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Efficiency Analysis of Operational Performance in Container Terminal: A Case Study in BICT Container Terminal, North Sumatera, Indonesia

By

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Acknowledgments

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Abstract

Maritime transportation has become an important role in global trade and economic growth. There is a significant increase in the demand for world trade volume through the sea lane. Therefore, containerization presents innovation in the development of the world maritime industry. Container terminals as a connecting point between the flow of goods from land and sea should innovate and optimize to handle the increase in container handling. Therefore, efficiency is an important factor which determines the competitiveness of the container terminal.

Indonesia is known as the largest archipelagic country in the world with the broadness of the waters territorial and thousands of islands. Thus, it makes the maritime transport very important, where inter-island trade and vessels play an important role in the national economy. Belawan International Container Terminal (BICT) is a container terminal at the Port of Belawan and the third largest container terminal in Indonesia. BICT also called as the Gateway of western Indonesia. The study objective is to analyze the Efficiency of Operational Performance at BICT.

The efficiency measurement analysis in this study uses the DEA analysis with the Stata program and an online questionnaire as an instrument to obtain primary data from respondents. This study conducts DEA Constant Return to Scale (CRS) based on input-oriented measurement of efficiency performance using Stata. There are four variables used as input, namely quay length, quay crane, container yard and yard equipment and throughput as the output variable. The container terminal is called efficient with the provision that the efficiency score of 1 means efficient and less than 1 means inefficient. Online questionnaires are designed using a Likert scale with a sample of 50 respondents. Respondents are senior staff at BICT.

The study revealed that the performance of BICT is identified as inefficient using only 84.9% of the input provided. To achieve the maximum efficiency score, BICT should reduce all inputs by 15.1%. Operational performance efficiency can be increased by reducing three input slacks, namely 154.7 units from QL, 1.7 units from QC and 10,989.6 units from CY. The result is also supported by the responses obtained from respondents who revealed that the performance of BICT is inefficient due to lack of resources utilization.

The findings reveal that sustainable development strategies and business activities for terminal operators are considered very important to accommodate current and future operational needs. This efficiency analysis will help stakeholders in BICT to measure efficiency and establish strategies to improve the efficiency of operational performance at the container terminal. Optimization should be done optimally to enhance terminal competitiveness and market share and eventually will benefit the development of the company.

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List of Abbreviations

AGV	Automated Guided Vehicle
ARTG	Automated Rubber Tyred Gantry
ASC	Automated Straddle Carrier
BICT	Belawan International Container Terminal
BOR	Berth Occupancy Ratio
BCC	Banker, Charnes, and Cooper
CCR	Charnes, Cooper and Rhodes
CRS	Constant Return to Scale
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
GDP	Gross Domestic Product
JICT	Jakarta International Container Terminal
MLWS	Mean Low Water Springs
RTG	Rubber Tyred Gantry
RMG	Rail Mounted Gantry Crane
TEU	Twenty Equivalent Unit
TPKS	Terminal Petikemas Semarang; Semarang Container Terminal
TPK Koja	Terminal Petikemas Koja; Koja Container Terminal
TPS	Terminal Petikemas Surabaya; Surabaya Container Terminal
PT Pelindo	PT Pelabuhan Indonesia; Indonesia Port Corporations
UNCTAD	United Nations Conference on Trade and Development
VRS	Variable Return to Scale
YOR	Yard Occupancy Ratio

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Chapter 1 – Introduction

1.1 Introduction and Background to the Study

Maritime transportation has become an important role in global trade and economic growth. It is shown by more than 90% of world trade in seaborne trade. In 2016, world seaborne trade reached 10.3 billion tonnes, an increase of 2.6%. This growth is in line with the growth of world Gross Domestic Product (GDP), which is 3.6% in line with economic growth in developing countries. Related to the growth of world trade volume through sea lane, maritime transportation demand during 2016 has increased by 3% (UNCTAD, 2017). In line with this increase, container transportation is experiencing very significant growth, due to it has many advantages over other traditional transportation. In 2016, international seaborne trade using containers experienced a very significant growth of 3.1% or reached 140 Million in TEU (UNCTAD, 2017).

Containerization was first introduced in 1965, which aims to reduce the cost of shipping cargo through sea transport and cargo handling costs at ports or terminals (Cooper & Levinson, 2006). The usage of container dramatically reduced the cost of international trade transport (Qianwen, 2010). Reduced transportation costs by using container mean that the handling of goods will be more efficient. Therefore, the container terminals have a vital function, namely as a gateway of economy and trade, the interface points between the flow of goods by sea and land. Container terminal has a strategic function in the country's economic development. Thus, the container terminals will experience several challenges and restructuring, to deal with the increasing flow of goods trade through the sea route by using containers. As a result, container terminals become complex systems part which operates in an uncertain global logistics environment that requires efficiency in terms of operational performance. They are also placing where several port stakeholders provide products and services and create shared value.

