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Evaluation of Container Terminal Efficiency Performance in Indonesia : Future Investment

by

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Acknowledgments

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Abstract

Indonesia is one of the biggest archipelagic countries in the world and its strategic location between the Indian Ocean and the Pacific Ocean makes maritime sector of great importance. It can be seen from the volume of containerized cargo, which is increasing gradually at the rate of around 7.7% each year. Implementation of domestic law No. 17/2008 on Shipping, eliminates the monopoly power of Pelindo as the main terminal operator and allows new-comers to compete in port business. However, in order to maintain its competitive position as the main terminal operator, Pelindo should maintain its efficiency as that is one of its key success factors.

This research uses three types of analyses: demand analysis, efficiency measurement analysis, and supply analysis for 18 container terminals in Indonesia using both time series and cross section data. A demand analysis is conducted by a container throughput projection for every 5 years using a GDP multiplier method, which is based on container throughput and GRDP from 2009 to 2013.

The efficiency measurement analysis utilizes a non-parametric method, called Data Envelopment Analysis (DEA) that is based on the conditions of 2014. The DEA Constant Return to Scale (CRS) model with input oriented version is used for the measurement of the efficiency performance applying Stata software. Seven input variables are taken namely container yard area, maximum draft, berth length, quay crane index, yard stacking index, vehicle, number of gate lanes and throughput as an output. A port is categorised as efficient, if the outcome equals 1 and inefficient, if it is less than 1.

Container terminal supply is evaluated using berth capacity and yard capacity. Berth capacity in TEU/year is calculated by multiplying berth lenght (m) by berth capacity per meter length (TEU/m). Berth capacity per meter lenght is assessed by multiplying call size (moves) with the berth occupancy ratio of each port and Teu factor. Yard capacity in TEU/ year is quantified by multiplying container yard capacity (TEU) by yard maximum utilisation (%) divided by separation factor (%), peaking factor (%) and dwelling time (days). Both throughput as a demand and as a supply capacity will be combined to assess the time when the bottleneck condition occurs.

The results show that total throughput projections for 2020, 2025, and 2030 are 23 million TEU/year, 37 million TEU/year, and 58 million TEU/year respectively. In this case, the biggest contributors are Tanjung Priok Port and JICT (23% and 26%). Moreover, by looking at its efficiency score which is equal to 1, it reveals that 7 out of 18 terminals are efficient, namely, Tanjung Priok, JICT, Tanjung Perak, TPS, BJTI, Makassar Port, and UTPM.

Furthermore, by looking at their capacity, it appears that 12 out of 18 container terminals carry over 80% of the current demand. Surprisingly, Tanjung Perak has the highest ratio, followed by Tanjung Priok, JICT, KOJA, and TPS.

Finally, supply and demand analysis assesses the appropriate time for investment as an indicator of congestion issues. It appears that 7 out of 18 container terminals are not only identified as efficient container terminals, but are also indicated as having the worst congestion conditions. Therefore, in the future, they should tackle the bottleneck issues and consider infrastructure investments to alleviate these congestion bottlenecks.

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List of Abbreviations

CAGR	Compound Annual Growth Rate
PPP	Public Private Partnership
BCC	Banker, Charnes and Cooper
CCR	Charnes, Cooper and Rhodes
CRS	Constant Return to Scale
DEA	Data Envelopment Analysis
DMU	Decision Making Unit, The terminology of DMU itself took from the study of Charnes, Cooper and Rhodes in 1978
GLC	Gantry Luffing Crane
RDEA	Recursive Data Envelopment Analysis
RMGC	Rail Mounted Gantry Crane
RTGC	Rubber Tyre Gantry Crane
TEU	Twenty Equivalent Unit
UNCTAD	United Nations Conference on Trade and Development
VRS	Variable Return to Scale
GDP	Growth Domestic Product
GRDP	Gross Regional Domestic Product
BOR	Berth Occupancy Ratio
YOR	Yard Occupancy Ratio

1. INTRODUCTION

1.1. Background and Business Relevance

Transportation becomes significantly necessary since economic globalization of economic increasingly emerges. The production of intermediate goods as an input of final goods tends to take place in different location and/ or country for economic reason. Lower-waged labor, lower tax, politics, inexpensive material cost, for example, have made transportation demand becomes such a derived demand. In line to this trend, container transportation even grows faster since it pledges various advantages than traditional transportation means. The fact that container terminal has a vital function, namely as an interface point of sea and hinterlands, indicates that its quality of productions and services cannot be neglected.

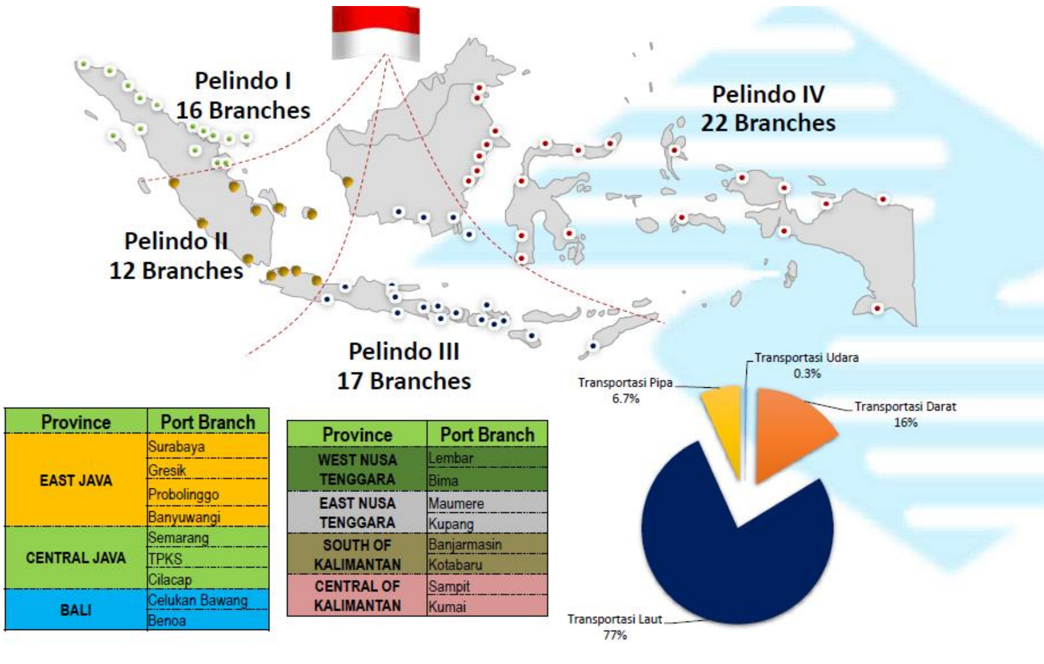
Related to the global container throughput, based on a projection of international port and export (IMEX) of manufactures, the throughput is forecasted to be 985 million TEU in 2020 from 650 million TEU in 2013 (Schäfer, 2015). The growth rate of the throughput achieves a 6.1% compound annual growth rate (CAGR) (Schäfer, 2015). Looking closely at Asia, it is projected to have 65% share of global throughput volume and transshipment traffic 32% of the total in 2020 instead of 56% and 22.5% in 2013 (World Cargo News, 2015). In 2002, study of Nations (2005) shows that Asia generates 55% of the total trade while it is expected to rise to 64% in 2015. Forecasting and fact indicate reasonable percentage of share, where in 2013 Asia takes 56% of share and in 2015 it is forecasted to rise to 64%. In addition, containerization has taken two third part of total general cargo in sea trade. Thus, containerization trend will enforce port to enhance their performance due to its ability to maintain the market and capture new market as well.

Investment on both infrastructure and superstructure can be one of the steps taken by port to face the growth trend in the container market. It is expected to propose better efficiency on cargo handling which will enhance cost reduction and raise better performance since port plays significant role in logistics chain. Eventually, it will enable port to capture bigger market on container which means to replenish the profit and gain economic advantages for the port itself and the shareholder as well. An aggressive infrastructure and superstructure investment has been taken by major gateway port, such as Port of Rotterdam, by means of container terminal automation in Maasvlakte II's. Despite its dreadfully cost, the port experiences a substantial rise on its capacity to justify such an investment either by lower the operating cost to attract the market or their competitor or enhance its performance. Automation of port allows stable product generation with consistent and reliable performance throughout all the time.

A commercial port in Indonesia plays an important role in the national and international logistic distribution. Port is not only as the gateway of cargoes anymore but also turned to be the logistic hub (Pettit & Beresford, 2009). Moreover, as for Indonesia, the biggest archipelagic country, where the ocean covers 70% of total area and due to its strategic location between Indian Ocean and Pacific Ocean, it has been being the main driver in the maritime business. From the last 5 years, the trade between islands in Indonesia has increased up to 37 % and predicted will be increasing in the near future, due to the growth of Indonesian GDP's (Susantono, 2012). The GDP annual growth rate in Indonesia has reached 4.71% in the first quarter of 2015 over the first quarter of 2014 (Trading Economic, 2015). In addition, in June 2015 it is reported that Indonesia had USD 477.7 million trade surpluses, switch over than the previous year where Indonesia had trade deficit. According to Drewry (2012), containerized cargo averagely increases by 8.4% each year and the throughput also grew around 7.7% per year.

In line to economic development of Indonesia that handles two-thirds of Indonesian international trade and container traffic, infrastructure building should be established as the main driver for a sustainable port business (Maritime Insight, 2014). Currently, Indonesia has lower score of port infrastructure among ASEAN+6 countries, it indicates bad performance of infrastructure quality (OECD, 2012).

Indonesia port managed by 4 (four) different state-owned enterprises those are divided based on the working area. Each stated-owned enterprise has different number of branches, PT Pelabuhan Indonesia I (Persero) or Indonesia Port Corporation Region I or Pelindo I comes along with 16 branches, PT Pelabuhan Indonesia II (Persero) or Indonesia Port Corporation Region II or Pelindo II holds 12 branches, PT Pelabuhan Indonesia III (Persero) or Indonesia Port Corporation Region I or Pelindo I comes along with 17 branches and PT Pelabuhan Indonesia IV (Persero) or Indonesia Port Corporation Region IV or Pelindo IV owns 22 branches. To be clear working area of each Pelindo deploy in
Figure **1** below:



Province	Port Branch
EAST JAVA	Surabaya
	Gresik
	Probolinggo
	Banyuwangi
CENTRAL JAVA	Semarang
	TPKS
	Cilacap
BALI	Celukan Bawang
	Benoa

Province	Port Branch
WEST NUSA TENGGARA	Lembar
	Bima
EAST NUSA TENGGARA	Maumere
	Kupang
SOUTH OF KALIMANTAN	Banjarmasin
	Kotabaru
CENTRAL OF KALIMANTAN	Sampit
	Kumai

Source : Suryanto (2015)

Figure 1 Working Area of Indonesian Port

Significantly changes occur in the year of 2008 when Indonesia has imposed domestic laws No. 17/ 2008 regarding Shipping. The provision splits regulator and operator function along the port, it's expected to conduct new port authority which will handle several functions held by Pelindo previously. Furthermore, through the separation of function, the enactment of Laws No. 17/ 2008 eliminates the monopoly power held by Pelindo beforehand. It allows other operators to compete in port business.

Since Indonesia is the biggest archipelagic country and containerized cargo averagely increases by 8.4% each year, while the throughput also grows around 7.7% per year, then better performance should be performed by Indonesia Port that will give an add-value to maintain the competitive position in the international port competition due to the implementation of domestic laws No.17/ 2008 regarding Shipping. It has been said above that Indonesia reveals such a bad performance of infrastructure quality according to OECD report, so an appropriate investment decision should be considered by all Indonesia Ports not only to deal with this throughput growth but also to attract more container vessel calls. Thus, an efficient performance of the container terminal should be taken into account to decide on future investment in order to improve the port performance or to keep it stable if it has a highly efficient performance which will attract more vessels to come to the port and gain more profits from this business segment.

Previous Indonesia research on the similar subject was done by Purwantoro (2004), Andenoworih (2010) and Sari (2014) that will be elaborated later in Chapter 2.4. Each researcher has a weak point, such as Purwantoro (2004) that deals with total port productivity which input comes from marine services, thus the definition of DMU is very rough since it involves all of the shipping sectors, and therefore, the result is also rough. Andenoworih (2010) has almost similar analysis as Purwantoro, but he has only 12 container terminals and fewer input. Furthermore, Sari (2014) focuses on the difference between two situations before and after investment and she has only 5 container terminals within the management of Pelindo II. Therefore, it’s more interesting for those researchers to do it in a different way that is by taking more container terminals, i.e. 18 container terminals, because it will make the outcome better since they will utilize more inputs than those in the previous study, i.e. seven inputs, and different program, namely Stata program. Throughput projection by multiplying effect of forecasting is also taken by this study, such as a demand analysis of container terminals which were not considered in the earlier study. In comparison to the West Africa internal study done by Ecorys which also measures the performance of 13 container terminals, the study proves that the port is so productive as time goes on and it is considered to have improved the demand than the input because when the demand increases then the productivity simultaneously increases. This internal study observes that the productive port probably confronts with large amount of congestion which is not measured in the earlier study of Indonesia. Thus, this research wil also analyze congestion in container terminal in Indonesia by taking into account the capacity analysis as terminal supply to be combined with throughput forecast result as a demand that will indicate the bottleneck level in Indonesian port.

1.2. Research Question and Objective

Related to the business relevance of Pelindo, the main research question will be distinguished on *how does Pelindo investment decisions need to look like to cope with an expected growth in container traffic related to its efficiency of performance.* The research will be tackled by finding the initial efficiency performance of container terminals in Pelindo as a benchmark, then followed by cargo throughput forecasting for each container terminal combined with capacity analysis to generate the capacity utilization level. The period of 2009 to 2013 will be taken as the basis to measure throughput growth. The outcome of throughput projection and capacity analysis could determine the appropriate time and type of investment. Hence, the research can be separated into the following objectives:

- To forecast the container terminal volume within the operational area of Pelindo for the targeted years;
- To quantify the terminal efficiency level among all the container terminals in Indonesian Port within the operational area of Pelindo;
- To establish the capacity analysis for container terminal in order to find the ratio of demand and suppy as an indication of capacity utilization level;
- To define an accurate investment decision recommendation on container terminal within the authority of Pelindo by taking into account future throughput as a demand and terminal capacity as a supply.

1.3. Scope and Limitation of the Research

The research is addressed to analyze the investment related to the efficient performance of container terminal in Indonesian Port. More specifically, the research would only consider 18 container terminal branches and/ or subsidiary since the research only focus on dedicated container terminal and 1 additional conventional container terminal due to its status as main class branch of Indonesia Port. Finally, the research considers 18 ports to the total of 43 ports in Indonesia within the management of Pelindo 1, 2, 3 and 4. More detailed information of the sample port can be deployed in Table 1. The period from 2009 to 2013 will be taken as the basis to measure throughput growth regarding throughput projection for the next 15 years.

Table 1 Detail Information of Port Category

Port Corporations	Port Administrative	Status	Class
Pelindo I	Belawan Port	Conventional Container Terminal	Main Class
	Belawan International Container Terminal (BICT)	Dedicated Container Terminal	Subsidiary
Pelindo II	Tanjung Priok Port	Dedicated Container Terminal	Main Class
	Teluk Bayur Port	Dedicated Container Terminal	Class I
	Palembang Port	Dedicated Container Terminal	Class I
	Panjang Port	Dedicated Container Terminal	Class I
	Pontianak Port	Dedicated Container Terminal	Class I
	Jambi Port	Dedicated Container Terminal	Class II
	Jakarta International Container Terminal (JICT)	Dedicated Container Terminal	Subsidiary
	Koja	Dedicated Container Terminal	Subsidiary
Pelindo III	Tanjung Perak Port	Dedicated Container Terminal	Main Class
	Banjarmasin Port	Dedicated Container Terminal	First A Class

Port Corporations	Port Administrative	Status	Class
	Terminal Petikemas Semarang Port	Dedicated Container Terminal	First B Class
	Terminal Petikemas Surabaya Port	Dedicated Container Terminal	Subsidiary
	Berlian Jasa Terminal Indonesia	Dedicated Container Terminal	Subsidiary
Pelindo IV	Makassar Port	Conventional Container Terminal	Main Class
	Unit Terminal Petikemas Makassar (UTPM Port)	Dedicated Container Terminal	Subsidiary
	Container Terminal of Bitung	Dedicated Container Terminal	Subsidiary
Total	**1 main class, 17 dedicated container terminals**		

Source: Own elaboration based on Pelindo Annual Report

The measuring of terminal performance utilizes input and output variable as benchmark indicator for the efficient performance among the terminals. The scope of input variables will be focused on operational aspect which assesses physical facilities, particularly for container yard area, the draft of port basin, container berth length, quay crane index, yard staking index, internal trucks and vehicle and number of gate. The output variable is the annual throughput since it indicates port productivity.

The Data Envelopment Analysis (DEA) will be conducted as quantitative analysis model using the available software, particularly Stata Programs related to the measurement of terminal efficiency based on the input and output variable associated with terminal performance. The model will be oriented to Constant Return to Scale (CRS) due to its relevance with the research that concerns with analysis of investment possibility, either to improve efficiency or to keep the sustainability of the business segment by replenishing container terminal's equipment and facilities. The capacity analysis will focus only on berth capacity and yard capacity since those are the two most important indicators of terminal capacity.

1.4. Research Methodology

To tackle the investment decision related to terminal efficient performance, this research will examine historical data related to 18 dedicated container terminals in Indonesian port. Therefore, DEA analysis model will be exploited to define initial container terminal efficient performance of each container terminal within the authority of Pelindo. Furthermore, throughput projection and capacity analysis will be applied in order to find out the capacity utilization level. In this case, throughput projection as a demand and capacity analysis as a supply will be combined to generate the appropriate time and the type of investment. The research will be conducted in both quantitative and qualitative analysis.

The qualitative analysis is performed by literature review on performance measurement indicator of container terminals and DEA linear programming model as a tool to define the efficient performance of container terminal. Moreover, literature review is also taken to make descriptive analysis of each port that has a container terminal within the authority of Pelindo and port investment related to the container terminal.

As having said above that a quantitative analysis through throughput projection, Data Envelopment Analysis (DEA) and capacity analysis will be conducted, taking the efficient performance and capacity analysis supported by literature review evaluation into account then proper investment for each port can be defined.

Data Envelopment Analysis (DEA) analysis is one of the most significant approaches to calculate the port performance. Cullinane et al. (2004) compares the use of DEA with traditional approach where the DEA was able to evaluate overall port performance since it uses multiple inputs and outputs. DEA CCR, developed by Charnes, Cooper and Rhodes in 1978, is non-parametric analysis used to quantify efficient production of the Decision making Units (DMUs) quantified by means of Linear Programming (LP) formulation and defined as the ratio of weighted sum of outputs to a weighted sum of inputs. Here, insufficient information about the multiple inputs and multiple outputs involved in Decision Making Units (DMUs) can be overcome by small assumption (Cooper, W. W., Seiford, L. M. & Zhu, 2011).

Initially, there will be 18 DMUs that comes from 18 container terminals within the management of Pelindo using the data in 2014 as the cross sectional data. The throughput forecast and capacity analysis is based on panel data from 2009 to 2013. Additionally, to be more comprehensive, quantitative analysis will be added by combining demand and supply analysis to define the appropriate time and type of investment.

The research, having consisted of 6 chapters, initiates the Introduction in chapter 1 which will present the background behind the research and how it will impact the entire business environment. This will also cover the research question and the purpose of conducting this research. Furthermore, scope and limitation of the research will also be identifyied clearly in this chapter. In addition, Research methodology utilized in this research is briefly explained. Chapter 2 addresses the previous studies of container port performance, the elucidation of DEA model application as a tool of measuring terminal performance which will specify the information on how the model works through the research. Chapter 3 provides the methodology to reach the research objective and describes the profile, existing assets, facilities and activities of each container terminal in Indonesia. Chapter 4 presents the result of the quantitative analysis, it summarizes it into a table. Chapter 5 observes the result of terminal performance through quantitative and qualitative. Quantitatively, it will be done by taking the slack for each calculation into account, while qualitative analysis mostly obtained from literature review. Chapter 6 extracts the result and analysis of the research into the conclusion and recommendation for further research.

2. LITERATURE REVIEW

2.1. Investment and Efficiency Performance of the Container Terminal

2.1.1. Port Investment Related Container Terminal

The growth of containerization around the world gives pressure to the ports to design and apply the proper further development in the port area together with their hinterland economies. If the infrastructure in container terminal is inadequate and poor, it will cause some logistic bottleneck and growth limitation in economy growth (Brooks & Perkins, 2014). Furthermore, Brooks & Perkins (2014) describe, in order to avoid that situation while increase the capacity and efficiency, the investment plan is extremely needed and also to stimulate demand. Several considerations, such as demand of hinterland, evolving maritime transport markets, port competition, and inland transportation condition also environmental issue will be taken into account in the process of investment decisions in container terminal. The container terminal planning problem consists of three areas, seaside area, the yard area and the landside area and each has different issue, seaside area related to the berth and quay crane, whereas yard area closely relate to the yard management (Bierwirth & Meisel, 2010). The issue in landside area mainly on hinterland operations, which are particularly tackled by railway companies, inland barge operators and trucking companies. While seaside and yard area mainly tackled by port operator. Pelindo as port operator also container terminal operator deal with the issues under seaside and yard area where taking into account on crane and yard management. Thus, the investment in accordance to efficiency performance in container terminal related to addition crane and container yard. Because the terminal performance less will be affected by the number and the condition of the cranes also with the density of the container yard that will lead to the level of dwelling time in that area. The implementation of the investment plan in these three main areas allegedly will be the future determinant of container terminal.

To minimize the cost that caused by the operation of ship time and port facilities are the goal of the port investment decision. Several experts stated that the complete objective is to maximize the advantages to gather net profit and internal rate of return (Edmond & Maggs, 1978). Several models are already developed nowadays related to the port investment. The involvement of private sector in this industry is increase as the result of globalization policy from the government. The high number of capital needed also become consideration to form partnership in the port development. Estimated in average, the investment level of port in the last 5 years has reach above $100 million, this condition is done by the public – private partnership (PPP) model with relatively equal investment for each party (Baird, 2002). Baird also had conducting the survey that showing the PPP model had shared the range of values from $25 million to over $250 million. This result of the survey has indicated that private and public sector as the relevant investors of the development in container terminals. Nowadays, Pelindo III faced with the challenge of many projects related to port development but with the limited capital resource available. Due to the few support or subsidy by the government and to manage the risk that could appear, the PPP model is one of the solutions. One of the success stories is the Surabaya Container Port, is the biggest business unit of Pelindo III that had being corporation with Dubai Port since 1999. The financial constraint not only the bottleneck of Pelindo III, in Jakarta the biggest port operator in Pelindo II, even sold 49% ownership of their two container terminals to the Hutchinson and to the Mitshui Group for the new mega project of container terminal, New Priok Port. Meanwhile in the western area of Indonesia, Pelindo I is almost finish their partnership plan project with the Port of Rotterdam to develop their new big project: Port of Kuala Tanjung. Unfortunately, this condition is not followed by eastern area of Indonesia which mostly under management of Pelindo IV, because the market is still not attractive enough for the private investor.

2.1.2. Efficiency Performance in Container Terminal

Play role as the facilitator of trade and linked chain in the logistic process, the efficiency is become most important issue in the container terminal, especially to allocate and use the limited economic resources (Wang, Song, & Cullinane, 2002). In the short term, the efficiency give benefit to the port by enhance its ability to attract customers by offering the competitive price to the customers, meanwhile for the longer term the development of the port is needed to ensure the costs recovery, especially those related to the investment (Wang & Cullinane, 2006). To avoid those circumstances, port is required to be more efficient in its productivity and actively measuring and maintain its efficiency.

The concept to measuring level of efficiency in the port efficiency is become important, consider that the efficiency will stimulate the competitiveness of the port and also become the booster of regional development (Merk & Dang, 2012). According to description of Merk & Dang (2012), due to invention of new technology in shipping industry also the new trend of international ocean traffic, such as containerization, integrated logistic service, etc., the port customers are given pressure to the seaports by demanding new development and technology to support the cost substracting in the logistic chain. The ports also being forced to doing non – stop efficiency, in order to keep them attractive and maintain their traffic by provide competitive advantages. Some operational activities will be the challenges for the ports to secure their ship call traffic flows and to compete with the nearby competitors. The challenges appear will include the activity of containers handling that need to be more rapid by providing more adequate and performing equipment. But also several infrastructure issues need to be overcome, like berth times and delays, the capacity of the yard to stack the containers also to ensuring the hinterland connectivity that will affected by inland multimodal transportation. Not only the traffic of the goods and the port users that will enjoy the benefits of port efficiency, but the nearby regions also will enjoy the positive effect, because the availability of direct and indirect access on related activities, such as finance, lower price, maritime insurance and etc. caused by the efficient performance of the port by provide the value added in the supply chain. The most tangible benefit for the region is the creation of jobs for the society.

Flexibility, reliability, speedy and cheap price is the requirement that requested by the customers today (E.-S. Lee & Song, 2010). Like being described by E.-S. Lee & Song, (2010), that those components are related to the effectivity and efficiency of an organization. Thus, the value of logistics in the maritime industry can be generated by the efficiency and effectiveness during the operation that will be affected the level of service and the satisfaction of their customer. How good the utilization of the resources in the organization is measured by the efficiency level, meanwhile the effectiveness more focus on the goals and targets that will achieved in the future based on the strategy of the organization. In order to measure the efficiency in logistic sector, the 4 components will be assessed, such as: costs, assets, reliability and responsiveness/flexibility. The components of: cost and assets are intended to measure the efficiency and the two others are intended to measure the effectiveness. E.-S. Lee & Song (2010) develop the measurement of efficiency and effectiveness in the transport logistic sector, as reflected in the Table 2 below. Because the transport logistic sector is also covering the maritime logistics the concept and framework is possible to be applied in assessing the value of maritime logistics.

Table 2 Measurement of Efficiency and Effectiveness in Transport Logistics Sector

Supply Chain Process	Measurement Criteria	Performance Indicators
Efficiency - related (Internal Facing)	Cost	• Total logistic management cost • Productivity • Return processing cost
	Asset	• Cash to cash cycle time • Inventory days of supply • Asset turns
Effectiveness - related (Customer facing)	Reliability	• Delivery performance • Order fulfillment performance
	Flexibility & Responsiveness	• Perfect order fulfillment • Response time • Production flexibility

Source: E.-S. Lee & Song (2010)

2.2. Efficiency Performance Measurement Indicators and Benchmarking

Efficiency performance plays significant role in the company's operation, in this case is ports as a Decision Making Unit (DMU). The most essential role of the efficiency performance measurement is that it can evaluate improvement in production since it measures not only the initial condition but also future performance. Performance measurement provide information as a based to deliver recommendation on expected behavior towards these performance measurement outcome to reach better performance and/ or maintain it as well. The system could be in the wrong direction as unintended effect occurred by mis-specified performance measures (Cullinane et al., 2004).

Traditionally, port performance evaluated by measured cargo-handling productivity at berth using only single factor productivity and comparing the throughput realization with the business plan over specific time period (Cullinane et al., 2004). Talley (2006, 500) describe that "*ports have traditionally evaluated their performance by comparing their actual and optimum throughputs (measured in tonnage or number of containers handled)*". Furthermore, comparing ports' actual throughputs over the optimum throughput is one of means to quantify performance at an intra-port level (Marlow & Paixão Casaca, 2003). Throughput has been experience to be the most widely used indicator to determine port performance. However, throughput does not taken into account the economic impact of the existence of the port to the regional development and port attractiveness as location to port-related industry (P. de Langen, Nijdam, & Horst, 2007). In addition, Bichou &

Gray (2004) infer that port measure commonly focus on sea leg connection than land-leg, thus better measurement should be taken for land-side efficiency.

Traditional port performance indicators suggested by UNCTAD (1976) has been summarized by Marlow & Paixão Casaca (2003) as shown in Table 3, it is indicate productivity and effectiveness.

Table 3 Performance Indicator

Financial Indicator	Tonnage works
	Berth occupancy revenue per ton of cargo
	Cargo handling revenue per ton of cargo
	Labor expenditure
	Capital equipment expenditure per ton of cargo
	Contribution per ton of cargo
	Total contribution
Operational Indicator	Arrival rate
	Waiting time
	Service time
	Turn-around time
	Tonnage per ship
	Fraction of time berthed ships worked
	Number of gangs employed per ship per shift
	Tons per ship-hour in port
	Tons per ship-hour at berth
	Tons per gang hours
	Fraction of time gangs idle

Source: UNCTAD (1976)

Based on Bichou & Gray (2004) port efficiency can be broken down into three categories, physical indicator, factor productivity indicator and economic and financial indicator. Physical indicator concern to the time measure of the ship such as ship turnaround time, ship waiting time, berth occupancy rate, working time at berth and time measurement on the co-ordination with landside such as dwell time (Bichou & Gray, 2004). Factor productivity indicator related to measurement of labor and capital involve in handling goods, furthermore, economic and financial indicator tend to focus on total income and expenditure related to maritime side (Bichou & Gray, 2004).

Moreover, Chung (2005) describe port performance as combination of operational performance such as vessel speed, cargo rate and cargo handling time to asset utilization and also financial perform. The detail indicator deploy in Table 4 below:

Table 4 Port Performance Indicator

1	Average ship turnaround time
2	Average tonnage per vessel day (hour)
3	Average vessel time at berth
4	Average vessel time outside
5	Average waiting (idle time)
6	Average waiting rate

7	Tons per gang hour
8	TEUs per crane (hook) (hour)
9	Dwell time
10	Berth throughput
11	Throughput per linear meter
12	Berth occupancy rate
13	Berth utilization rate
14	Income per GRT of shipping
15	Operating surplus per ton cargo handled
16	Rate of return on turnover

Source : Chung (2005)

Furthermore, productivity indicators are used as a based to measuring container terminal performances categorized into berth, crane, yard/storage, gang/stevedore, and gate (Kasypi & Shah, 2007). To be clear, the performance indicator can be deploying in Table 5 as follow:

Table 5 Port Indicator Based On Terminal Productivity

Terminal Element	Productivity Indicator	Measurement
Berth	Service time	Vessel service time (hours)
Berth Utilization		Vessel per year per berth
Crane	Crane productivity	Moves per acre of storage
	Crane utilization	TEUs per year per crane
Yard Storage	Storage Productivity	TEUs per acre of storage
		TEUs per year per gross acre
Gang/ stevedore	Labor Productivity	Number of moves per man-hour
Gate	Truck Turn Round Time	Truck cycle time in terminal
	Gate Throughput	Container per hour per lane

Source: Kasypi & Shah (2007)

Port performance cannot be rely only on the basis of single factor productivity since port is service provider vessel, cargo and inland transportation (Cullinane et al., 2004). The multiple indicators should be considered since it's taken into account multiple inputs and multiple outputs in accordance to port production characteristic. Thus, multiple indicators accommodate overall evaluation of port performance.

Frontier statistical model can be utilized as a model to evaluate technical efficiency of multi-port performance where throughput as an output and resource as an input are examined to define port efficiency (Talley, 2006). It called technical efficient in case that the throughput perform the maximum value against certain levels of resources, conversely, technical inefficient for the throughput less than the maximum for certain levels of resources (Talley, 2006). Thus, Data Envelopment Analysis (DEA) are widely use to analyses port performance since utilize multiple inputs and outputs. As was describing in Talley (2006, 512), "*DEA techniques is non-parametric mathematical programming techniques for deriving the specification of the frontier model*".

In this globalization era, port faces hard competition each other, performance being very substantial strategy to maintain satisfactory services to port users and enhance the market share. On occasion, the requirement to upgrade capacity by build new terminal is unavoidable. However, to execute the investment decision it's very substantial to analyze the maximum utilization of existing facility compare to maximum output given by the facility. Thus, the output-oriented model perform a benchmark for the container terminal (Cullinane et al., 2004).

The benefit of defining port performance indicators is the possibility to evaluate port performance by comparing the actual and optimum indicator. In line to economic aspect, ports management is able to control the variables called port performance indicator (i.e. choice indicator) for optimizing operating objective. For maximizing profit aim, port management should select the value of variable which produce maximum profit for the port. Thus, the values of variable called indicators' standards (or benchmark). According to Talley (2006, 507) "*If the actual values of the indicators approach (depart from) their perspective standards over time, the port's performance with respect to the given economic objective has improved (deteriorated) over time*".

Benchmarking are used by European seaport to find out the performance over their competitor as a respond against toward an increased modal competition (Barros, 2006). While Italian seaport face changing on port business by put an effort on the improvement of the input efficiency through benchmarking towards best port performance (Barros, 2006). DEA as a linear programming technique which is involved multiple inputs and outputs allows providing benchmarking for inefficient seaport.

Inter port competition has encourage ports management to evaluate their performance to reach expected efficiency since the investment in infrastructure and land utilization are very costly. Common method in evaluating terminal performance is by compare it to other better port in the term of performance or in other words it's called benchmarking and it influenced by three factor (Rankine, 2013) :

1. Trade and terminal size
   Benchmarking should be departing with the equal size and competitor around;
2. Characteristic of local factor such as navigation, the shape of the terminal and hinterland connectivity
3. Measurement point such as labor productivity, service level, capital and charges.

Productivity and efficiency of a terminal affected by vary factor, benchmark provide standard since it depicted as the most efficient DMUs or in this case is ports. Thus, port performance can be evaluated over time by taken into account the performance benchmark to maintain its level and/ or increase it as well.

2.3. DEA for Container Terminal Performance Measurement

"DEA is a multi-factor productivity analysis model for measuring the relative efficiencies of a homogenous set of decision making units (DMUs).The DEA approach identifies a set of weights (all weights must be positive) that individually maximizes each DMU's efficiency while requiring the corresponding weighted ratios (i.e., using the same weights for all DMUs) of the other DMUs to be less than or equal to one". (Sharma & Yu, 2009, 5017).

