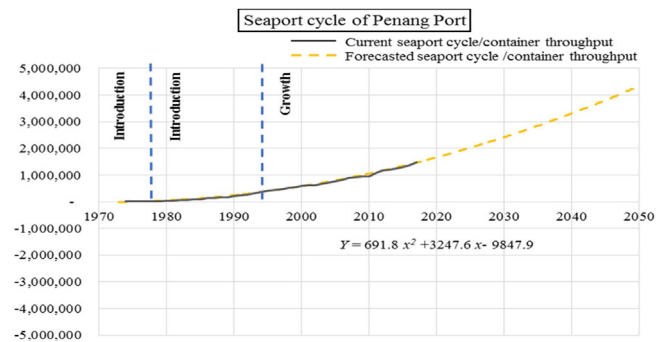


Fig. 5. Penang Port SLC from 1974 to 2050.

Source: Authors.

2050. Penang Port is a crucial container seaport which serves the container gateway traffic in Northern Malaysia and the container transshipment of the Indonesia–Malaysia–Thailand Growth Triangle regions. Penang Port is currently in its growth stage, and the port is expected to have continuous growth from 2018 to 2050. Penang Port was designed to handle 2 million TEUs in 2017 and is expected to be fully utilised before 2025, based on the forecasted container throughput. Therefore, Penang Port needs to cooperate with PBCT and ICT, to ensure that the handling capacity may cater to long-term future demand, especially in the northern regions of Peninsular Malaysia.

Currently, PBCT contributes 40 per cent, and ICT contributes 10 per cent of cargo to this seaport. This indicates that these dry ports have great potential in providing additional cargo to support Penang Port's operations. Furthermore, the location setting as mid-range dry ports of both dry ports to Penang Port will be an added value for this seaport to utilise the capacity of these dry ports for future development. At the growth stage, the capacity of the seaport will increase, and the presence of dry ports may prevent additional financial-based investment in Penang Port by infusing PBCT and ICT in the daily operations. This infusion is critical due to the decreasing trend in the number of port calls from 6419 to 6226 in 2003 and 2015, respectively. This indicates that Penang Port is unable to perform in the growth stage, and requires an immediate support system from the external environment. Hence, PBCT and ICT need to be incorporated to support Penang Port's operations by increasing the number of port calls as well as maintaining the competitiveness level at the optimum stage.

5.4. Johor Port: a declining trend in SLC

The quadratic regression analysis result for Johor Port's container throughput data shows that R-squared is 0.957, which means that 95.7 per cent variations in the dependent variable Y are explained by the independent variables present in this model. The significant value of this model is 0.000, and the estimated quadratic regression equation used to develop Johor Port's seaport life cycle curve is $Y = -2042.4x^2 + 90419.4x - 122081.8$. Johor Port's development as a container port began in the late 1990s. It operated as a liquid bulk port since it commenced operations in 1977 and served both liquid bulk and dry bulk cargoes. Johor Port received its first batch of container cargoes in 1990, and recorded 26,083 TEUs in that year. Johor Port's introduction stage began when the seaport's dedicated container terminal commenced in 1993, and the seaport activities and container throughput volume have increased considerably after the introduction of the non-bulk cargo in the form of containers. Accordingly, this seaport handled 168,315 TEUs in 1993 and 235,659 TEUs in 1994.

Johor Port's growth stage started from 1995 to 2007 after it was fully privatised in 1995 (see Fig. 6). The seaport's activity and capa-

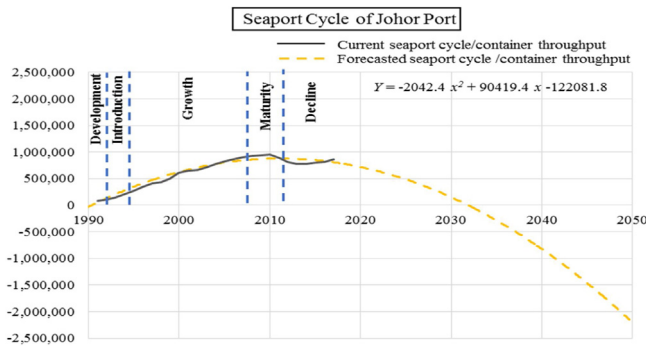


Fig. 6. Johor Port SLC from 1990 to 2050.

Source: Authors.

city grew in this period as a result of private investments towards several seaport expansion and construction projects, infrastructure and facilities, and standardisation and innovation of seaport operation processes. Besides, Johor Port's container volume grew significantly from 1995 to 2007 as the seaport handled substantial transhipped containers during these years. In 2017, the utilisation rate of this seaport had reached almost 75 per cent, which indicates that this seaport requires immediate support. In that case, SIP, which is significantly underutilised, can be utilised by the Johor seaport to improve its capacity as well as reduce the pressure of capacity optimisation.