Based on data released by the United Nations Conference on Trade and Development (UNCTAD), in 2017 there are 5 countries control the world's voyages, namely Greece, Germany, Japan, Singapore, and China with a market share of 49.5% of cargo carrying capacity (dwt). Container vessels have various advantages in terms of transport, such as sailing time, loading capacity, and loading speed, therefore it can reduce the waiting time of the vessel in the port which will have an impact on the low cost of transportation than other vessel types. The safety level of the goods transported using container vessels are also very good which can prevent damage or loss during shipping. Therefore, the trust level of the shipper and the receiver is higher. On the other hand, container vessels require particular ports or terminals that can serve their loading and unloading activities, and not all ports or terminals can be visited by container vessels. Therefore, the role of container terminals is very important to serve the loading and unloading activities of container vessels.

Indonesia is known as the largest archipelago countries in the world located in Southeast Asia and has a strategic location between the Pacific Ocean and the Indian Ocean. Geographically strategic location between two oceans, making this country at the center of major regional and global trade routes. Furthermore, due to the broadness of the waters territorial and the number of islands, the maritime sector becomes very important, where inter-island trade and connectivity using vessels has an important role in the national and global economy. Therefore, the Indonesian government as one of the developing countries where the origin of exported goods in

America, Europe, and Asia, is trying to provide and build port facilities that capable to serve container vessel. Especially for West Indonesia, Belawan Port is a port that can serve export and import container vessels managed by PT Pelabuhan Indonesia I (Persero) (Pelindo I).

Figure 1: Port of Belawan
Source: Sea Routes, 2018

Currently, Belawan Port is the third largest port in Indonesia and operated under the management of Pelindo I. Belawan Port has strategic location and function as it is in international shipping line in Malacca Strait. Maritime traffic across the Malacca Strait continues to grow each year consistently. Looking closer to Malacca Strait, the transit value in 2017 reached the highest number of 84,456 transits (Seanews, 2018). The number of transits will continue to increase every year. As a feeder port, this increase becomes an opportunity for Port Belawan to capture some of the volume of the container that across the Malacca Strait. Furthermore, the flow of the logistic distribution of export and import goods in Belawan Port will increase every year. It makes the Port of Belawan become the most important port and the economic gateway for western Indonesia.

Belawan International Container Terminal (BICT) is a container terminal at the Port of Belawan and the third largest container terminal in Indonesia after Tanjung Perak, Surabaya and Tanjung Priok, Jakarta. The domestic terminal has the quay length of 350 m and the international terminal quay length of 500 m. In 1987, BICT development was inaugurated by the President of the Republic of Indonesia. Since 2012, the quay length has been added to 400 m at the domestic terminal and 550 m at the international terminal. This addition will make the quay capacity to serve the container vessels, and container loading and unloading activity will be higher. Currently, BICT is the only terminal that provides container handling activities for western Indonesia. On the other hand, the Kuala Tanjung container terminal still in the same province as BICT is still under construction. Therefore, BICT becomes the main choice of port users in using sea transportation services with container facilities. Besides that, it also causes container loading and unloading activities through BICT tend to increase every year.

In 2017, BICT has been serving container loading and unloading activities of 526,039 Teus. And over the last 5 (five) years showed an increase in traffic average of 3.7% per year. Syafaaruddin (2015) revealed that BICT throughput decreased in 2013 due to the inefficiency of Container terminals operational performance. By looking traffic conditions in 2017, there is a gradual increase in throughput from the previous year. Hence, BICT needs to perform the efficiency and optimize the handling performance of container loading and unloading activity to accommodate the growth of container traffic.

With regard to the growth of container traffic and technology innovations in the maritime industry, it requires container terminals to provide the advanced technology in order to confront these developments. The container terminal is also forced to increase terminal efficiency in order to attract more container traffic (Nyema, 2014). It will be a challenge for terminal operators in order to secure traffic flow and prevent the transfer of container loading and unloading activities to other terminals. Therefore, container terminals need to increase speed in handling containers, reducing turnaround time of the vessel, providing adequate equipment, enabling large storage capacity and ensuring integrated inland transportation connections (Castro, 1999).