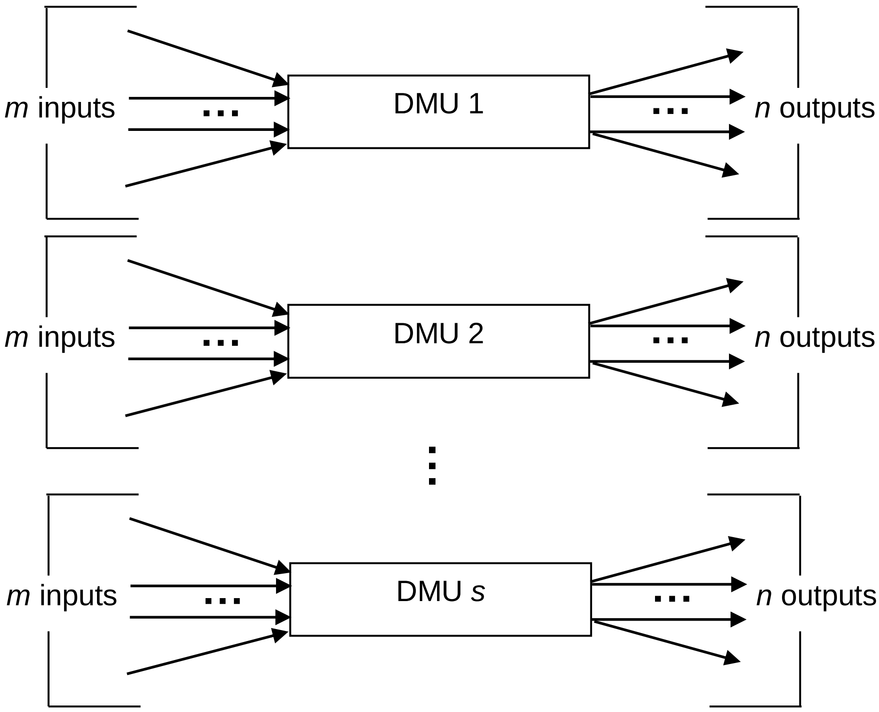
DEA is non-parametric analysis of quantifying the Decision Making Units (DMUs) efficiency by accommodate multiple inputs and/or multiple outputs without initially assigning a production function (Cullinane et al., 2004). Talley (2006) also define

DEA techniques as non-parametric mathematical programming techniques for acquiring a relative efficiency ranking for the DMUs or in this case is port. The outcome of the DEA is the relative efficiency rating among the DMU or in this case is the ports without assumption since it was the frontier statistical model. Frontier statistical model mainly focus on container terminal and many literature explain common combination of both variable related to port efficiency and performance measurement (Bichou & Gray, 2004).

Data Envelopment Analysis initially applies by Charnes, Cooper and Rhodes (CCR) in 1978, it was developed from Farrell's (1957) notion of assessing technical efficiency concerning a production frontier (Kasypi & Shah, 2007). The CCR allows to measuring the relative technical efficiency of similar Decision Making Units (DMU) by constant returns to scale (CRS) assumption, this is accomplished by measuring the ratio of a weighted sum of outputs over a weighted sum of inputs (Kasypi & Shah, 2007). Kasypi & Shah (2007, 97) convey that *"the weights for both the inputs and outputs are selected so that the relative efficiencies of the DMUs are maximized with the constraint that no DMU can have a relative efficiency score greater than one"*.

There are two basic model of DEA commonly used base on envelopment surface, the efficiency measurement and the orientation, constant return to scale (CRS) and variable return to scale (VRS) (Sharma & Yu, 2009). CRS model basically was the CCR model on the basis of constant return to scale that the output rises proportionally to the increase of input at any level of production. The CCR continue to developed by Banker, Charnes and Cooper in 1984 and it's called the BCC Model (Kasypi & Shah, 2007). The BCC models enable production technology to perform increasing returns-to-scale (IRS) and decreasing returns-to-scale (DRS) which is called Variable Return to Scale (VRS) (Kasypi & Shah, 2007). Thus the BCC model exhibit better outcome since it perform aggregate measure of technical and scale efficiency while the CCR model only quantifying technical efficiency (Sharma & Yu, 2009).

Wang et al. (2002) define *"DEA as measurement of relatively productivity of a DMU by comparing it with other homogeneous units transforming the same group of measurable positive inputs into the same types of measurable positive outputs"*. Figure 2 below express the DMU and the input-output:



Source: Wang et al.(2002)

Figure 2 DMU and the Homogeneous Unit

One should be taken into account when select the DMUs and the factor driven of DMUs is the homogenous unit, in other words it should be express similar assignment and goal within an equal set of market situation and the variable (input and output) (Mokhtar, 2013). Figure 2 reveal the coherence between the input, the output and the DMU, thus the input can be describe easily by matrixes *X* and *Y* as shown in equation Equation 1 and Equation 2. Here x_{ij} refers to the i^{th} input data of DMU *j*, whereas y_{ij} is the i^{th} output of DMU *j* (Wang et al., 2002).

$$X = \begin{pmatrix} x_{11} & x_{12} & \cdots x_{1s} \\ x_{21} & x_{22} & \cdots x_{2s} \\ \vdots & & \\ x_{m1} & x_{m2} & \cdots x_{ms} \end{pmatrix}$$ Equation 1

$$Y = \begin{pmatrix} y_{11} & y_{12} & \cdots y_{1s} \\ y_{21} & y_{22} & \cdots y_{2s} \\ \vdots & & \\ y_{n1} & y_{n2} & \cdots y_{ns} \end{pmatrix}$$ Equation 2

Having said above that efficiency can be calculated by measuring the ratio of a weighted sum of outputs over a weighted sum of inputs of the DMU's and its a fragment of productivity, where it is also a ratio of factual output over the criterion intended output, its asserted in equation Equation 3 and Equation 4 (Kasypi & Shah, 2007). Furthermore, higher performance can be achieved by larger DMUs and the number of DMUs should not be less than twice the number of input and output (Mokhtar, 2013).

$$Productivity\ index = \frac{output\ acquired}{input\ expected} = \frac{performance\ achieved}{resources\ consumed} = \frac{effectiveness}{efficiency}$$

Equation 3

$$Efficiency = \frac{Output}{Input}$$

Equation 4

The equation Equation 3 and Equation 4 can only be practiced for simple data, mostly efficiently measurement cases involve multiple inputs and output, thus it should be converted by the weight cost approach by the equation Equation 5 (Kasypi & Shah, 2007).

$$Efficiency = \frac{\sum weighted\ of\ outputs}{\sum weighted\ of\ inputs}$$

Equation 5

Supposed that all weight is uniform, mathematically it can be rewrite as follows:

$$Efficiency = \frac{\sum_{r=1}^{n} u_r y_r}{\sum_{s=1}^{n} v_s x_s}$$

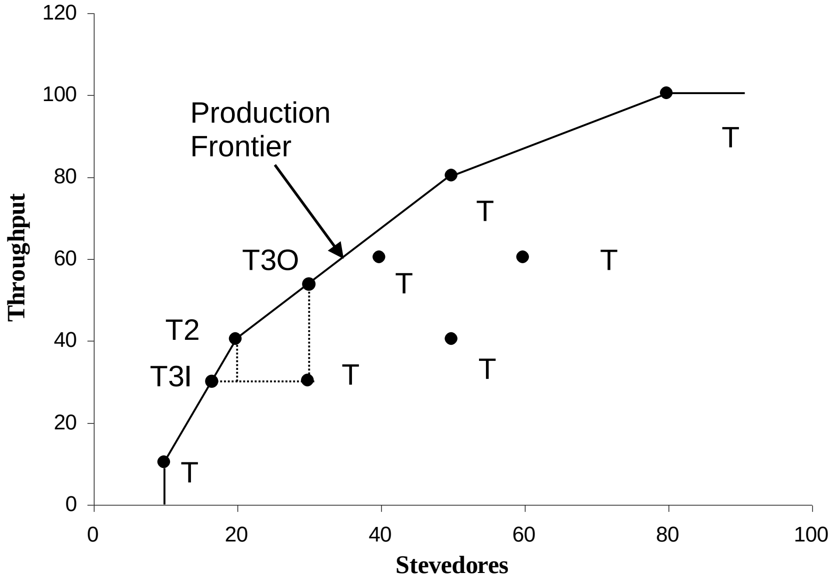
Equation 6

Where:

y_r = quantity of output *r*
u_r = weight attached to output *r*
x_s = quantity of input *s*
v_s = weight attached to input *s*

It's called efficient if the outcome equal to 1, the unit efficiency is 0 < efficiency $\leq$1

Wang et al., (2002) define one additional model of DEA apart from widely studied model DEA CCR model and the BCC model, it is the Additive model. The BCC model equal to the Additive model with respect to the production frontiers. The main distinction between them is the forecasting lane to the production frontier. To be clear, the difference is shown in Figure 3. For BCC model, supposed the inefficient T3 will be forecasted to reach the production frontier in order to be efficient to the point of T3I or T3O, but for additive model it will be projected to T2. The distinction among three model is the possibility to obtain different efficiency outcome since they have different path to the production frontier (Wang et al., 2002).



Source : (Wang et al., 2002)

Figure 3 Distinction BCC and Additive Models

2.3.1. DEA Linear Programming and Model Orientation

The basic knowledge of Data Envelopment Analysis (DEA) is establishing frontiers by utilizing the most efficient Decision Making Unit (DMUs) in order to indicate the level of improvement for each inefficient DMUs on the basis of quantifiable input and output elected. Since DEA is non-parametric analysis, the Linear Programming as the mathematical alteration of the equation is only explain academically without elaborating from the port data. The DEA only exploit the application software to measure the efficiency degree of DMUs.

According to Mokhtar (2013), the efficiency measures under the basic model namely constant return to scale (CRS) are acquired by N linear programming issue under Charnes et.al.1978 as follows :

$$Min_{\psi,\lambda}\psi_{\lambda}$$
$$\sum_{i=1}^{N}\lambda_i y_{ri} \geq y_j; \quad r = 1, \ldots\ldots, R$$
$$\sum_{i=1}^{N}\lambda_i x_{si} \geq \psi_j x_j; \quad s = 1, \ldots\ldots, S$$
$$\lambda_i \geq 0; \quad \forall_i$$

Equation 7

Where:

$y_i = (y_{1i}, y_{2i}, \ldots, y_{Ri})$ = the output vector

$x_i = (x_{1i}, x_{2i}, \ldots, x_{si})$ = the input vector

Tackle equation Equation 7 for every *N* container terminal for *N* weight then *N* optimum completion will be defined. Every optimum completion $\psi^*{}_j$ is the efficiency indicator of container terminal *j* and setting up$\psi^*{}_j \leq 1$. Thus, easy to recognize that container terminal with $\psi^*{}_j < 1$ are categorized as inefficient and conversely for $\psi^*{}_j = 1$ are the efficient ones. Has been explained above that the Constant Return Scale (CRS) model developed further by Banker et al (1984) which was then generalized as Variable Return to Scale (VRS) by put additional constraint $\sum_{i=1}^{N} \ddot{e}_i = 1$. The model modified as below:

$$Min_{\vartheta,\lambda}\vartheta_\lambda$$
$$\sum_{i=1}^{N} \lambda_i y_{ri} \geq y_j; \quad r = 1, \ldots\ldots, R$$
$$\sum_{i=1}^{N} \lambda_i x_{si} \geq \vartheta_j x_j; \quad s = 1, \ldots\ldots, S$$
$$\sum_{i=1}^{N} \lambda_i = 1; \ \lambda_i \geq 0; \quad \forall_i$$

Equation 8

Mokhtar (2013) identify the differences between DEA-CCR and DEA-BCC is that DEA-CCR called constant return to scale (CRS) model allow identifying relative's efficiency and recognizing the resources then asses the inefficient ones. While DEA-BCC or variable return to scale (VRS) model able to differentiate technical and scale inefficiencies. Thus by estimating the chance of the rising as well as reducing or constant return to scale is existing for the further development. To be conclude, for CCR model, DMUs called efficient is both scale and technical efficient are satisfied but for BCC model, DMUs can be categorized as efficient only by meet the technically efficient (Mokhtar & Shah, 2013).

Charnes, Cooper and Rhodes (CCR) model enable performing multiple inputs and multiple output for every DMUs, it is described as a ratio of the virtual input over the virtual output and the outcome is the efficiency value which then easy to be compare to other DMUs in this case is the port (Sharma & Yu, 2009). Based on Sharma & Yu (2009)Linear programming to express the ratio can be define as follow:

$$\max \quad h_o(u, v_i) = {\sum_r (u_r y_{ro})}\Big/{\sum_i (v_i x_{io})}$$

Equation 9

Where:

u_r = output value

v_i = input value

y_{ro} = inspected number *y* of output r generated by DMU_0 from the input x_{io}

x_{io} = inspected number of ouput *i* utilized to generate number of *y* by the output Of *r* for DMU_0

By adding special restriction to specify the ratio of abstract input to abstract output for every DMUs should be not more than one, the linear programming can be defined as follows:

$$\max \quad h_o(u, v_i) = {\sum_r (u_r y_{ro})}\Big/{\sum_i (v_i x_{io})}$$

Subject to

$$\sum_r (u_r y_{rj}) \Big/ \sum_i (v_i x_{ij}) \le 1 \qquad for\ j = 1, \dots\dots, n,$$
$$u_r v_i \ge 0 \quad for\ all\ i\ and\ r$$

Equation 10

For special thorough expansion the constraint $u_r v_i \ge 0 \quad for\ all\ i\ and\ r$ can be substitute with a non-archimedean factor Ɛ to be $\frac{u_r}{\sum_{i=1}^{m} v_i x_{io}}, \frac{u_r}{\sum_{i=1}^{m} v_i x_{io}} \ge \varepsilon > 0$ and Ɛ should be smaller than all positive real number (Sharma & Yu, 2009).

An overall efficiency of DMUs can be categorized as strong (i.e. absolutely efficient) or weak (i.e. inefficient) depends on the existence of the slack. For instance, DMUs can be classified as absolutely efficient if Θ* = 1 and all slacks are likely to be zero. Conversely, DMUs called less efficient if Θ* = 1 with some slacks. The constraint in LP assign the type of overall efficiency; by the non-archimedean factor, the outcome will be absolutely efficient DMUs, others constraint express overall efficient DMUs should be categorized as low efficient. Table 7 deploy shape of the Farrel model which accommodate the existence of less efficient DMUs.

Sharma & Yu (2009) says that for each inefficient DMUs, DEA analyze the efficient units that can be used as a benchmark for the improvement of the inefficient ones. Thus, the benchmark can be generated from the dual problem i.e. Farrel model as shown in Table 7 where Θ is the efficiency value and the λs are the dual variable. Dual problem identify inefficient DMUs by analyze other set of DMUs (composite DMUs) which exploit lower input but generate at least the same degree of output to the inefficient DMUs. Thus, the units implicated in the form of the composite DMU can be exploited as benchmarks for those inefficient DMUs.

2.4. DEA Research for Container Terminals

2.4.1. Worldwide DEA Research

Much study regarding efficiency measurement has been conducted during past year. DEA-CCR model first founded by Charnes in 1978 then experienced by incredible expansion of theory, methodology and application for the last period and it was expressed by great number of citations over 700 times since 1999 (Cullinane et al., 2004). Practically, most precedent study concentrate on efficiency production at the degree of the terminal (Wang et al., 2002). Thus, most of the study focus on a terminal basis and not port basis. To be clear summary of DEA study related to efficiency performance of port are shown in Table 6 Summary of DEA Study Related Port Industry.

In 2000, a research undertaken to measure the efficiency of 31 container ports over world's top 100 container in the year of 1998. It was conducted by R.Gray & V.F.Valentine (2000) aiming to compare port efficiency to define the relation between typical kind of ownership and organizational structure. The research apply DEA-CCR model utilize multiple inputs i.e. total berth length and container berth length also multiple output i.e. number of container and total tons throughput. The outcome of the research express relation between the ownership structure and organization theory toward the efficiency, thus in the term of ownership structure the privates port indicate the most efficient port followed by public-owned port.

Nevertheless, the research point out the requirement for more input such as port size, berth length, and main function of the port, simultaneously with the restrictions of utilizing assets as an input so that it can reach identical comparison (R.Gray & V.F.Valentine, 2000).

Tongzon (2001) establish DEA study to analyze the factors affected the performance and efficiency of a port among 4 Australian and 12 other international container ports for the year 1996. The study presented two sets of model, DEA-CCR model and additive model, exploiting multiple inputs and outputs. The inputs consist of 6 (six) variable specifically number of cranes, number of container berths, number of tugs, terminal area, delay time and unit of labor towards 2 (two) output namely throughput and ship working rate. The finding of the study define that port size or function is not the only factor of determining the efficiency, in other word port efficiency degree does not strictly rely on the port size or function.

Table 6 Summary of DEA Study Related Port Industry

Reference	Aim of Applying DEA	Data Description	The DEA Model	Inputs	Outputs
R.Gray & V.F.Valentine (2000)	Port efficiency comparison to define the relation between typical kind of ownership and organizational structure	31 container ports over world's top 100 container ports for the year 1998	CCR	- Total length of berth - Container berth length	- Number of containers - Total tons throughput
Tongzon (2001)	Analysis of factors affected the performance and efficiency of a port	4 Australian and 12 other international container ports for the year 1996	CCR Additive	- Number of cranes - Number of container berths - Number of tugs - Terminal area - Delay time - Labor	- Cargo throughput - Ship working rate
Cullinane et al. (2004)	DEA windows analysis application for world's leading container port efficiency measurement based on panel data	25 major container port in the world	CCR BCC	- Quay length - Terminal area - Quayside gantry - Yard gantry - Straddle carrier	- Cargo throughput
Lee, Kuo, & Chou (2005)	Efficiency performance ranking of Asia	25 major container port in the world	Recursive DEA (RDEA)	- Number of cranes - Number of	- Throughput

Reference	Aim of Applying DEA	Data Description	The DEA Model	Inputs	Outputs
	Pacific ports			container berths - Number of tugs - Terminal area - Delay time - Labor units	- Ship working rate
Wang & Cullinane (2006)	Analyzing maximum efficiency within new core business named supply chain management	104 container port in 7 region in Europe in 2003	CCR BCC	- Terminal length - Terminal area - Equipment cost	- Container throughput
Herrera & Pang (2008)	Assessment of efficiency frontier for container ports	86 container port in the world	Free Disposable Hull (FDH) & DEA with VRS	- Terminal area - Number of ship to shore gantries (SSG) - Number of quay, yard and mobile gantries (QYM) - Number of terminal truck (TT)	- Container throughput
Mokhtar (2013)	Measuring terminal efficiency and container movement	6 main container terminals in Peninsular Malaysia using panel data from 2003 to 2010	DEA-CCR DEA-BCC Output oriented model	- Terminal area - Draft - Berth length - Quay crane index - Yard stacking index - Vehicles - Number of gate lanes	- Container throughput
DEA Study Related Port Industry In Indonesia					
Seo, Ryoo, & Aye, (2012)	Evaluate the relative efficiency of container port operations	30 ASEAN ports including 4 Indonesian ports: Belawan, Tanjung Priok, Tanjung Perak, Makassar	DEA-CRR Output oriented model	- Number of berth - Berth length - Container yard area - Number of cranes	- Container throughput

Reference	Aim of Applying DEA	Data Description	The DEA Model	Inputs	Outputs
Merk & Dang (2012)	Measuring efficienci performance of container terminal and bulk terminal	42 world containers terminal including Tanjung Priok		- Berth length - Yard area - Reefer point - Quay cranes - Yard cranes	- Container throughput
		35 world coal bulk terminals including Balikpapan and Tanjung Bara		- Berth length - Storage area - Load/ unload capacity	- Cargo throughput
(Purwantoro, 2004)	Measuring the performance efficiency of 24 port in Indonesia in 2002 with DEA method	24 port within the work area of Pelindo II and Pelindo IV in 2002	DEA-BCC Output oriented model	- Infrastructur e - Auxiliary vessel - Equipment - Haulage	- Ship flows call - Ship flows GT - Cargo flow - Container flow
Andenoworih (2010)	Measure container terminal efficiency in Indonesia	12 container terminals within management of all Pelindo	DEA-CCR DEA-BCC Input oriented model	- Berth length - Number of employee - Number of gantry crane - Yard area	- Throughput
Sari (2014)	Measure the port efficiency level of container terminals before and after the new equipment investment	5 container terminals within the management of Pelindo II (IPC)	DEA-CRS Input oriented model	- Berth length - Container yard area - Number of quay crane - Number of yard equipment - Service time	- Cargo throughput - Container moves per hour - Number of ship call

Source: Own elaboration based on various source

Further study executed by Cullinane et al. (2004) with the intention of DEA windows analysis application for world's leading container port efficiency measurement based on panel data. It takes 25 major container ports in the world to both DEA-CCR and DEA-BCC implication. The research considers multiple inputs i.e. quay length, terminal area, quayside gantry, yard gantry and straddle carrier and single output i.e. cargo throughput. The major finding of the study is that inefficiency is not primary derive from the production scale factor expressed by constant return to scale performance yielded of most ports in study. The study shows that the port that emerges to be highly efficient is not those who have incredible investment overtime.

It's contrary to their low efficient set who heavily invests in the port equipment and/ or infrastructure to deal with competitiveness business environment. Thus, denote that port competition and competitiveness possibly play a major role and straight effect on the quantifiable degree of overall efficiency beneath container ports.

Furthermore, Lee et al. (2005) carry on Recursive DEA (RDEA) on the research aiming to define the overall efficiency rank for Asia Pacific ports utilizing a multi-scenario ranking method. Additional, identical input and output to the study of Joze Tongzon in 2000 are exerted, apply with DEA CCR then re-counting by RDEA to generate comprehensive ranking in highly precise outcome. RDEA model enable to tackle inadequate and too many quantity of DMUs as well. In this case once again DEA has proven to be able to generate port efficiency by given input and output variable obtained from port performance indicator.

The research continue to follow in 2006 by Wang & Cullinane aiming to analyze the maximum efficiency within the new core business named supply chain management. It's conducted to 104 container ports within 7 region di Europe namely Scandinavia, The British Isles, West Europe, South Europe, Central Europe, Southeast Europe and East Europe. Both CCR and BCC model are generated in this research utilizing terminal length, terminal area and equipment cost as an input and throughput as an output. The primary finding of the research show that almost all terminal under the research perform substantial inefficiency. The average efficiency for container port is in the range 0.43 for CRS model and 0.44 for VRS model. The VRS model consider as more realistic than CRS model, on average terminal improve their degree of the output by increase 2.3 times similar to latter-day degree by the equal input. The research exploit large sample which entail main benefit for the efficiency to be more stable and robust. Hence, the resulting efficiency is less susceptive to variation.

The DEA study continue to expand in 2008 by Herrera & Pang which analyze 86 container port in the world by utilizing Free Disposable Hull (FDH) and VRS model. The objective of the paper is to assess the efficiency frontier of the container port. The paper measure the maximum achievable output by given input and quantify the efficiency as a gap of noticed set of input-output to the frontier itself. The paper express three delighting characteristic of this oncoming as follow: "*(1) it is based on an aggregated measure of efficiency despite the existence of multiple inputs; 2) it does not assume any particular functional relationship between inputs and outputs; and 3) it does not rely on a-priori peer selection to construct the benchmark*" (Herrera & Pang, 2008, 1). The finding of the paper indicates that the most inefficient port exert input in overage of 20 to 40 percent of the degree utilized in the most efficient ports. Others beneficial finding of the paper exhibit that most port in developing countries able to degrade scale inefficiency by enhance operation scale. In addition, around one third of that port shall drop their inefficiency by applying scale of operation.

Table 7 DEA Model Types

Charnes-Cooper Transformation	LP dual ("Farrell model")	LP dual solution (score)
Input-oriented DEA Model		
max $z = \sum_{i=1}^{s} \mu_r u_{ro}$	$\Theta^* = \min \Theta$	Solution: $\Theta^* \leq 1$
subject to $z = \sum_{i=1}^{s} \mu_r u_{ro} - \sum_{i=1}^{m} v_i x_{ij} \leq 0$	subject to $\sum_{j=1}^{n} x_{ij} \lambda_j \leq \Theta x_{io}, \quad i = 1,2,\ldots,m;$	Score: $if\ \Theta^* \leq 1$, DMU is inefficient $if\ \Theta^* = 1$, DMU is efficient
$\sum_{i=1}^{m} v_i x_{ij} = 1$	$\sum_{j=1}^{n} y_{ij} \lambda_j \geq y_{ro}, \quad i = 1,2,\ldots,s;$	
$\mu_r, v_i \geq 0$	$\lambda_j \geq 0, \quad j = 1,2,\ldots,n;$	
Output-oriented DEA Model		
max $q = \sum_{r=1}^{m} v_i x_{io}$	$\Theta^* = \max \Theta$	
subject to $z = \sum_{i=1}^{m} v_i x_{ij} - \sum_{i=1}^{s} \mu_r u_{rj} \geq 0$	subject to $\sum_{j=1}^{J} z_j x_{jn} \geq \Theta u_{jm}, \quad m = 1,2,\ldots,M;$	Solution: $\Theta^* \leq 1$
$\sum_{i=1}^{s} \mu_r u_{ro} = 1$	$\sum_{j=1}^{J} z_j x_{jn} \leq x_{jn}, \quad n = 1,2,\ldots,N;$	Score: $if\ \Theta^* \leq 1$, DMU is inefficient $if\ \Theta^* = 1$, DMU is efficient
$\mu_r, v_i \geq \varepsilon$	$z_g \leq 0, \quad j = 1,2,\ldots,J;$	

Source : Sharma & Yu (2009)

The latest study done by Mokhtar (2013), aiming for measuring terminal efficiency and container movement of 6 main container terminals in Peninsular Malaysia exploiting panel data from 2003 to 2010 utilizing DEA-CCR and DEA-BCC. The model orientation used in this research is output oriented model. Mokhtar (2013) trying to develop DEA using relatively new input compare to previous study which are terminal area, draft, berth length, quay crane index, yard stacking index, vehicle and number of gate lanes but exploit similar output namely throughput. The paper defines diverse estimating between DEA-CCR and DEA-BCC in the term of efficiency type. DEA-CCR considers being more comprehensive since it tackled both scale and technical efficiency while DEA-BCC simply focuses on the technical efficiency. The major outcome denotes that there is no substantial relationship between container terminal yard size and efficiency. Hence, efficiency not solely specifies from the size of terminal but it's depending also on allocation of resources.

2.4.2. Previous DEA Application Within Indonesian Ports

DEA application related to the Indonesian port has been established by Seo et al. (2012) and Merk & Dang (2012). Seo et al. (2012) analyzed the efficiency of 30 ASEAN Ports including 4 Indonesian ports namely Belawan Port, Tanjung Priok Port, Tanjung Perak Port and Makassar Port using DEA-CCR with output oriented model. The study utilizes 4 input, viz. number of berth, berth length, container yard area, number of cranes and 1 inputs namely container throughput. While Merk & Dang (2012) conduct a research of 42 world container terminals including Tanjung Priok Port and 35 world bulk terminal including Balikpapan Port and Tanjung Bara Port. The input uses for container terminal are berth length, yard area, refeer point, quay cranes and yard cranes while the output is container throughput. For the second research, Merk & Dang (2012) analyze bulk terminals using 3 inputs, viz. berth lenght, storage area and load/unload capacity with the outputs cargo throughput.

With respect to the performance analysis by DEA for Indonesian port, three studies can be mentioned, viz. by Purwantoro (2004), by (Andenoworih, 2010) and by (Sari, 2014). Purwantoro (2004) analyzed the efficiency 24 ports within the work area of Pelindo II and Pelindo IV using DEA-BCC model. The research uses 4 inputs viz. infrastructure, auxiliary vessels, equipment and haulage and generates 4 outputs namely call, ship flows GT, cargo flow and container flows. By using *DEA Solver Software*, it perform that in 2002, 8 ports categorized as inefficient port over 24 ports as sample. The research does not distinguish the cargo type for each port since the input is summarizing of all the resource utilized to generate the output. And the output itself is mix variable among ship, bulk and container. Furthermore, the study modify the input variables into four categories to get the level of discrimination ("degree of freedom") in the analysis of the "re-scaling" for each attribute value to the product in the form of standard normal distribution equation has made the study lost the ability to detect how large the reduction of input variables that can be done in order to eliminate all surplus/ slack. The study by Purwantoro (2004), deal with the total port productivity which the input comes from marine services, thus the definition of DMU was very rough since its involve all the shipping sector and therefore the result is also rough. Anyhow, its interesting because it show that there is Indonesia literature regarding efficiency measurement of port by DEA Analysis.

Andenoworih (2010) conduct DEA Analysis specifically for 12 container terminals within management of all Pelindo in Indonesi utilizing both DEA-CRS (DEA-CCR) and DEA-VRS (DEA-BCC) with input oriented approach. Taken primary data related to 2007- 2009, the input in this study are berth length, number of employee, number of gantry crane and yard area, while the output is the throughput. By applying *DEA Frontier Software*, the outcome of first model (both DEA-CRS and DEA-VRS) show that 4 out of 12 categorized as efficient container terminals. DEA-VRS reveal 5 over 12 classify as technically efficient (different container terminal to the first model), conversely to DEA-CRS model which is categorized these 5 terminals as inefficient. The research aiming to find the efficiency of container terminals and show the peers for each container terminal as benchmark, yet it does not provide detail information for stakeholder to tackle the appropriate investment as an improvement step.

Sari (2014) evaluate the efficiency of 5 container terminals within the management of Pelindo II utilizing DEA-CRS input oriented model and compare the result with the data from terminal operational performance in 2010 (before investment) and 2013 (after investment). The *DEA Frontier Software* using to analyze the inputs which is consist of berth length, container yard area, number of quay crane, number of yard equipment, and the service time while the output are cargo throughput, container moves per hour and number of ship call. The analysis divided to 2 phase, first phase utilize all input and 2 first output with the data in 2010 (before investment) and 2013 (after investment) to come across direct effect of investment and second phase exploiting all input and output using the panel data from 2010 to 2013 to evaluate the changing in efficiency performance. The outcome of the study show that by first phase almost all terminal categorized as inefficient both before and after investment. By the second phase only 2 terminals categorized as inefficient. The productivity before and after investment in additional equipment, its appear that afterwards when the equipment has been installed there, the productivity decrease. In fact more input does not mean more output, its in line to sufficient demand. The research by Sari (2014), focus on the difference between two situation before and after investment and it had only 5 container terminals within the management of Pelindo II.

This research will analyze 18 dedicated container terminals within the management of all Pelindo which are to some extent comparable and the DMU's are better than the previous study in Indonesia Port. *STATA program* in DEA-CRS input oriented model is used in this study to analyze the efficiency performance in 2014 by using 7 inputs which are container yard, maximum draft, berth length, quay crane index, yard stacking index, internal vehicles and number of gate lanes and 1 output namely throughput in TEU. The projection of the throughput will show the future demand while the capacity analysis will asses the capability to cope with future demand. Thus, the result will reveal the efficiency performance compared to the fact of bottleneck as an effect of inability of terminal capacity (as a supply) to bear with the throughput (as a demand). Hence the outcome of the study provides useful information regarding the appropriate investment in terms of time and the urgency.

3. METHODOLOGY

The research apply both qualitative and quantitative methods, where quantitative are exploited to analyze the efficiency performance of the container terminal and throughput forecasting while qualitative are utilized to accomplished by literature review of academic journals and article from various source in line to the study which already countered in Chapter 2.

Efficiency performance for the initial condition will analyze all dedicated container terminals in Indonesia within the management of Pelindo I, II, III and IV. The cross section data for the observation will taken from the year of 2014 followed by the efficiency performance analysis for the future condition utilizing the impedent throughput. Thus, throughput forecasting analysis will be conducted in order to be able to acquire the oncoming efficiency performance.

Moreover, the descriptive assessment will be established to analyze the result of the DEA quantitave analysis both for initial condition and impedent situation by taking into account throughput projection. Briefly explanation and historical data regarding the profile of each container terminal will be conducted to support the descriptive analysis.

Having said before that to boost the qualitative method of performance analysis, the study conduct a quantitative method namely utilizing Data Envelopment Analysis (DEA) Model as *non-parametric mathematical programming techniques* to quantify the efficiency and find the frontier model as a benchmark of the DMU whose located outside the frontier line. DEA model will assist the measurement of the efficiency performance through Stata program which not be free to installed in private notebook. Thus can be solved by exert the software provided in laboratorium room of the university.

3.1. Efficiency Performance Measurement

Efficiency performance measure the current condition of the container terminal based on the recent resources that have been utilized to generate the container throughput. Taking into accout several input as a resources were entirely exploited in yieding the output showing efficiency performance of the DMU. As being said above, according to Kasypi & Shah (2007) productivity indicators are used as a based to measuring container terminal performances categorized into berth, crane, yard/storage, gang/stevedore, and gate (Kasypi & Shah, 2007). Thus, several input related to the productivity are defined to measure efficiency of the container terminal.

There are two basic model of DEA commonly used base on envelopment surface, the efficiency measurement and the orientation, constant return to scale (CRS) and variable return to scale (VRS) (Sharma & Yu, 2009). In this case, CRS model are exploited since it was CCR model on the basis of constant return to scale that the output rises proportionally to the increase of input at any level of production. Mokhtar (2013) identify that DEA-CCR called constant return to scale (CRS) model allow identifying relative's efficiency and recognizing the resources then asses the inefficient ones. By the CRS model, the outcome concentrate on the overall input utilization against the related ouput where DEA will show the restraint problem through the slack result which indicate the input that should be substract for a given output to reach an efficient performance. As also mentioned by Kasypi & Shah,

(2007) that the CCR allows to measuring the relative technical efficiency of similar Decision Making Units (DMU) by constant returns to scale (CRS) assumption, this is accomplished by measuring the ratio of a weighted sum of outputs over a weighted sum of inputs. Furthermore, Constant Return to Scale (CRS) model will be exploited simultaneously with input oriented model since it was considered as corresponding approach to the overall container terminal mission which is aiming to exploit lessen input to produce maximum output. Input oriented considered as relevant method since major issue of the research related to the future investment in the container terminal.

To come across the exact year of the appropriate investment, the research will conduct DEA analysis through Stata Program for the initial condition using port data in the year of 2014 and multiple inputs but single output. DEA Analysis for initial condition will show current efficiency of each container terminal as base to analysis investment possibility by taking into account the capacity of the terminal as a supply toward the throughput produced as a demand. When the demand continue to increase and supply remain the same, thus congestion will be occured as an indicator to enhance the supply through several expansion namely investment on technology and/or phisic in certain year.

DEA Analysis through Stata program analize the efficiency performance of the container terminal where frontier statistical model can be utilized as a model to evaluate technical efficiency of multi-port performance where throughput as an output and resource as an input are examined to define port efficiency (Talley, 2006). The are seven input taken from various technical efficiency indicator namely container yard area, maximum draft, berth length, quay crane index, yard stacking index, vehicle, number of gate lanes and throughput as an output using port data in the year of 2014 as shown in the Table 8 below:

Table 8 Input and Output Efficiency Measurement by DEA

Number of DMU	Input				Output			
	Year	Total	Variable	Abbreviation	Year	Total	Variable	Abbreviation
18 Container Terminal	2014	7	Container Yard (M^2)	(CY)	2009 - 2014	1	Throughput (TEUs)	(T)
			Maximum Draft (M)	(MD)				
			Berth Length (M)	(BL)				
			Quay Crane (Index)	(QC)				
			Yard Stacking Index	(YS)				
			Trucks and Vehicle	(V)				
			Gate Lanes	(GL)				

Source : Own elaboration

Once the efficiency from DEA Analysis for initial condition are obtained, the maximum terminal capacity measurement could be calculated by observe actual condition in Indonesia. Typically terminal capacity depend on the terminal's limiting factor where in many terminal the yard capacity (i.e. throughput capacity supported by the yard) is the limiting factor (Saanen & Rijsenbrij, 2015). In addition, there are several terminals have a different limiting factor which is concern in quay and quay cranes. Eventually, for some terminal but it seldom occured, the gate or the rail facility consider as the limiting factor for future expansion (Saanen & Rijsenbrij, 2015). Taken into account the most cases, the research will measure terminal capacity by yard capacity and quay capacity as the most cases for container terminal.