In 2008, Johor Port recorded a growth rate in container volume of less than 1 per cent because the port was consolidated with PTP to compete with Port Singapore Authority (PSA). The frequency in the number of port calls has declined from 6526 in 2004 to 4880 in 2010. This implies that the effects of an increase in the size of container vessels served succeeded to overcome the negative effects of the considerable reduction in the number of port calls, so that the throughput volume could reach the peak point with a small increasing rate. Johor Port merely upgraded its port facilities and equipment because the seaport capacity had reached a bottleneck, and the expansion of the seaport area has been limited in recent years. In 2011, Johor Port's container volume declined from the peak volume of 2010 as a result of the continuous decline in the number of port calls, and the throughput volume continued to drop in the following years until 2017. Johor Port is a multipurpose seaport that mainly serves liquid bulk cargo, although it also contains various types of terminals, namely dry bulk, break-bulk, ferry and container terminals. The container terminal of Johor Port serves as the container gateway traffic of the Southern Malaysia Industrial Area, and its transshipment volume has gone down since PTP emerged.

Due to the emergence of PTP and the limited expansion of container terminal business in Johor Port, the seaport capacity has been kept in the status quo for some time. Besides, the most crucial factor is the container handling services, which will not be eliminated and closed in the coming years. In order to avoid its continuous decline, cooperation with SIP is urgently required to transform the declining stage into a growing stage or eventually, return to the maturity stage in the future.

In order to create a new growth stage, with minimum financial implications, the port capacity needs to be increased through the incorporation of SIP and the reengineering of the overall port processes. Furthermore, SIP needs to be incorporated to avoid having to perform land reclamation to develop new berths or port storage, preventing the refurbishment of advanced equipment, minimum investment towards process innovation of terminal operating systems, and enhancing port community systems. However, investment needs to be made in channel dredging to cater to larger vessels in the future. For Johor Port, 2018 was the accurate time

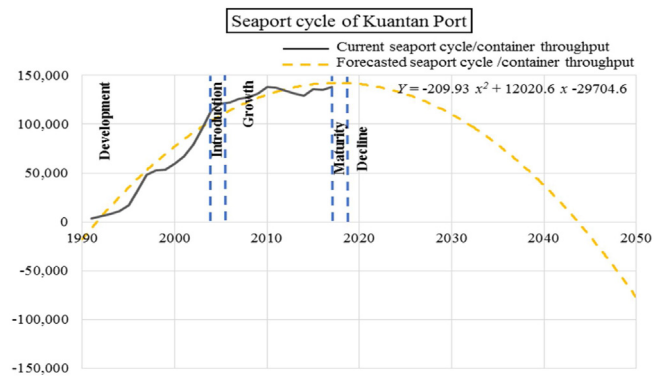


Fig. 7. Kuantan Port SLC from 1990 to 2050.

Source: Authors

to improve their collaboration with SIP in order to prolong the life cycle of this seaport at the maturity level.

5.5. Kuantan Port: a declining trend in SLC

Quadratic regression analysis results for Kuantan Port's container throughput data shows that the *R*-squared is 0.959, which means that 95.9 per cent variations in the dependent variable *Y* are explained by the independent variables present in this model. The significant value of this model is 0.000, and the estimated quadratic regression equation used to develop Kuantan Port's seaport life cycle curve is $Y = -209.93x^2 + 12020.6x - 29704.6$. Kuantan Port's development as a container seaport started in the early 1990s by serving its first batches of containers in 1988. During the development stage (1988–2002), the seaport served general and bulk cargoes, and containers with basic and non-standardised services and facilities. Seaport investment in Kuantan Port focused on dedicated container terminals and infrastructure during that period.

Kuantan Port handled 2343 TEUs containers in the 1990s, and the volume increased to 87,795 TEUs in 2002. The introduction stage of Kuantan Port started when the seaport had its dedicated container terminal in 2003. The container throughput volume and the number of port calls have considerably increased after the introduction of the container terminals, the seaport handled 104,848 TEUs and received 2280 ports of calls in 2003. Kuantan Port entered the growth stage from 2004 until 2017, as the seaport implemented several expansion projects, invested in basic infrastructure, and standardised seaport operation processes during the period. The expansion projects resulted in the seaport's annual capacity increasing from 135,000 TEUs to 600,000 TEUs. As the container vessels become bigger, the container throughput increased over time although the number of seaport calls declined. Kuantan Port's market share increased when the seaport began to serve intra-regional container shipping on a small scale in 2009.

Fig. 7 shows the seaport life cycle curve of Kuantan Port and its forecasted seaport life cycle curve from 2018 to 2050. Kuantan Port is the largest container port along the east coast of Malaysia, and is an under-developed container port that has the lowest container throughput among other major Malaysian container seaports. Fig. 7 indicates that Kuantan Port was in the growth stage in 2017 and has entered the maturity stage in 2018. Besides, the container seaport is forecasted to go into the decline stage and handle lesser containers until 2050. However, this declining trend may not happen as a seaport expansion project known as New Deep-water Terminal is in progress. The construction of the phase 2 berth that includes a container terminal has been started after the completion of the phase 1 berth (for bulk terminal) in 2019. The above-forecasted result only predicts the future trend of the seaport using the available historical data without considering other external changeable factors like

the future additional capacity of the new terminal and the future demands of the seaport.