Container Terminal plays a strategic role in ensuring the smooth flow of containers in-out in a region. Operational efficiency is an essential part of the service. Container terminal efficiency can be reflected from shipping rates charged to shipping companies. The lower turnaround time of the vessel and the container dwelling time will make the shipping cost lower. This condition will provide more attractiveness for container terminal users. The fast performance and efficient services will also enhance the competitiveness of the terminal and provide added value to the company.

Currently, BICT is experiencing an increase in container traffic every year. To manage this increase, BICT is expected to perform the efficiency in its operational activities to prevent overcapacity in the terminal. The high growth of container flows forces BICT to evaluate the productivity and performance efficiency of terminal infrastructure, equipment, facilities and operating systems. Efficiency analysis of operational performance at container terminals is necessary to obtain information on efforts to improve future performance or maintain current efficient performance to attract more vessels to arrive and to maximize container terminal business (Syafaaruddin, 2015). To perform the analysis, it requires input indicators to produce the most efficient level of output from the operational performance of container terminal BICT. By knowing the efficiency of operational performance, BICT is expected in the future to provide maximum service to customers and provide added value for the company. Eventually, this increase will have an impact on national and global economic growth.

1.2 Research Objectives

In conducting the analysis carried out to complete this thesis, the research study attempts to answer the following research question and its respective sub-research questions.

Main Research Question:

What is the efficiency of operational performance at BICT in order to improve productivity, and sustainable development?

Sub-Research Questions:

i. What are the factors affecting the operational performance of the BICT container terminal?
ii. How does the infrastructure influence BICT container terminal efficiency and productivity?
iii. How is sustainable development of BICT container terminal in order to face the development of trade?

1.3 Scope and Research Limitations

The scope of this research focuses on the analysis of the operational efficiency of container terminals operations with case studies on Belawan International Container Terminal (BICT). This study is conducted to obtain measures of efficiency of operational performance at BICT. A descriptive explanation will be discussed in this study about operational performance efficiency, quantitative analysis of the main indicators supporting the expected terminal operational performance efficiency can be presented to investigate whether operational performance at BICT is optimal or not. The measurement of terminal performance is done by using input and output variables as an efficient operational performance indicator in the container terminals. Hence it needs to be limited to the following issues:

1. Research location or study area and data collection only on the scope of Belawan International Container Terminal.
2. This research involves parties who play a role in container terminals operational activities at BICT.
3. Input variables: assessing the performance of quay length, quay crane, container yard, and yard equipment.
4. Output variables: annual throughput value to show container terminals productivity.

1.4 Research Methodology

Methodology Research in a study is a systematic step that is done in the process of collecting data which then followed by analyzing data. Research methodology held in this research is arranged in several stages, beginning with data collection process, data analysis and description of the result of data processing. Discussion on this research is Efficiency Analysis of Operational Performance in Container Terminal.

In order to answer the research questions, this study will examine data related to the characteristics of container terminals, infrastructure, container loading and unloading facilities and other supporting data affecting the performance of container terminals (Onut, Tuzkaya, & Torun, 2011). This study will examine historical data related to Belawan International Container Terminal (BICT) compared to the other three major international terminals in Indonesia as benchmarking namely Terminal Peti Kemas Koja (TPK Koja), Terminal Peti Kemas Semarang (TPKS) and Terminal Petikemas Surabaya (TPS), with throughput as projections. Therefore, the method in this research will use qualitative and quantitative analysis approach. To determine the operational performance of container terminal BICT and how efficiency can be performed will use the Methodology with DEA analysis. Data Envelopment Analysis (DEA) will be conducted by using Stata software which can be used to measure terminal performance efficiency measurements based on input and output variables. The data, formulas, and methods of the literature review to obtain performance indicators will be processed to determine the extent to which operational performance efficiency of BICT has been conducted and how future container terminal development plans will be developed.

Qualitative analysis involves analyzing information in the form of a qualitative data analysis framework which includes several steps such as literature review related to studies, communication with container terminals operators and distributing questionnaires to several stakeholders in the BICT container terminal to measure their responses to several questions related to container terminal performance. Data is collected based on the variables used to study the performance efficiency of container terminals. The data already obtained will be collected and arranged to obtain relationships in accordance with the data categories that will yield strong proportions and conclusions (Saunders, Lewis, & Thornhill, 2016). Qualitative analysis is performed as an indicator to measure the performance of container terminals and quantitative analysis using Data Envelopment Analysis (DEA) to determine the efficiency of container terminal performance. Quantitative analysis using the DEA program will analyze data between equipment utilization, facilities, and throughput of container terminals. The methodology developed in this study can measure the efficiency of container terminals and the elements that affect the efficiency level.