3.2. Demand Forecast Using GDP Multiplier

Having said before that the DEA Analysis will be combined with the terminal capacity design to evaluate the congestion in the container terminal. Thus, considering that terminal capacity as the supply remain the same and throughput as the demand continue to increase year by year, in certain year the demand will exceed the maximum supply. In that level, the expansion through certain investment should be taken to accommodate the increasing demand.

Furthermore, throughput forecasting method will be utilized to obtain the future throughput as a demand. Since container throughput trade highly correlated to the Growth Domestic Product (GDP) as an indicator of economic growth, it considered to forecast the container throughput by directly linked to the GDP. P. W. de Langen, van Meijeren, & Tavasszy (2012) combine a forecast model by taking into account the expert judgment and allow to tackle nuisance of past growth trend, container multiplier taken to forecast container throughput in the Hamburg-Le Havre on the basis of the past two decades. Therefore, throughput forecasting will utilize multiplier effect forecast method to obtain the future throughput of each container terminal.

As mentioned in Chapter 1 that container terminal in Indonesia spread through different management and different province in Indonesia. Taking GDP to calculate the multiplier effect only adjust the global economic development of Indonesia and it does not adduce the actual economic development of each province. To tackle this problem, the share of Gross Regional Domestic Product (GRDP) at constant price for each province are analyzed to obtain the economic development corresponds to the growth of container throughput volumes in each port. Basically, GRDP in constant use to determine economic growth in real terms from year to year or that economic growth is not influenced by price (Department of Statistic, 2004).

Multiplier effect is also called container elasticity is the ratio of the Compound Annual Growth Rate (CAGR) of the container throughput (the total of international trade consist of exported, imported and related empty container also domestic trade encompasses loading and unloading) over the CAGR of GDP as presented below:

$$Container\ Elasticity = \frac{CAGR\ Througput}{CAGR\ GRDP}$$

Equation 11

$$CAGR = \left(\frac{Tt}{To}\right)^{1/t} - 1$$

Equation 12

$$T_t = T_o\ x\ (1 + (container\ elasticity\ x\ g)^t$$

Equation 13

Where :

$T_t = GRDP\ or\ throughput\ in\ targeted\ year$

$T_o = GRDP\ or\ throughput\ in\ initial\ year$

$t = the\ number\ or\ years$

$g = GRDP\ growt\ rate\ forecasted$

Clear description of the research methodology framework can be depicted in Appendix 2.

3.3. Data and Collection

The research mainly utilize secondary data where the main data source is cross section data and panel data of the annual operation from 18 container terminals within the authority of Pelindo. The cross section data is the facility data regarding the operational of container terminal in the year of 2014 as the input, while panel data is the container throughput of each container terminal in Indonesia from 2009 to 2014. Legality and validity of the data is assured since it was collected from internal source of Pelindo, nevertheless the data categorized as confidential data to be published in line with Pelindo regulation. Since the data correspond to all Pelindo (i.e. Pelindo I, II, III and IV), it was gathered from various sources mainly from the management report (i.e. internal report) by directly contact the person in charge from each container terminal. Some data also collected from Pelindo annual report. The detail data source of each input and output depicted in Table 9.

Table 9 Detail Data Source

No	Input Variable	Data	Sources	Year
1	Container Yard (M^2)	Container Yard Area	Annual Report Pelindo	2014
2	Maximum Draft (M)	Draft Range	Annual Report Pelindo	2014
			Internal Report	2014
3	Berth Length (M)		Annual Report Pelindo	2014
			Internal Report	2014
4	Quay Crane (Index)	Number of sea to shore crane	Annual Report Pelindo	2014
5	Yard Stacking Index	Number of yard stacking crane	Annual Report Pelindo	2014
		Container yard capacity	Internal Report	2014
		Stacking height	Internal Report	2014
6	Trucks and Vehicle	Number of internal vehicle	Internal Report	2014
7	Gate Lanes	Number of gate lanes	Direct Interview	2014
No.	**Output Variabel**	**Data**	**Sources**	**Year**
8	Throughput (TEUs)	Number of gate lanes	Internal Report	2009-2014

Source: Own elaboration

3.3.1. Belawan Port Profile

Port of Belawan is the biggest of all ports located in Northern Indonesia, precisely in east coast of Sumatera Island in the North Sumatera Province and face directly with the Strait of Malacca, one of the busiest strait in the world. Port of Belawan is the main class branch of Pelindo 1, with total area of 26.25 m2, Belawan Port's location at the mouth of the river Belawan that connected with Malacca Strait by a shipping channel as far as 12 km, with a groove width of 100 m and a depth of -9.50 m LWS. The main commodity handled by this port is palm oil.

There are has 7 terminals and 6 Private Terminals (TUKS) in Port of Belawan. From those 7 terminals, one of them is dedicated to handle container cargo and rest of them to handle general cargo and liquid bulk. The 6 of private terminals are operated by different big companies which mainly to handle their own cargoes or as their operation business area (dock yard). But from all of the terminals there only two terminals and two TUKS which has compliance with the International Ship and Port Facility Security Code (ISPS Code). There are Belawan International Container Terminals, Ujung Baru Terminal, PT. Semen Andalas Indonesia and Pertamina Persero. Last year Belawan Port handles 45.980 TEUs, which most of them are domestic containers from and to other islands in Indonesia. Container terminal in Belawan Port is primarily as a buffer and back up area of Belawan International Container Terminal. The facilities and equipment Port of Belawan are described in Appendix 1.

3.3.2. Belawan International Container Terminal (BICT) Profile

Belawan International Container Terminal (BICT) is a business unit especially in the field of container services both for import and export activities of container handling between islands. Belawan International Container Terminal located in Belawan Port 30 km from the center of Medan which has a strategic location for shipping activities because it is located in the international shipping lanes and has excellence as part of the export of agricultural commodities such as rubber industry around, crude palm oil, cocoa, coffee and results Other forest of the hinterland in the province of North Sumatra, Aceh and Riau. While the main commodity imports such as flour, soy, chemicals, machinery parts and fertilizers. For inter-island handling containers, discarded dominant commodity form of Tanjung Priok and Tanjung Perak is flour, soap, tea and other food and main commodities loaded with the purpose to Jakarta is general cargo.

The existing facilities and equipment, majority intended to provide the stevedoring and stacking service. BICT activities particularly serves feeder ships with the destination of Penang, Port Klang, Singapore and domestic ships to Tanjung Priok, Tanjung Perak and other ports. With the last throughput of almost 1 million TEUs, the biggest in Sumatra island, the service of BICT supported by 214 thousand m^2 container yard with single RTG and seven reach stacker, meanwhile on the offshore side supported by 950 meters of berth length equipped by 11 container cranes and two mobile harbor cranes. The depth of the basin area -10 to -11 meters LWS and delivery channels that measure 13 miles in length. The facilities and equipment BICT are depicted in Appendix 1.

3.3.3. Tanjung Priok Port Profile

The Port of Tanjung Priok or simply can be written Tanjung Priok Port is the biggest and busiest port in Indonesia. The port which is located in North Jakarta and facing directly to the Java Sea. The location of the port is at a latitude of 54844' 00'' South and longitude of 52578' 00'' West and the time zone. The Tanjung Priok port is economic indicators of Indonesia because it handles 50% of goods flow in and out Indonesia also handles more than 30% of non - oil and gas commodity in Indonesia. This port play important role as the economic gateway of many industrial parks area around capital city of Jakarta and it also play a role as transshipment hub for many smaller feeder ports in the country.

Tanjung Priok Port is connected with many cities in Indonesia by various intermodal transportation. Tanjung Priok Port is the main class port of Pelindo 2 and it serves almost all kind of cargoes like container, dry bulk, break bulk and liquid bulk which mostly for industrial purpose and with its characteristic and facility, this port is able to serve direct call of new generation ships. For the container cargo, the throughput in Tanjung Priok is the highest rank in the country, in 2014 with approximately 6.4 million TEUs.

The container handling service in Tanjung Priok Port mostly is conducted by three different management company; all of them are still the business line of Pelindo II. First company is the Port of Tanjung Priok (PTP), the new subsidiary company with 100% share owns by Pelindo II. Before it was a branch of Pelindo 2, but in 2014, in order to boost its performance, it is being spanned off to be a new subsidiary. The second company is Jakarta International Container Terminal (JICT), which the ownership is divided by Pelindo 2 and Hutchison Port Holding Group (HPH Group) from Hongkong and the third company is Koja Container Terminal with the still Pelindo 2 and Hutchinson Group as the Shareholders but with different number of share, and the few number of containers handle by Multi Terminal Indonesia (MTI) also own 100% by Pelindo 2. Even though handle fewer containers compared to three others, but only MTI that provide the Container Freight Station service in Tanjung Priok Port area.

1. Port of Tanjung Priok Company (PTP)

As the 14th subsidiary of Pelindo 2, PTP is facing the challenge when the container traffic is dropped 3, 11 % from 5.893.262 TEUs in 2013 to be 5.709.889 TEUs in 2014. The reason of this slowdown because Indonesia just held its legislative and presidential election in 2014 and caused business players took waits and see stance. The higher decline is happened in non-containerized cargo from 22,329,631 of tons in 2013, its decreased 8.68% to be 20,391,878 tons in 2014, due to the same reason with containerized cargo. Container service in PTP is provided in 2 of their 3 terminal (terminal 2 and 3), these terminals are not dedicated for container only but mixed with break bulk cargoes, such as project cargo, steel and coil. The existing draft in PTP is -5,5 to 12 m LWS and with the current dredging project it estimated can reach 14 m LWS, with berth length 10,562 m and equipped by new generation of container crane, the terminal is be able to serve several vessels at the same time. The container yard is 796,121 m^2 with maximum capacity 30,476 TEUs. Since PTP still as a branch (in 2009), 24 hours operation already implemented.

2. Jakarta International Container Terminal (JICT – IPC – Hutchison)

In 1999, the economic crisis was push Pelindo 2 to sell 51% ownership of one of its terminal to HPH Group and established the new subsidiary which focuses on container business called Jakarta International Container Terminal (JICT). Run the business with two terminals (terminal I and II) with 2,150 meters of berth lenght and 54 Ha of container yard in total, JICT success to handle up to 2.3 million TEUs in 2014. Now day, JICT is the most modern container terminal in Indonesia supported by its sophisticated terminal operating system and as the pioneer of auto gate system in the country. JICT is connected in direct routes of 20 shipping lines to several ports in 25 countries in the world with 24 hours services per day. Draft in JICT is the deepest in all terminals in Tanjung Priok Port area with -11 to -14 m LWS.

3. Koja Container Terminal (IPC – Hutchison)

One year before JICT, Pelindo II and PT. Ocean Terminal Peti Kemas (OTPK) was form a joint venture operation in one of its area in Tanjung Priok and establish Koja Container Terminal (TPK Koja), but lately the share belongs to OTPK is sold to HPH group. In 2014 around 800,000 TEUs containers are handled in TPK Koja. Within its

-13 meters of draught, TPK Koja is capable to accommodating vessels with capacity 1.500 – 2.000 which supported by 7 quay cranes alongside its 650 meters wharf, meanwhile the containers can be stored in 21.8 Ha of container yard. In the next few years, consider the throughput forecasting, TPK Koja will extend its berth for 200 meters more.
The facilities and equipment Tanjung Priok Port are deployed in Appendix 1.

3.3.4. Panjang Port Profile

Port of Panjang located in province of Lampung in the Southern Part of Sumatra island at 28.23' south & Longitude 19.03' east. Enjoy its strategic location between two main islands in Indonesia, Port of Panjang plays important role as the gateway for economic corridor is western Indonesia. Based on its infrastructure, hinterland and connectivity, this port is categorized as the first class port and under jurisdiction of Pelindo 2. With maximum -16 m LWS draught and 401 meters berth length that supported by 7 quay crane, Port of Panjang is be able to handle two 200 meters LOA container vessels at the same time. The main commodity today in Port of Panjang is agriculture product and dry bulk that are moved through a network of modern railways and highways to Port of Panjang where they will ship to many destinations abroad. For container cargo, in the last five years has increased steadily and predicted to have continuously growth in the future. Export cargo in Port of Panjang is higher than import, since the vessel call is dominated by the ocean going vessel instead the domestic vessel that serve the inter-island trade. With the container yard capacity of 75.000 m2 in the 2014 Port of Panjang had handle throughput of 107,546 TEUs.

Port of Panjang with 6 nautical miles of channel and total area more than 100 Ha is operated 24 hour a day in seven days a week. Equipped with modern equipment for several types of cargo including several new facilities which can provide the service in all weather. In terms of dry bulk, Port of Panjang nowadays is capable to handling capacity up to 50,000 DWT bulk carriers. The facilities and equipment Panjang Port are described in Appendix 1.

3.3.5. Palembang Port Profile

The Port of Palembang is the river port located on the Musi River in Palembang province, South Sumatra. Related to the growth and development of its hinterland industries of agriculture, mining and manufacturing, the investment plan for future development of this port is extended until Lais river area to provide land space for industrial activity. Port of Palembang also categorized as the first class branch of Pelindo II which play important role to support the economy activity in southern area of Sumatra Island. Port of Palembang is heritage of Dutch colonial that had been built since 1928 and experiences many changes and move of location and management. Since 2013, the development and re – lay out project of Port Palembang already give the good result in terms of productivity and throughput increase.

In the previous year’s Port of Palembang is faced chaotic operation problems caused by traditional model of cargo handling where the stuffing and stripping activity is done alongside the berth instead inside the warehouse or second line. But after the massive development and improvement, nowadays Port of Palembang turned into modern terminal which supported by modern equipment such as Rail Mounted Gantry Crane (RMGC) to stacking the container replace some of reach stackers and side loaders. On the shore side, new 7 Quay Crane is planted alongside 266 meters berth with 9 meters of drafts than can accommodate vessels or barges. The challenge and bottleneck that still appear is the presence of the ancient graveyard in the middle of container yard, that cannot being replaced due to the local custom and tradition also the presence of the Ampera bridge above Musi river that give limitation to height of ships, especially in tidal season.The facilities and equipment Palembang Port are depicted in Appendix 1.

3.3.6. Pontianak Port Profile

Same as Port of Palembang, Pontianak Port is a river port which categorized as the first class branch of Pelindo II. Located on Kapuas River, West Kalimantan Province, Port Pontianak is the gateway port for the industrial activities in its hinterland such as plantation, forestry, mining and raw material processing. There are two small ports area under supervision of Pontianak Port, Sintete Port and Ketapang Port that mainly handle general cargo like forestry and livestock. There are two types of terminals in the Pontianak Port, first is the container terminal with 47.794 m2 container yard and 295 meters berth length equipped by 4 quay cranes. The second is multipurpose terminals with 6 berths that used for general cargo, passenger and military force. Like many river port, Port of Pontianak face the limited draught problems caused by river material sedimentation, the draught in Pontianak Port only -6 m LWS, so only vessel with capacity of 400 TEUs can be berthing in this port.

From year to year the port has increased quite rapidly. It can be seen from the traffic of ships and goods that had increasing, particularly in container cargo. This is influenced by the status of a special terminal handling of containers that have been owned by the port. An increase from the last two years is ± 15%, from 150,114 TEUs in 2010 to be 172,892 TEUs. The high activity inside the port and stevedore cannot be separated from the role of facility and enough equipment to support.

In period 2013 to 2014, Pontianak Port was become the pilot project to implement the control tower concept together with reconfiguration terminal lay out that succeed to increasing its productivity and reducing its high yard occupation ratio (YOR), caused by limited land area. The facilities and equipment of Pontianak Port are shown in Appendix 1.

3.3.7. Teluk Bayur Port Profile

Port of Teluk Bayur is the located in western area of Sumatra island facing Indian ocean, this port is the economic gate away for West Sumatra province where approximately 67% flows of goods in this region handled in Teluk Bayur Port. In connection with the increasing container throughput in the last few years, in 2013 the dedicated container terminal had been launched, with 222 meters of berth and equipped by 5 container cranes, this port is available to accommodate container vessels with 1.500 – 2.000 TEUs capacity. Teluk Bayur Port is the second largest crude palm oil (CPO) port after Dumai Port, meanwhile for the dry bulk cargo is dominated by coal which has increase 1,6 million tons from last year.

Now, Pelindo II is considering to build the railway connection to connect the Teluk Bayur port with its hinterland, this project also to to support the Special Economic Zone (SEZ) plan that will be built in this region. In current time, almost all cargoes in Teluk Bayur port is the domestic cargo, however, several containerized commodity like rubber and furniture are being shipped abroad but not in direct call ship but through nearby hub port. All terminals in Teluk Bayur Port is operated 24 hours per day with no tidal restrictions, with 62.250 m2 container yard, Teluk Bayur Port is capable to handle 4.825 TEUs containers per day. Because the container terminal still quite new, the stacking equipment still rely on reach stacker, side loader and top loader. The facilities and equipment Teluk Bayur Port are described in Appendix 1.

3.3.8. Jambi Port Profile

The Port of Jambi is located in Jambi province alongside Batanghari River with total land area 271 Ha. Port of Jambi is divided into three areas namely Kuala Tungkal Port, Talang Duku Port and Muara Sabak Port, Talang Duku is the main and biggest area where the container terminal is located, this area can accommodate vessel with a capacity of up to 750 dwt. The local government has also prepared a plan flat area of 560 ha in the Eastern District of Jambi relatively close to the port area, with a regional development area designation export oriented industries. Hinterland Port Jambi produces such as rubber, plywood, and molding, which is an export commodity to the USA, Europe, Middle East, Japan, and Korea. Kinds of ships that dock were varied from boat, outboard motor (outboard motor), speed boat, a motor boat, armpit (small craft), until the motor tug boat (tug boat) and a barge (barge). For smooth loading and unloading operation, the Port Talang Duku is equipped with a floating dock, to overcome different water level during the rainy and dry seasons that can reach 8 meters.

Meanwhile, Kuala Tungkal port, which is located in the District of Tanjabbar, within 110 km east towards the city of Jambi. Dock that has a capacity of berthing vessels up to a weight of 800 dwt, every day serve traffic hydrofoil (speed-boat) linking Kuala Tungkal (Jambi) to Batam, Tanjung Pinang and other islands in Riau Islands province. This area also a place of fishermen sail that contribute to the marine fishery products. The last one is Muaro Sabak Port which located in Tanjung Jabung region (within 100 East towards the city of Jambi), is the largest marine docks in Jambi Province, which can accommodate 5,000 dwt vessels. The berth is facing the Strait of idols that are connected directly to the Malacca Strait, would be upgraded to be able to accommodate 15,000 dwt vessels. One of the companies that use the facilities at the area is Petro China International Jabung Ltd.

The draught of all terminals in Jambi Port is not deep enough from -3 m LWS to -9 m LWS and need to be dredged routinely to keep the draught sufficient for vessels or barges to be berthed. In 2014, the container throughput in Jambi Port has slightly increased to be 29.379 TEUs. The container service activity is supported by 14.649 m2 container yard with 302 meters berth length and 2 container cranes. The facilities and equipment Jambi Port are depicted in Appendix 1.

3.3.9. Tanjung Perak Port Profile

Tanjung Perak is the main branch of Pelindo III which located in Surabaya, North Java Province. Tanjung Perak is the second busiest port in Indonesia after the Tanjung Priok in Jakarta. This port is also a major port in eastern Indonesia. At the beginning, to improve the traffic flow of trade, freight and transportation, facilities available at the Port of time was inadequate. Therefore in 1875 Ir. W. de Jonght plan to build the Tanjung Perak for loading and unloading activities without the use of barges and boats. Unfortunately, this plan was rejected because it requires a lot of funds. Only in the first 10 years of the 20th century, W.B. Van Goor make plans, to suppress ocean ships to lean closer to kade. After 1910, the construction of the Port of Tanjung Perak began. Since then, the Port of Tanjung Perak has given a considerable contribution to the economic development and has an important role not only for increasing trade flows in East Java but also in the whole of Eastern Indonesia.

Tanjung Perak Port handles multiple cargoes type, from dry bulk, container and liquid bulk. There are five terminals in Tanjung Perak Port namely Nilam Terminal, Jamrud Terminal, Mirah Terminal, Kalimas Terminal and Gapura Surya Putra Terminal as the passenger terminal. Jamrud Terminal and Kalimas Terminal are intended to handle non-container cargoes, meanwhile the container cargoes are scattered in Nilam Terminal and Mirah, with the total of 601.920 TEUs that supported by 34.880 m^2 container yards with 7 RTG and 320 meters berth with 9 container cranes. To increase the performance of Tanjung Perak Port in the future development project planning will move all the containers to Surabaya Container Terminal (TPS) which is the subsidiary of Pelindo III. The previous container terminals will be dedicated terminal for liquid bulk (Nilam Terminal) and car terminal (Mirah Terminal). Because the quite limited draught, only -8 m LWS, Tanjung Perak Port is not available to welcoming the big ships.The facilities and equipment Tanjung Perak Port are deployed in Appendix 1.

3.3.10. Banjarmasin Port Profile

Port of Banjarmasin or in local name usually called Trisakti Port is located in capital city of Banjarmasin, South Kalimantan, located on the edge of the Barito River, about 20 miles from the mouth of the Barito River in position 03 "20" 18 "latitude, 114 '34' 48" East. Banjarmasin port is the main supporter of sea transport which directly or indirectly play active role in the economic development of South Kalimantan. Banjarmasin Port is categorized as the first class branch of Pelindo III and already have one dedicated terminal for container cargo, Banjarmasin Container Terminal (TPKB) which driven by the fast growing industrial activities in their hinterland in the last few years. Meanwhile the rest of 5 terminals in used to serve multipurpose and passenger. Because with their history and some attraction spot like floating market, statue and others, the Port of Banjarmasin is one of the tourism destination in Kalimantan.

The cargoes in this port is dominated by forest products and mining, to improve the performance in handling cargoes, several development projects related to infrastructure and equipment has been conducted by Banjarmasin Port, especially to deal with the nature problem of Barito river characteristic which have shallow depth and narrow channel. Meanwhile the container terminal facility is 505 meters berth length and 81,133 m^2 of container yard, Banjarmasin Port was handling 413,737 TEUs of container in 2014. In order to response the predicted growth of container in southern area of Kalimantan island, the existing facilities will be improved, such as the berth length will be extended to be 1,240 meters and the draught will be dredged until reach -8 m LWS, also the additional equipment like 6 new container crane and 11 new units of RTG. The facilities and equipment of Banjarmasin Port are shown in Appendix 1.

3.3.11. Terminal Petikemas Semarang (TPKS) Profile

Terminal Petikemas Semarang (TPKS) is located in the Central Java region, which plays important role to support economic activity in the region and surrounding areas, as the main gateway of cargo flow via Java Sea. To improve the service performance with oriented in customer satisfaction, TPKS is projected to be a subsidiary at the end of 2015, which is still fully owned by PT. Pelabuhan Indonesia III. TPKS also of the three major international container flows in Pelindo III, together with main port of Tanjung Perak and Surabaya Container Terminal. In average around 40 to 50 foreign flagged vessels visited every month, consisting of 80% and 20% direct feeder service, while the average throughput production of ± 500,000 TEUS in each year.

The several main commodities that handled by TPKS are Furniture for export and Plastic for import. As container terminal where the cargo containers are transshipped in and out of the gate, TPKS has Container yard (CY) which is divided into 6 areas. The first, fifth, and sixth CY are being used as export and import activities. These areas located close to the berth in order to make faster movement for the trucks when they are transporting container to be loaded to the ship. The second CY is for the empty container and dangerous cargo. The third CY is being used as be-handle container or it is being used for the containers which waiting for the customs clearance. The fourth CY is being used as containers that have been checked by the customs. TPKS has more than 11.000 TEU installed capacity in total. TPKS has 495 meters of berth that can be used for 2 feeder vessels at the same time with -10 meter draught at the pond. Besides that, TPKS has 2 Container Freight Station (CFS) that being used to stripping/ stuffing activities. The facilities and equipment of TPKS are described in Appendix 1.

3.3.12. Terminal Petikemas Surabaya (TPS) Profile

Surabaya Container Terminal or in Indonesian abbreviation called TPS, is the subsidiary company of Pelindo III which being incorporated with Dubai Port since 1999. TPS is located in area of Tanjung Perak Port which on the northern shore of eastern Java along the edge of Madura Strait. TPS is the gateway to Eastern Indonesia, serving international and domestic trade for a wide-ranging hinterland. The throughput of container in TPS is the highest among other business units of Pelindo III with 1.343.520 TEUs in 2014. The unique view that can found in TPS is the berth and container yard is connected by 2 kilometer bridge access, which meant to reach deep water for berthing the vessel. Not only as the gateway, TPS also hub port for many container terminals in eastern part of Indonesia. TPS is connected by railway and road access to several industrial parks in eastern and central Java Island. With the new dredging project in western channel, it will expect to welcoming new generation container vessels.

As the third biggest container terminal, TPS has modernize its facilities such as their harbor which being able to visited by vessels up to PANAMAX compatible with draft up to 11 meters. TPS is operating different berth for international and domestic container, equipped with 11 quay cranes and 15 RTG also 6 reachstackers. TPS is the 24/7 port service activity and also awarded as the best container terminal in 2008 by the International Ship Owners Association of Indonesia. The facilities and equipment of TPS are deployed in Appendix 1.

3.3.13. Berlian Jasa Terminal Indonesia (BJTI) Profile

PT Berlian Jasa Terminal Indonesia (PT BJTI) is a subsidiary of PT Pelabuhan Indonesia III (Persero), which 100% owned by Pelindo III. Since 2002, BJTI is entrusted to manage Berlian Terminal of Surabaya, Tanjung Perak Terminal for non-containerized commodity and a dedicated container terminal in Tenau since early 2012. As the port operator for a decade, PT BJTI has been widely believed by many Indonesian and foreign companies in the management of international container, container terminal domestic, dry bulk terminal, intermodal services, and a variety of other supporting services of loading and unloading. Establishment PT BJTI done through the process of separation of one business unit Pelindo 3 namely Multipurpose Terminal Business Division (DUTS) that focuses on services "Cargo and Container" in the conventional terminal. DUTS has been in operation since 1974.

In the last year, total of 1.158.947 TEUs is handled by BJTI which operating 3 terminals of container vessels with maximum draft of – 9.6 m LWS with 23 container cranes and several stacking equipment in their total of 43.300 m^2 container yard. Operating in fully 24 hours per day and 7 days per week, BJTI also provide the CFS facility for LCL container in their area. The facilities and equipment of TPS are depicted in Appendix 1.

3.3.14. Makassar Port Profile

The Hatta Quay of Ujung Pandang Port (recently renamed Makassar Port) is the biggest existing port in the eastern Indonesia which located in Makassar, the capital city of North Sulawesi and play important role as the hub for several minor ports in eastern part of Indonesia. The Port of Makassar is main branch of Pelindo IV. The port is split into two operating companies – Makassar port and the Makassar Container Terminal. The Makassar port company focuses on domestic cargo – which is substantially bulk cargo of fertilizer and cement and little amounts of container cargo. The Makassar Container Terminal is the main operator of all container traffic for international and domestic imports and exports.

Makassar Port had 5 berths in total, but because of the economy slowdown, only 4 berths being utilized. Superannuation of the facilities had also made it necessary to impose a cargo loading limit of only 1.5 tons per meter. Several facilities in the port risked collapse in the next few years unless corrective action was taken. The container throughput in this port is only 7.080 TEUs in 2014, most of container cargoes are going to Makassar Container Terminal and Bitung Port with better infrastructure and facility. For the future development this port will extend its area through reclamation in order to meet the future requirement of growth. The facilities and equipment of Makassar Port are shown in Appendix 1.

3.3.15. Unit Terminal Petikemas Makassar (UTPM) Port Profile

Makassar Container Terminal (MCT) is the unit business of Pelindo IV which dedicated to handle and serve container cargo. In the term of throughput and facility, MCT is the biggest in the eastern Indonesia with total throughput of 562.050 TEUs in 2014. The adequate infrastructure and facility in this port are 114.450 m2 of container yard with 11 RTG, 2 reach stacker and 1 side loader, meanwhile in the offshore, it supported by 1.000 meters quay that equipped by 5 container cranes. The terminal capacity will increased to be able to handle 1,200,000 TEUs in 2020.
The facilities and equipment of UTPM are shown in Appendix 1.

3.3.16. Bitung Container Terminal Profile

Bitung Container Port (BCT) is one of the largest in Sulawesi Island, which is supported by adequate infrastructure. This port is categorized as the first class branch of Pelindo IV. This port is being used as a gateway of necessary goods distribution, and thus it become the economy stimulator by improving trades for North Sulawesi people. In international trade, Bitung Port supports Tanjung Priok and other three international ports to distribute export and import commodities from/to North Sulawesi. Currently, the growing issue of Bitung Port is the status upgrade into international hub port. Once it’s upgraded, the port traffic would increase, especially from the export and import activities conducted by international vessels. As international hub, Bitung Port may able to conduct transshipment activities (including charges and discharges of containers and cargoes from other countries) and distribution of export commodities from Bitung Port directly to the North East Countries such as Philippines, China, Hongkong, Japan, South Korea, or even United States without passing Singapore or Malaysia (the current nearest hub ports). These shipping patterns could be more efficient than the current pattern, especially for north-east trades. Therefore, the upgrading would be positive for Indonesian. The facilities and equipment of BCT are deployed in Appendix 1.

4. DATA PROCESSING

4.1. Multiplier Effect Forecasting Result

4.1.1. Economic Development

Indonesia denoted as the largest economy in South Asia where industry as the largest contributor have share 46.5 percent of total Gross Domestic Product (GDP), its followed by services account for 38 percent Next GDP contributor rank is mining and quarrying constitute for 12 percent then agriculture hold the remaining 15 percent (Trading Economic, 2015). From 2000 to 2015, Indonesia GDP annual growth rate averaged 5.39 percent, the lowest margin noted of 1.56 percent in the fourth quarters of 2001 and the highest margins reach in the fourth quarter of 2004 around 7.16 percent (Trading Economics, 2015). Indonesia GDP annual growth rate are shown in the Figure 4.

Source : Trading Economic (2015)

Figure 4 Indonesia Annual Growth Rate

One substantial indicator to determine the economic conditions in a country in a given period is Gross Domestic Product (GDP), both at current prices and at constant prices (Indonesia, 2015). According to Indonesia, (2015), GDP is the amount of value added generated by all business units within a particular country, or the total value of final goods and services produced by the entire economic unit. GDP at current prices illustrates the added value of goods and services is calculated using prices prevailing at each year, while the GDP at constant prices shows the value-added goods and services calculated using prices prevailing in the base year.

Meanwhile, Gross Regional Domestic Product is an important indicator to specify the condition of the economy in certain region within a certain period, both at current prices and at constant prices (Department of Statistic, 2004). Basically, GRDP at current prices illustrates the added value of goods and services is calculated using the price in the current year, while the GRDP at constant prices indicate the value-added of goods and services calculated using prices prevailing in a given year as the base year. Furthermore, GRDP in current prices used to determine the ability of economic resources, shifts, and economic structure of a region. Meanwhile, GDP in constant use to determine economic growth in real terms from year to year or that economic growth is not influenced by price (Department of Statistic, 2004).

Since, container terminal ports are located in different province in Indonesia, the share of GRDP at constant price for each province are analyzed to obtain the economic development corresponds to the growth of container throughput volumes in each port. The share of GRDP and its Compound Annual Growth Rate (CAGR) for each province are presented in Table 10. The Compound Annual Growth Rate (CAGR) works as follows taking DKI Jakarta as an example:

$$CAGR = \left(\frac{Tt}{To}\right)^{1/t} - 1$$

$$CAGR = \left(\frac{477{,}285.25}{371{,}469.50}\right)^{1/4} - 1 = 6.47\%$$

Table 10 CAGR of GRDP in Constant Market Prices of 2000

No.	Province	GRDP in Thousand Billion Rupiahs		CAGR
		2,009	2013	
1	North Sumatra	111.56	142.54	6.32%
2	DKI Jakarta	371.47	477.29	6.47%
3	Lampung	36.26	46.12	6.20%
4	South Sumatra	60.45	76.41	6.03%
5	West Kalimantan	28.76	36.08	5.83%
6	West Sumatra	36.68	46.64	6.19%
7	Jambi	16.27	21.98	7.80%
8	East Java	320.86	419.43	6.93%
9	South Kalimantan	29.05	36.20	5.65%
10	Central Java	176.67	223.10	6.01%
11	South Sulawesi	47.33	64.28	7.96%
12	North Sulawesi	17.15	22.87	7.46%
Total Indonesia		2,094.36	2,661.07	6.17%

Source: Own calculation based on Indonesia (2015)

Having said before that there will be 18 container terminals to be analyzed and they are located in 12 different provinces around Indonesia as presented in Table 10 above. For CAGR assessment the period 2009 to 2013 are being used since the GRDP data only available to 2013 and the container throughput data provided from 2009. The highest growth rate reaches by South Sulawesi province, while the lowest perform by Central Java. Java Island is the greatest contributor for Indonesia GDP since there is so many manufactures there but it’s contrary for Central Java CAGR due to its tourism service potency as a heritage area.

Since GRDP data is not provided for 2014, thus forecasted CAGR GDP for Indonesia are utilized to generated CAGR GRDP for each province by extrapolate it. The forecasted CAGR based on OECD long-term forecast are deploying in Table 11.