Unfortunately, there are no specific dry ports that have been developed along the east coast of Peninsular Malaysia. This will be a drawback for Kuantan Port to incorporate dry ports to prolong its life cycle at the maturity level without entering the declining stage. In that case, Kuantan Port may utilise SIP as it is the closest dry port to Kuantan Port (154 km) compared to NIP (204 km), ICT (427 km) and PBCT (739 km). With this new collaboration, the continuous declining stage could be avoided as Kuantan Port is now situated in the growth stage. This incorporation will improve inland connectivity, especially between the east and west coasts. This will become a step towards balancing the regional development between the two coasts, which is currently biased in favour of the west coast compared to the east coast. Kuantan Port is located along the east coast of the peninsular, and serves vessels that navigate along the South China Sea. To sustain its position in the global trade, Kuantan Port depends on the geographical location and its attractive services provided to its clients. The demand for Kuantan Port is highly dependent on bilateral trade cooperation with China, and the international trade benefitted from the One Belt One Road Initiative. With a guarantee for future container seaport demand, the extension of Kuantan Port's growth stage is possible if the seaport continues to develop as a sustainable seaport in the future.

6. Discussion

Currently, the four major seaports along the east and west coasts of Peninsular Malaysia are experiencing the growth stage. Therefore, the infusion of dry ports is highly required to assist these seaports to transform from introduction-growth-maturity stages respectively. At this point, dry ports are needed to assist seaports in increasing and enhancing their productivity regardless of the stage at which they are. Furthermore, according to Jeevan et al. (2019), the infusion of dry ports in the seaports system has managed to enhance seaport performance, increase service variations for seaports, improve seaport-hinterland proximity, increase seaport trade volume and enhance seaport capacity. In the next three decades, Penang Port and Port Klang are expected to continue growing, and prepare to enter the maturity stage. This development indicates that additional capacity from dry ports is required to assist these seaports during their transition points. The assistance serves to improve their productivity and reducing additional investment towards space issues at seaports. At this point, the assistance from dry ports may help seaports stretch their facilities inland to ensure prompt services can be provided to the clients, and accomplish economic of scales and scope to enhance the competitiveness of seaports and dry ports.

On the other hand, PTP, Johor Port and Kuantan Port are predicted to enter the declining stage within the next three decades. In that case, the utilisation of dry ports in these seaports' operations is compulsory as one of the innovation strategies to extend seaports' growth stage as well as to prolong the length of their life cycle. Currently, Malaysian dry ports are playing their roles as extended seaports, regional intermodal nodes and an interface terminal. Hence, the assimilation of dry ports with seaports may expand the seaports' role in these areas. Besides, this infusion is substantial to accelerate national and international trade, activate intermodalism in the nation, improve seaport competitiveness, enhance regional economic development, and establish Malaysian port policy. This indicates that the combination of dry ports with seaports provides significant benefits during freight transport from the point of origin to the point of destination. Besides changing the trend of these seaports from entering the decline stage, dry ports, in this case, have the potential to improve the seaports' attractiveness in various directions.

Seaport development is a process of creation and adaptation to satisfy the changing demands of clients with shifting requirements from basic seaport facilities to logistical facilities on a geographic scale, from local to intercontinental presence. It is difficult for Port Klang, PTP, Penang Port, Johor Port and Kuantan Port to react to logistical or operational changes in their network due to time, cost and space limitations. Dry ports, as flexible and agile terminals, can assist seaports to adapt to the changes, and develop into a core component for seaport development.

7. Conclusion

The outcome of this paper elucidates that all Malaysian seaports are at different stages of their life cycle. At the same time, they are heading toward different directions in the next three decades. At the current stage, the result shows that Port Klang, Penang Port, PTP and Kuantan Port are experiencing the growth stage in their seaport life cycles, while Johor Port is at the decline stage of the seaport life cycle. However, in the next three decades, Penang Port and Port Klang are expected to continue growing until 2050. Meanwhile, PTP, Johor Port and Kuantan Port are predicted to enter the decline stage in the next three decades. The outcome of this paper suggests that PTP, Kuantan Port, Johor Port, Port Klang and Penang Port require the implementation of an innovation strategy by cooperating with dry ports to extend the seaports' growth stage, as well as prolong the length of their seaport life cycles. Besides innovation strategies, a development strategy needs to be emphasised in all dry ports, especially on rail network development, modal split facilities and simplifications on cross border transactions between Thailand–Malaysia–Singapore. Enhancement of the coordination between seaports–dry ports–hinterland should also be emphasised.

Moreover, the functionality of dry ports needs to be understood in order to assist seaports in prolonging their life cycle. For example, transport, logistics, administration and other value-added functions of dry ports improve seaports functions towards the inland. From the transport function aspect, the collaboration of seaports and dry ports reduces the container dwelling time in terminals, decreases inland transport costs, and increases shippers' connectivity to the seaports. Furthermore, the combination of dry ports in seaports manages to expedite customs clearance, immigration, and police inspection for domestic and international containers distributions. The incorporation of dry ports increases seaport functions by enhancing the value-added services not only at the seaport area but also towards the hinterland. As a consequence, the incorporation of these nodes will reduce waiting times at seaports, provide an effective clearance system, decrease freight costs, facilitate cross border transactions, and reduce empty container movements. Although the current situation shows a significant gap between seaports and dry ports, the functionality and the potential benefits gained by seaports via dry ports indicate that dry ports manage to assist seaports in enhancing operational efficiency without substantial investment.