Container terminal operating performance indicators consist of four categories; quay length, quay crane, yard container, and yard equipment. This performance indicator will be used as input to determine the efficiency level of operational performance BICT container terminals. This indicator also serves as an initial condition to show the current efficiency of the container terminal as a basis for the possible analysis of increased production and efficiency by taking into account the terminal capacity as a supply to the resulting output as demand throughput. As the throughput continues to increase, congestion will occur as an indicator to improve efficiency or development of new facilities in the form of investment. A quantitative DEA analysis can be used to take account of the efficiency of container terminals over time (Cullinane et al., 2004). The existence of ease of use, application, and flexibility has become the basis of DEA analysis has been widely used to analyze the efficiency of operational performance (Allen et al., 1997).

1.5 Thesis Structure

The thesis structure consists of five chapters which discuss the different parts of the research carried out. The description of each chapter is shown in the following table:

Table 1: Thesis Research Structure

Chapter Number and Title	Description of Contents
1. Introduction	Chapter 1 provides information on the research background, research objectives and include research questions. Furthermore, the scope and limits of the study will also be briefly explained in this chapter
2. Literature Review	Chapter 2 will discuss the existing data, the literature studies on the definition of container terminals, container terminal operation, and operating performance. In addition, this chapter will also explain the analytical structure used to measure the performance of the container terminal and analyze the operational performance efficiency discusses on the existing data on information that is relevant to this study. This chapter also presents what literature and research have been done in relation to the idea of this thesis and looks at how this existing information may be of use to support this study.
3. Research Methodology	Chapter 3 will explain the methodology used to achieve research objectives, provide an explanation of the data collection process and data analysis methods.
4. Data Processing and Analysis	Chapter 4 will explain the data processing and analysis. This chapter also presents the results of testing of the data obtained using a qualitative and quantitative analysis approach.
5. Conclusions and Recommendations	Chapter 5 is the final step in the preparation of the study which contains the conclusions of the analyzes that have been conducted and suggestions or recommendations for the future on how the study can be used for further research.

Source: Own elaboration

Chapter 2 – Literature Review

2.1 Overview

This chapter will cover the relevant literature on research topics with issues relevant to the operational efficiency of container terminal operations. From several previous studies on the operational efficiency of container terminal operations reviewed for this study. The terms of reference in this study are based on guidelines contained in the problems and objectives of the study. Therefore, this study is considered relevant to review the theoretical studies relating to factors affecting the efficiency of terminal performance. Many theoretical perspectives and models describe the factors affecting operational performance efficiency have been developed for the operational performance of container terminals.

In order to optimize operational costs, shipowners choose ports or terminals taking into account their performance (Tongzon & Sawant, 2007; Tongzon, 2009). There are two main concepts related to terminal operational container performance namely productivity and efficiency. The concept of productivity is defined as the ratio of the size of the output volume to the size of the input volume used. The efficiency concept, aimed at measuring the efficiency of each container terminals unit by considering input and output factors, is supported by container terminals efficiency theory (Budria-Martinez et al., 1999; Gonzalez & Trujillo, 2008). For the purposes of observation in this study, the review will focus on the theoretical aspects of operational performance efficiency in container terminals using Data Envelopment Analysis (DEA). Finally, this study will show the analyzed and hypothesized variables, conceptual framework, empirical review, existing literature responses, findings and research summary.

2.2 Belawan International Container Terminal (BICT)

Port of Belawan serves as Gateway, Interface, and Link for western Indonesia. This port is the third largest port in Indonesia after Tanjung Priok and Tanjung Perak. Port of Belawan is located in the East Sea of Sumatra coast between Belawan River and Deli River. Port of Belawan is a port with the main class level operated under the management of PT. Pelabuhan Indonesia I (Persero).

Geographically Port of Belawan lies in the coordinate position: 3°46'59"N- 98°41'26"E. Port of Belawan is about 27 km from Medan City which is the center of government and economy of North Sumatra. Both are connected by highways, state roads, and railways, including to hinterland areas in the provinces of North Sumatra and Aceh. The port was established in 1890, serves to provide a meeting location to serve the activities of loading and unloading tobacco from rail to ship. Over time, the Port continues to be developed to meet the needs of national and international trade (Wikipedia, 2018). And in 1985 held a major restructuring with the construction of container terminal. The construction of this container terminal was completed and inaugurated in 1987 which is currently Belawan International Container Terminal (BICT). With the construction of this container terminal, Port of Belawan soon captures approximately one-fifth of total container exports in Indonesia.