Table 11 Forecasted GDP Growth Rates

No.	Year	Growth Rate
1	2014	5.70%
2	2015	6.26%
3	2016	5.90%
4	2017	5.80%
5	2018	5.78%
6	2019	5.75%
7	2020	5.72%
8	2021	5.66%
9	2022	5.59%
10	2023	5.51%
11	2024	5.42%
12	2025	5.33%
13	2026	5.22%
14	2027	5.11%
15	2028	5.00%
16	2029	4.89%
17	2030	4.78%

Source : Knoema (2013)

The GDP CAGR in 2013 is 5.9%, thus we can calculate the percentage of CAGR change for each year. The outcome of the CAGR percentage change is used to extrapolate the CAGR of GRDP for each province each year by analyze the GRDP CAGR of previous year. Thus, the CAGR GRDP forecasted can be obtained by taking into account CAGR GDP forecasted. The CAGR GRDP for DKI Jakarta as an example can be calculated as follows:

$$GDP\ CAGR\ 2013 = 5.9\%\ (based\ on\ data)$$
$$GDP\ CAGR\ 2014 = 5.7\%\ (forecasted\ by\ OECD)$$
$$Percentage\ change = \frac{(5.7\% - 5.9\%)}{5.9\%} = -3.45\%$$
$$GRDP\ 2012\ (billion\ rupiahs) = 449{,}805.4$$
$$GRDP\ 2013\ (billion\ rupiahs) = 477{,}285.2$$
$$CAGR\ DKI\ Jakarta\ 2013\ over\ 2012 = \left(\frac{477{,}285.2}{449{,}805.4}\right)^{1/1} - 1 = 6.11\%$$

Taking into account the GDP CAGR 2013 and GDP CAGR 2014 (forecasted):

$CAGR\ DKI\ Jakarta\ 2014\ over\ 2013 = 6.11\% + (6.11\%\ x\ (-3.45\%)) = 5.90\%$
$GDP\ CAGR\ 2014 = 5.7\%\ (forecasted\ by\ OECD)$
$GDP\ CAGR\ 2015 = 6.26\%\ (forecasted\ by\ OECD)$

$$Percentage\ change = \frac{(6.26\% - 5.7\%)}{5.7\%} = 9.82\%$$

Taking into account the GDP CAGR 2014 and GDP CAGR 2015 (forecasted):

$CAGR\ DKI\ Jakarta\ 2015\ over\ 2014 = 5.90\% + (5.90\%\ x\ (9.82\%)) = 6.48\%$
(Not given in Table 12)
Thus, GRDP CAGR can be calculated for each province and each year so that the CAGR average for given period can be obtained as presented in Table 12 below:

Table 12 CAGR of GRDP by Province in Target Period

No.	Province	CAGR Forecasted		
		2013 - 2020	2020 - 2025	2025-2030
1	North Sumatra	5.95%	5.60%	5.09%
2	DKI Jakarta	6.06%	5.69%	5.17%
3	Lampung	5.91%	5.56%	5.05%
4	South Sumatra	5.93%	5.58%	5.07%
5	West Kalimantan	6.03%	5.67%	5.15%
6	West Sumatra	6.12%	5.76%	5.23%
7	Jambi	7.81%	7.35%	6.67%
8	East Java	6.49%	6.10%	5.54%
9	South Kalimantan	5.14%	4.83%	4.39%
10	Central Java	5.76%	5.41%	4.92%
11	South Sulawesi	7.58%	7.13%	6.48%
12	North Sulawesi	7.38%	6.94%	6.31%
Total Indonesia		5.85%	5.50%	5.00%

Source: Own calculation

4.1.2. Container Throughput

Corresponding to the period of GRDP data, container throughput data also taking periods 2009 to 2014 for categories international trade both for export container and import container and domestic trade for load container and unload container. During the 4 years period, container throughput experienced to increase for various number of growth rate. The smallest container growth rate experienced by Jambi Port which have the growth rate less than 1%, while Makassar Port reach more than 27% growth rate as the highest growth rate but once should be denoted that the amount

of container throughput of this port perform the lowest value among 18 container port in Indonesia.
The second largest growth rate for more than 21% experienced by Tanjung Priok as the biggest port and the main gate of container trade in Indonesia, it's rising from 1.2 million TEUs in 2009 to 2.6 million TEU in 2013. By the value of container throughput, Tanjung Priok standing at the second rank after Jakarta International Container Terminal (JICT) which is always in the first rank during 2009 to 2013. As the remainder JICT is located near Tanjung Priok Port as the main gate port and positioned under the management of Pelindo II in collaboration with Hutchison Terminal Operator.
Container Terminal of Bitung (Bitung Container Terminal) starts to operate in 2010, here the throughput data provided only from 2011 to 2013. Thus, the container throughput in 2011 is 104,866 TEUs and the CAGR calculated by the data during 2011 and 2013. Throughput growth rate for each port can be deploying in Table 13.

Table 13 Container Throughput Growth Rate

No.	Port Name	Area	Province	Throughput (TEU/year)		CAGR
				2,009	2013	
1	Belawan Port	Pelindo I	North Sumatra	138,453	45,982	-24.09%
2	Container Terminal	Pelindo I	North Sumatra	580,210	900,395	11.61%
	Subtotal Pelindo I			***718,663***	***946,377***	***7.12%***
3	Tanjung Priok	Pelindo II	DKI Jakarta	1,219,789	2,617,147	21.03%
4	Panjang Port	Pelindo II	Lampung	104,175	124,165	4.49%
5	Palembang Port	Pelindo II	South Sumatra	84,403	122,155	9.68%
6	Pontianak Port	Pelindo II	West Kalimantan	133,419	201,527	10.86%
7	Teluk Bayur Port	Pelindo II	West Sumatra	47,633	68,701	9.59%
8	Jambi Port	Pelindo II	Jambi	24,033	24,678	0.66%
9	Jakarta International Container Terminal (JICT) - IPC - Hutchison	Pelindo II	DKI Jakarta	1,445,912	2,424,230	13.79%
10	KOJA (IPC-Hutchison)	Pelindo II	DKI Jakarta	620,172	851,885	8.26%
	Subtotal Pelindo II			***3,679,536***	***6,434,488***	***15.00%***
11	Tanjung Perak Port	Pelindo III	East Java	326,753	665,145	19.45%
12	Banjarmasin Port	Pelindo III	South Kalimantan	244,617	428,478	15.04%
13	Semarang Port (TPKS)	Pelindo III	Central Java	356,461	499,427	8.80%
14	Terminal Petikemas Surabaya Port (TPS)	Pelindo III	East Java	1,117,554	1,341,835	4.68%
15	Berlian Jasa Terminal Indonesia (BJTI)	Pelindo III	East Java	825,713	986,953	4.56%
	Subtotal Pelindo III			***2,871,098***	***3,921,838***	***8.11%***
16	Makassar Port	Pelindo IV	South Sulawesi	2,950	7,742	27.28%
17	Unit Terminal Petikemas Makassar Port (UTPM)	Pelindo IV	South Sulawesi	372,532	550,916	10.28%
18	Bitung Port (Container Terminal of Bitung)	Pelindo IV	North Sulawesi, Data start at 2011	104,866	144,959	17.57%
	Subtotal Pelindo IV			***480,348***	***703,617***	***10.01%***
	Total Pelindo I, II, III, IV			***7,749,645***	***12,006,320***	***11.57%***

Source: Own calculation based on Internal Report Pelindo I, II, III and IV

4.1.3. Container Elasticity and Relation between Container Throughput and GRDP

The coherence between container throughput growth rate and GDP growth rate called container elasticity or multiplier is the ratio of the CAGR or the container throughput (the total of international trade consist of exported, imported and related empty container also domestic trade encompasses loading and unloading) over the CAGR or GDP. Since each port located in different province, Growth Regional Domestic Product (GRDP) are exploited to quantify the multiplier effect due to its function as one of the indicator to express economic growth within the region i.e. province. Thus, container throughput can be forecasted by directly linked to the GRDP. P. W. de Langen, van Meijeren, & Tavasszy (2012) combine a forecast model by taking into account the expert judgment and allow to tackle nuisance of past growth trend, container multiplier taken to forecast container throughput in the Hamburg-Le Havre on the basis of the past two decades. The elasticity value considers being lower than the elasticity of the past which is shown in very high value due to the three reasons:

1. Container volume driven by the growth of intermediates goods which experience to be high due to the global sourcing around the world. While in the coming year intermediate flows influenced by industrial production which is considered to be adequate.
2. A temporary trend of imported consumer goods where essentially imported from low wage countries.
3. Perpetuated containerization in the deficient level over the past decade.

(P. W. de Langen et al., 2012)

Taking Tanjung Priok Port located in DKI Jakarta province as an example, the container elasticity can be quantified as follows:

$$DKI\ Jakarta\ GRDP\ CAGR\ 2009 - 2013 = 6.47\%$$
$$Tanjung\ Priok\ Container\ Throughput\ CAGR\ 2009 - 2013 = 21.03\%$$
$$Container\ Elasticity\ of\ Tanjung\ Priok\ Port\ 2009 - 2013 = \frac{21.03\%}{6.47\%} = 3.25$$

The resulting multiplier are deployed in Table 14.

Table 14 and it’s diverging from -3.81 to 3.43. Almost all values are greater than one except for 5 port namely Belawan Port, Panjang Port, Jambi Port, Terminal Petikemas Surabaya (TPS) Port and Berlian Jasa Terminal Indonesia (BJTI) port, in other word the growth of container throughput excessively higher than the growth of GRDP. TPS and BJTI located in the same province, East Java, which is have high growth rate and considered as one of the biggest contributor for Indonesia GDP. Growth of container volume both in BJTI and TPS less than the growth of GRDP of Surabaya since there is new container terminal under Tanjung Perak Port managed by Pelindo III namely Nilam Multipurpose which is makes the market share of container among container terminal in Surabaya less than before.

While Tanjung Perak Port with its new container terminal i.e. Nilam Multipurpose has the highest container elasticity, the corresponding container volume growth considerably more than 3 times higher than the East Java GRDP growth rate. Here, the market share of container trade in East Java considered to be split into 3 main container terminals.

Table 14 Container Elasticity for 18 Ports

No.	Port Name	Area	Province	CAGR GRDP (2009 - 2013)	CAGR Throughput (2009 - 2013)	Container Elasticity Values (2009 - 2013)	Container Elasticity Values (2013 - 2030)
1	Belawan Port	Pelindo I	North Sumatra	6.32%	-24.09%	(3.81)	1.09
2	Belawan International Container Terminal (BICT)	Pelindo I	North Sumatra	6.32%	11.61%	1.84	1.84
3	Tanjung Priok	Pelindo II	DKI Jakarta	6.47%	21.03%	3.25	1.81
4	Panjang Port	Pelindo II	Lampung	6.20%	4.49%	0.72	1.09
5	Palembang Port	Pelindo II	South Sumatra	6.03%	9.68%	1.61	1.61
6	Pontianak Port	Pelindo II	West Kalimantan	5.83%	10.86%	1.86	1.86
7	Teluk Bayur Port	Pelindo II	West Sumatra	6.19%	9.59%	1.55	1.55
8	Jambi Port	Pelindo II	Jambi	7.80%	0.66%	0.09	1.09
9	Jakarta International Container Terminal (JICT)	Pelindo II	DKI Jakarta	6.47%	13.79%	2.13	2.13
10	KOJA (IPC-Hutchison)	Pelindo II	DKI Jakarta	6.47%	8.26%	1.28	1.09
11	Tanjung Perak Port	Pelindo III	East Java	6.49%	19.45%	3.00	1.81
12	Banjarmasin Port	Pelindo III	South Kalimantan	5.65%	15.04%	2.66	1.81
13	Terminal Petikemas Semarang Port (TPKS)	Pelindo III	Central Java	6.01%	8.80%	1.46	1.46
14	Terminal Petikemas Surabaya Port (TPS)	Pelindo III	East Java	6.49%	4.68%	0.72	1.09
15	Berlian Jasa Terminal Indonesia (BJTI)	Pelindo III	East Java	6.49%	4.56%	0.70	1.09
16	Makassar Port	Pelindo IV	South Sulawesi	7.96%	27.28%	3.43	1.81
17	Unit Terminal Petikemas Makassar Port (UTPM)	Pelindo IV	South Sulawesi	7.96%	10.28%	1.29	1.09
18	Bitung Port (Container Terminal of Bitung)	Pelindo IV	North Sulawesi	7.46%	17.57%	2.35	1.81
	Average Container Elasticity					1.45	

Source: Own calculation

Table 15 Throughput and GRDP in 2009 and 2013

No.	Port Name	Area	Province	2,009		2,013	
				Throughput (TEU/year)	GRDP in Thousand Billion Rupiahs	Throughput (TEU/year)	GRDP in Thousand Billion Rupiahs
1	Belawan Port	Pelindo I	North Sumatra	138,453	111.56	45,982	142.54
2	Container Terminal	Pelindo I	North Sumatra	580,210	-	900,395	-
3	Tanjung Priok	Pelindo II	DKI Jakarta	1,219,789	371.47	2,617,147	477.29
4	Panjang Port	Pelindo II	Lampung	104,175	36.26	124,165	46.12
5	Palembang Port	Pelindo II	South Sumatra	84,403	60.45	122,155	76.41
6	Pontianak Port	Pelindo II	West Kalimantan	133,419	28.76	201,527	36.08
7	Teluk Bayur Port	Pelindo II	West Sumatra	47,633	36.68	68,701	46.64
8	Jambi Port	Pelindo II	Jambi	24,033	16.27	24,678	21.98
9	Jakarta International Container Terminal (JICT) - IPC - Hutchison	Pelindo II	DKI Jakarta	1,445,912	-	2,424,230	-
10	KOJA (IPC-Hutchison)	Pelindo II	DKI Jakarta	620,172	-	851,885	
11	Tanjung Perak Port	Pelindo III	East Java	326,753	320.86	665,145	419.43
12	Banjarmasin Port	Pelindo III	South Kalimantan	244,617	29.05	428,478	36.20
13	Semarang Port (TPKS)	Pelindo III	Central Java	356,461	176.67	499,427	223.10
14	Terminal Petikemas Surabaya Port (TPS)	Pelindo III	East Java	1,117,554	-	1,341,835	-
15	Berlian Jasa Terminal Indonesia (BJTI)	Pelindo III	East Java	825,713	-	986,953	-
16	Makassar Port	Pelindo IV	South Sulawesi	2,950	47.33	7,742	64.28
17	Unit Terminal Petikemas Makassar Port (UTPM)	Pelindo IV	South Sulawesi	372,532	-	550,916	-
18	Bitung Port (Container Terminal of Bitung)	Pelindo IV	North Sulawesi, Data start at 2011	104,866	17.15	144,959	22.87
	Total			***7,749,645***	***1,252.51***	***12,006,320***	***1,612.93***

Source : Own collaboration based on various sources

Container elasticity obtained from the average elasticity of each port is 1.45 while the elasticity gained from all ports taken together is 1.77, thus it considered to use the first elasticity. Utilizing the latter elasticity generates lower margin higher than the initial elasticity namely 1.33 instead of 1.09 respectively. Hence, using the latter elasticity with lower margin 1.33 will eliminate more elasticity value of each port replaced by this lower margin. Conversely, the first elasticity with lower margin 1.09 will accommodate more elasticity value so that the value replaced by lower margin is not too many.

By taking the similar method to calculate the container elasticity for 43 ports around Indonesia which have container traffic (both conventional and dedicated container terminal) are quantified. Thus, it's experienced that 15 ports perform low container elasticity and the smallest value calculated to be -9.3 occurred in Balikpapan Port managed by Pelindo IV, while the highest container elasticity is 18 reach by Lembar Port managed by Pelindo III. The average container elasticity around the 43 port in Indonesia is 1.85. Its indicate that the container elasticity of the port in Indonesia tend to be vary and there is no clear rising or reducing trend can be tracked. The elasticity of container port in Indonesia exploit in Table 16.

Given that the multiplier values indicated for all ports in Indonesia are considerably higher (only 17 ports over 43 ports show the value less than 1) which is mean that the corresponding container volume growth considerably higher than the growth rate of GRDP, it can be concluded that there is no excuse to assume that the elasticity of dedicated container terminals (18 ports that will be analyzed) lower than the past. The low and negative value for some ports lead by the other factors beyond the transportation sector such as education, politics, natural port location and its development potency of related province.

The average container elasticity around the 43 port produces higher elasticity value, viz. 1.85 than the elasticity assessed from 18 ports taken together, viz. 1.77. thus, indicate that the elasticity value become more varied with the increasing number of ports involved.

Furthermore, since the research does not studying into detail for each province, there is no scientific reason for unrealistic value of CAGR both for GRDP and throughput. Many disturbing effect behind the figure which will affect the forecasting method. To deal with this problem, a boundary are taken as upper and lower margin. Hence, for forecast the container elasticity value to 2030, the 25% margin as the lowest and highest volume are taken into account based on previous study and experience adjustment, its observed that the values lying between 25% minus (1.09) and 25% plus (1.81) from the average value of the period 2009 to 2013. The elasticity values for period 2013 to 2030 can presented in Table 14.

Table 16 Container Elasticity of Ports in Indonesia

No.	Port Name	Area	Container Elasticity
1	Belawan Port	Pelindo I	(3.81)
2	Belawan Container Terminal	Pelindo I	1.84
3	Tanjung Priok	Pelindo II	3.25
4	Panjang Port	Pelindo II	0.72
5	Palembang Port	Pelindo II	1.61
6	Pontianak Port	Pelindo II	1.86
7	Teluk Bayur Port	Pelindo II	1.55
8	Jambi Port	Pelindo II	0.09
9	Tanjung Perak Port	Pelindo III	3.00
10	Benoa Port	Pelindo III	(0.35)
11	Banjarmasin Port	Pelindo III	2.66
12	Kota Baru Port	Pelindo III	0.19
13	Kumai Port	Pelindo III	2.95
14	Sampit Port	Pelindo III	1.03
15	Tanjung Emas Port	Pelindo III	(8.87)
16	Kupang Port	Pelindo III	2.62
17	Lembar Port	Pelindo III	18.08
18	Maumere Port	Pelindo III	(1.99)
19	Terminal Petikemas Semarang Port	Pelindo III	1.46
20	Terminal Petikemas Surabaya Port	Pelindo III	0.68
21	Berlian Jasa Terminal Indonesia	Pelindo III	0.66
22	Makassar Port	Pelindo IV	3.43
23	Balikpapan Port	Pelindo IV	(9.26)
24	Samarinda Port	Pelindo IV	2.72
25	Bitung Port	Pelindo IV	(2.35)
26	Ambon Port	Pelindo IV	1.86
27	Sorong Port	Pelindo IV	0.42
29	Jayapura Port	Pelindo IV	(0.68)
30	Tarakan Port	Pelindo IV	0.59
31	Pantoloan Port	Pelindo IV	1.54
32	Ternate Port	Pelindo IV	2.54
33	Kendari Port	Pelindo IV	0.56
34	Biak Port	Pelindo IV	8.36
35	Manokwari Port	Pelindo IV	0.85
36	Merauke Port	Pelindo IV	11.76
37	Gorontalo Port	Pelindo IV	(0.12)
38	Fakfak Port	Pelindo IV	1.10
39	UTPM Port	Pelindo IV	1.29
40	Toli Toli Port	Pelindo IV	1.49
41	Tanjung Redeb Port	Pelindo IV	6.76
42	Nunukan Port	Pelindo IV	13.25
43	Bitung Port (Container Terminal of Bitung) start at 2010	Pelindo IV	2.35
Average			1.85

Source: Own calculation

4.1.4. Container Throughput Forecast

The container throughput projection can be evaluated based on the growth of future GRPD and container elasticity value. The projection will be executed for target years 2020, 2025 and 2030. Taking Tanjung Priok Port as an example, the throughput forecast works as follows:

$Throughput\ 2013 = \ 2{,}617{,}147\ \text{TEUs}$

$Container\ elasticity\ 2013 - 2030 = 1.81$

$CAGR\ GRDP\ 2013 - 2020 = 6.06\%$

$$t = 2020 - 2013 = 7$$

$$T_t = T_o\ x\ (1 + g)^t$$

$$Throughput\ 2020 = 2{,}616{,}147\ x\ \left(1 + (1.81\ x\ 6.06\%)\right)^7 = \ 5{,}430{,}272.12 \approx 5{,}430{,}272$$

$$CAGR\ GRDP\ 2020 - 2025 = 5.69\%$$

$$t = 2025 - 2020 = 5$$

$$Throughput\ 2025 = 5{,}430{,}272\ x\ \left(1 + (1.81\ x\ 5.69\%)\right)^5 = 8{,}878{,}848.38\ \approx 8{,}878{,}848$$

$$CAGR\ GRDP\ 2025 - 2030 = 5.17\%$$

$$Throughput\ 2030 = 8{,}878{,}848\ x\ \left(1 + (1.81\ x\ 5.17\%)\right)^5 = 13{,}907{,}735.36\ \approx 13{,}907{,}735$$

The calculation work the same way for others port and Table 17 show complete calculation for container throughput for target years 2020, 2025 and 2030.

Table 17 Forecasted Container Throughput

No.	Port Name	Area	Province	Throughput (TEUs)		Throughput Forecasted (TEUs)		
				2,009	2,013	2,020	2,025	2,030
1	Belawan Port	Pelindo I	North Sumatra	138,453	45,982	71,374	95,943	125,626
2	Belawan International Container Terminal (BICT)	Pelindo I	North Sumatra	580,210	900,395	1,862,501	3,039,016	4,751,263
3	Tanjung Priok Port	Pelindo II	DKI Jakarta	1,219,789	2,617,147	5,430,272	8,878,848.36	13,907,734.86
4	Panjang Port	Pelindo II	Lampung	104,175	124,165	192,174	257,826	336,993
5	Palembang Port	Pelindo II	South Sumatra	84,403	122,155	230,895	354,489	524,145
6	Pontianak Port	Pelindo II	West Kalimantan	133,419	201,527	424,310	700,670	1,107,517
7	Teluk Bayur Port	Pelindo II	West Sumatra	47,633	68,701	129,605	198,721	293,474
8	Jambi Port	Pelindo II	Jambi	24,033	24,678	43,703	64,211	91,196
9	Jakarta International Container Terminal (JICT)	Pelindo II	DKI Jakarta	1,445,912	2,424,230	5,672,867	10,061,062	16,979,576
10	KOJA (IPC-Hutchison)	Pelindo II	DKI Jakarta	620,172	851,885	1,332,031	1,799,442	2,366,812
11	Tanjung Perak Port	Pelindo III	East Java	326,753	665,145	1,449,803	2,450,777	3,957,866
12	Banjarmasin Port	Pelindo III	South Kalimantan	244,617	428,478	799,518	1,216,845	1,784,927
13	Terminal Petikemas Semarang Port (TPKS)	Pelindo III	Central Java	356,461	499,427	880,329	1,289,332	1,825,903
14	Terminal Petikemas Surabaya Port (TPS)	Pelindo III	East Java	1,117,554	1,341,835	2,163,810	2,984,471	4,000,738
15	Berlian Jasa Terminal Indonesia (BJTI)	Pelindo III	Jawa Timur	825,713	986,953	1,591,536	2,195,153	2,942,643
16	Makassar Port	Pelindo IV	South Sulawesi	2,950	7,742	19,082	35,052	61,094
17	Unit Terminal Petikemas Makassar Port (UTPM)	Pelindo IV	South Sulawesi	372,532	550,916	959,739	1,394,531	1,960,604
18	Bitung Port (Container Terminal of Bitung)	Pelindo IV	North Sulawesi	104,866	144,959	349,570	632,713	1,087,922
Total					12,006,320	23,603,119	37,649,104	58,106,035
Throughput CAGR						10.14%	9.79%	9.07%

Source: Own calculation

The total container throughput rising from 13 million TEUs in 2013 to 23 million TEUs in 2020 and the corresponding growth rate reach 10.14%. The corresponding growth rate for target year 2025 and 2030 are 9.79% and 9.07% respectively. Thus, it's analyzed that container throughput growth rate experienced to decrease but it still related to the average past growth rate for period 2009 – 2013 which have value 11.58%.

4.2. DEA Result for Initial Condition

Having explained above that "*DEA techniques are non-parametric mathematical programming techniques for deriving the specification of the frontier model*" (Talley, 2006, 512). It enables the use of multiple inputs and multiple outputs in accordance with port production characteristics. Thus, multiple indicators accommodate overall evaluation of port performance. The research focus on input and output of the technical aspect and the number of DMUs should not be less than twice the number of input and output due to homogeneity of the result (Mokhtar, 2013). Hence, Mokhtar (2013) develop DEA using relatively new input which are terminal area, draft, berth length, quay crane index, yard stacking index, vehicle and number of gate lanes and exploit throughput as an output.

Table 18 Input and Output Variable Definition

Input Variables	**Description**	**Unit**
Container yard area	One of the port facility at which containers are accommodated for load and unload from onboard ships to the consignee	1,000 m^2
Maximum draft	Maximum draft in the terminal dedicated for container ship berthing.	Meter
Berth length	Total quay length in the terminal dedicated for container ship berthing	Meter
Quay crane index	Number of sea to shore crane (e.g. CC, QC, HMC, GLC, mobile crane or gantry jib crane) times lifting capability index. $\sum(number\ of\ crane\ x\ lifting\ capability\ index)$ Lifting capability index (in TEU) measured as follows : Conventional 20ft = 1, Twin 20ft = 2, Tandem 40ft = 2 Two tandems = 4, Triple 40ft = 6	TEUs
Yard stacking index	Number of yard staking crane (e.g. RTG, RMGC, reachstacker, side loader, top loader or forklift) times ground storage capacity times stacking height $(\sum crane)\ x\ ground\ storage\ capacity\ x\ stack\ height$ Ground storage capacity defined as container yard capacity divided by container yard area	TEUs/ 1000 m^2
Truck and vehicle	Number of internal truck and other supporting vehicle	Number
Gate lanes	Number of gate lanes at the terminal gate dedicated for container	Number
Output Variables		
Throughput	Total number of container (expressed in TEU) loaded and unloaded in a port in a year period. Its the sum of import, export and container transhipment.	1,000 TEUs

Source : Own elaboration based on various source

Taking into account that port production factor which consist of land, labor and capital, thus seven inputs and one output are defined consist of container yard area, maximum draft, berth length, quay crane index, yard stacking index, vehicle, number of gate lanes and throughput as an output. The definition of each input and output defined in Table 18. By examine indices, the handling variation and knowledge are observed for the divergence of technological performance for instance quay crane and yard staking index.

4.2.1. Data for Measuring Container Terminal Efficiency

The data utilized for input and output in the DEA shown in Table 19 respectively, thus the cross section data from Pelindo 1, 2, 3 and 4 in the year of 2014 will be exploited for bring out the result in DEA model. The detail of the data will presented in the Appendix 3.

Since each port have the different amount of container yard and berth respectively for container, thus container yard area and berth length presented in Table 19 show the sum of container yard in each port and the sum of berth for container vessel berthing. As mentioned before that quay crane index measured by considered the amount of sea to shore crane and the lifting capability index.

Table 19 Data Input and Output for DEA

No.	Port Name	Container Yard (CY) (1000 M^2) (CY)	Maximum Draft (M) (MD)	Berth Length (M) (BL)	Quay Crane (Index) (QC)	Yard Stacking Index (YS)	Trucks and Vehicle (V)	Gate Lanes (GL)	Throughput (in thousand) (T)
1	Belawan Port	80.29	7	675	5	1,918.09	0	2	45.98
2	Belawan International Container Terminal (BICT) Port	214.71	11	950	13	17,300.69	61	8	900.40
3	Tanjung Priok Port	796.12	12	1030	88	20,288.72	0	4	2,463.91
4	Panjang Port	75.00	16	401	7	5,113.17	13	2	107.55
5	Palembang Port	57.36	9	266	7	8,773.82	14	2	137.69
6	Pontianak Port	47.79	6	295	4	8,637.70	18	4	227.13
7	Teluk Bayur Port	62.25	12	222	5	3,487.95	14	2	66.94
8	Jambi Port	14.69	9	302	2	11,361.78	6	2	29.38
9	Jakarta International Container Terminal (JICT) - IPC - Hutchison	547.40	14	2150	38	29,155.28	139	13	2,373.47
10	KOJA (IPC-Hutchison)	218.00	13	650	14	9,480.95	48	6	872.51
11	Tanjung Perak Port	34.88	8	320	9	3,573.39	17	2	601.92
12	Banjarmasin Port	81.13	7	505	6	5,573.56	25	4	413.74
13	Terminal Petikemas Semarang (TPKS) Port	187.17	10	495	10	9,534.96	44	4	575.67
14	Terminal Petikemas Surabaya (TPS) Port	397.00	10.5	1000	22	23,726.20	87	13	1,343.52
15	Berlian Jasa Terminal Indonesia (BJTI)	43.30	9.6	1420	23	29,840.51	127	5	1,158.95
16	Makassar Port	60.04	13	1200	3	1,169.26	1	2	7.08
17	Unit Terminal Petikemas Makassar (UTPM) Port	114.45	12	1000	5	8,697.55	30	2	562.05
18	Bitung Container Terminal (BCT)	33.00	11	365	3	17,166.90	11	2	200.15

Source : Own modification based on various source

The quay crane index and yard staking index can be calculated as follows, taking Belawan International Container Terminal (BICT) as an example :

- Sea to shore crane for BICT consist of eleven container crane (CC) and two harbour mobile crane (HMC).
- Lifting capability index for CC is 1 since it categorized as conventional 20ft, its similar for HMC.
- $\sum(number\ of\ crane\ x\ lifting\ capability\ index)$
- $Quay\ crane\ index = (11\ x\ 1) + (2\ x\ 1) = 13$
- Yard staking crane for BICT consist of twenty five (25) transtrainer mc, seven (7) reach staker, three (3) side loader, six (6) forklift.
- $Number\ of\ yard\ staking\ crane = 25 + 7 + 3 + 6 = 41$
- Container yard capacity consist of 8,600 TEUs for international and 6,500 TEUs for domestic, thus the sum of container yard capacity is 15,100 TEUs.

- Stacking height in container yard vary from 4 tier to 6 tier. For input data, the maximum staking height are taken, in this case 6 tier are assumed since the number of container yard for 4 tier less than those 6 tier.
- Container yard area in 1,000 m^2 is 214.71.
- $Ground\ storage\ capacity = \frac{container\ yard\ capacity\ (TEUs)}{container\ yard\ area\ (1{,}000\ m^2)}$
- $Ground\ storage\ capacity = \frac{15{,}100\ TEUs}{214.71\ (in\ 1{,}000\ m^2)} = 70.33\ TEUs/1{,}000\ m^2$
- $Yard\ stacking\ index = yard\ stacking\ crane\ x ground\ storage\ cap. x stack\ height$

$$Yard\ stacking\ index = 41\ x\ 70.33\ TEUs/1{,}000\ m^2\ x\ 6 = 17{,}300.69\ TEUs/1{,}000 m^2$$

As an output, throughput are taken since it indicates the productivity of the port by quantified the tonnage or number of containers handled by a port in a year and has been widely used to evaluate port performance (Talley, 2006). Each input and output will be abbreviated as follows container yard area (CY), maximum draft (MD), berth length (BL), quay crane index (QC), yard stacking index (YS), truck and vehicle (V), gate lanes (GL) and throughput (T).

Stata Program utilized to process data port and generate port performance. The DEA model used here are the basic ones namely Constant Return to Scale (CRS) with input oriented since it will be observed investment related to the input. The LP in STATA solve *n* times which is run for every time for every DMU by the program, thus it exploit two (2) stage model since it provides optimas solution.

Table 20 depict the descriptive statistics of the data which presente the maximum, minimum, average and standard deviation of input and output. The maximum and minimum of CY are 796.1 (1,000 m^2) and 14.61 (1,000 m^2) respectively. The average and standard deviation of CY are 170.3 (1,000 m^2) and 209.6 (1,000 m^2) respectively. Maximum and minimum quay crane index are 88 and 2 respectively with the average and standard deviation 14.67 and 20.47. As for output, the maximum and minimum T (thousand) TEUs at 2,464 and 7.075 respectively with average and standard deviation at 671.6 and 752.1. The descriptive statistics performs the variety in outcome since the container terminals in Indonesia are distinct in size, equipment and throughput. In addition, correlation between input variables measure the strength and direction of linear relationship among variables as deploy in Table 21. The lowest correlation at weak correlate (0.1829) yet positive is between MD and YS. The highest correlation are 0.9167 and 0.9097 between CY and QC, also CY and T. All variables are accepted since there are no negative correlation. Furthermore, almost all input variables have a strong positive correlation to the outputs since the value in the range of 0.6 to 1, except for MD which show weak positive correlation.

Table 20 Descriptive Statistic on Input and Output Data

VARIABLES	(1) N	(2) mean	(3) Sd	(4) min	(5) max
CY	18	170.3	209.6	14.69	796.1
MD	18	10.56	2.643	6	16
BL	18	735.9	506.9	222	2,150
QC	18	14.67	20.47	2	88
YS	18	11,933	8,977	1,169	29,841
V	18	36.39	42.01	0	139
GL	18	4.389	3.567	2	13
T	18	671.6	752.1	7.075	2,464

Source: Own calculation

Table 21 Correlation Between Input Variables

	CY	MD	BL	QC	YS	V	GL	T
CY	1.0000							
MD	0.3516	1.0000						
BL	0.5652	0.3929	1.0000					
QC	0.9167	0.2552	0.4857	1.0000				
YS	0.5584	0.1829	0.6682	0.5602	1.0000			
V	0.3105	0.1935	0.7391	0.2222	0.8006	1.0000		
GL	0.5964	0.2008	0.6578	0.3612	0.7126	0.7986	1.0000	
T	0.9097	0.2909	0.7235	0.8796	0.7658	0.6040	0.6960	1.0000

Source: Own calculation

4.2.2. DEA Result

Having measured 18 container terminals within the area of Pelindo, the DEA observe only 7 terminals have achieve the efficiency scores equals to 1 and its spread among pelindo II, III and IV. From 6 container terminals categorized as effiecient terminal, 1 of them are conventional container terminal but as a main class i.e. Makassar Port and the least are dedicated container terminal namely Tanjung Priok, JICT, Tanjung Perak, TPS, BJTI and UTPM. Bear in mind that technical efficient called when the throughput perform the maximum value against certain levels of resources (Talley, 2006). Thus, the given input are completely exploited since it could reach the maximum value of the efficiency score. Having said in the literature review that efficiency of the DMUs can be categorized as strong (i.e. absolutely efficient) if all slacks are likely to be zero, less efficient for some slacks or weak (i.e. inefficient) (Sharma & Yu, 2009). DEA result on Stata are performed in Appendix 4.

By the Table 22, it can be observed that in year 2014, 2 of 8 container terminals within the area of Pelindo II, 2 of 5 container terminals within the area of Pelindo III and 2 of 3 within the area of Pelindo IV consider as the efficient container since it utilize certain levels of resource expressed by the input to generate maximum output expressed by the output. Combining the data based on Table 22 and Table 24, it can be said that the absolute efficient container terminal namely Tanjung Priok Port, JICT, Tanjung Perak Port, TPS, BJTI and UTPM since the efficiency score are 1 and all slacks are likely to be zero. While Makassar port consider as less efficient due to some slacks on the input eventhough the efficiency score equal to 1. By the Table 22 Makassar could be categorized as an absolute efficient by taking Tanjung Perak Port as the peers or benchmark. Tanjung Perak Port define as the relevant part of the frontier to the Makassar Port and hence assigned as efficient production for Makassar Port. According to Kopman definition, Makassar port does not represent the efficient score since it can decrease the use of input (i.e. called slack) and still produce the same output. The targets of Makassar Port as DMU 16 would therefore be to reduce the usage of all the inputs by 1.175% and substracting the input by 59.628 unit of CY, 12.906 unit of MD, 1196.24 unit of BL, 2.88 unit of QC, 1127.26 unit of YS, 0.800 unit of V and 1.976 unit of G (deploy in Table 24) to reach the efficient frontier.