The understanding of the Malaysian life cycles is very crucial to restructure the existing policies, which has been implemented without considering the life cycle of these nodes at the particular year. Hence, a precise seaport life stage from 2017 until 2050 may provide significant guidance to the policymakers to streamline the development strategy. Although the application of dry ports in the Malaysian seaport system has been proposed to improve the competitiveness of seaports in a dynamic environment, the application of dry ports has also been proposed to extend the seaports' life cycle with minimum financial implications. Suffice to say, the enhancement of freight transport connectivity between seaports and dry ports, the awareness on the functionalities of dry ports in the seaport systems, and the transformation of competing for mode towards collaborating mode between seaports and dry ports

need to be executed immediately to lengthen the life cycle of these seaports.

N.A. – non-available.

Source: Compiled from different resources.

Appendix A. Appendix 1

Port Klang Container Seaport cycle

Limits date	Port Klang Container Seaport cycle		
	Development Early of 1970s	Introduction 1973–1985	Growth 1986–2017
Port activities	<ul style="list-style-type: none"> • Handle conventional cargo. • Planning to construct container handling facilities. • Handle 1st container 1973. 	<ul style="list-style-type: none"> • Handle container cargo • Port activity increase with growing throughput. 	<ul style="list-style-type: none"> • Port privatised in 1986, and fully privatisation in 1994. • Handle gateway traffic and transshipment (also declared as National Load Centre in 1988) • Port activities increase. <ul style="list-style-type: none"> ○ 1996 – Westport started operation. ○ 1997 – Westport offer bunkering services. ○ 2004 – Southpoint handle 1st Ro-ro vessel. ○ 2016 – Transshipment activities grow 14.3%
Investment on port facilities and infrastructure	<ul style="list-style-type: none"> • Construction of container terminal and others basic facilities included wharf, container freight station, warehouse. • Investment on container handling equipment included three quay cranes eight straddle carrier. 	<ul style="list-style-type: none"> • Investment on Second Northport Extension project, phase 1 and 2 completed 1977 and 1983. 	<ul style="list-style-type: none"> • Investment on port area expansion <ul style="list-style-type: none"> ○ 1992 – Westport construction project ○ 2004 – Southpoint Free Zone. ○ 2016 – Expansion of CT9 and CT8 of Westport. • Investment on infrastructure and facilities <ul style="list-style-type: none"> ○ 1994 – Westport infrastructure and facilities ○ 2014 – Wharf infrastructure, Wharf 8A of CT4. ○ 2016 – Upgrading of various facilities • Investment on Standardisation and innovation process <ul style="list-style-type: none"> ○ 1999 – IT application at free commercial zone ○ 2000 – certified ISO 9000, received Excellent Service Award from NNCCIM. ○ 2004 – certified MS ISO 9002 ○ 2007 – IT application in Port Management ○ 2011 – initialling PORT KLANG NET, ○ 2016 – enhance internet leased line and cyber security in ICT system
Container throughput	<ul style="list-style-type: none"> • Zero before 1973. • Handle 13,321 TEUs in 1973. 	<ul style="list-style-type: none"> • Grow steadily from 1973 to 1985, with 37% annual growth. 	<ul style="list-style-type: none"> • Increase steadily from <ul style="list-style-type: none"> ○ 1986 to 1990, with 16% annual growth, ○ 1991 to 2000, with 21% annual growth, ○ 2001 to 2010, with 6% annual growth, ○ 2011 to 2017, with 5% annual growth
Hinterland Accessibility	<ul style="list-style-type: none"> • Limited to Northern Peninsular Road connectivity <ul style="list-style-type: none"> ○ Access to Federal Highway 2 	<ul style="list-style-type: none"> • Limited to Northern Peninsular and restricted by nearby cities such as Klang and Kuala Lumpur. Road connectivity <ul style="list-style-type: none"> ○ Access to Federal Highway 2 ○ 1985 – Access to North Klang Straits Bypass ○ 1978 – Access to ICD Sg Way 	<ul style="list-style-type: none"> • Expanded to many non-adjacent cities. Rail connectivity <ul style="list-style-type: none"> ○ Access PBCT ○ 1989 – Access to ICT ○ 1998 – Access to SIP, ○ 1998 – 14-kilometre rail link to the West Port of Port Klang Road connectivity <ul style="list-style-type: none"> ○ 1993 – access to Thailand border (opened of Klang Valley Expressway and North-South Expressway) ○ 1994 – access to Johor-Singapore Causeway border (opened of southern North-South Expressway)