Figure 2: Belawan International Container Terminal (BICT)
Source: Google Earth, 2018

Water access to Belawan Port has a cruise channel from the Malacca Strait along 13.5 km with a width of 100 m to the port and with the channel depth of - 9.5 MLWS. There is also has a port basin and turning basin for vessels as a maneuvering area during berthing process on the quay wall.

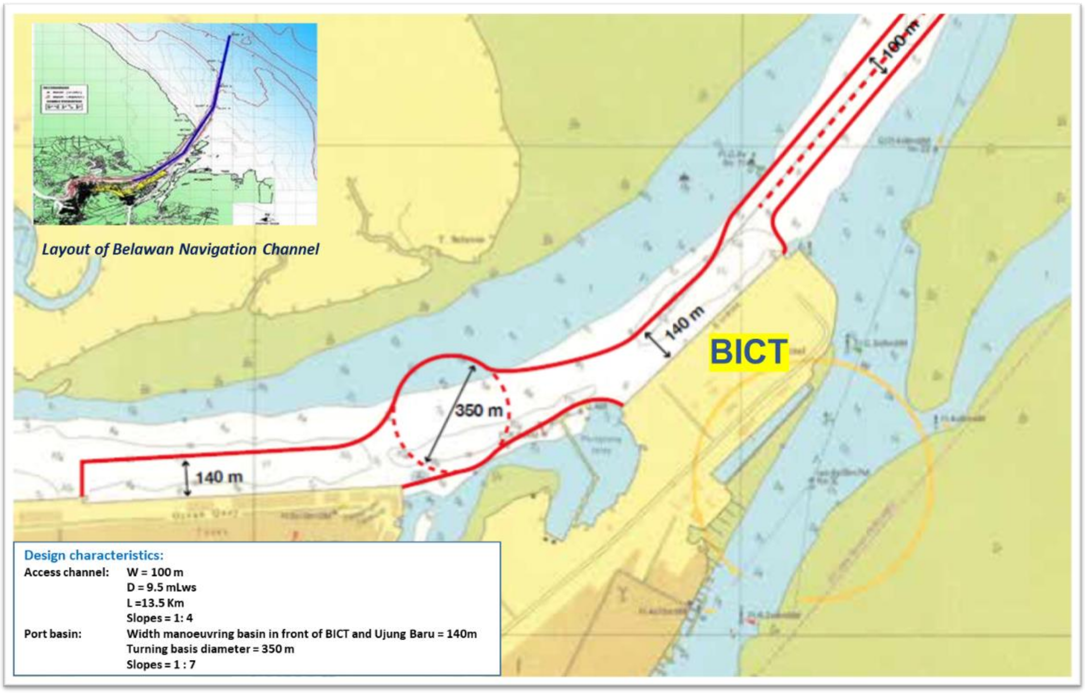

Figure 3: Belawan Navigation Channel
Source: Pelindo I, 2018

BICT container terminal located at Belawan Port in coordinate position: 3°43'00"N - 98°42'08" E. Geographically Belawan port is very strategic because it is located in International Strait Melaka Strait line so that it is directly related to business activities among ASEAN countries. This strategic position provides both market opportunities as well as competition threat from ports around the Strait of Malacca such as Port Klang, Tanjung Pelepas, and Singapore. BICT currently serves container handling activity for both international and domestic containers.

Currently, BICT has berth facilities with total quay length 950 m, separate into two berth functions the international berth with a length of 550 and 400 meters for the domestic berth. The depth of the international berth is - 11.0 MLWS and domestic - 10.0 MLWS that can serve container vessels with a capacity of 2,500 TEUs (fully cellular size). BICT is also equipped with other facilities to support the operation of a proper container terminal. The current international container terminal facilities in BICT can be seen in Table 2 as follows:

Table 2: Container Terminal Facilities

Facility		Volume
1.	Quay Length	550 x 32 m
2.	Depth	10 – 11 MLWS
3.	Container Yard	158,464 m2
4.	Workshop Area	1,452 m2
5.	Reservoir	1,000 m3
6.	Office Building	1,000 m2
7.	Road	72,204 m2