Table 22 shown that Belawan Port only utilized 32.85% of its a given input, all input could be reduced by 67.15%. In addition, Table 24 shown that the performance of Belawan Port by substracting 5 input namely 11.514 units of CY, 2.075 units of MD, 202.485 units of BL, 251.375 units of YS and 0.582 units of GL. Those 5 inputs could be reduced even after Belawan Port has reduced all inputs by 67.15%. Table 23 presented that the efficient production as a peer of Belawan Port is DMU 3 namely Tanjung Priok Port by linear combination where the weigth is 1.87%. BICT as a part of Belawan Port but under different management and has declared as dedicated container terminal show relative high performance but not so efficient since its efficiency score less than 1. BICT should reduce its inputs consumption by 3.41% to be efficient and substracting 4 inputs withouth worsening any other input and output. Table 24 describe that BICT should be substract 49.024 units of CY, 6524.870 units of YS, 14.945 units of V and 3.765 units of GL in order to be more efficient. The efficient point of BICT lies on a line joining DMU 9 (JICT), DMU 11 (Tanjung Perak Port) and DMU 17 (UTPM) with a linear combination weight 17.94%, 41.61% and 39.87%, hence JICT, Tanjung Perak Port and UTPM define as efficient production of BICT.

Pelindo II have 7 dedicated container terminals, 2 of it classified as efficient container terminal but 5 of them characterized as inefficient since its have very low efficiency score. Panjang Port and Palembang Port have efficiency score less than 30%, it means that they have to discharge of all input for more than 70% to reach efficiency frontier.The details can be deploy in Table 24, Panjang Port should be diminish 5 inputs namely for CY for 10.964 units, MD for 2.289 units, BL for 35.939 units, YS for 545.976 units and GL for 0.108 units in order to be more efficient. Similar case for Palembang Port where they have to degrade 5 inputs namely 8.225 units of CY, 0.763 units of MD, 1704.66 units of YS, 0.102 units of V and 0.124 units of GL. In addition, the inputs mentioned above could be substract even after Panjang Port and Palembang Port has degrades all inputs by more than 70%. By the Table 23, its known that Tanjung Priok and Tanjung Perak Port as the peers of Panjang Port while Palembang Port lies on Tanjung Perak Port and UTPM as its peers. Thus, they define as the efficient production for Panjang and Palembang Port. Pontianak Port shows better performance than the previous ones, it utilized the inputs for 73.31%. Meaning that it has to drop all the inputs by 26.69% outright with substracting CY, MD, BL, YS, V and GL by some unit where shown in Table 24. The peers for Pontianak Port are Tanjung Perak Port and UTPM with linear combination 25.61% and 13.62%. The efficiency performance of Teluk Bayur and Jambi Port even worse than Panjang and Palembang Port, less than 20% and have to diminish all the inputs for more than 80% in order to reach the efficiency frontier. Table 24 presented the slack of the input, its indicated that the value of inputs consumption in units that has to be substracted to reach the efficient performance. Thus, Teluk Bayur and Jambi Port has similar inputs that should be reduced namely for CY, MD, BL, YS, V and GL. They also have the same efficient production which is Tanjung Perak Port and UTPM but different linear combination, Teluk Bayur Port lies on the linear combinations' weight 10.15% and 1.03%, while Jambi Port on 3.55% and 1.43%.

Furthermore, Pelindo III have 4 dedicated container terminals where two of them deemed as efficient terminal (i.e. TPS and BJTI) and its remaining categorized as inefficient terminal (i.e. Banjarmasin Port and TPKS). In addition, Tanjung Perak Port as a main class port in Pelindo III yet defined as conventional container terminal even achieve efficient performance. It was not surprising that Banjarmasin Port have efficiency score less than 1 since its just operated in 2008. Its need to reduce all the input to be efficient by 11.5% simultaneously substracting 11.199 units of CY, 5.7E-05 units of BL, 467.495 units of YS, 4.079 units of V and 1.959 units of GL. DMU 9 (JICT), DMU 11 (Tanjung Perak Port) and DMU 17 (UTPM) defined as efficient production of Banjarmasin Port which is lies on linear combination by the weight 3.31%, 29.38% and 28.18%. Semarang Container Terminal (TPKS) fully managed independly since 2001, therefore it was surprising that its efficiency score only reach 81.66% less than Banjarmasin Port who experience shorter than TPKS. Further, its has to degrade all the usage of its input by 18.34% together by substracting particular input by certain amount as shown in Table 24. CY as one of the inputs should be degrade by 106.45 units, YS by 3575.72 units, V by 17.417 units and GL by 1.310 units in order for TPKS to reach the effiency score equal to 1. Three efficient port observed as peer where the efficient production of TPKS lies namely on JICT, Tanjung Perak Port and UTPM with the weight in this linear combination are 0.51%, 81.15% and 13.35%.

Pelindo IV have 2 dedicated container terminals and its have different performance, for UTPM characterized as efficient terminal while BCT categorized as inefficient terminal since its has efficiency score 79.48%. BCT has to lower the consumption of all the inputs by 20.52% to be defined as efficient terminal. Moreover, 5 inputs should be substracted namely for MD by 5.237 units, BL by 58.404 units, YS by 11498.6 units, V by 0.566 units and GL by 0.9 units. Tanjung Perak and UTPM is the peer for BCT since BCT will reach efficient frontier on a line joining points of Tanjung Perak and UPTM.

Table 22 DEA Efficiency Scores 2014

No.	DMU Container Terminal	Area	Efficiency Score
1	Belawan Port	Pelindo I	0.3285
2	Belawan International Container Terminal (BICT)	Pelindo I	0.9659
3	Tanjung Priok Port	Pelindo II	1.0000
4	Panjang Port	Pelindo II	0.2320
5	Palembang Port	Pelindo II	0.2912
6	Pontianak Port	Pelindo II	0.7331
7	Teluk Bayur Port	Pelindo II	0.1931
8	Jambi Port	Pelindo II	0.1954
9	Jakarta International Container Terminal (JICT) - IPC - Hutchison	Pelindo II	1.0000
10	KOJA (IPC-Hutchison)	Pelindo II	0.9029
11	Tanjung Perak Port	Pelindo III	1.0000
12	Banjarmasin Port	Pelindo III	0.8850
13	Terminal Petikemas Semarang (TPKS)	Pelindo III	0.8166
14	Terminal Petikemas Surabaya (TPS)	Pelindo III	1.0000
15	Berlian Jasa Terminal Indonesia (BJTI)	Pelindo III	1.0000
16	Makassar Port	Pelindo IV	1.0000
17	Unit Terminal Petikemas Makassar (UTPM)	Pelindo IV	1.0000
18	Bitung Container Terminal (BCT)	Pelindo IV	0.7948

Source : Own calculation

Table 23 Reference Peers of Targeted DMU

No.	DMU Container Terminal	Reference (λ)																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Belawan Port	.	.	0.01866	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.
2	Container Terminal (BICT)	.	.	.	.	.	.	.	.	0.179431	.	0.41609	.	.	.	.	.	0.398667	.
3	Tanjung Priok Port	.	.	1	.	.	.	.	.	0	.	.	.	.	0	.	.	.	.
4	Panjang Port	.	.	0.00031	.	.	.	.	.	.	.	0.1774	.	.	.	.	.	.	.
5	Palembang Port	.	.	.	.	.	.	.	.	.	.	0.22309	.	.	.	.	.	0.0060592	.
6	Pontianak Port	.	.	.	.	.	.	.	.	.	.	0.25015	.	.	.	.	.	0.13622	.
7	Teluk Bayur Port	.	.	.	.	.	.	.	.	.	.	0.10152	.	.	.	.	.	0.0103865	.
8	Jambi Port	.	.	.	.	.	.	.	.	.	.	0.03549	.	.	.	.	.	0.0142672	.
9	Container Terminal (JICT) - IPC - Hutchison	.	.	0	.	.	.	.	.	1	.	.	.	.	0	.	.	.	.
10	KOJA (IPC-Hutchison)	.	.	.	.	.	.	.	.	0.0280746	.	1.20824	.	.	.	.	.	0.139878	.
11	Tanjung Perak Port	.	.	0	.	.	.	.	.	0	.	1	.	.	.	0	.	.	.
12	Banjarmasin Port	.	.	.	.	.	.	.	.	0.0330759	.	0.2938	.	.	.	.	.	0.281807	.
13	Terminal Petikemas Semarang (TPKS)	.	.	.	.	.	.	.	.	0.0051272	.	0.81152	.	.	.	.	.	0.13351	.
14	Terminal Petikemas Surabaya (TPS)	.	.	0	.	.	.	.	.	0	.	0	.	.	1	.	.	.	.
15	Berlian Jasa Terminal Indonesia (BJTI)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
16	Makassar Port	.	.	.	.	.	.	.	.	.	.	0.01175	.	.	.	.	.	.	.
17	Unit Terminal Petikemas Makassar (UTPM)	.	.	0	.	.	.	.	.	.	.	0	.	.	.	.	.	1	.
18	Bitung Container Terminal (BCT)	.	.	.	.	.	.	.	.	.	.	0.16567	.	.	.	.	.	0.178695	.

Source : Own calculation

The "." in table expressed small numbers less than 10 to the minus 12 power, which mostly can be ignored.

Table 24 DEA Input and Output Slack

No.	DMU	Input Slack							Output Slack
	Container Terminal	CY	MD	BL	QC	YS	V	GL	T
4	Panjang Port	10.9644	2.28888	35.9391	.	545.976	.	0.10793	.
5	Palembang Port	8.22501	0.76298	.	.	1704.66	0.1019	0.12402	.
6	Pontianak Port	10.7232	0.76283	8.79E-06	.	4253.72	4.85685	2.1597	.
7	Teluk Bayur Port	7.29189	1.38062	1.59E-06	.	220.484	0.66625	0.16243	.
8	Jambi Port	1.75E-07	1.30313	33.3755	.	1968.73	0.14086	0.29121	.
9	Container Terminal (JICT) - IPC - Hutchison	0	.	.	.	0	0	0	.
10	KOJA (IPC-Hutchison)	123.309	.	.	.	2207.58	14.6997	2.35611	.
11	Tanjung Perak Port	.	.	.	0	.	0	0	.
12	Banjarmasin Port	11.1994	.	5.7E-05	.	467.495	4.07919	1.95889	.
13	Terminal Petikemas Semarang (TPKS)	106.45	.	.	.	3575.72	17.4168	1.3097	.
14	Terminal Petikemas Surabaya (TPS)	.	.	.	.	0	0	0	.
15	Berlian Jasa Terminal Indonesia (BJTI)	.	0	0	0	1.09E-11	0	0	.
16	Makassar Port	59.628	12.906	1196.24	2.89421	1127.26	0.80018	1.97649	.
17	Unit Terminal Petikemas Makassar (UTPM)	0	0	0	.	0	.	.	.
18	Bitung Container Terminal (BCT)	.	5.27345	58.4045	.	11498.6	0.56593	0.90093	.

Source : Own calculation

4.3. Terminal Capacity Analysis

Container terminal capacity is the minimum of four sub capacities, namely berth capacity, yard storage capacity, yard handling capacity and gate capacity. Rule of thumb of asset utilization in container terminal is that always optimize the most expensive resource or asset means that the biggest utilization should be around the most expensive asset in the terminal. The most expensive asset in the terminal is quay wall, obviously the biggest utilization is in the berth. Thus, berth capacity is the most important factor since its always be the bottleneck. Other important sub system in container terminal is yard storage capacity as a buffer resource to support container handling system since storage function is one of the container terminal role which is allow to organized sea leg and hinterleg (decoupled) (Saanen & Rijsenbrij, 2015). According to Saanen & Rijsenbrij (2015), berth capacity, yard storage capacity, yard handling capacity and gate capacity is the limiting factor, where the in many terminal yard storage capacity being the majority of the limiting factor. Nevertheless, in others terminal quay capacity or the quay crane capacity is the limiting factor. Eventually, the gate or rail capacity could also be the limiting factor for the next terminal expansion but this is the rare case. In this research, berth capacity as the most important factor and yard capacity as the majority of the limiting factor are undertaken to analyze the supply side by a given demand analyzed before.

4.3.1. Berth Capacity

Berth capacity or quay capacity is the maximum volume handled (over vessels and its exchange size) for berthing for the customer, i.e. in this case in vessels, without raising unacceptable waiting time (Saanen, 2015). Rule of thumb for the berth capacity is that deepsea vessels have to waith for berthing time less than 2% of the overall time quantified more than 8 hours. Hence, the bigger the container terminal, the higher volume per meter berth length (Saanen, 2015). Berth capacity is hard to define since it depend on many variable such as vessels type, the exchange size per ship call, the number of operational quay crane per berth, the quay crane productivity and natur condition sunc as tide, weather or local constraint (Saanen & Rijsenbrij, 2015).

According to the Saanen & Rijsenbrij (2015), quay capacity is quay length times quay capacity per meter of quay wall. Hence, the berth productivity can be calculated by the quation below:

$$call\ size\ (moves)\ = \frac{ships\ size\ (TEU)}{teu\ factor} x\ load\ factor\ (\%) x\ port\ market\ share\ (\%)$$

Equation 14

$$Berth\ capacity\ \left({TEU}/{m\ length}\right) = call\ size\ (moves) x\ BOR\ x\ Teu\ Ratio$$

Equation 15

$$Berth\ capacity\ \left({TEU}/{year}\right) = berth\ length\ (m) x\ berth\ capacity\ (\frac{TEU}{m\ quay\ lenght})$$

Equation 16

Based on best practice, container market dominated by domestic trade except for big container terminal such as Tanjung Priok, JICT, Koja and TPS where the average LOA for vessel container is 200m and the capacity is 1,000 TEU. As stated by Nur & Achmadi (2014), for domestic trade, container vessel size varies greatly from 80 TEUs to 1,360 TEUs and the average for ship size is 490 TEUs. Domestic container vessels most widely operated has a size of 350-500 TEUs with the number of ships to 78 units (37%), size of 500 to 800 TEUs container ships totaling 56 units (26%), while the largest size container ships with large or more than 1,000 TEUs 19 units (9%) in total (Nur & Achmadi, 2014). For ocean going vessel, the biggest container vessel ever handled by JICT is 4000 TEU. In addition, the trends in vessel size due to the economic of scale is increasing vessel size to the new generation count for 14,000 to 22,000 TEUs called Ultra Larger Container Ship (ULCS), the change in vessel generation deploy in Table 25 as follows.

Table 25 Draft and LOA by Vessel Size

Generation	Draft (m)	LOA (m)	Capacity (TEU)
First	< 9m	135 - 200	500 - 800
Second	< 10 m	< 210 Max 215	1,000 - 2,500
Third	11 - 12	250 - 290	3,000 - 4,000
Fourth	11 - 13	<300 Max 335	4,000 - 5,000
Fifth	13 - 14	275 - 305	5,000 - 8,000
Sixth	15.5	397	11,000 - 14,500
Seventh	< 16.5	<405	14,000 - 22,000

Source : Jahiddin (2010)

By taking into account the draft of each terminal and consider the fact that the biggest domestic vessels size in Indonesia is 1,360 TEUs and also the information via each terminal website which is rare provided, thus the average vessel size theoritically in each container terminal can be predicted in Table 26. The average LOA is 175 m not far from the best practice statement that the average LOA in Indonesia is 200m. JICT, KOJA and Tanjung Priok located in the capital city Jakarta, as the biggest container port in Indonesia handled the biggest vessel size since its ability to cover the minimum requirement for the draft and handling system of big vessel, while Makassar Port handle the smallest ship on average since its role begin to replace by UTPM which is dedicated container teminal. Second biggest container port such as Tanjung Perak Port, BICT, TPS, TPKS, UTPM and BCT handled vessel on the range size between 1,000 and 1,750 TEU. Other small container terminal handled small vessels less than 1,000 TEU as their main market is domestic container trade. According to Bottema (2015), teu ratio for AsiaEurope tipically 1.65, hence teu ratio for Indonesia assume to be 1.6 since Indonesia is not completely fabrication country such as India and China eventhough some assembly industry located in Indonesia but several part still imported from other country. Furthermore, by many imported goods in Indonesia, it categorized Indonesia also as consumable country where its require light cargo and more volume.

Table 26 Average Vessel Size by Container Terminal

No.	Port Name	Draft (M)	Average Ship Size (TEU)	Average LOA (m)
1	Belawan Port	-5 to -7	550	149
2	Belawan International Container Terminal (BICT) Port	-10 to -11	1750	151
3	Tanjung Priok Port	-10 to -12	2500	208
4	Panjang Port	-7 to -16	600	36
5	Palembang Port	-6 to -9	775	194
6	Pontianak Port	-6	500	135
7	Teluk Bayur Port	-10 to -12	300	208
8	Jambi Port	-6 to -9	775	194
9	Jakarta International Container Terminal (JICT) - IPC - Hutchison	-8.6 to -14	3000	300
10	KOJA (IPC-Hutchison)	-13	3000	300
11	Tanjung Perak Port	-8	750	188
12	Banjarmasin Port	-7	600	162
13	Terminal Petikemas Semarang (TPKS) Port	-10	1000	215
14	Terminal Petikemas Surabaya (TPS) Port	-7.5 to -10.5	1625	137
15	Berlian Jasa Terminal Indonesia (BJTI)	-6.5 - 9.6	970	204
16	Makassar Port	-11 to -13	200	17
17	Unit Terminal Petikemas Makassar (UTPM) Port	-9 to -12	1200	97
18	Bitung Container Terminal (BCT)	-11	1360	250
Average LOA				**175**

Source : Own estimation based on various sources

Currently, it is widely accepted that the nominal figure of vessel utilization around 90 to 95% statisticly but for small size vessels its a bit lower around 80% to 85% (Bottema, 2015). By this fact, Indonesia classify to have load factor on a range 80% to 85% and to be more precise the load factor divided based on throughput range (TEU) as can be depicted in Table 27, so as the load factor for each container terminal can be determined by reconcile the throughput in 2014 to the throughput range as can be shown in Table 28. Obviously that big container terminal have the highest load factor namely 85% since they handled big vessel which utilize better than small vessel.

Table 27 Load Factor Based On Throughput Range

No	Throughput Range (TEU)	Load Factor (%)
1	< 50,000	80
2	50,000 - 100,000	80.5
3	100,000 - 150,000	81
4	150,000 - 250,000	81.5
5	250,000 - 350,000	82
6	350,000 - 500,000	82.5
7	500,000 - 650.000	83
8	650,000 - 800,000	83.5
9	800,000 - 950,000	84
10	950,000 - 1,050,000	84.5
11	> 1,050,000	85

Source : Own estimation based on Bottema (2015)

As Indonesia, the biggest archipelagos country, where the ocean cover 70% from total area, the hinterland of the container trade in Indonesia majorily in Java Island as the most developed island in Indonesia. Taking island as the hinterland considered too widely since Indonesia's infrastructure is not too good, simultaneously transported container via road will only raising the logistic cost. The shipper should fine the most closely port to the consignee to cut the logistic cost, thus its require to narrowing down the hinterland to be each province. Suppose that the hinterland is South Kalimantan, there are three container terminal located there, one of it is dedicated container terminal namely Banjarmasin Port while two of them is conventional container terminal namely Kotabaru Port and Samarinda Port. The port market share should be devided through these three container terminals since there are three gate entrance to penetrate the market in South Kalimantan. Taking into account the container throughput from 2009 to 2013 and considered South Kalimantan as the total market share, it can be calculated the average port market share for each port. The calculation of port market share can be depicted in Table 29. For the province with only one port meaning there only one gate entrance and the port market share considered to be 100%.

Table 28 Load Factor by Container Terminal

No.	Port Name	Throughput (TEUs) (2014)	Load Factor (%)
1	Belawan Port	45,982	80
2	Belawan International Container Terminal (BICT) Port	900,395	84
3	Tanjung Priok Port	2,463,908	85
4	Panjang Port	107,546	81
5	Palembang Port	137,685	81
6	Pontianak Port	227,130	81.5
7	Teluk Bayur Port	66,942	80.5
8	Jambi Port	29,379	80
9	Jakarta International Container Terminal (JICT) - IPC - Hutchison	2,373,470	85
10	KOJA (IPC-Hutchison)	872,511	84
11	Tanjung Perak Port	601,915	83
12	Banjarmasin Port	413,737	82.5
13	Terminal Petikemas Semarang (TPKS) Port	575,671	83
14	Terminal Petikemas Surabaya (TPS) Port	1,343,523	85
15	Berlian Jasa Terminal Indonesia (BJTI)	1,158,947	85
16	Makassar Port	7,075	80
17	Unit Terminal Petikemas Makassar (UTPM) Port	562,046	83
18	Bitung Container Terminal (BCT)	200,153	81.5
Load Factor Range			**80 - 85**

Source : Own modification based on Bottema (2015)

Table 29 Port Market Shares by Province

Province	Port Name	Throughput (TEUs)										Average Port Market Share (%)
		2,009	(%)	2,010	(%)	2,011	(%)	2,012	(%)	2,013	(%)	
North Sumatra	Belawan Port	138,453	19	1,111,398	62	1,277,709	63	1,304,237	61	45,982	5	5
	BICT	580,210	81	690,059	38	739,292	37	835,388	39	900,395	95	95
	Kuala Tanjung Port							643	0.04	3,085	0.17	
	Total	***718,663***		***1,801,457***		***2,017,001***		***2,140,268***		***949,462***		
West Sumatra	Teluk Bayur Port	47,633	100	49,434	100	56,716	100	61,808	100	68,701	100	100
	Total	***47,633***		***49,434***		***56,716***		***61,808***		***68,701***		
South Sumatra	Palembang Port	84,403	100	87,988	100	113,616	100	114,479	100	122,155	100	100
	Total	***84,403***		***87,988***		***113,616***		***114,479***		***122,155***		
Jakarta	Tanjung Priok Port	535,247	19	1,762,912	33	2,228,112	36	2,955,733	42	2,617,147	39	34
	JICT	1,721,059	60	2,095,010	39	2,295,264	37	2,346,898	34	2,424,230	36	41
	KOJA	620,172	22	753,984	14	823,730	13	820,730	12	851,885	13	15
	Sunda Kelapa Port		-	14,121	0.26	30,734	0.50	38,947	0.56	42,063	0.62	0.39
	MTI		-	753,984	14	823,730	13	820,730	12	851,885	13	10
	Total	***2,876,478***		***5,380,011***		***6,201,571***		***6,983,037***		***6,787,211***		
Lampung	Panjang Port	104,175	100	99,851	100	106,644	100	107,724	100	124,165	100	100
	Total	***104,175***		***99,851***		***106,644***		***107,724***		***124,165***		
West Kalimantan	Pontianak Port	133,419	100	150,114	100	172,892	100	184,557	100	201,527	100	100
	Total	***133,419***		***150,114***		***172,892***		***184,557***		***201,527***		
Jambi	Jambi Port	24,033	100	32,551	100	32,516	100	23,607	100	24,678	100	100
	Total	***24,033***		***32,551***		***32,516***		***23,607***		***24,678***		
South Kalimantan	Banjarmasin Port	244,617	59	296,611	63	367,704	65	421,561	65	428,478	63	63
	Kotabaru Port	9,420	2	9,413	2	13,273	2	27,060	4	9,839	1	2
	Samarinda Port	159,349	39	166,212	35	188,861	33	199,864	31	244,885	36	35
	Total	***413,386***		***472,236***		***569,838***		***648,485***		***683,202***		
East Java	Tanjung Perak Port	326,753	14	365,446	15	569,968	22	611,438	21	665,145	22	19
	Terminal Petikemas Surabaya Port	1,117,554	49	1,212,494	50	1,260,240	48	1,340,262	47	1,341,835	45	48
	Berlian Jasa Terminal	825,713	36	829,549	34	792,958	30	912,791	32	986,953	33	33
	Total	***2,270,020***		***2,407,489***		***2,623,166***		***2,864,491***		***2,993,933***		
Central Java	Terminal Petikemas Semarang Port	356,461	100	384,522	100	427,468	100	457,055	100	499,427	100	100
	Total	***356,461***		***384,522***		***427,468***		***457,055***		***499,427***		
South Sulawesi	Makassar Port	2,950	0.79	4,824	1.08	5,397	1.18	6,367	1.19	7,742	1.39	1
	UTPM	372,532	99.2	442,553	98.92	450,567	98.82	529,396	98.81	550,916	98.61	99
	Total	***375,482***		***447,377***		***455,964***		***535,763***		***558,658***		
North Sulawesi	Bitung Container Terminal					104,866	56	127,178	57	144,959	68	60
	Bitung Port	148,754	100	166,298	100	82,537	44	95,125	43	68,884	32	64
	Total	***148,754***		***166,298***		***187,403***		***222,303***		***213,843***		

Source : Own calculation

Knowning all the driving factors, berth capacity can be calculated using Equation 14 and Equation 16. The berth capacity taking Tanjung Priok Port as an example as follows:

$$call\ size\ (moves) = \frac{2{,}500\ (TEU)}{1.6} x\ 85\%\ x\ 34\% = 894\ moves$$

BOR is berth occupancy ratio, how much the berth utilized presented by percentage. In fact, many terminal maintain the berth occupancy ratio below 60 – 65% in order as a safety margin for early and/ or lately vessels arrivals (Saanen & Rijsenbrij, 2015). To calculate berth capacity, BOR set to be 60%.

$$Berth\ capacity\ \left({}^{TEU}/_{m\ length}\right) = 894\ moves\ x\ 60\%\ x\ 1.6 = 857.77\ {}^{TEU}/_{m\ length}$$

$$Berth\ capacity\ \left({}^{TEU}/_{year}\right) = 1{,}030\ m\ x\ 857.77\ {}^{TEU}/_{m} = 883{,}507\ {}^{TEU}/_{year}$$

Calculation for all container terminals can be deploy in Table 30, in comparison to throughput in 2014 there are ten container terminals indicated to reach its maximum berth capacity namely for Tanjung Priok Port, Pontianak Port, Teluk Bayur Port, KOJA, Tanjung Perak Port, Banjarmasin Port, TPS, TPKS, BJTI and Makassar Port. While the rest still have sufficient capacity to support terminal volume as the demand. The condition whera the maximum capacity has been passed by the demand adduce the bottleneck condition. Congestion often occur in this circumstances adding on vessel waiting time before berthing, consequently add for more cost for total logistic.

Table 30 Berth Capacity

No.	Port Name	Average Ship Size (TEU)	Load Factor (%)	Port Market Share (%)	Call Size (Moves)	Berth Capacity (TEU/ m Quay)	Berth Length (M)	Berth Capacity (TEU/ Year)	Throughput (TEUs) (2014)
1	Belawan Port	550	80	5	28	26	675	17,820	45,982
2	Belawan International Container Terminal (BICT) Port	1,750	84	95	1,746	1,676	950	1,592,010	900,395
3	Tanjung Priok Port	2,500	85	34	894	858	1,030	883,507	2,463,908
4	Panjang Port	600	81	100	608	583	401	233,863	107,546
5	Palembang Port	775	81	100	785	753	266	200,378	137,685
6	Pontianak Port	500	81.5	100	509	489	295	144,255	227,130
7	Teluk Bayur Port	300	80.5	100	302	290	222	64,336	66,942
8	Jambi Port	775	80	100	775	744	302	224,688	29,379
9	Jakarta International Container Terminal (JICT) - IPC - Hutchison	3,000	85	41	1,308	1,255	2,150	2,698,837	2,373,470
10	KOJA (IPC-Hutchison)	3,000	84	15	461	442	650	287,614	872,511
11	Tanjung Perak Port	750	83	19	148	142	320	45,353	601,915
12	Banjarmasin Port	600	82.5	63	389	373	505	188,522	413,737
13	Terminal Petikemas Semarang (TPKS)	1,000	83	100	1,038	996	495	493,020	575,671
14	Terminal Petikemas Surabaya (TPS)	1,625	85	48	826	793	1,000	793,095	1,343,523
15	Berlian Jasa Terminal Indonesia (BJTI)	970	85	33	342	328	1,420	466,138	1,158,947
16	Makassar Port	200	80	1	2	2	1,200	2,591	7,075
17	Unit Terminal Petikemas Makassar (UTPM) Port	1,200	83	99	1,231	1,182	1,000	1,181,762	562,046
18	Bitung Container Terminal (BCT)	1,360	81.5	60	836	802	365	292,832	200,153

Source : Own calculation

By the Table 30, it shown that Tanjung Perak indicated as the most utilized port lead to the congestion condition as the throughput has exceeded more than 4 times of its berth capacity. Second rank is Tanjung Priok, the demand count almost 3 times of its supply. BJTI has outreach its capacity for more than twice its demand (throughput), then TPS over its capacity around 1.5 times to its demand.

4.3.2. Yard Capacity

Yard capacity is terminal volume supported by yard where in many terminal, this is the limiting factor. Saanen (2015, 47) said that *"yard capacity is measured as the number of yard (TEU) visits that the yard can handle"*. Yard storage capacity dependend variable to the footprint of the yard (NCY), stacking system (stacking height and maximum utilisation), dwell time, transhipment factor (ratio), peaking factor and surge (separation) factor (Saanen, 2015). Yard capacity determined by the following calculation :

$$Yard\ capacity\ (TEU/year) = \frac{TGS\ x\ Max.stack\ height\ x\ Max.utilisation\ x\ days\ period}{Separation\ factor\ x\ Peaking\ factor\ x\ Average\ dwell\ time}$$

Equation 17

In the Appendix 3, its already depicted container yard capacity (TEU) where in the Equation 17 its reflected by $(TGS\ x\ Max.stacking\ height)$. Yard maximum utilisation typically 60% - 80% in peak (Saanen, 2015). Based on expert experience the average utilisation in Indonesia is 70% and still on the range of typically utilisation.

Peak factor is the outcome of seasonal fluctuation and the throughput divergence of the week. In several cases, it also comprise a justification for the peaking condition in dwell time, as the value over the year is not constant, and concure with the seasonal peak (Saanen & Rijsenbrij, 2015). Typically value for peak factor are on the range 1.2 and 1.5 (Saanen & Rijsenbrij, 2015), thus it takes 1.2 as the value for the next calculation since Indonesia only have peak season when the Eid Mubarrak as the feast of Moslem which is most religion in Indonesia.

Other peaking measure also observe in the during vessels handling. Generally, the first couple hours vessel incline to unload, consequently raising the yard occupancy. This is called as surge and reflected as surge factor, particularly the value is 1.05, which is mean that extra peaking over the average peak is 5% (Saanen & Rijsenbrij, 2015).

Dwell time is the time container stay in container yard from the first day its storage until it leave the terminal through vessel, road, rail or barge (Saanen, 2015). Y. Saanen (2015, 63) said that *"long stay containers can skew the measured dwell times since they remain in the yard and are therefore not counted until they leave"*. Dwell time in Indonesia very long since there are several ministry involve regarding the container. Particularly in Indonesia, customs and clearance takes too longer and other relevan ministry does not maximize to utilize the one-stop system provided by the port. According to Artakusuma (2012), dwelling time in JICT counted 6.74 days, KOJA is 5.5 days and Multi Terminal Indonesia (MTI) is 8.23 hari. In addition, by the information through maritime news Belawan also have long dwelling time, its counter 7 to 10 days. Hence, it is assume that the average dwell time is around 6 to 7 days. Yard capacity can be calculated by Equation 17, taking Tanjung Priok as an example :

$$Yard\ capacity\ (TEU/year) = \frac{30{,}476\ TEU\ x\ 70\%\ x\ 365}{1.05\ x\ 1.2\ x\ 7} = 882{,}837\ \ TEU/year$$

Complete calculation for each container terminal depicted in Table 31 in comparison with throughput as demand in the year of 2014. Yard capacity is throughput capacity supported by the yard, thus there are 11 port categorized as over capacity namely for BICT, Tanjung Priok Port, Pontianak Port, JICT, KOJA, Tanjung Perak Port, Banjarmasin Port, TPKS, TPS, BJTI and UTPM. Whereas the rest categorized as port with sufficient capacity to support terminal volume as the demand. As being said before that this bottleneck condition drive congestion which is lower the performance of the terminal. Tanjung Perak and BJTI within the management of Pelindo III have the highest ratio between supply and demand, the demand counted more than 4 times than its supply. Its indicate that both port have to expand the capacity to deal with the demand covered. Moreover, Tanjung Priok throughput counted more than twice its yard capacity while the rest less than twice.

Table 31 Yard Capacity

No.	Port Name	Throughput Capacity (TGS x Stacking Height)	Dwell Time (Days)	Yard Capacity (TEU/ Year)	Throughput (TEUs) (2014)
1	Belawan Port	3,500	6	118,287	45,982
2	Belawan International Container Terminal (BICT) Port	15,100	6	510,324	900,395
3	Tanjung Priok Port	30,476	7	882,837	2,463,908
4	Panjang Port	6,848	6	231,437	107,546
5	Palembang Port	4,376	6	147,893	137,685
6	Pontianak Port	3,753	6	126,838	227,130
7	Teluk Bayur Port	4,825	6	163,067	66,942
8	Jambi Port	1,855	6	62,692	29,379
9	Jakarta International Container Terminal (JICT) - IPC - Hutchison	46,940	7	1,359,770	2,373,470
10	KOJA (IPC-Hutchison)	18,454	7	534,580	872,511
11	Tanjung Perak Port	3,895	6	131,637	601,915
12	Banjarmasin Port	6,460	6	218,324	413,737
13	Terminal Petikemas Semarang (TPKS) Port	10,816	6	365,541	575,671
14	Terminal Petikemas Surabaya (TPS) Port	34,252	6	1,157,591	1,343,523
15	Berlian Jasa Terminal Indonesia (BJTI)	7,426	6	250,971	1,158,947
16	Makassar Port	2,925	6	98,854	7,075
17	Unit Terminal Petikemas Makassar (UTPM) Port	9,480	6	320,389	562,046
18	Bitung Container Terminal (BCT)	12,875	6	435,133	200,153

Source : Own calculation

5. Comparison Container Port Capacity and Throughput

Table 22 reports the efficiency measurement of the 18 container terminals in Indonesia where six of them are categorised as absolute efficient container terminals namely Tanjung Priok Port, JICT, Tanjung Perak Port, TPS, BJTI and UTPM since their efficiency score is 1 and all slacks are likely to be zero. In addition, the efficient container terminals utilise certain levels of resources expressed by the input to generate a maximum output.