PTP Container Seaport cycle

PTP Container Seaport cycle			
Limits date	Development 1996–1998	Introduction 1999	Growth 2000 until 2017
Port activities	<ul style="list-style-type: none"> Construction of container berths at Phase 1. 	<ul style="list-style-type: none"> PTP port started operation and handle container cargoes. Handle 1st container cargos in 1999. 	<ul style="list-style-type: none"> Serve as hub and cargo transshipment centre. Port Expansion and Development at Phase 2. Port activities increase. <ul style="list-style-type: none"> 2001–2003 Partnership with Maersk SeaLand 2005–2017 PTP FTZ's tenants (warehousing, logistic, manufacturing) increased and lead regional container trade increased. 2013 – Serving container vessel with capacity over 18000 TEUs.
Investment on port facilities and infrastructure	<ul style="list-style-type: none"> Investment on Construction of 6 container terminal and others basic facilities included wharf, container freight station, warehouse. Investment on the advanced container handling equipment. 	<ul style="list-style-type: none"> Investment on hinterland accessibility. 1999 – Rail link from Kempas to PTP 	<ul style="list-style-type: none"> Investment on construction of Phase II Expansion for 8 Berths. <ul style="list-style-type: none"> 2005 – Berth Bo.7 &8 2006 – Berth No.9 &10 2008 – Berth No.11&12 2011 – Berth No.13&14, container yard No. 19-21 Investment on Channel Dredging <ul style="list-style-type: none"> 2006–2010 – Approach channel and port basin dredging 2017 – Draft widening to 18.5 metre Investment on infrastructure and facilities <ul style="list-style-type: none"> 2006–2010 & 2016 – Upgrade operating equipment and storage facilities. 2016 – Upgrading of various facilities in FTZ Investment on Standardisation and innovation process <ul style="list-style-type: none"> 2001–2005 – Container Security Initiative implemented. 2002 – implemented electronic and paperless Vessel Clearance System (VCS) 2006–2010 – Computerised information management and port operation upgraded and expansion of the navigational safety system 2008 – Certificated Integrated Management System Increase rapidly from <ul style="list-style-type: none"> 2000 to 2005, with 392% annual growth, 2006 to 2010, with 5.2% annual growth, 2011 to 2017, with 4% annual growth. Expanded to many non-adjacent cities.
Container throughput	<ul style="list-style-type: none"> Zero throughput. 	<ul style="list-style-type: none"> Handled 20,698 TEUs containers in 1999. 	<ul style="list-style-type: none"> 2000 to 2005, with 392% annual growth, 2006 to 2010, with 5.2% annual growth, 2011 to 2017, with 4% annual growth.
Hinterland Accessibility	N.A.	<p>Rail & Road connectivity</p> <ul style="list-style-type: none"> 1998 – Access to SIP, <p>Road connectivity</p> <ul style="list-style-type: none"> 1993 – access to Thailand border (opened of Klang Valley Expressway and North-South Expressway) 1994 – access to Johor-Singapore Causeway border (opened of southern North-South Expressway) 1995 – Access to NIP 	<p>Air access</p> <ul style="list-style-type: none"> Nearby Changi and Senai International Airports 2003 – dedicated sea-air cargo links at PTP-Sultan Ismail Airport <p>Rail & road connectivity</p> <ul style="list-style-type: none"> Access to SIP 2002 – Direct access link from PTP to Kempas 2003 – Dedicated PTP to Haadyai container train service reach to Southern Thailand <p>Road connectivity</p> <ul style="list-style-type: none"> 2000 – Access to NIP 2000 – Access Road to Port of Tanjung Pelepas, Johore 200 – Access road to Thailand border (North–South Expressway) 2000 – Access to Johor-Singapore Causeway border
Port services and services provider	<ul style="list-style-type: none"> Provide by private operator. 	<ul style="list-style-type: none"> Basic and not standardised such as cargo handling, pilotage, fire services, security, shipping and forwarding. Provide by private operator. 	<ul style="list-style-type: none"> Port Services being process standardised. Provide by interested private suppliers.
Core production factor	<ul style="list-style-type: none"> Capital 	<ul style="list-style-type: none"> Human Capital Capital Equipment 	<ul style="list-style-type: none"> Capital Equipment
Port competitor	N.A.	<ul style="list-style-type: none"> PSA, Port Klang. 	<ul style="list-style-type: none"> PSA, Port Klang, Penang Port
Market share & scope of freight distribution	N.A.	<ul style="list-style-type: none"> Low market share 	<ul style="list-style-type: none"> Market share and scope of freight distribution expanded. <ul style="list-style-type: none"> 2000: 682 Port calls 2011: 5125 Port calls 2017: 4404 Port calls 2003 – serve container Cargo from ASEAN and other Asian countries. 2007 – serve Asia-Europe route 2009 – serve as world class transshipment port, serve CMA CGM 2013 – Served 1st Triple E call. 2015 – Served World largest boxship MSC Oscar call 2017 – Served Madrid Maersk Maiden Voyage
Port capacity	N.A.	<ul style="list-style-type: none"> Port capacity of 1999: 3.7 million TEUs 	<ul style="list-style-type: none"> Port capacity increase. <ul style="list-style-type: none"> 2005: 6 million TEUs 2008: 7.2 million TEUs 2009: 9 million TEUs 2016: 10.5 million TEUs 2017: 12.5 million TEUs

N.A. – not available.

Source: Compiled from different resources.