Source: Pelindo I

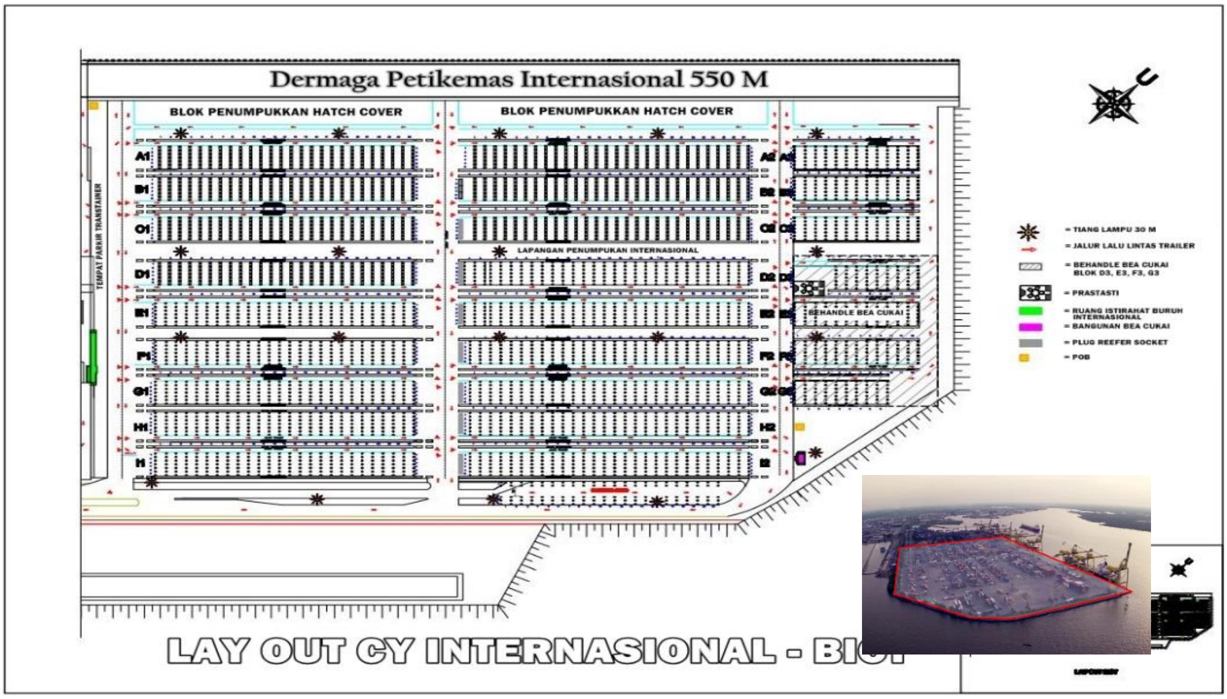

Figure 4: BICT Facility
Source: Pelindo I, 2018

The maximum capacity of facilities and equipment can be achieved if the requirements for the operation are met and in a balanced condition. The composition of the equipment is determined based on the capacity of each facility and equipment which is expected to continue to run without having to be in standby condition long enough. Long standby conditions on the main equipment will bring a bottleneck to the supporting equipment during the execution of a series of activities. The BICT terminal has a capacity of 550,000 TEUs / year, from data obtained by BICT facilities and equipment capacity still showing a balanced condition. Terminal capacity data in BICT as follows:

Table 3: Container Terminal Capacity

Facility		Volume
1.	Quay wall	550 x 32 m
2.	Container yard	158,464 m2
3.	Groundslot	3,342 TEU groundslot (TGS) / 15,726 Teus
4.	Throughput capacity per year	1,132,272 TEU/year
5.	Blocks	25 blocks
6.	Reefer plug	144 points

Source: Pelindo I

The availability and composition of BICT equipment are currently sufficient and balanced to handle (handling) the container according to the capacity of the plan. To support the performance of loading and unloading activities the equipment should be in a ready and reliable condition. Container Crane or quay crane is equipment for the lift on / lift off container on quay and ship, head truck and chassis are used for container shifting activity from quay to stacking area and vice versa (haulage) while RTG, Side Loader, and Reachstacker are equipment for lifting on / lift off or stacking containers in a stacking area. The number of equipment in BICT can be seen in Table 2.2 as follows:

Table 4: Container Terminal Equipments

Equipment		Volume
1.	Container Crane	6 units
2.	RTG	11 units
3.	Reach Staker	2 units
4.	Side Loader	1 unit
5.	Truck	29 units
6.	Reefer Container	106 plugs

Source: Pelindo I

2.3 Terminal Petikemas Koja (TPK Koja)

Terminal Petikemas Koja (TPK Koja) is one of the largest container terminals in Indonesia located in Port of Tanjung Priok, Jakarta. Several container terminals in Indonesia are still fully operational under Pelindo management, while other container terminals have been privatized. TPK Koja is one of the container terminals in Indonesia which is a joint venture company between Indonesia Port Corporations (IPC) or Pelindo II and Hutchinson Port Hong Kong (Tpkkoja, 2018). In 2017, it was the highest achievement in the operational performance of TPK Koja. TPK Koja achieved the total throughput of 1,095 million TEUs exceeding the initial target of throughput 830,531 TEUs in 2017 (Liputan6, 2018). It shows that in 2017 TPK Koja experienced a significant increase in international container traffic by 32.4% from 2016 of 827,198 TEUs.