The efficiency performance of Tanjung Priok Port and JICT are possibly driven by regional economic activities. These ports play an important role as the economic gateways of many industrial parks located around the capital city of Jakarta. They also play a role as transshipment hubs for many smaller feeder ports in Indonesia. In addition, these ports also serve for international trade that simultaneously produces larger throughput than other container terminals which account for 23% and 26% of total Indonesian throughput respectively. In other words, the utilisation of resources generate a maximum output and thus make Tanjung Priok and JICT efficient container terminals.

Tanjung Perak Port (second biggest port in Indonesia), TPS (third biggest container terminal) and BJTI are all located in Surabaya, the second biggest city in Indonesia. They serve both international and domestic container trade. TPS is not only a gateway but also serves as a hub port for many container terminals in the eastern part of Indonesia. TPS is connected by railway and road access to several industrial parks in Eastern and Central Java Island. Hence, it also generates higher throughput than other container terminals and it is considered to be a port with maximum output.

UTPM is the Eastern Indonesian gateway and in terms of throughput and facility, it is considered to be the biggest container terminal in Eastern Indonesia that has an adequate infrastructure and the necessary facilities. Based on these facts, UTPM is likely to generate the maximum output. Because all the efficient container terminals reach maximum output, we can deduce that throughput market share is the determinant of container terminals performance. Furthermore, 4 out of 6 container terminals serve as peers or production frontiers for inefficient container terminals, viz. Tanjung Priok, JICT, Tanjung Perak and UTPM. While Makassar port is considered to be less efficient due to some slacks on the input side even though the efficiency score equal to 1.

The efficiency scores of other container terminals is ranging from a low score of 0.1931 (19%) to the maximum score of 1 (100%). Teluk Bayur Port and Jambi Port are recorded as the most inefficient container terminals. Based on the study of Sari (2014), Teluk Bayur port and Jambi port are consideredto be inefficient container terminals since their scores are only 31.23% and 56.91% respectively. The differences on the score value are mainly due to the different input and output in DEA Analysis. The efficiency performance of Teluk Bayur and Jambi Port is less than 20% and has to diminish all the inputs by more than 80% in order to reach the efficiency frontier. Table 24 presents the slack of the inputs; it is indicated that the value of inputs of consumption in units that has to be subtracted to reach the efficient performance. Moreover, higher efficiency scores are achieved by Panjang Port and Palembang Port though still less than 30%. This means that they have to discharge all input for more than 70% to reach the efficiency frontier. Pontianak Port has a better performance than the ports we analysed above as it utilised the inputs for 73.31%. This means that it has to drop all the inputs by 26.69% outright. Panjang Port is the gateway for Lampung province. As a feeder of giant vessels scheduled for Singapore where two ships around 180 – 200 LOA commonly berth together it runs the risk of excess capacity. On a day when the berth is unutilized this is especially the case. While Palembang port is a gateway for South Sumatra province, it is categorised as a river port and serves smaller ships than Panjang Port. These five ports are within the management of Pelindo II.

Belawan Port almost similar to Panjang Port and Palembang Port which only utilised 32.85% of its given input. BICT is a part of Belawan Port but under different management and has declared itself a dedicated container terminal that shows relatively high performance but is not so efficient since its efficiency score is less than 1. BICT should reduce its input consumption by 3.41% to be efficient and subtract 4 inputs without worsening any other input and output. Belawan Port container throughput dramatically fell in the year 2013. This possibly happened due to the operation of the Belawan International Container Terminal (BICT) in 2009. Container cargo has begun to shift to BICT and by the year 2013 more than 96% of the throughput moved to BICT.

Furthermore, Pelindo III has 2 dedicated container terminals categorised as inefficient terminals (i.e. Banjarmasin Port and TPKS). It was not surprising that Banjarmasin Port has an efficiency score less than 1 since it just operated in 2008. It needs to reduce all the inputs by 11.5% to be efficient; i.e. to reach efficient frontier. Semarang Container Terminal (TPKS) has been managed independently since 2001. That is why it was surprising that its efficiency score only reached 81.66%, less than Banjarmasin Port which had much less experience than TPKS. Bitung Container Terminal (BCT) within the management of Pelindo IV is categorised as an inefficient terminal since it has an efficiency score of 79.48%. Banjarmasin Port, TPKS and BCT mainly serve domestic trade as a feeder for three international ports and distributed the cargo to each province.

In addition, subtracting inputs is difficult to do in practice since the inputs are the resources of the container terminals and they are considered as fixed assets. Moreover, DEA analysis highlights the fact that there is excess input for inefficient container terminals. However, excess resources could be an indication that the container terminals have sufficient resources or infrastructure, making it possible to optimise to capture future cargo. In other words, the efficiency performance of the terminal potentially increases in the future. Efficiency performance of the terminal could also be enhanced through increasing container throughput by means of improving operating systems to capture potential container market share.

In comparison with the West Africa Study by Ecorys (2015) which also measures the performance of 13 container terminals using cross-sectional analysis, Indonesia performed differently since the efficiency scores in the year of 2013 ranged from 60% to 100%. The West Africa study selected almost the same inputs and identical outputs. The difference is that the input was only in the terminal area instead of in the container yard area in this study. In comparison with Indonesia, West Africa shows better performance for container terminal efficiency since the lowest score reached 60% while Indonesia has only a container terminal efficiency score of 19%. But one thing should be taken into account – the most efficient container terminal in

Indonesia reaches 7 terminals while in West Africa this is only 1. Thus, West Africa still performs better in terms of technical efficiency performance which on average reaches 84% while Indonesia reaches only 74%.

Table 32 dan Table 33 present the available capacity over current demand in container terminals in Indonesia.

Table 32 Ratio Demand and Berth Capacity

No.	Port Name	Berth Capacity (TEU/ Year)	Throughput (TEU/ Year) (2014)	Ratio Demand and Capacity (%)
1	Belawan Port	17,820	45,982	258
2	Belawan International Container Terminal (BICT) Port	1,592,010	900,395	57
3	Tanjung Priok Port	883,507	2,463,908	279
4	Panjang Port	233,863	107,546	46
5	Palembang Port	200,378	137,685	69
6	Pontianak Port	144,255	227,130	157
7	Teluk Bayur Port	64,336	66,942	104
8	Jambi Port	224,688	29,379	13
9	Jakarta International Container Terminal (JICT) - IPC - Hutchison	2,698,837	2,373,470	88
10	KOJA (IPC-Hutchison)	287,614	872,511	303
11	Tanjung Perak Port	45,353	601,915	1327
12	Banjarmasin Port	188,522	413,737	219
13	Terminal Petikemas Semarang (TPKS)	493,020	575,671	117
14	Terminal Petikemas Surabaya (TPS)	793,095	1,343,523	169
15	Berlian Jasa Terminal Indonesia (BJTI)	466,138	1,158,947	249
16	Makassar Port	2,591	7,075	273
17	Unit Terminal Petikemas Makassar (UTPM) Port	1,181,762	562,046	48
18	Bitung Container Terminal (BCT)	292,832	200,153	68

Source : Own calculation

Table 33 Ratio Demand and Yard Capacity

No.	Port Name	Yard Capacity (TEU/ Year)	Throughput (TEUs) (2014)	Ratio Demand and Capacity (%)
1	Belawan Port	118,287	45,982	39
2	Belawan International Container Terminal (BICT) Port	510,324	900,395	176
3	Tanjung Priok Port	882,837	2,463,908	279
4	Panjang Port	231,437	107,546	46
5	Palembang Port	147,893	137,685	93
6	Pontianak Port	126,838	227,130	179
7	Teluk Bayur Port	163,067	66,942	41
8	Jambi Port	62,692	29,379	47
9	Jakarta International Container Terminal (JICT) - IPC - Hutchison	1,359,770	2,373,470	175
10	KOJA (IPC-Hutchison)	534,580	872,511	163
11	Tanjung Perak Port	131,637	601,915	457
12	Banjarmasin Port	218,324	413,737	190
13	Terminal Petikemas Semarang (TPKS) Port	365,541	575,671	157
14	Terminal Petikemas Surabaya (TPS) Port	1,157,591	1,343,523	116
15	Berlian Jasa Terminal Indonesia (BJTI)	250,971	1,158,947	462
16	Makassar Port	98,854	7,075	7
17	Unit Terminal Petikemas Makassar (UTPM) Port	320,389	562,046	175
18	Bitung Container Terminal (BCT)	435,133	200,153	46

Source: Own calculation

In general, the capacity calculated, can be categorised as less precise due to the lack of data but overall it is acceptable because its value is close to the typical number of the variable related theoretically. Appendix 5 shows the estimation of overall current capacity against the current demand; in this case the throughput for 2014. Currently, 80% capacity utilisation is the used benchmark level of capacity in container ports, which is more than the percentage of port congestion impeding the container service. 100% utilisation or even above is not impossible, but one should take into account that 20% margin should be available since various operational overage commonly occur such as early or ship delays, peak factors, seasonality and so on. Moreover, since shipping lines require reliability and stability of container line schedule, the 20% spare should be provided by the container terminal to bear with early or delay and other operational factors, particularly for interlining and feedering container market such as in Indonesia. Appendix 5 shows that 12 out of 18 container terminals show more than 80% ratio of current demand and capacity with respect to berth capacity. This is extremely high (sometimes even more than 100%). Tanjung Perak Port for instance has reached more than 1200%. Belawan Port, Tanjung Priok Port, TPS, KOJA, BJTI and Makassar Port have reached more than 200%.

The ratio of demand and capacity shows extraordinary values in excesss of 100% for many ports. This outcome could possibly occur because of the assumption during the capacity calculation. In fact, when calculating the figure, some factors needed to be taken into account such as the oversupply cases. The excess of 100% reflects the situation where there are also other berths which can be used for the same vessels. It means that in the berth capacity calculation, berth lenght imprecisely corresponds to that extra berth space. The vessel coming to the official berth but if it is full it goes to other berth called multipurpose berth. This is the case while in the calculation the reserve capacity is not taken into account. For instance, berth capacity of Tanjung Perak Port is 45 thousand TEU/year while the throughput is 600 thousand TEU/year. This implies a utilisation level of more than 1.200%. It possibly occurs because domestic containers are often handled in Mirah Terminal which has a berth length of 640m. In this case, the reserve capacity in Mirah Terminal does not take into account the capacity calculation because its not a dedicated container terminal. Similar conditions apply to the Tanjung Priok Port where containers are handled in Terminal 2 and 3. It also handled in Terminal 1 as the reserve capacity.

The result shows that bottlenecks have occurred in major container terminals in Indonesia, and thus port congestion becomes a serious issue since the berth are fully utilised and it requires reserve capacity from other terminals. The ratio of current demand and capacity are depicted in Appendix 5.

In the term of yard capacity, we show that 11 out of 18 container terminals have reached the ratio of more than 80%. Even though the value is not as high as the capacity before, still congestion has become a serious issue. As the earlier issue, Tanjung Perak Port remains to have the highest ratio of all the container terminals in Indonesia, there is a strong indication that currently intense congestion is a vital bottleneck that occurs in Tanjung Perak, both by the berth capacity and yard capacity. Other container terminals, namely Tanjung Priok Port and BJTI, have a demand and supply ratio of more than 200%, while BICT, Pontianak Port, Banjarmasin Port and TPKS count for more than 100%. Longer dwelling time for most container terminals in Indonesia is believed to be the main driver for capacity shortage since containers stay longer in the yard and lead to high Yard Occupancy Ratios (YOR) in most container terminals in Indonesia.

The Indonesian Ministry of Transportation has enacted new local regulation through Ministerial Decree No. KPT.807/2014 that the maximum YOR is 65%, but in fact it's more. For instance JICT has YOR 77% and it's even worse for KOJA, the latter shows a YOR of 92%. Longer dwelling time in Indonesia possibly occurs because there are 18 ministries involved in container trade. It goes without saying that the ministry has to team up to cut the dwelling time; they have to be able to maximize the function of one-stop systems provided by Pelindo management. Currently, these 18 ministries do not use well the one-stop service caused inefficiency since the owner of the container has to come to each ministry office to manage the document.

Similar to the previous ratio, it shows extraordinary value in excess of 100% for many ports, the outcome possibly occur because of the assumption during the capacity calculation. Dwelling time is the main factor for yard capacity calculation, thus the assumption of dwelling time is around 6 to 7 days. Since this research does not go into detail as to the initial design of the container yard, the excess of 100% reflects the situation where the initial design of the container yard is possibly using shorter dwelling time. It means that in the yard capacity calculation, dwelling time assumption imprecisely corresponds to that of the initial design.

Additionally, in West Africa where the highest ratio is around 95% in Tema Port, the ratio of many ports in the region range from 80% to- 90%. Thus, the situation with West African Ports is similar to that in Indonesia, both being developing countries which mainly serve interlining and feedering container market. By this fact, capacity is still within the benchmark of container-port saturation, namely 80%, and port congestion will become a serious problem in the next several years if West Africa cannot improve the supply side.

Table 34 Summarize of Related Investment

No.	Container Terminal	Indicated Year		Related Investment
		Berth Capacity	Yard Capacity	
1	Belawan Port	2013	2030	Investment can be neglected since the development focus on car terminal
2	Belawan International Container Terminal (BICT) Port	2018	2009	Yard capacity as investment priority but its require deeply analysis since Pelindo I develop Kuala Tanjung Port as container terminal
3	Tanjung Priok Port	2009	2009	Severe congestion but its require deeply consideration since Pelindo II develop NewPriok Terminal
4	Panjang Port	2023	2023	No bottleneck issue
5	Palembang Port	2018	2014	Priority investment mainly on yard capacity
6	Pontianak Port	2011	2009	Hardly congestion, thus investment should be tackled immediately
7	Teluk Bayur Port	2013	2023	Improvement priority on berth capacity
8	Jambi Port	≈	2026	No investment related capacity in the near future
9	Jakarta International Container Terminal (JICT) - IPC - Hutchison	2015	2009	Bottleneck in yard capacity but its require deeply consideration since Pelindo II develop NewPriok Terminal
10	KOJA (IPC-Hutchison)	2009	2009	Severe congestion but its require deeply consideration since Pelindo II develop NewPriok Terminal
11	Tanjung Perak Port	2009	2009	Severe congestion but its require deeply consideration since Pelindo III has operated Teluk Lamong Container Terminal and develop JIIPE Project
12	Banjarmasin Port	2009	2009	Indicated bottleneck both in yard and berth but tackled by several project mainly on CY expansion and berth extension
13	Terminal Petikemas Semarang (TPKS) Port	2014	2010	Bottleneck in yard capacity and TPKS has take investment step by expand the CY. Berth also indicate to begin to be bottleneck and its need more attention
14	Terminal Petikemas Surabaya (TPS) Port	2009	2011	Severe congestion but its require deeply consideration since Pelindo III has operated Teluk Lamong Container Terminal and develop JIIPE Project
15	Berlian Jasa Terminal Indonesia (BJTI)	2013	2009	Severe congestion but its require deeply consideration since Pelindo III has operated Teluk Lamong Container Terminal and develop JIIPE Project
16	Makassar Port	2009	≈	Can be neglected since the throughput too small
17	Unit Terminal Petikemas Makassar (UTPM) Port	2023	2009	Bottleneck indicated to occur in yard from the start it was operated. Investment should prior to yard
18	Bitung Container Terminal (BCT)	2018	2022	No investment related capacity in the near future

Source : Own calculation

To be clear, the related investment and the time for it are summarised in Table 34. Investment related berth capacity can be coped with by capacity management programmes and/ or capacity planning. Capacity management programmes improve the berth capacity by means of using several optimisation strategies such as terminal optimisation, planning strategies, operation processes, enhance labor productivity and equipment upgrade in this case is sea to shore upgrade to increase the productivity of the equipment (Ecorys, 2015). Furthermore, capacity management to improve yard capacity can also be done by reducing dwelling times, thus coordination with all the stakeholders such as all the ministry related to the port will facilitate the administration of the container and finally cut dwelling times. Container terminals can also enact additional charges to the consignee for container storage per day stay since the major case of the longer dwelling time mainly applies to imported containers where the importer lets the container stay longer in container yard. Furthermore, capacity planning tackled by the berth length extension and container yard (CY) expansion. Thus, capacity management programmes are classified as less capital intensive than capacity planning.

The evaluation of investment for each container terminal could be depicted in Appendix 6.

6. Conclusion and Recommendation

6.1. Conclusion

The use of DEA Analysis helps decision-makers to interpret only one measurement value - productivity performance. This indicator is obtained from the calculation model that involves many variables that can define the "least efficient" productivity performance level of a port. In addition to that, DEA Analysis also provides a suggestion to include target achievements that should be reached by the port that has not been streamlined to be classified as an "efficient" port. Based on the analysis of 18 container terminals within the area of Pelindo I, II, III and IV, we find that the efficiency score is not the only indicator for resource utilisation levels. Capacity analysis is conducted to obtain the ratio of demand and capacity as an indicator of capacity utilisation level.

The outcome of DEA Analysis generate the idea that 7 out of 18 container terminals identified as efficient namely for Tanjung Priok, JICT, Tanjung Perak, TPS, BJTI, Makassar Port and UTPM. While the other container terminals is categorized as inefficient terminals, which have efficiency performance ranging from 20% to 96%. The lowest efficiency performance refers to Teluk Bayur Port and Jambi Port due to excess resources and less incoming cargo.

In terms of berth capacity, the analysis shows that 12 out of 18 container terminals have more than 80% ratio of current demand and capacity as a benchmark of capacity utilisation. An extremely high ratio is seen in Tanjung Perak Port followed by Belawan Port, Tanjung Priok Port, TPS, KOJA, BJTI and Makassar Port. Also, capacity analysis points to the bottleneck in major container terminals in Indonesia: port congestion. Berth is fully utilised but each port has a reserve capacity which is difficult to calculate. It explains the tendency of higher capacity utilisation in many Indonesian ports.

In terms of yard capacity, 11 out of 18 container terminals have reached the ratio of more than 80%. Again, Tanjung Perak Port holds the highest ratio over all the container terminals in Indonesia followed by Tanjung Priok Port and BJTI. Longer dwelling times are believed to be the driving factors for capacity shortage in most container terminals in Indonesia and once again this bottleneck remains to be a critical problem for all the container ports in Indonesia. Similar to berth, the yard is fully utilised but each port has a different initial design which makes it a bit difficult to find patterns that could explain it.

By combining demand and supply analyses, the results show that several terminals should start to invest in order to improve their capacities. The analyses also show that 7 out of 18 container terminals which are currently identified as efficient, are against bottleneck issue as driven factor for severe congestion.

6.2. Areas for Further Research

Due to the nature of the DEA method being characterised as a "*sample specific*" model, productivity measurement results tend to depend on the set of data included. Moreover, DEA only analyzes the level of performance based on relative efficiency between all DMU's in the sample. It is not providing absolute efficiency values since they change along with the data set. Another limitation of the research is the availability of panel data for facilities, equipment and operational performance for all container terminals since they are managed by different stated-owned enterprises.

For further research, it is important to broaden the DEA model by using other DEA models such as DEA BCC in output oriented combined with malmquist index to obtain productivity changes over time. Additionally, it is also important to use the precise data regarding the call size, Teu Ground Slot (TGS) and dwelling time which will help to find ou the precise capacity of each container terminal.

Therefore, the combination of DEA model with the capacity analysis provides useful information for Pelindo management to understand their position regarding the efficiency performance and the right investment to tackle existing bottlenecks. Finally, steps for further improvements by the container terminals will increase the satisfaction level for liner shippers and reinforce the competitive level of container terminals in Indonesia.

6.3. Recommendation

Taking into account the results we received from the study conducted with the use of the DEA model, the management of Pelindo should consider taking various improvement measures necessary for each container terminal to enhance efficiency performance.

Demand and supply analyses provide information regarding the appropriateness and urgency of the investment in each container terminal. Thus, management of Pelindo should consider investment into containter terminals depending on the degree of priorities needed and need to do so not merely by means of capital intensive investment but also through possible capacity management programme.

Pelindo management should carry out continuous evaluation regarding the efficiency performance of container terminals to enhance the value or even maintain the level of their performance.

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APPENDICES

Appendix 1

Facilities and Equipment of Belawan Port

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	675	HMC	1
Depth (m)	-5 to -7	Mobile Crane	4
Container Yard Area (m^2)	80,288	Forklift Diesel	11
Container Yard Capacity (TEUs)	3,500		
Stacking Height (Tier)	4		

Sources : Own elaboration from various sources

Facilities and Equipment of BICT

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	950	CC	11
Depth (m)	-10 to -11	HMC	2
Container Yard Area (m^2)	214708	Transtainer MC (RTG)	25
Container Yard Capacity (TEUs)	14100	Reachstaker	7
Stacking Height (Tier)	4 to 6	Side loader	3
		Forklift Diesel	6
		Headtruck	61

Sources : Own elaboration from various sources

Facilities and Equipment of Tanjung Priok Port

Facilities (Berth for Container Vessel)		Equipment (number)	
PTP			
Length (m)	1030	HMC	29
Depth (m)	-10 to -12	Crane	10
Container Yard Area (m^2)	796121	QCC	17
Container Yard Capacity (TEUs)	30476	GLC	13
Stacking Height (Tier)	5	Shore crane	1
		RTG	52
		RMCG	9
		Top Loader	3
		Reachstaker	20
		Side loader	1
		Forklift	21
JICT			
Length (m)	2150	QCC	19
Depth (m)	-11 to -14	RTG	74
Container Yard Area (m^2)	547400	Reachstaker	5
Container Yard Capacity (TEUs)	15100	Side Loader	6
Stacking Height (Tier)	4	Forklift	21
		Head Truck	139
KOJA			
Length (m)	650	CC	7
Depth (m)	-13	RTG	25
Container Yard Area (m^2)	218000	Reachstaker	3
Container Yard Capacity (TEUs)	15100	Head Truck	48
Stacking Height (Tier)	4		

Sources : Own elaboration from various sources

Facilities and Equipment of Panjang Port

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	401	CC	3
Depth (m)	-7 to -16	Gantry Jib Crane	4
Container Yard Area (m^2)	214,708	Transtainer	5
Container Yard Capacity (TEUs)	796,121	Top Loader	1
Stacking Height (Tier)	4	Side Loader	1
		Forklift	7
		Headtruck	13

Sources : Own elaboration from various sources

Facilities and Equipment of Palembang Port

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	266	CC	3
Depth (m)	-6 to -9	Gantry Jib Crane	4
Container Yard Area (m^2)	57,357	RMGC	4
Container Yard Capacity (TEUs)	4,376	Reachstaker	1
Stacking Height (Tier)	5	Side Loader	2
		Forklift	16
		Headtruck	14

Sources : Own elaboration from various sources

Facilities and Equipment of Pontianak Port

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	295	CC	2
Depth (m)	-6	Gantry Jib Crane	2
Container Yard Area (m^2)	47,794	RMGC	4
Container Yard Capacity (TEUs)	3,753	Reachstaker	4
Stacking Height (Tier)	5	Side Loader	4
		Forklift	10
		Head Truck	4
		Road Truck	6
		Terminal Tractor	4
		Truck	4

Sources : Own elaboration from various sources

Facilities and Equipment of Teluk Bayur Port

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	222	GLC	4
Depth (m)	-10 to -11	Mobile Crane	1
Container Yard Area (m^2)	62,250	Top Loader	1
Container Yard Capacity (TEUs)	4,825	Side Loader	1
Stacking Height (Tier)	5	Reachstaker	3
		Forklift	4
		Head Truck	10
		Truck	4

Sources : Own elaboration from various sources

Facilities and Equipment of Jambi Port

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	302	Mobile Crane	2
Depth (m)	-6 to -9	Reachstaker	1
Container Yard Area (m^2)	14,649	Forklift	10
Container Yard Capacity (TEUs)	1,855	Mobile crane	2
Stacking Height (Tier)	5	RMGC	3
		Fix jib crane	2
		Head Truck	6

Sources : Own elaboration from various sources

Facilities and Equipment of Tanjung Perak Port

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	320	Gantry Crane	3
Depth (m)	-8	HMC	6
Container Yard Area (m^2)	34,880	RTG	7
Container Yard Capacity (TEUs)	3,895	Forklift	1
Stacking Height (Tier)	4	Truck	17

Sources : Own elaboration from various sources

Facilities and Equipment of Banjarmasin Port

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	505	CC	4
Depth (m)	-7	Mobile Crane	2
Container Yard Area (m^2)	81,133	RTG	11
Container Yard Capacity (TEUs)	6,460	Side Loader	2
Stacking Height (Tier)	5	Forklift	1
		Head Truck	25

Sources : Own elaboration from various sources

Facilities and Equipment of TPKS

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	495	CC	5
Depth (m)	-10	RTG	19
Container Yard Area (m^2)	187,168	Top Loader	1
Container Yard Capacity (TEUs)	10,816	Side Loader	2
Stacking Height (Tier)	5	Reachstaker	3
		Forklift	8
		Head Truck and Terminal Tractor	44

Sources : Own elaboration from various sources

Facilities and Equipment of TPS

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	1,450	CC	11
Depth (m)	-9.5 to -10.5	RTG	28
Container Yard Area (m^2)	397,000	Reachstacker	6
Container Yard Capacity (TEUs)	34,252	Skystacker	3
Stacking Height (Tier)	4 or 5	Forklift	18
		Headtruck	80
		Translifter	7

Sources : Own elaboration from various sources

Facilities and Equipment of BJTI

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	1,420	HMC+LHM	23
Depth (m)	-6.5 to - 9.6	RTG	15
Container Yard Area (m^2)	43,301	Reachstacker	4
Container Yard Capacity (TEUs)	7,426	Forklift	10
Stacking Height (Tier)	6	Headtruck+trailer	115
		Yard truck+chasis	12

Sources : Own elaboration from various sources

Facilities and Equipment of Makassar Port

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	1,200	Mobile Crane	3
Depth (m)	-11 to -13	Reachstacker	2
Container Yard Area (m^2)	60,038	Forklift	5
Container Yard Capacity (TEUs)	2,925	Loader	1
Stacking Height (Tier)	5	Headtruck	1

Sources : Own elaboration from various sources

Facilities and Equipment of UTPM

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	1,000	RTG	11
Depth (m)	-9 to -12	Side Loader	1
Container Yard Area (m^2)	114,446	Reachstacker	2
Container Yard Capacity (TEUs)	9,480	Forklift	7
Stacking Height (Tier)	5	Headtruck	30

Sources : Own elaboration from various sources

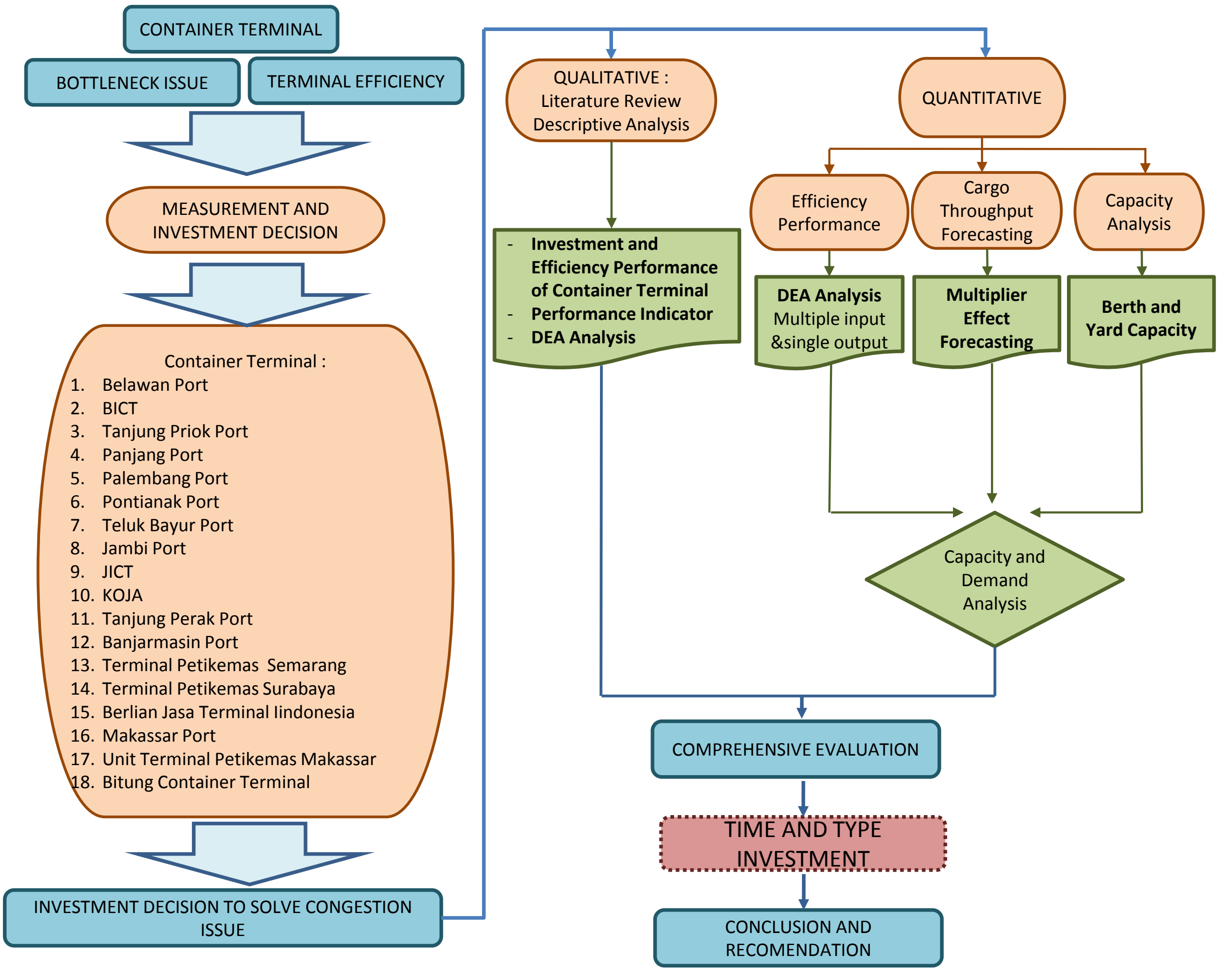
Facilities and Equipment of BCT

Facilities (Berth for Container Vessel)		Equipment (number)	
Length (m)	365	RTG	4
Depth (m)	-11	Reachstacker	2
Container Yard Area (m^2)	33,000	Forklift	5
Container Yard Capacity (TEUs)	12,875	Headtruck	11
Stacking Height (Tier)	4		

Sources : Own elaboration from various sources

Appendix 2

Research Methodology Framework



Source: Own arrangement

Appendix 3

Raw Data For Input

No.	Port Name	Container Yard (CY) (M^2)	Maximum Draft (M)	Berth Length (M)	Quay Crane (Index)			Yard Stacking Index					Trucks and Vehicle		Gate Lanes	Throughput (in million)
					Type of Crane	Amount	Lifting Capacity	Type od Crane	Amount	Container Yard Capacity (TEUs)		Stacking height (Tier)	Type of Vehicle	Amount		TEUs
1	Belawan Port	80,288	-5 to -7	675	HMC	1	1	Forklift Diesel	11		3,500	4		-	1 in 1 out	45,982
			7		Mobile Crane	4	1								2	
2	Container Terminal (BICT) Port	214,708	-10 to -11	950	CC	11	1	Transtainer MC (RTG)	25	International	8,600	4 to 6	Headtruck	61	4 in 4 out	900,395
					HMC	2	1	Reachstaker	7	Domestic	6,500	6			8.00	
								Side loader	3	Total capacity	15,100					
								Forklift Diesel	6							
								Total number	41							
3	Tanjung Priok Port	796,121	-10 to -12	1030	HMC	29	1	RTG	52		30,476	was 4 now 5		-	2 in 2 out	2,463,908
					Crane	10	1	RMCG	9			5			4	
					QCC	17	2	Top Loader	3							
					GLC	13	1	Reachstaker	20							
					Shore crane	1	2	Side loader	1							
								Forklift	21							
								Total number	106							
4	Panjang Port	75,000	-7 to -16	401	CC	3	1	Transtainer	5		6,848	4	Head Truck	13	1 in 1 out	107,546
					Gantry Jib Crane	4	1	Top Loader	1						2	
								Side Loader	1				Total number	13		
								Forklift	7							
								Total number	14							
5	Palembang Port	57,357	-6 to -9	266	CC	3	1	RMGC	4		4,376	5	Head Truck	14	1 in 1 out	137,685
					Gantry Jib Crane	4	1	Reachstaker	1						2	
								Side Loader	2				Total number	14		
								Forklift	16							
								Total number	23							
6	Pontianak Port	47,794	-6	295	CC	2	1	RMGC	4		3,753	5	Head Truck	4	2 in 2 out	227,130
					Gantry Jib Crane	2	1	Reachstaker	4				Road Truck	6	4	
								Side Loader	4				Terminal Tractor	4		
								Forklift	10				Truck	4		
								Total number	22							
													Total number	18		
7	Teluk Bayur Port	62,250	-10 to -12	222	GLC	4	1	Top Loader	1		4,825	5			1 in 1 out	66,942
					Mobile Crane	1	1	Side Loader	1				Head Truck	10	2	
								Reachstaker	3				Truck	4		
								Forklift	4							
								Total number	9				Total number	14		
8	Jambi Port	14,694	-6 to -9	302	Mobile Crane	2	1	Reachstaker	1		1,855	5			1 in 1 out	29,379
								Forklift	10				Head Truck	6	2	
								Mobile crane	2				Total number	6		
								RMGC	3							
								Fix jib crane	2							
								Total number	18							
9	Jakarta International Container Terminal (JICT) - IPC - Hutchison	455,000	-11 to -14	1640	QCC	19	2	RTG	74		46,940	4	Head Truck	139	6 in 7 out	2,373,470
		92,400	-8.6	510				Reachstaker	5						13	
								Side Loader	6				Total number	139		
								Forklift	21							
								Total number	85							
10	KOJA (IPC-Hutchison)	218,000	-13	650	CC	7	2	RTG	25		18,454	4	Head Truck	48		872,511
								Reachstaker	3						6	
								Total number	28							
11	Tanjung Perak Port	34,880	-8	320	Gantry Crane	3	1	RTG	7		3,895	4	Truck	17	1 in 1 out	601,915
					HMC	6	1	Forklift	1						2	
								Total number	8							
12	Banjarmasin Port	51,833	-7	240	CC	4	1	RTG	11		6,460	5	Head Truck	25	2 in 2 out	413,737
		10,000	-7	265	Mobile Crane	2	1	Side Loader	2						4	
		19,300						Forklift	1							
								Total number	14							
13	Terminal Petikemas Semarang (TPKS) Port	187,168	-10	495	CC	5	2	RTG	19		10,816	5	Head Truck + Ter	44	2 in 2 out	575,671
								Top Loader	1						4	
								Side Loader	2							
								Reachstaker	3							
								Forklift	8							
								Total number	33							
14	Terminal Petikemas Surabaya (TPS) Port	350,000	-7.5 to -10.5	1000	CC	11	2	RTG	28	International	32,223	4 or 5	Headtruck	80	4 in 2 out	1,343,523
		47,000		450				Reachstacker	6	Domestic	2,029	5	Translifter	7	3 in 2 out	
								Skystacker	3	Total Capacity	34,252		Total number	87	1 in 1 out	
								Forklift	18						13	
								Total number	55							
15	Berlian Jasa Terminal Indonesia (BJTI)	43,301	-9.6	540	HMC+LHM	23	1	RTG	15		7,426	6	Headtruck+trailer	115	3 in 2 out	1,158,947
			-8	740				Reachstacker	4				Yard truck+chasis	12	5	
			-6.5	140				Forklift	10				Total number	127		
								Total number	29							
16	Makassar Port	60,038	-11 to -13	1200	Mobile Crane	3	1	Reachstacker	2		2,925	3	Headtruck	1	1 in 1 out	7,075
								Forklift	5						2	
								Loader	1							
								Total number	8							
17	Unit Terminal Petikemas Makassar (UTPM) Port	114,446	-9 to -12	1000	CC	5	1	RTG	11		9,480	5	Headtruck	30	1 in 1 out	562,046
								Side Loader	1						2	
								Reachstacker	2							
								Forklift	7							
								Total number	21							
18	Bitung Container Terminal (BCT)	33,000	-11	365	CC	3	1	RTG	4		12,875	4	Headtruck	11	1 in 1 out	200,153
								Reachstacker	2						2	
								Forklift	5							
								Total number	11							