Penang Container Seaport Cycle

Penang Container Seaport Cycle			
Limits date	Development Late of 1960s–1977	Introduction 1978–1993	Growth 1994 until 2017
Port activities	<ul style="list-style-type: none"> Handled general, liquid bulk and bulk cargoes. Handled 1st container 1974. Implemented 1st and 2nd Penang Port Expansion Project. Implemented facilities construction and acquire container handling equipment. 	<ul style="list-style-type: none"> Handled container cargoes with 2 container berths. Implemented 2nd Penang Port Expansion Project. Planned, designed and implemented Project North Butterworth Container Terminal (NBCT). Introduced modern container handling equipment. Port activities increase with growing throughput. 1986 – Butterworth Deepwater Wharves commenced. 1978–1979 Investment on modern container handling equipment. 	<ul style="list-style-type: none"> Port privatised in 1994 under Penang Port Sdn Bhd, and fully privatisation in 2014 under MMC. Handle gateway traffic, less transshipment cargoes. Undertaken Phase II, III of NBCT Project. Port activities increase. <ul style="list-style-type: none"> 1994 – NCBT started operation and expended overtime. 2000 – 2005 Improved some supporting ancillary services. 2012 – storage, relabelling, repackaging
Investment on port facilities and infrastructure	<ul style="list-style-type: none"> 1966–1976 Investment on construction of wharves, Deepwater wharves. 1977 Investment on conversion of conventional berth to container cum RoRo berth. 1976–1977 Investment on container handling equipment and RoRo facilities. 	<ul style="list-style-type: none"> 1981–1985 Investment on dredging of the North Channel. 1991–1994 Investment on construction of NBCT. Investment on standardisation 1985 – Pelkon 1 text-based system commenced. 	<ul style="list-style-type: none"> Investment on port expansion project. <ul style="list-style-type: none"> 1998–2003 NBCT Phase IIA, IIB, IIB(B) construction project. 2006 – Land reclamation for construction container yard 2007 – NBCT Phase III expansion project 2011 – Dredging of the North Channel 2012 – Port Deepening Investment on infrastructure and facilities. <ul style="list-style-type: none"> 1995 – Direct rail link to new NBCT 2001–2010 NBCT infrastructure, facilities and modern equipment. 2006 – Container handling equipment and incorporating value-added services 2007 – Container stacking area 2012 – Landside infrastructure, facilities and superstructure Investment on Standardisation and innovation process <ul style="list-style-type: none"> 1996 – Pelkon 2 online system introduced. 2001–2005 – E-commerce port business undertaken. 2005 – EDI and computerised container system introduced. 2005 – Attained ISO9001:2000 2006 – Pelkon 3, the upgraded container Management system implemented. 2012 – certificated MS2900:2005 2016 – Achieved ISO/IEC 27001:2013 Information Security Management System
Container throughput	<ul style="list-style-type: none"> Zero before 1974. Handle 2994 TEUs in 1974. 	<ul style="list-style-type: none"> Growing from 1974 to 1993, with 36% annual growth. 	<ul style="list-style-type: none"> Increase from <ul style="list-style-type: none"> 1994 to 2000, with 10% annual growth, 2001 to 2010, with 4.27% annual growth, 2011 to 2017, with 7.03% annual growth. Expanded to many non-adjacent cities.
Hinterland Accessibility	<ul style="list-style-type: none"> Limited to East Coast and Southern Peninsular and restricted by nearby cities. 	<ul style="list-style-type: none"> Limited to East Coast and South Peninsular and restricted by nearby cities. <p>Rail Connectivity 1983 – Access to Padang Besar CargoTerminal</p> <p>Road connectivity 1984 – Access to ICD, Prai</p>	<p>Rail & road connectivity</p> <ul style="list-style-type: none"> Access to PBCT 1989 – Access to ICT 2000 – 3 km direct rail connection from new NBCT to Penang railway station <p>Road connectivity</p> <ul style="list-style-type: none"> Access to Thailand border (opened of Klang Valley Expressway and North-South Expressway) 1994 – access to Johor-Singapore Causeway border (opened of southern North-South Expressway) 1996 – Butterworth-Kulim Highway 2000 – 2nd access bridge to NBCT. 2005 – Access to East-West highways 2011–2015 Penang 2nd Bridge provide better accessibility to Penang International Airport
Port services and services provider	<ul style="list-style-type: none"> Basic and not standardised such as cargo handling, pilotage, shipping and forwarding. Provide by Penang Port Klang Commission. 	<ul style="list-style-type: none"> Basic and not standardised such as cargo handling, pilotage, shipping and forwarding. Provide by Penang Port Klang Commission. 	<ul style="list-style-type: none"> Port Services being process standardised. Provide by private licensed operators.

Core production factor	• Labour and Human capital	• Labour • Capital Equipment • PSA, Port Klang • Market share increase	• Capital Equipment • PSA, Port Klang, PTP • Market share and scope of freight distribution expanded. ○ 2003: 6419 Port calls ○ 2015: 6226 Port calls ○ 2005 – Serve IMT-GT area ○ 2009 – serve inter regional container shipping. ○ 2012 – Serve China, Korea & Hong Kong ship calls. ○ 2015 – Serve ships to Middle East • Port capacity increase. ○ 1994: 238,000 TEUs ○ 2005: 770,000 TEUs ○ 2008: 1,004,000 TEUs ○ 2012: 2 million TEUs ○ 2017: 2 million TEUs
Port competitor	N.A.		
Market share & scope of freight distribution	N.A.		
Port capacity	N.A.	• Port capacity increase.	

N.A. – not available.

Source: Compiled from different resources.