To support the smooth operation in the terminal, TPK Koja has good container terminal facilities and equipment. TPK Koja is equipped with seven quay cranes along 650-meter of quay wall with the draft of 13 meters and a container yard area of 257,200 m2. Currently, TPK Koja is able to serve container vessels berthing with a capacity of 1,500 - 2,000 TEU. TPK Koja continues to optimize and plan for terminal development to increase service capacity for container traffic which continues to grow every year and ready to serve larger container vessels of fourth-generation.

Details of TPK Koja facilities and equipment are deployed in Appendix 1.

2.4 Terminal Petikemas Semarang (TPKS)

Similar to Belawan International Container Terminal (BICT), Terminal Petikemas Semarang (TPKS) is owned and operated under Pelindo III management. TPKS is located at the Port of Tanjung Emas, Semarang, Central Java. TPKS provides international and domestic container loading and unloading services. However, the traffic of domestic container is smaller than international.

TPKS has a total quay length of 531 meters with a maximum draft of 10 meters. There are six container yard areas with the total area of 195,386 m2. In 2017, TPKS experienced to increase in container throughput of 3.1% or 634,365 TEUs from the 2016 throughput volume of 615,132 TEUs. To serve loading and unloading activities at the terminal, TPKS is equipped with seven quay cranes and 12 RTGs. In 2016, to improve service quality and reduce dwelling time, TPKS increased the capacity of loading and unloading equipment in the container yard, namely 11 units of Automated Rubber Tyred Gantry (ARTG). With the modernization of yard equipment, TPKS is able to reduce dwelling time and accelerate loading and unloading activities.

Details of TPKS facilities and equipment are deployed in Appendix 1.

2.5 Terminal Petikemas Surabaya (TPS)

Similar to the TPK Koja, Terminal Petikemas Surabaya (TPS) is a joint operation of a state-owned company, Pelindo III cooperates with private companies, Dubai Port World (Pelindo, 2018). TPS is the second largest terminal in Indonesia after Jakarta International Container Terminal (JICT). TPS has a very strategic location that is geographically located at Port of Tanjung Perak on the north coast of East Java along the edge of the Madura Strait with the coordinates 7°12'23"S-112°43'41"E. TPS is also called as the Gateway of Eastern Indonesia since it is directly connected to the railway routes and the Surabaya tollway access that connects the terminal to several industrial areas.

TPS provides international and domestic container loading and unloading services. For international container services, a quay is available with the total quay length of 1,000 meters with a maximum draft of 13 meters. For TPS domestic container service, the total quay length is 450 meters with a maximum draft of 8 meters. To reach the maximum depth, TPS has a length of 2 Kilometer trestle that connects the quay with a container yard. On the land side, there is a container yard with the total area of 35 Ha for international and 4.7 Ha for domestic. It makes TPS is able to handle higher container throughput above 1 million TEUs. Hence, in 2017 TPS achieved the total throughput of 1,306,878 TEUs. To optimize the terminal operating performance, TPS is also equipped with enough and reliable loading and unloading equipment.

Details of TPS facilities and equipment are deployed in Appendix 1.

2.6 Hinterland of Belawan Port

Hinterland is a buffer area of a port that serves as the origin of production or industrial centers of goods to be transported by sea transport. Plantations and its derivative industries dominate the hinterland of Belawan Port. Export activities at BICT are agricultural commodities such as rubber, palm oil derivative products, cocoa, tea, coffee and other agricultural / forestry products originating from hinterland in North Sumatra, Nanggroe Aceh Darussalam and Riau. While the main commodities imported are fertilizers, wheat, soybeans, chemicals, and machine components.