Source: Own elaboration based on various source

Appendix 4

DEA-Stata Result

```
      name:  dealog
       log:  D:\Officially Study @MEL\Thesis\Run STATA\dea.log
  log type:  text
 opened on:   8 Aug 2015, 02:06:38

options: RTS(CRS) ORT(IN) STAGE(2)
CRS-INPUT Oriented DEA Efficiency Results:
```

	rank	theta	ref: 1	ref: 2	ref: 3	ref: 4	ref: 5	ref: 6	ref: 7	ref: 8	ref: 9	ref: 10	ref: 11
dmu:1	14	.328455	.	.	.0186622	.	.	.	.	.	.	.	0
dmu:2	8	.965888	.	.	.	.	.	.	.	.	.179431	.	.41609
dmu:3	1	1	.	.	1	.	.	.	.	.	0	.	.
dmu:4	16	.231989	.	.	.0003101	.	.	.	.	.	.	.	.177403
dmu:5	15	.291154	.	.	.	.	.	.	.	.	.	.	.223087
dmu:6	13	.733109	.	.	.	.	.	.	.	.	.	.	.250149
dmu:7	18	.193116	.	.	.	.	.	.	.	.	.	.	.101516
dmu:8	17	.19536	.	.	.	.	.	.	.	.	.	.	.035487
dmu:9	1	1	.	.	0	.	.	.	.	.	1	.	.
dmu:10	9	.902886	.	.	.	.	.	.	.	.	.0280746	.	1.20824
dmu:11	1	1	.	.	0	.	.	.	.	.	0	.	1
dmu:12	10	.885023	.	.	.	.	.	.	.	.	.0330759	.	.293802
dmu:13	11	.816602	.	.	.	.	.	.	.	.	.0051272	.	.811515
dmu:14	1	1	.	.	0	.	.	.	.	.	0	.	0
dmu:15	6	1	.	.	.	.	.	.	.	.	.	.	.
dmu:16	7	1	.	.	.	.	.	.	.	.	.	.	.0117542
dmu:17	1	1	.	.	0	.	.	.	.	.	.	.	0
dmu:18	12	.79483	.	.	.	.	.	.	.	.	.	.	.165669

	ref: 12	ref: 13	ref: 14	ref: 15	ref: 16	ref: 17	ref: 18	islack: CY	islack: MD	islack: BL	islack: QC	islack: YS	islack: V
dmu:1	.	.	.	.	.	.	.	11.5143	2.07524	202.485	.	251.374	.
dmu:2	.	.	.	.	.	.398667	.	49.0242	.	.	.	6524.87	14.9446
dmu:3	.	.	0	.	.	.	.	0	.	.	.	0	0
dmu:4	.	.	.	.	.	.	.	10.9644	2.28888	35.9391	.	545.976	.
dmu:5	.	.	.	.	.	.0060592	.	8.22501	.762981	.	.	1704.66	.101904
dmu:6	.	.	.	.	.	.13622	.	10.7232	.76283	8.79e-06	.	4253.72	4.85685
dmu:7	.	.	.	.	.	.0103865	.	7.29189	1.38062	1.59e-06	.	220.484	.666251
dmu:8	.	.	.	.	.	.0142672	.	1.75e-07	1.30313	33.3755	.	1968.73	.140862
dmu:9	.	.	0	.	.	.	.	0	.	.	.	0	0
dmu:10	.	.	.	.	.	.139878	.	123.309	.	.	.	2207.58	14.6997
dmu:11	.	.	.	0	.	.	.	.	.	.	0	.	0
dmu:12	.	.	.	.	.	.281807	.	11.1994	.	.0000571	.	467.495	4.07919
dmu:13	.	.	.	.	.	.13351	.	106.45	.	.	.	3575.72	17.4168
dmu:14	.	.	1	.	.	.	.	.	.	.	.	0	0
dmu:15	.	.	.	1	.	.	.	.	0	0	0	1.09e-11	0
dmu:16	.	.	.	.	.	.	.	59.628	12.906	1196.24	2.89421	1127.26	.800179
dmu:17	.	.	.	.	.	1	.	0	0	0	.	0	.
dmu:18	.	.	.	.	.	.178695	.	.	5.27345	58.4045	.	11498.6	.565929

	islack: GL	oslack: T
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dmu:3	0	.
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dmu:9	0	.
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dmu:13	1.3097	.
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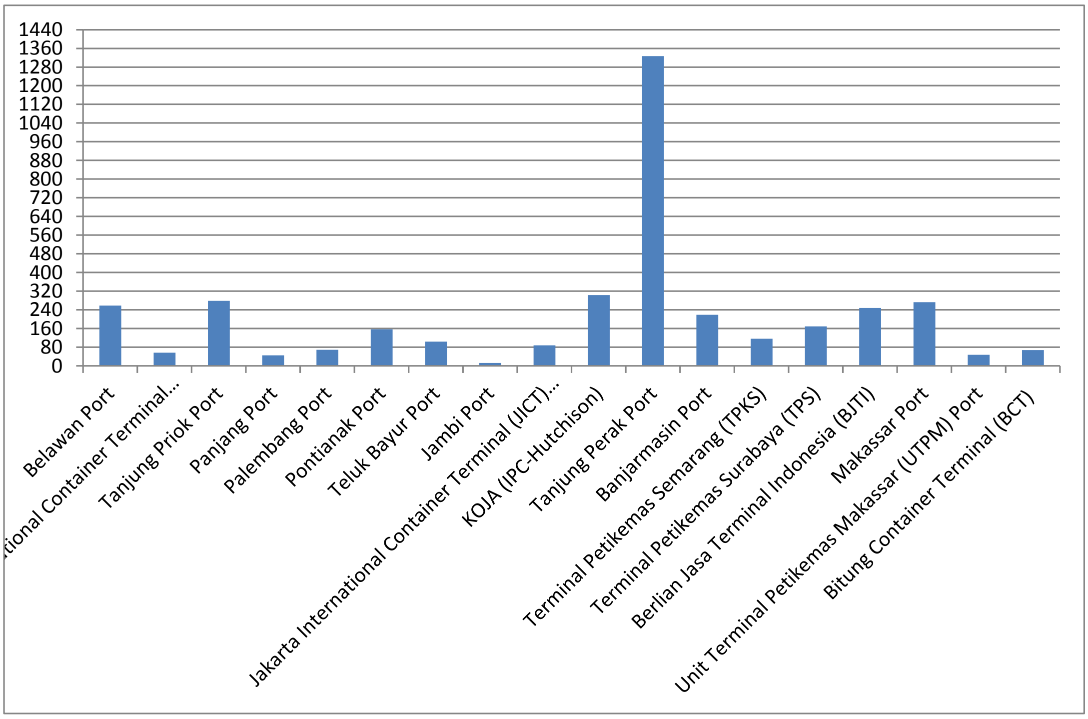
Source: Own elaboration

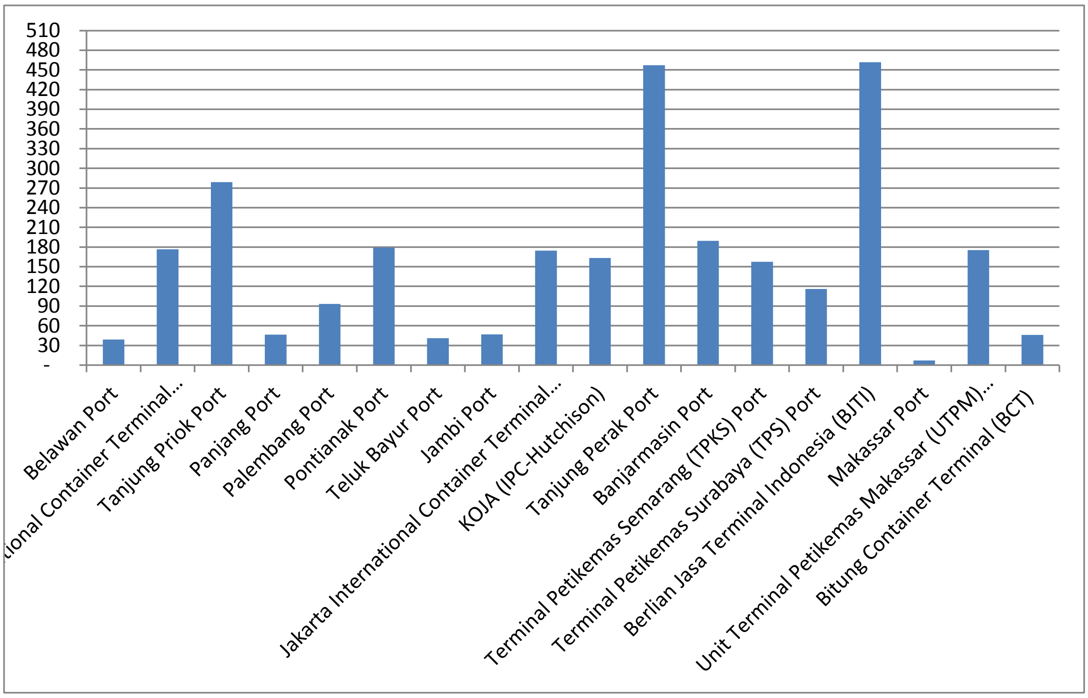
Appendix 5

Ratio of Current Demand to Capacity



Source: Own modification

Ratio of Current Demand to Calculated Berth Capacity



Source: Own modification

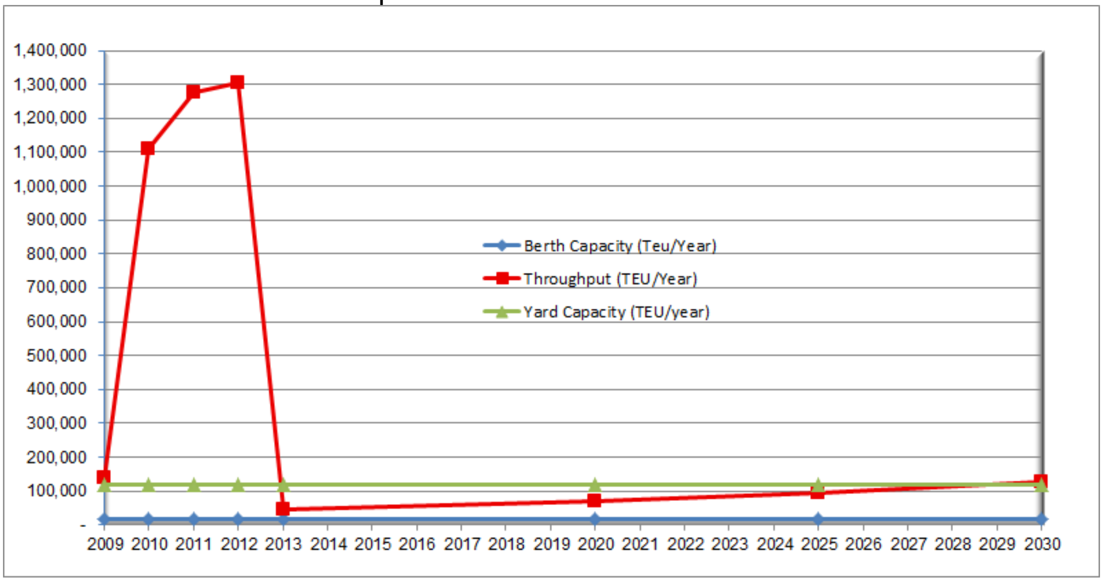
Ratio of Current Demand to Calculated Yard Capacity

Appendix 6

Evaluation of Each Container Terminals

1. Belawan Port

The terminal efficiency reach by Belawan Port in the year of 2014 indicate to be low equal to 32.85%, 5 input should be subtracted to reach the efficient number namely for container yard area, maximum draft, berth length, yard stacking index and gate lanes. It also can be achieve by enhance the market share of container so that the throughput raising. Figure 5 depicted the capacity based on yard capacity and berth capacity, it shown that the throughput dramatically fall by the year of 2013. Its possibly occur due to the operational of Belawan International Container Terminal (BICT) in 2009. It was one of the sub units in Belawan Port but by the year of 2009 it become subsidiary of Pelindo I with own management separate from Belawan Port and declared to be dedicated container terminal. Container cargo begins to shift to BICT and by the year of 2013 more than 96% throughput move to BICT. Figure 5 also shown that even though the throughput decrease but it's still more than berth capacity theoretically since berth capacity equal to 17.820 TEU/ year and the throughput in 2013 is 45.982 TEU/year. Hence, the investment regarding the berth capacity should consider from now since its already shown bottleneck in berth. Conversely for yard capacity, it's still capable to support the throughput till 2030, in addition its inline to slack result in the efficiency measurement that it has to subtract the container yard. The fact that currently, Belawan Port plan to develop car terminal, thus all container cargo possibly shifted to BICT. In this case the investment regarding yard and berth capacity can be neglected and the focus of investment will on the development of car terminal.

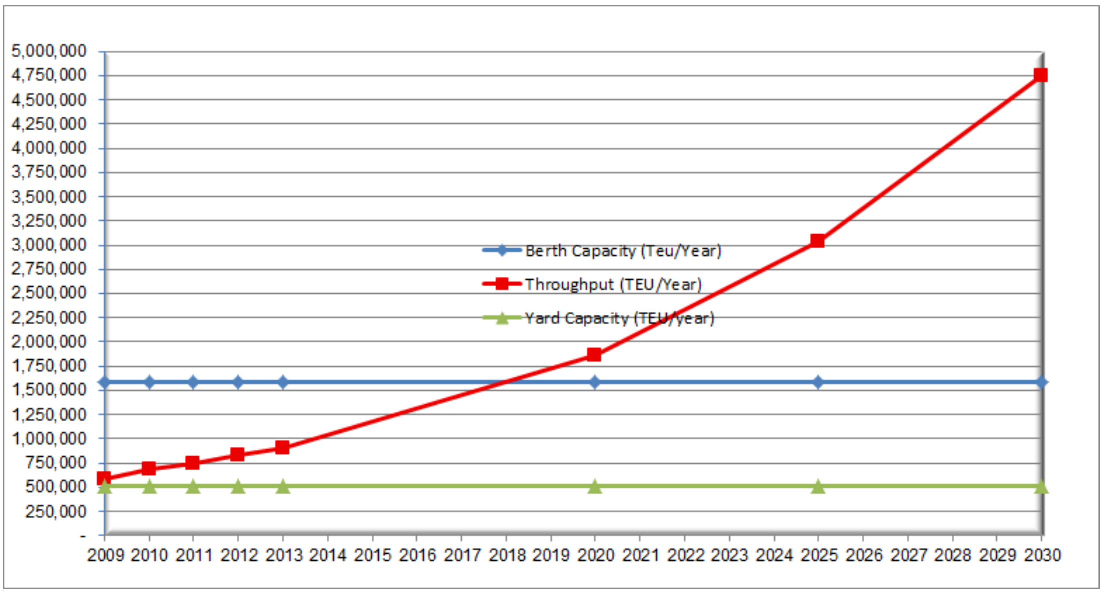


Source: Own calculation

Figure 5 Yard and Berth Optimal Capacity of Belawan Port

2. Belawan International Container Terminal (BICT)

BICT perform high terminal efficiency equal to 96.59% indicated that 4 input should be subtracted to achieve the efficient performance namely for container yard area, yard stacking index, vehicle and gate lanes. Increase the container throughput roughly will maximize the utilization of the source so that raise the efficiency. Figure 6 deploy the capacity as supply against throughput per year as a demand by using the throughput data combine to forecasted. Since it was operated in 2009, berth capacity show sufficient volume than its demanded, possibly due to utilization of the Gabion terminal as container terminal which is the old terminal. By this fact, the investment related to berth should be forced by the year of 2018 to avoid the congestion in container handled. Moreover, to tackled surge on throughput demand, Pelindo I has carry investment project since 2014 mainly on berth extension by 700m in total and additional container crane type Post Panamax which will complete by the year of 2016 (Bisnis Indonesia, 2014). It considered as the appropriate investment since bottleneck predicted to be occurred in 2018, the berth extension possibly solve the congestion issue. Conversely for yard capacity, since 2009 it's already show lower than its demanded since currently throughput has reach 900,395 TEU/year while capacity only support 510.324 TEU/year. The investment related yard area should be enforce to avoid bottleneck in yard area simultaneously with reducing the dwelling time in BICT which have been said to be 7 to 10 days. The burden BICT probably spread by the fact that currently Pelindo I has establish the development of Kuala Tanjung Port (same province as BICT, South Sumatra) which afford to handle 1 to 2 million TEUs per year. Kuala Tanjung Port predicted to be hub port in South Sumatra East Cost to counterbalance Singapore and Port Klang, Malaysia (Skyscrapercity, 2013).



Source: Own calculation

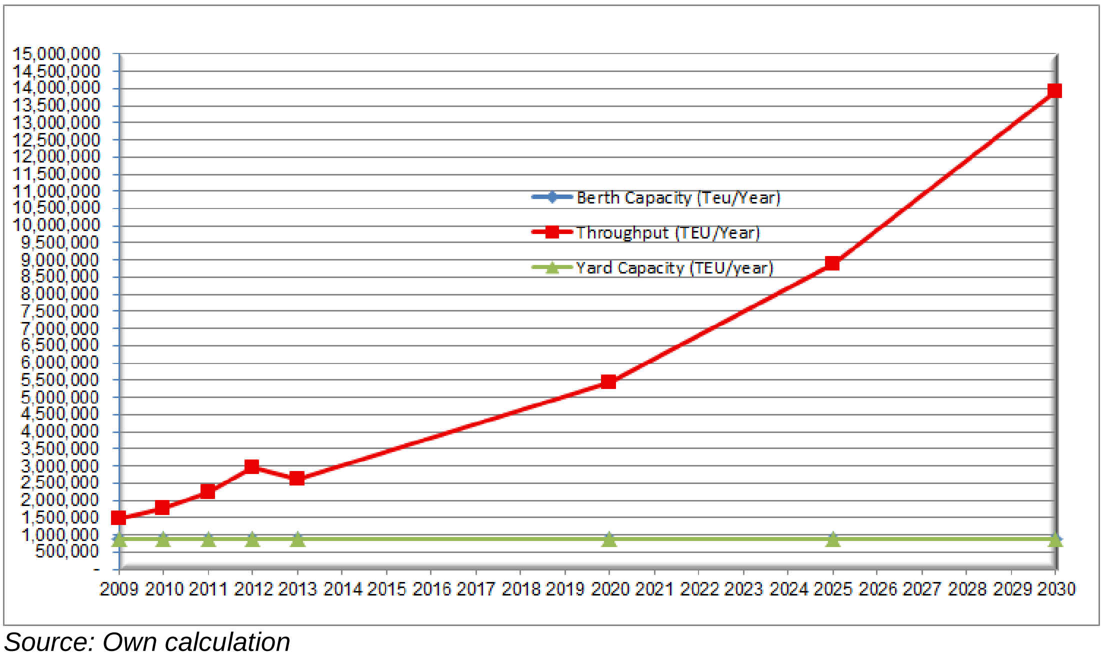
Figure 6 Yard and Berth Optimal Capacity of BICT

3. Tanjung Priok Port, Jakarta International Container Terminal (JICT – IPC – Hutchison) and Koja (IPC – Hutchison)

Tanjung Priok Port, JICT and KOJA located in same area and play important role as the economic gateway of many industrial parks area around capital city of Jakarta and it also play a role as transshipment hub for many smaller feeder ports in the country. Tanjung Priok Port and JICT categorized as efficient terminal since its efficiency score equal to 1, while KOJA 0.9029.

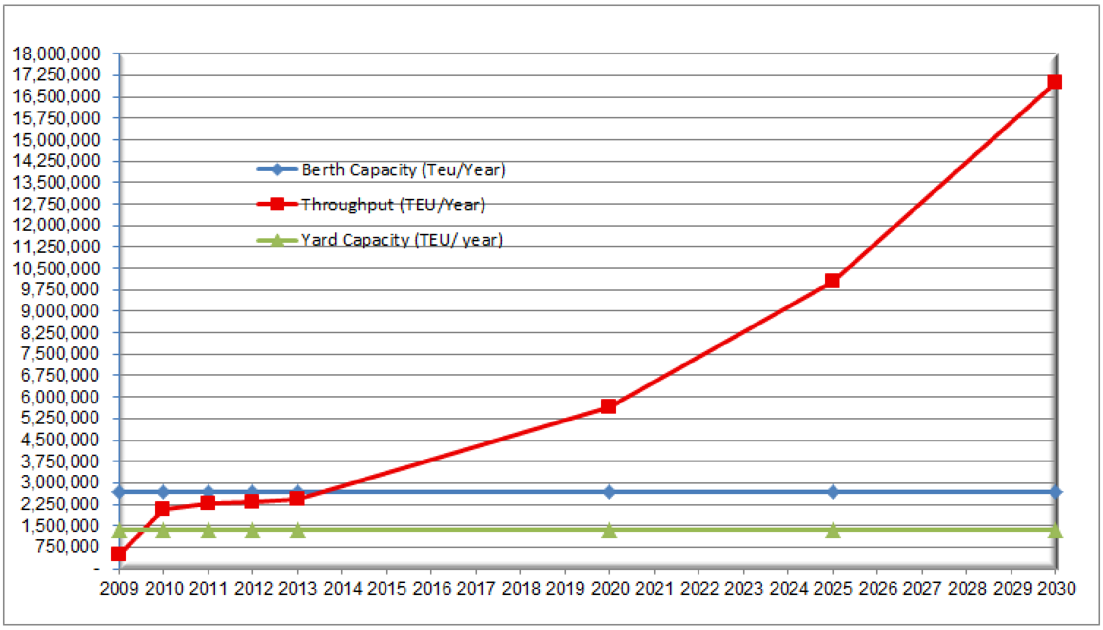
Figure 7, Figure 8, Figure 9 deploy the capacity as supply against throughput per year as a demand by using the throughput data combine to forecasted in Tanjung Priok Port, JICT and KOJA. Severe congestion indicated here, since all the terminal show has over its capacity both on yard and berth. Efficiency performance showed by these three terminals does not reflect perfect condition; utilize minimum input to generate maximum output. Hence, bottleneck occur both on yard and berth, related investment should be taken into account immediately to tackle this problem and to guarantee the service satisfaction for the shipping line as the major consumer since they require reliability schedule of the liner.

In addition, currently Pelindo I trying to improve capacity and congestion issue by develop NewPriok Terminal which will allow Triple E class (12,000 – 15,000 TEUs) to visit to Indonesia without transshipment since the maximum ship size allow to handle by Tanjung Priok is 6,000 TEUs. According Indonesia Port Corporation (2014) by the end of 2014, the progress of NewPriok is 38.28%. The project divided to 2 phase, first phase complete in 2017 with capacity 4.5 million TEU/ year while second phase planned 2018 – 2023 with total capacity 8 million TEU. Investment for NewPriok considered as the appropriate investment since forecasted demand show continuous escalation. By the end of 2025, its forecasted that total demand in Tanjung Priok Port, JICT and KOJA around 20.5 million TEU and still the development of NewPriok will be insufficient to support this demand. Others improvement should be considered to tackled congestion issue such as subtracting the dwelling time and upgrade the crane productivity.



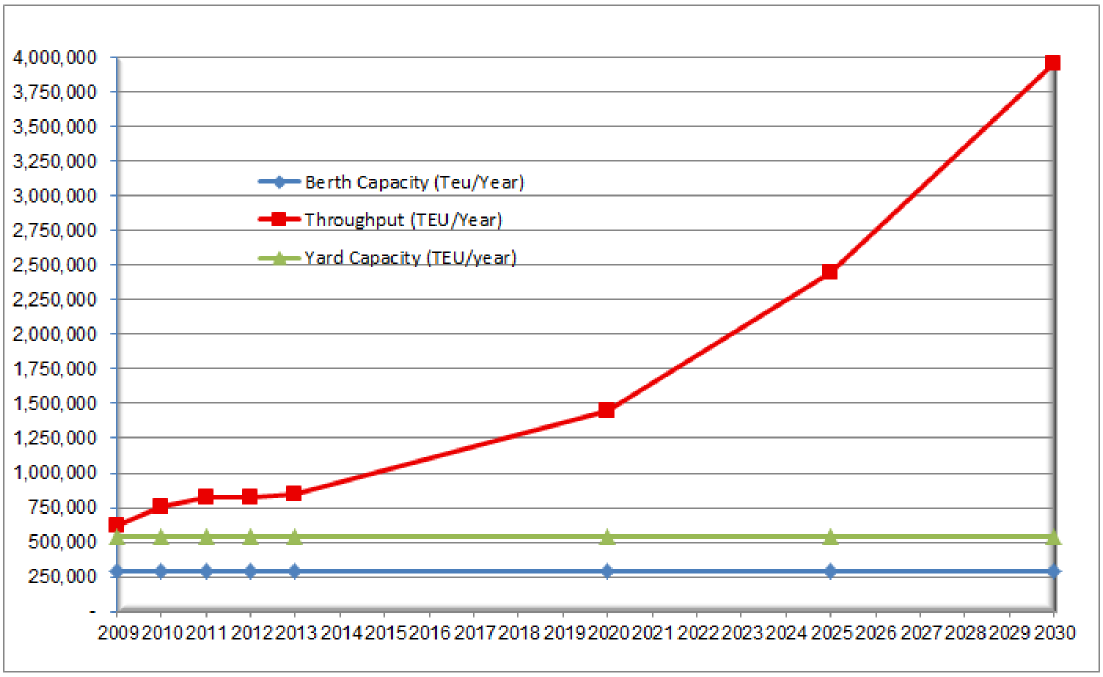
Source: Own calculation

Figure 7 Yard and Berth Optimal Capacity of Tanjung Priok Port



Source: Own calculation

Figure 8 Yard and Berth Optimal Capacity of JICT



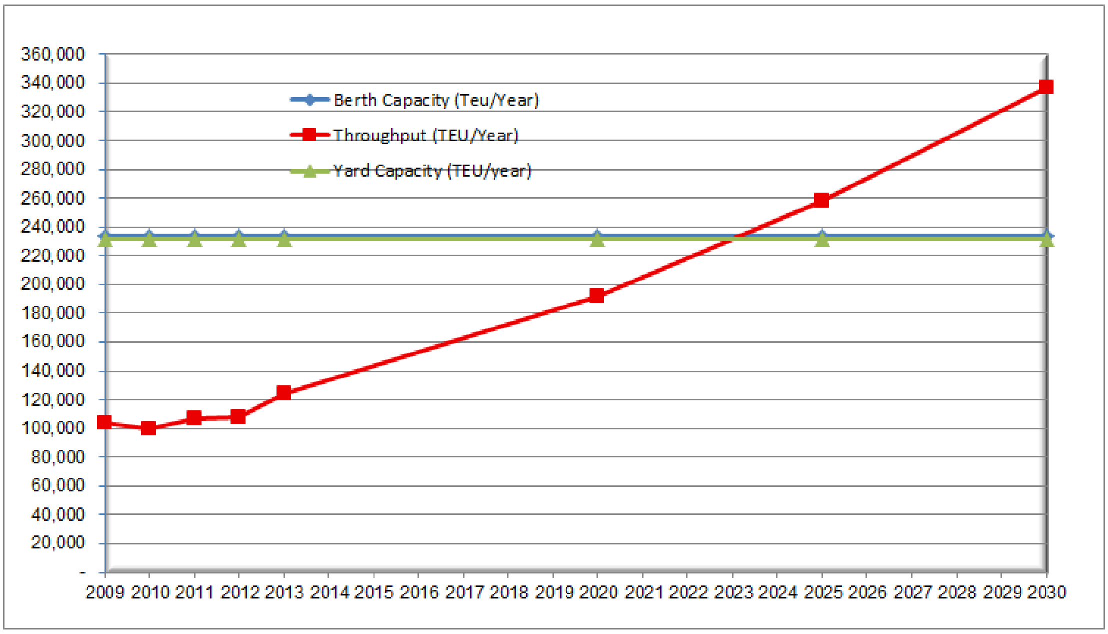
Source: Own calculation

Figure 9 Yard and Berth Optimal Capacity of KOJA

4. Panjang Port

Efficiency performance of Panjang Port categorized to be low equal to 23.20%, to be more efficient Panjang Port should be diminish 5 inputs namely for container yard area, maximum draft, berth length, yard stacking index and gate lanes. By the

Figure 10 describe that congestion is not the issue now day since the capacity enable to support throughput demand, thus the ratio of demand and capacity only 45%. By the year of 2023, when the throughput demand seems to be 2 hundred thousand TEU/year, the bottleneck begins. Pelindo II as the mother company of Panjang Port should consider taking investment related to the yard and berth capacity upgrade to tackle congestion issue.

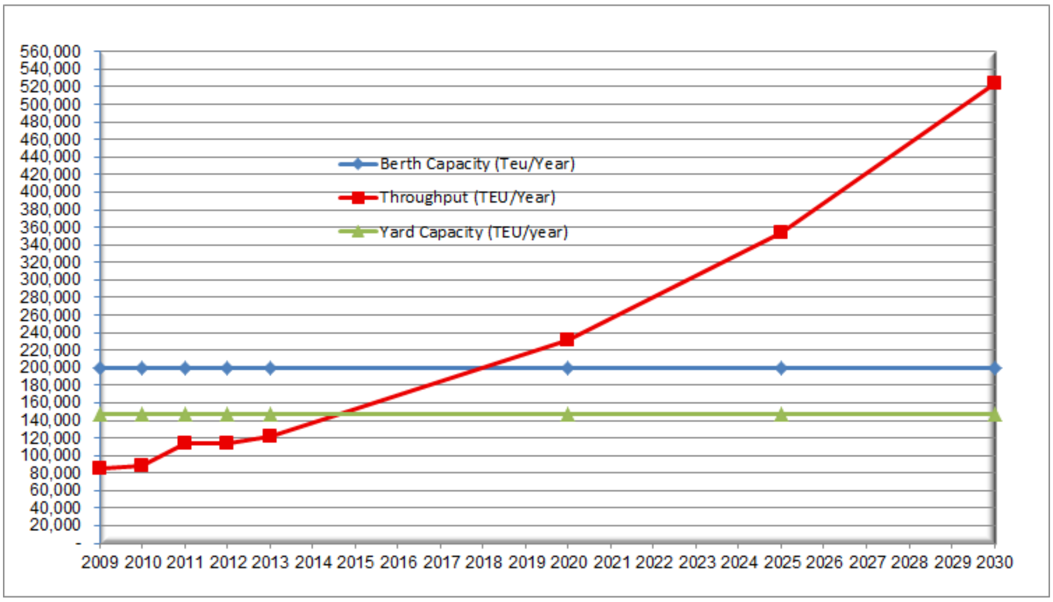


Source: Own calculation

Figure 10 Yard and Berth Optimal Capacity of Panjang Port

5. Palembang Port

Palembang port categorized as inefficient container terminal since it efficiency only 29.12%, thus the efficient frontier can be reach by reducing the input namely on container yard, maximum draft, yard stacking capacity, internal vehicle and gate lanes. In the term of berth capacity, it's still sufficient to support currently throughput demand since the throughput in 2013 only 122,155 TEU/year and the capacity able to assist to 200,378 TEU/ year. By the year of 2018, bottleneck would be the threat since the demand has exceed the capacity provided, hence Pelindo II has to enhance investment program related berth capacity to avoid congestion in Palembang Port. Moreover, by the end of 2014 the investment related yard capacity should be already considered since it was the point where the bottleneck occurs due to demand surplus. The stuffing and stripping activities inside the container yard also contribute to congestion issue since container yard should be dedicated area for container storage.

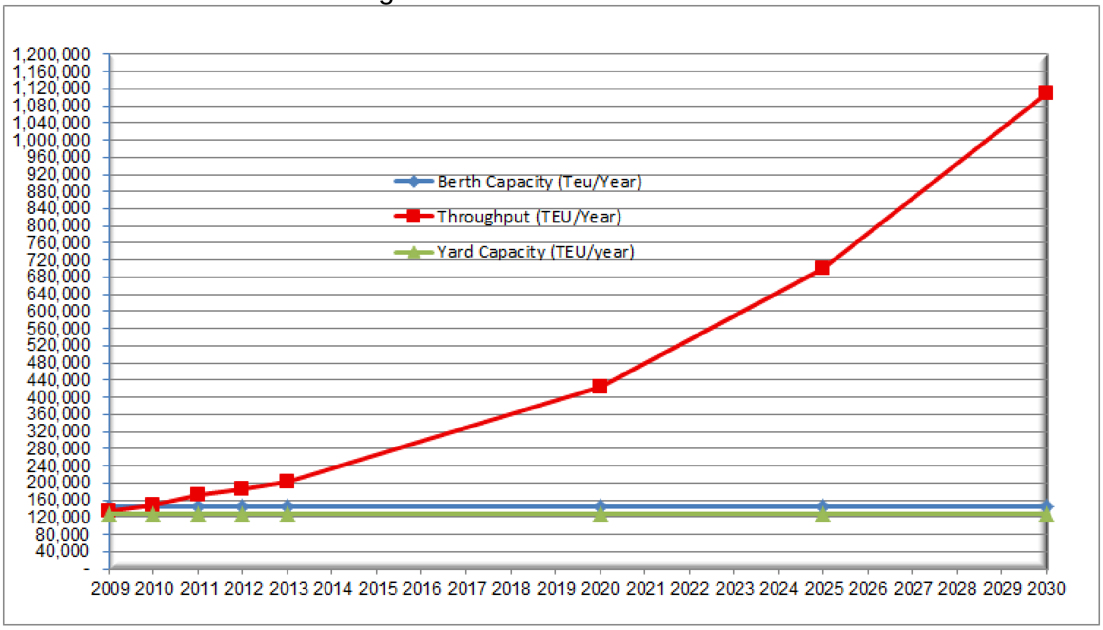


Source: Own calculation

Figure 11 Yard and Berth Optimal Capacity of Palembang Port

6. Pontianak Port

Efficiency performance of Pontianak Port equal to 73.31%, the input that reduce to reach the efficient condition are container yard, maximum draft, berth length, yard stacking capacity, internal vehicle and gate lanes. Figure 12 shows that currently congestion has already the serious problem since both capacities no longer adequate to accommodate the throughput demand. Moreover, the investment in line to berth and yard capacity should have started 5 years ago. The fact that stuffing and stripping activities of rubber and plywood handled inside the container yard also contribute on the level of congestion.