Johor Container Seaport cycle

Johor Port Container Seaport cycle					
Limits date	Development Early of 1990s	Introduction 1993–1994	Growth 1995–2007	Maturity 2008–2010	Decline 2011 until 2017
Port activities	<ul style="list-style-type: none"> Handled dry and liquid bulk cargoes. Handled 1st container 1990. Implemented Phase 4 Port Expansion. Developed infrastructural facilities and acquire modern equipment. 	<ul style="list-style-type: none"> Handled container cargoes with dedicated container terminal. Port activities increase with growing throughput. 1993 – Dedicated Container Terminal commenced. 1993 – Corporatised 	<ul style="list-style-type: none"> Handled container cargoes. Port fully privatisation in 1995. Handle high gateway traffic & transhipment cargoes. Undertaken Johor Port Phase 5 Expansion Project. Increased equipment and facilities. Investment on port expansion project. ○ 1996 – Construction of Johor Port Phase 5 expansion project. ○ 2006 – New south & north wharves and ancillary works Investment on infrastructure and facilities. ○ 1996–2000 Berth Appropriation Scheme, AICS, pre-customs clearance ○ 2007 – Upgraded facilities and procuring new equipment Investment on Standardisation and innovation process ○ 1996–2000 Automation and computerised of container terminal operating system. ○ 2007 – ICT management system 	<ul style="list-style-type: none"> Handled container cargoes. Upgraded port facilities and equipment. Being consolidated with sister Port, PTP. 	<ul style="list-style-type: none"> Handled container cargoes. Rehabilitation Works of Container Terminal Yard and Ancillary Works Port activity start decrease. 2014: Transhipment volume fell 53%.
Investment on port facilities and infrastructure	<ul style="list-style-type: none"> Investment on Phase 4 port expansion project. ○ 1991 – Land reclamation, construction of container berths, infrastructural works and related industrial activities in port area. Investment on infrastructural facilities and modern container handling equipment. ○ 1991 – Ancillary facilities and modern equipment. 				<ul style="list-style-type: none"> Investment on rehabilitation Works of Container Terminal Yard and Ancillary Works

Container throughput	<ul style="list-style-type: none"> • Zero before 1990. • Handle 26,083 TEUs in 1990. 	<ul style="list-style-type: none"> • Growing with 40%. <ul style="list-style-type: none"> ○ 1993: 168,315 TEUs ○ 1994: 235,659 TEUs 	<ul style="list-style-type: none"> • Increase steadily from <ul style="list-style-type: none"> ○ 1995 to 2000, with 23% annual growth ○ 2000 to 2005, with 9% annual growth ○ 2005 to 2007, with 8% annual growth • Expanded to many non-adjacent cities. 	<ul style="list-style-type: none"> • Increase from 2008 to 2010, with 1% annual growth. • Expanded to many non-adjacent cities. 	<ul style="list-style-type: none"> • Decline from 2011 to 2017, with –1% annual growth. • Expanded to many non-adjacent cities.
Hinterland Accessibility	<ul style="list-style-type: none"> • Limited to Northern Peninsular (connected by rail) and restricted by nearby cities. • Access to Pasir Gudang Highways. 	<ul style="list-style-type: none"> • Expanded to non-adjacent cities. Road connectivity <ul style="list-style-type: none"> ○ 1993 – Access road to Thailand border (North-South Expressway) ○ 1994 – Access to Johor-Singapore Causeway border 	<ul style="list-style-type: none"> • Expanded to many non-adjacent cities. Road connectivity <ul style="list-style-type: none"> ○ Access road to Thailand border (North-South Expressway) ○ Access to Johor-Singapore Causeway border ○ Road link to SIP • Port Services being process standardised. • Provide by private licensed operators. 	<ul style="list-style-type: none"> • Expanded to many non-adjacent cities. Road connectivity <ul style="list-style-type: none"> ○ Access road to Thailand border (North-South Expressway) ○ Access to Johor-Singapore Causeway border ○ Road link to SIP • Port Services being process standardised. • Provide by private licensed operators. 	<ul style="list-style-type: none"> • Expanded to many non-adjacent cities. Road connectivity <ul style="list-style-type: none"> ○ Access road to Thailand border (North-South Expressway) ○ Access to Johor-Singapore Causeway border ○ Road link to SIP • Provide by private licensed operators.
Port services and services provider	<ul style="list-style-type: none"> • Basic and not standardised such as navigation, cargo handling and pilotage. • Provide by Johor Port Authority. 	<ul style="list-style-type: none"> • Basic and not standardised such as navigation, cargo handling, pilotage, fire services, security, shipping and forwarding Provide by Johor Port Authority. 	<ul style="list-style-type: none"> • Capital Equipment • PSA • Market share near peak and scope of freight distribution expanded. ○ 2003: 6877 Port of call (Peak) ○ 2004: 6526 Number of seaport calls (start decline) ○ 2007 – Serve 23 main liner calling of port • Port capacity increase. 	<ul style="list-style-type: none"> • Capital Equipment • PSA, PTP • Market share increase to peak point. ○ 2009: mainly serve large scale inter regional container shipping lines from Thailand, Hong Kong, Japanese (known as K-line). ○ 2010: 4880 Port calls • Capacity near bottleneck. ○ 2008: 1.06 mil TEUs 	<ul style="list-style-type: none"> • Capital Equipment • PTP, PSA • Market share decrease. 2017: 3951 Port calls • Serve as hub of Johor local hinterland cargo business. • Focus on regional connectivity to Asia Pacific Region and East Malaysia. • Peak Capacity ○ 2013: 1.2 mil TEUs
Core production factor	<ul style="list-style-type: none"> • Labour and Human capital 	<ul style="list-style-type: none"> • Labour • Capital Equipment • PSA • Market share increase 			
Port competitor	N.A.				
Market share & scope of freight distribution	N.A.				
Port capacity	N.A.	<ul style="list-style-type: none"> • Port capacity increase. 			

N.A. – not available.

Source: Compiled from different resources.

Kuantan Container Seaport cycle

	Kuantan Container Seaport cycle		
Limits date	Development 1988–2002	Introduction 2003	Growth 2004 until 2017
Port activities	<ul style="list-style-type: none"> • Handled general and bulk cargoes. • Handled 1st container in 1988 • Privatised by Kuantan Port Consortium Sdn Bhd in 1997. Implemented port expansion. 	<ul style="list-style-type: none"> • Handle container at dedicated container terminal. 	<ul style="list-style-type: none"> • Handled container with dedicated Container Berth • Port Expansion and Development.
Investment on port facilities and infrastructure	<ul style="list-style-type: none"> • Investment on Construction of a dedicated container terminal and others basic infrastructure. • Investment on port basin dredging works • Investment on standardisation and innovation process. 1996–2000 Simplification of procedures and practice, computerisation and automation for container operation 	-	<ul style="list-style-type: none"> • Investment on Port Expansion Project. <ul style="list-style-type: none"> ○ 2011 – Container Berth Extension ○ 2015 – New Deepwater Terminal Project ○ 2016 – New breakwater • Investment on infrastructure and facilities <ul style="list-style-type: none"> ○ 2011–2015 Provide basic infrastructure and facilities. • Investment on Standardisation and innovation process <ul style="list-style-type: none"> ○ 2006–2010 Computerised information management and port operation upgraded and expansion of the navigational safety system ○ 2008 – Attained MS ISO 9001:2008 ○ 2013 – Certificated ISO/IEC 27001:2007 ○ 2014 – Certificated ISO 27001:2013
Container throughput	<ul style="list-style-type: none"> • Zero throughput before 1988. • Handled 2343 TEUs containers in 1990. • Increase to 87,795 TEUs in 2002, with annual growth of 38%. 	<ul style="list-style-type: none"> • Handled 104,848 TEUs containers in 2003. 	<ul style="list-style-type: none"> • Increase from 2004 to 2017, with 3% annual growth. ○ 2004 – 122,745 TEUs ○ 2017 – 147,041 TEUs

Hinterland Accessibility	<ul style="list-style-type: none"> • Expanded to many non-adjacent cities. <p>Road Connectivity</p> <ul style="list-style-type: none"> ○ Access to Federal Highway 2 ○ Access to Kuala Lumpur-Karak Highway ○ Access to Thailand border (opened of Klang Valley Expressway and North-South Expressway) ○ 1994 – access to Johor-Singapore Causeway border (opened of southern North-South Expressway) 	<ul style="list-style-type: none"> • Expanded to many non-adjacent cities. <p>Road Connectivity</p> <ul style="list-style-type: none"> ○ Access to Federal Highway 2 ○ Access to Kuala Lumpur-Karak Highway ○ Access to Thailand border (opened of Klang Valley Expressway and North-South Expressway) 	<ul style="list-style-type: none"> • Expanded to many non-adjacent cities. <p>Road Connectivity</p> <ul style="list-style-type: none"> ○ 2012 – East-Coast Highway access Kuantan to Terengganu
Port services and services provider	<ul style="list-style-type: none"> • Basic and not standardised such as cargo handling, pilotage, fire services, security, and forwarding. • Provide by Kuantan Port Authority before 1998, provided by the private operator after 1997. • Labour and Human Capital 	<ul style="list-style-type: none"> • Basic and not standardised such as cargo handling, pilotage, fire services, security, shipping and forwarding. • Provide by the private operator. 	<ul style="list-style-type: none"> • Provide by interested private suppliers.
Core production factor	<ul style="list-style-type: none"> • Port Klang, PTP • Market share grew with an increased number of port calls. ○ 1998: 1410 Port calls ○ 2002: 2067 Port calls 	<ul style="list-style-type: none"> • Human Capital • Capital Equipment • Port Klang, PTP • Market share increase. ○ Number of seaport calls 2003: 2280 	<ul style="list-style-type: none"> • Capital Equipment
Port competitor			<ul style="list-style-type: none"> • Port Klang, PTP • Market share and scope of freight distribution expanded. ○ 2004: 2382 Port calls ○ 2009: 2447 Port calls, serve intra regional container shipping in small scale ○ 2017: 1924 Port calls
Market share & scope of freight distribution			<ul style="list-style-type: none"> • Port capacity increase. ○ 2010: 135,000 TEUs. ○ 2017: 600,000 TEUs
Port capacity	N.A.	N.A.	

N.A. – non-available.

Source: Compiled from different resources.

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