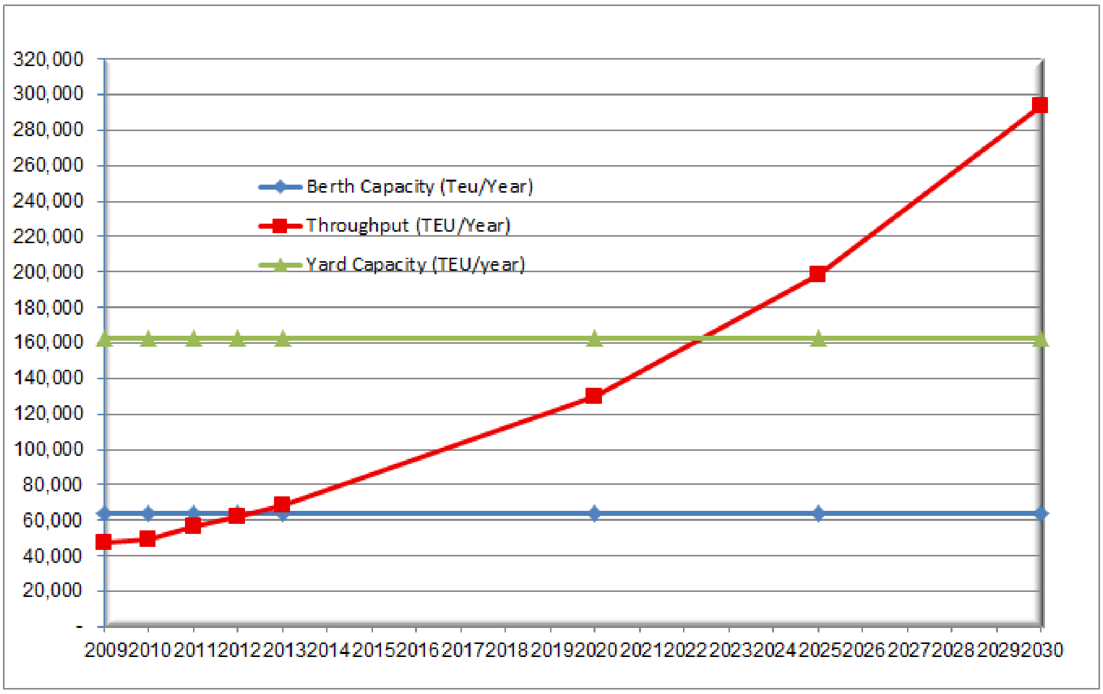


Source: Own calculation

Figure 12 Yard and Berth Optimal Capacity of Pontianak Port

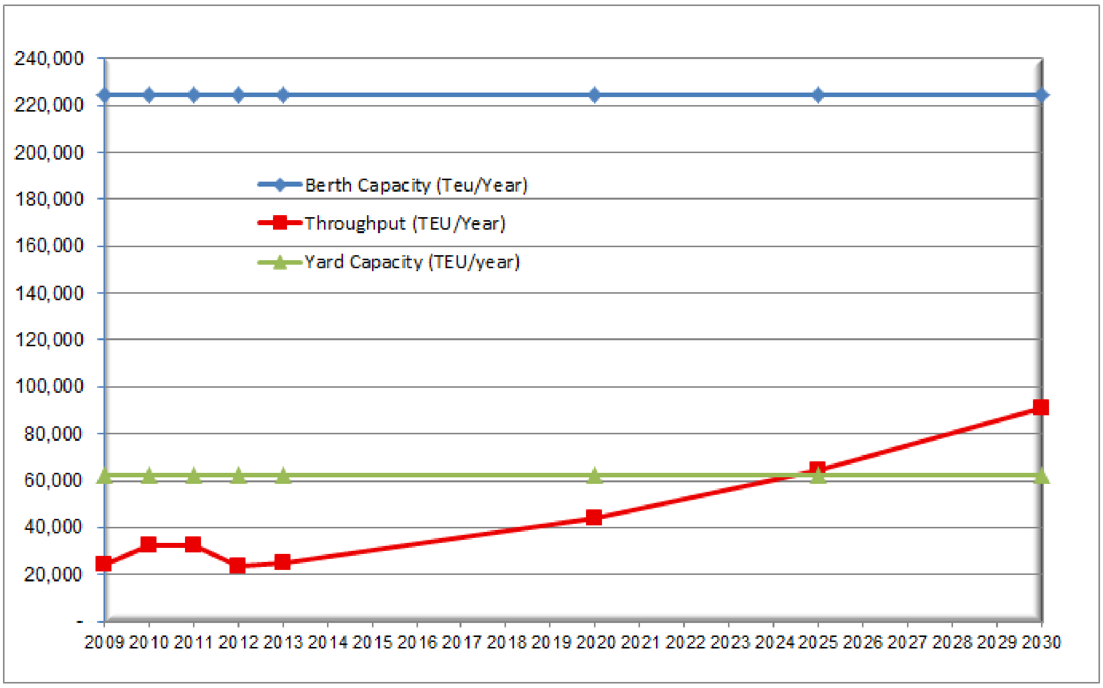
7. Teluk Bayur Port and Jambi Port

Both Teluk Bayur Port and Jambi Port have very low efficiency performance less than 20% several input should be subtracted as well namely for container yard, maximum draft, berth length, yard stacking capacity, internal vehicle and gate lanes. Thus, its indicate that both Teluk Bayur Port and Jambi Port are equipped by sufficient number of resources but less incoming cargo. Better performance can be achieved by improve the operating system to capture better container market share and gain more from the potential market. Figure 13 deploy the supply and demand for Teluk Bayur Port, it reflected that berth capacity has reach its optimum point which can cause bottleneck and raising the ship waiting time while yard capacity more than enough to support throughput demand to 2023. Thus, the urgently required is the investment related the berth capacity. Conversely for Jambi Port, by the Figure 14 both yard capacity and berth capacity sufficient enough to support throughput demand. Particularly for berth capacity, it's more than enough to cope with long term demand of container throughput and management of pelindo II can allocate the investment to other branch as well.



Source: Own calculation

Figure 13 Yard and Berth Optimal Capacity of Teluk Bayur Port



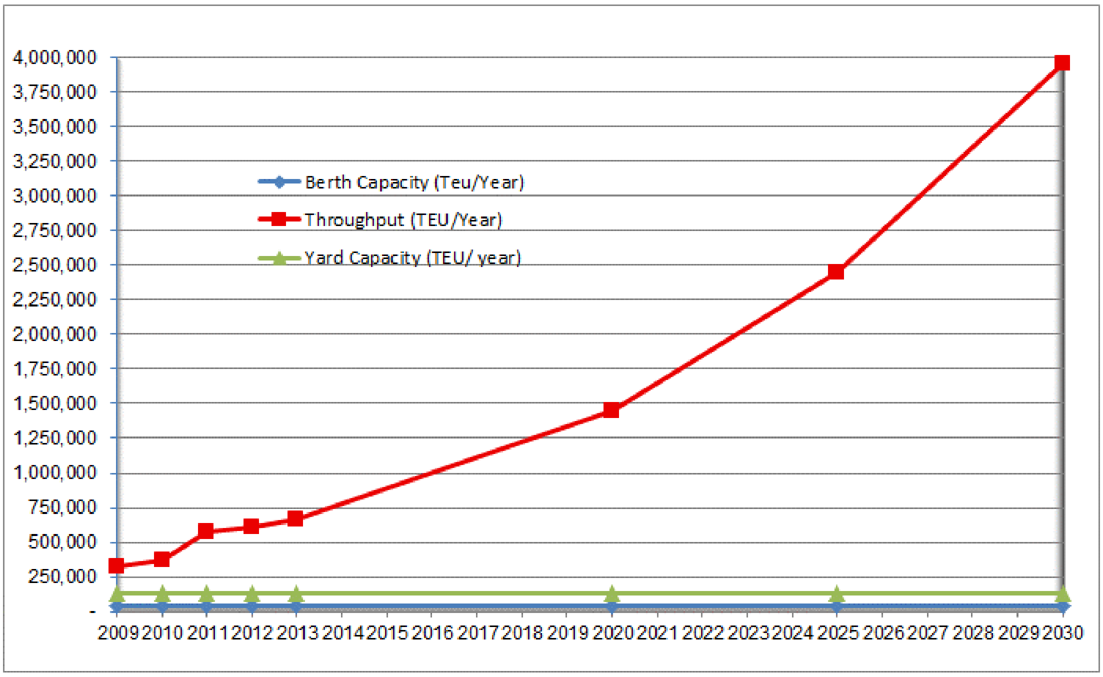
Source: Own calculation

Figure 14 Yard and Berth Optimal Capacity of Jambi Port

8. Tanjung Perak Port, Terminal Petikemas Surabaya (TPS) and Berlian Jasa Terminal Indonesia (BJTI)

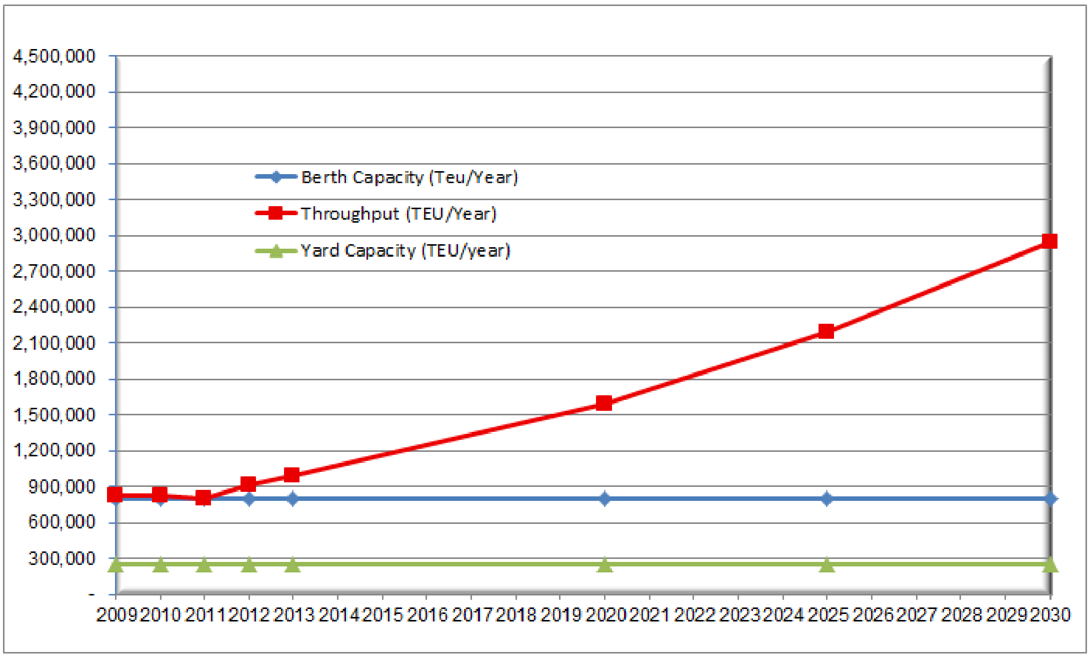
Tanjung Perak Port, TPS and BJTI classify as the absolute efficient container terminal since it efficiency score equal to 1 and does not any slack. The efficient performance showed by both terminals does not reflect the optimal condition where minimum input is utilized to generate maximum output; it's depicted by Figure 15 and Figure 16. Tanjung Perak Port capacity only 1.3 hundred thousand TEU/year in the term of yard capacity and 45 thousand TEU/year in the term of berth capacity while the throughput demand in 2014 more than 6 hundred thousand. Thus, indicate the bottleneck in the both resource lead to the congestion in Tanjung Perak Port as the second biggest port in Indonesia. Similar condition occur on BJTI, the capacity both for berth and yard is not sufficient anymore to support the demand for current throughput since the capacity of berth less than 8 hundred thousand TEU/year for berth and 2.5 hundred thousand for yard while the throughput counted for more than 9 hundred thousand TEU/year. Severe congestion occurs in BJTI as well. Investment both for berth and yard should be tackled immediately otherwise the operational performance of both terminal degrade and end up on customer unsatisfactory since liner shipping business is scheduled business which is required the reliability of berth and handling system. Hence, BJTI has establish appropriate investment in 2015 namely for construction of new CY in ex- Indomarco, ex- PTPN X, ex. AKR and ex. Yonif Marinir land. Figure 17 show the capacity of Terminal Petikemas Surabaya (TPS) which depict the identical tendency to be congestion condition since has exceed the capacity. TPS demand has reached more than 1.3 million TEU/year in 2013 while the capacity less than 8 hundred thousand TEU/year for berth and 1.1 million TEU/year for CY. Thus, TPS has planned to invest on new CY in 2016 located North direction of Block T. This the right investment to tackle the bottleneck issue but one should take into account is investment in the term of berth.

Moreover, to tackle congestion issue, Management of Pelindo III has established new container terminal namely Terminal Teluk Lamong located near to Tanjung Perak Port and BJTI. Teluk Lamong as the first sophisticated container terminal (since its automated container terminal) has just operated in the 2014 and able to handle container around 1.5 million TEU/ year. While Mirah Terminal as the container terminal of Tanjung Perak planned to be general cargo, RORO and car port terminal. In addition, currently Pelindo III has establish mega project called Java Integrated Industrial and Port Estate (JIIPE) located in Manyar, Gresik. It is a large scale integrated industrial and port estate which have container capacity to 6 million TEUs/ year and operated in 2017 .



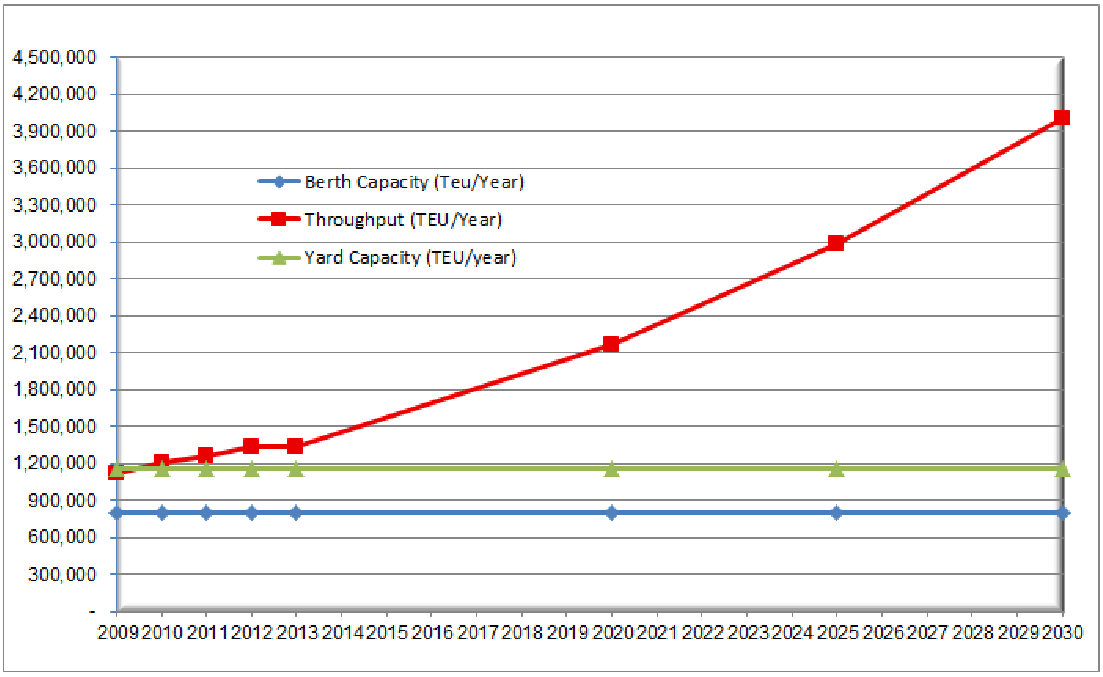
Source: Own calculation

Figure 15 Yard and Berth Optimal Capacity of Tanjung Perak Port



Source: Own calculation

Figure 16 Yard and Berth Optimal Capacity of BJTI



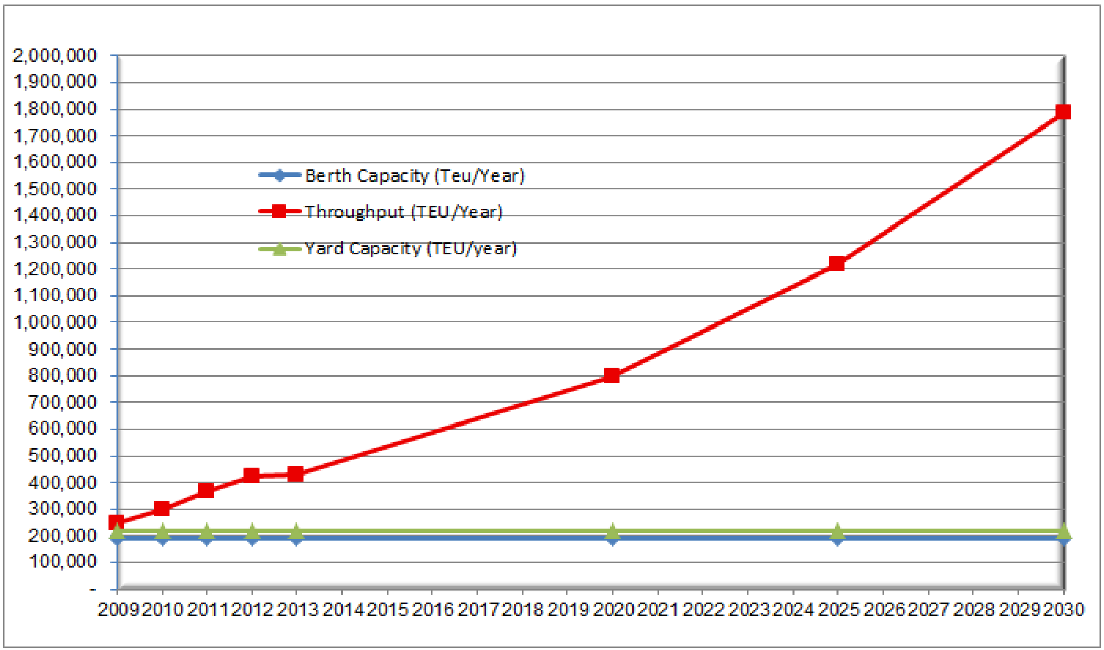
Source: Own calculation

Figure 17 Yard and Berth Optimal Capacity of TPS

9. Banjarmasin Port and Terminal Petikemas Semarang (TPKS)

Both Banjarmasin Port and TPKS efficiency performance counted for more than 80%. Banjarmasin Port should subtract all the input to categorized as efficient container terminal while TPKS only have to decrease container yard area, yard stacking index, internal vehicle and gate lanes. Banjarmasin Port counted to be lacked of capacity since it first operated where at that time the demand has reach more than 2 hundred thousand TEU/year while the capacity around 2 hundred thousand TEU/year. Over the time, demand increasing lead to the bottleneck in both resources. Management of Pelindo III has to considered investment in both resources to fulfill the minimum ratio of demand and supply in container terminal which is counted for 80%. Hence, Banjarmasin Port has appropriate investment in line to bottleneck in berth and yard such as:

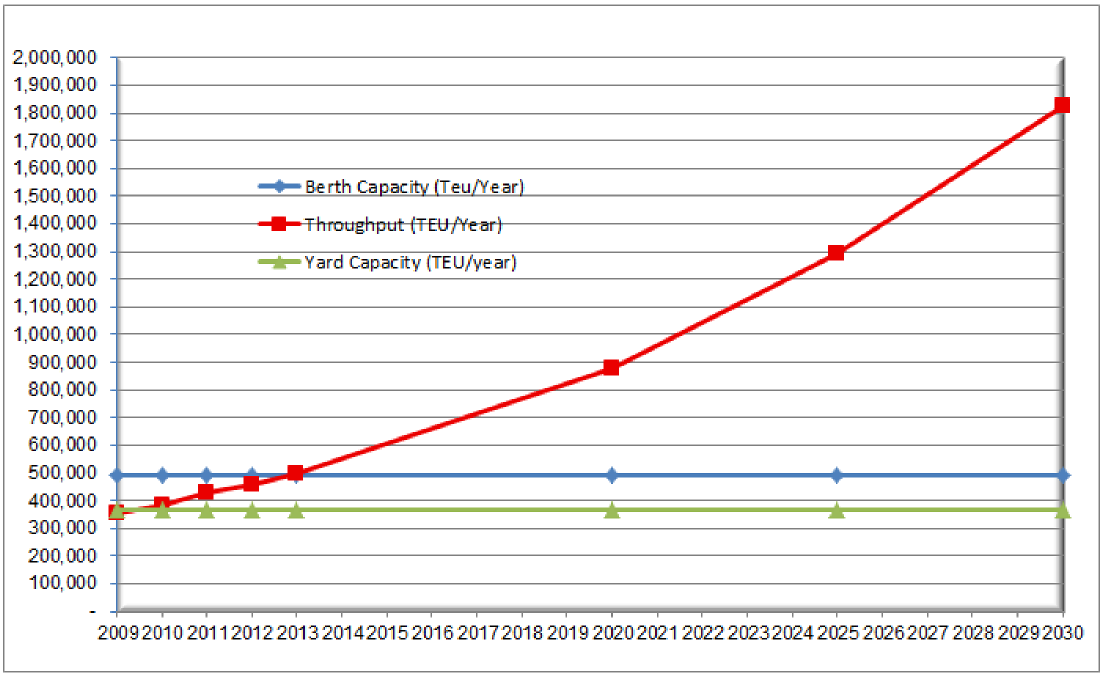
1. New berth construction in 2015 with berth length 150m (in cooperation with PT. TLMI);
2. New berth construction in 2017 with berth length 160 m;
3. Construction of 1.5 Ha CY in Terusan Bromo in 2016;
4. Construction of new CY in Terusan Bromo in 2016;
5. Construction of new CY located in ex- PT Hendratna in 2014;
6. Berth extension for Martapura Baru terminal by 50 m in 2014;
7. New construction of container berth located in ex-coal terminal and ex- Tonasa 265 m x 36 m in 2016;
8. Construction of 2 Ha new CY located in Lumba-lumba in 2017;
9. Construction of 5,000 m^2 CY located in ex- customs office in 2017;
10. Construction of 1,000 m^2 CY located in ex- engineering office in 2017;
11. Construction of 8,500 m^2 CY located in ex- Tonasa in 2017;
12. Construction of empty CY located in ex- official resident in 2017.



Source: Own calculation

Figure 18 Yard and Berth Optimal Capacity of Banjarmasin Port

In the term of berth capacity TPKS shown bottleneck condition since 2013 but for yard capacity it depicts excess demand since 2011. In 2013, when the throughput demand counted to be 5 hundred thousand and berth capacity less than thus number, bottleneck start to be moderate issue. Thus, TPKS should start to put investment to enhance berth and yard capacity.



Source: Own calculation

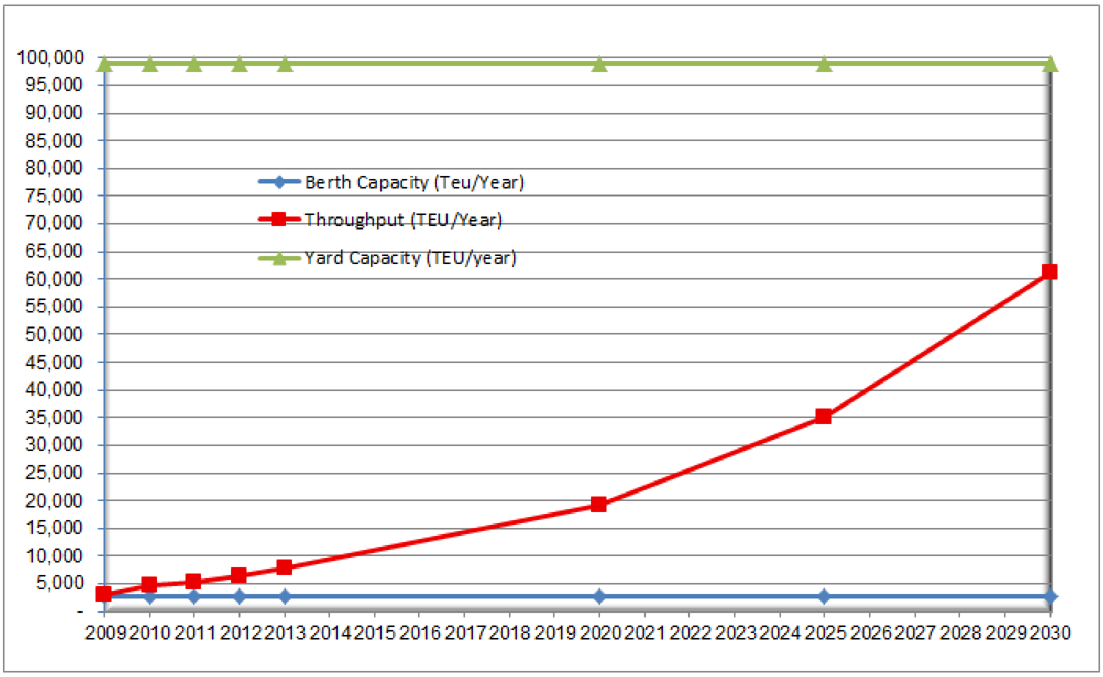
Figure 19 Yard and Berth Optimal Capacity of TPKS

Currently, TPKS has established investment related to capacity, namely construction of two new 3.2 Ha CY and berth. In 2016, there will be new CY located in ex- AKR. It needs deep information regarding the design of the CY and berth to be able to say that the new CY and berth has already tackled the bottleneck issue.

10. Makassar Port and Unit Terminal Petikemas Makassar (UTPM)

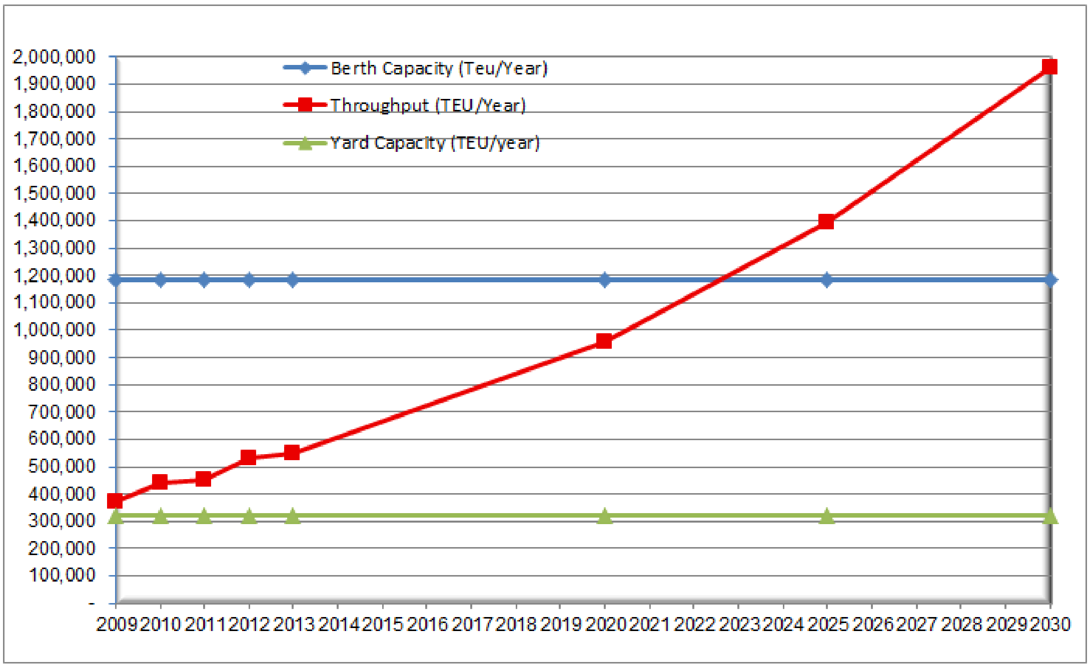
Makassar Port and UTPM located in the same area but different terminal, both has efficiency score equal to 1. The differences is that Makassar Port categorized as less efficient due to some slack on the input while UTPM classify as absolute efficient container terminal. Makassar Port has very small throughput less than 10 thousand TEU/year and the capacity almost 1 hundred thousand TEU/year, it's considerably more than sufficient to handle the throughput demand. The container market share in Makassar Port should be neglected since it's very small, possibly occur due to the existence of UTPM which is located in same area but in different management. These phenomena supported by the fact that UTPM have throughput more than 5 hundred thousand TEU/ year and back up by the capacity more than 1 million TEU/year in the term of berth while yard capacity counted more than 3 hundred thousand TEU/year. Thus, by the year of 2023 has to tackle the bottleneck problem since it is the point where the demand has outreaches the capacity. In the term of yard capacity, UTPM should start to plan an investment since it has passed the capacity itself.
Furthermore, Pelindo IV planned to develop Makassar New Port as a part of sea highway project which will targeted to catch container volume around 4.2 million TEU/ year and will be operated in 2018. By the throughput projection, it's known that in 2030 the throughput in UTPM less than 2 million TEUs. Thus, Makassar New Port

could be excessive project which will generate excess capacity since the demand is less than 2 million TEU/year.



Source: Own calculation

Figure 20 Yard and Berth Optimal Capacity of Makassar Port



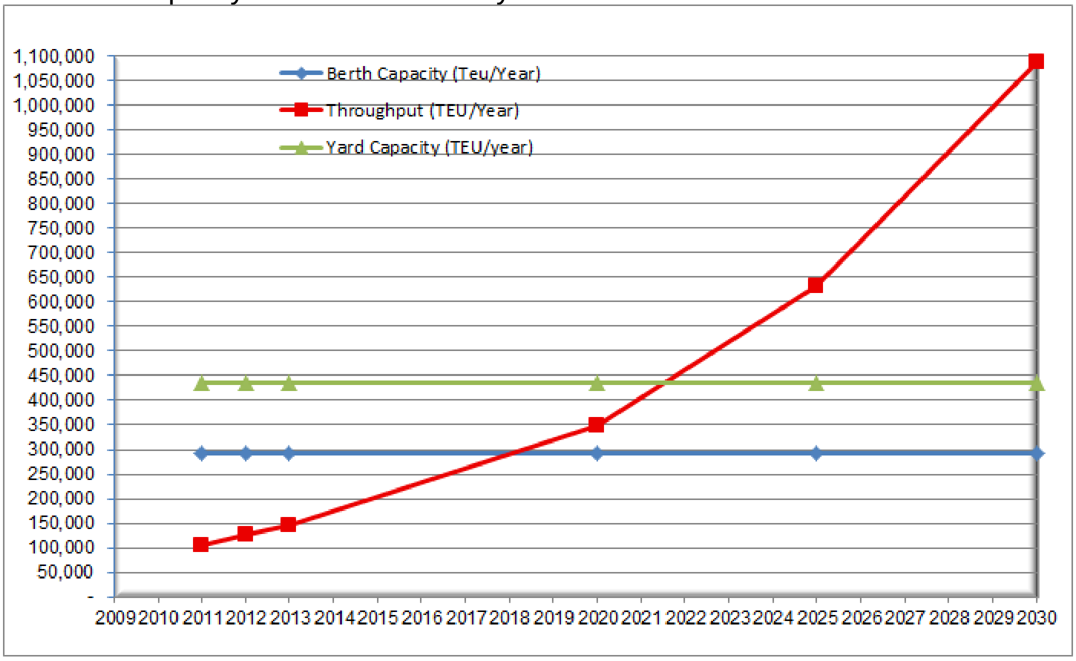
Source: Own calculation

Figure 21 Yard and Berth Optimal Capacity of UTPM

Moreover, Makassar New Port predicted to be operated in 2018 and the throughput demand at that year projected to be less than 1 million TEU/ year. The investment on Makassar New Port will be white elephant investment since the demand is not as big as the supply and UTPM considerably enough to be a path of sea highway. Hence, the appropriate investment is in yard capacity of UTPM since it's already over the optimum capacity. In addition, investment to improve yard capacity is not as costly as investment on new container terminal.

11. Bitung Container Terminal (BCT)

Efficiency performance reach by BCT is 79.48%, 5 inputs should be subtracted namely for maximum draft, berth length, yard stacking index, internal vehicle and gate lane in order for BCT to reach efficient performance. Figure 22 depict the fact that BCT still supply sufficient capacity both for yard and berth. Berth capacity nudges its maximum carrying capacity in 2018 when the demand equal to 3 hundred thousand TEU/ year. In addition, by the year of 2022 yard capacity predicted to burden beyond its carrying capacity since throughput demand almost reach the optimum value of yard capacity around 4.5 hundred thousand TEU/ year.
In addition, management Pelindo IV has taken one step further to develop BCT by 3 phases. First phase estimated to be completed in 2017, encompasses CY expansion by 6.5 Ha and berth extension by 500m. Second phase start in 2018 and planned to be finished in 2022, cover CY expansion by 46.8 Ha and berth extension by 250 meter. The last phase focuses on additional CY expansion and bulk terminal. By demand and capacity analysis it can evaluated that Pelindo IV has conduct almost precise investment. By the year of 2018, throughput has gone beyond berth capacity and it's covered by berth expansion which predicted to be available by 2017. Moreover, since yard capacity able to cover the throughput till 2022, there is no strong reason to expand CY in 2017. This kind of investment should be delay or move to second phase which predicted to finish by 2022, the year when the yard capacity has been exceeded. Deep analysis to evaluate the demand and supply side supported by detail data will perform comprehensive result to determine the additional capacity can be absorbed by the terminal.



Source : Own calculation

Figure 22 Yard and Berth Optimal Capacity of BCT