2.7 Container Terminal

The terminal definition is an organization that provides a package of goods services from the handling process, storing and controlling cargo from one mode of transportation to other modes of transportation to minimize costs (Saanen & Rijsenbrij, 2018). The container terminal is a facility or place for container vessels to berth and to carry out container loading and unloading activities from different modes of transportation, land and sea transportation (Wikipedia, 2018). In general, container terminals are equipped with several major components, namely terminal infrastructure, container handling equipment, and operational systems. Figure 5 will show the cross section of BICT as follows:

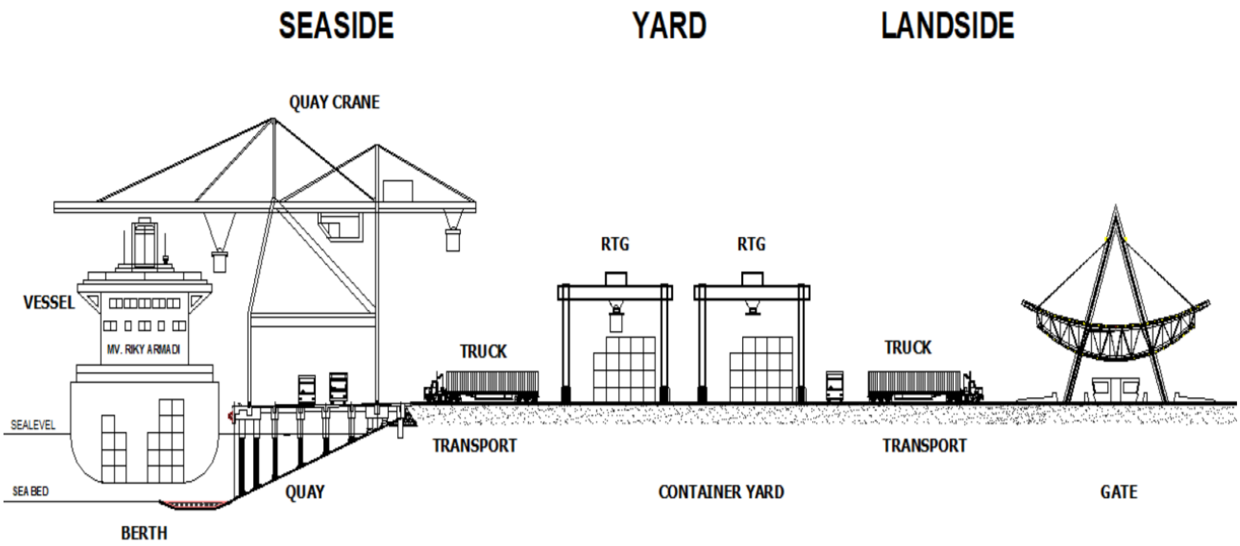

Figure 5: Cross Section View of Belawan International Container Terminal
Source: Own Design

The terminal infrastructure consists of the quay, stacking area, buildings, roads, rails, gates and others. Container handling equipment is a facility to carry out the container handling activities from land transportation to sea transportation and vice versa. Examples of container handling equipment are quay cranes, RTG, trailers, mobile harbor cranes and more. Operational systems include operational procedures, information, and communication technology system and labor. Transportation of goods by sea using containers increases every year. Ease of placement of various goods in one container and loading and unloading activities that can be done by mechanization make container as the primary choice of goods delivery. Thus, the cargo loaded in the container can be transported more easily and quickly.

The terminal as part of the port sub-system has a function as the interface of two types of land and sea transportation modes. In the transport chain, container terminals have two main functions as the transhipment location from mode to container mode and container temporarily (Saanen & Rijsenbrij, 2018). The container terminal activity is serving the loading and unloading activities of the container from sea to land transportation or vice versa. In container loading activities, the container is loaded into a trailer using a ground crane then taken to the quay, then loaded onto the vessel using quay cranes (Ng & Mak, 2005). Speed in performing loading and unloading activities becomes an external value added in container terminals operations. However, this activity is influenced by several factors, as follows:

1. The arrival of ships that are not in accordance with the schedule caused by various factors, such as tidal conditions, weather, engine damage, and others.
2. Delayed loading and unloading activities due to congestion or incomplete documents.
3. Damage of loading and unloading facilities.
4. Overcapacity in the stacking area.

2.8 Container

The container definition is a large, square-shaped box made of steel made with standard weather-resistant dimensions. Container functions for the transport and storage of goods that can be transported in a long distance and can be transferred from one mode of transportation to other transportation easily without having to remove the contents (Kramadibrata, S, 1977). Based on the Customs Convention on Containers 1972, the container is a casket-shaped carriage of goods in which partly or the whole part is closed so that the cargo of goods can fill it. It has a sturdy and permanent shape that can be used to transport goods repeatedly without changing its physical shape. Thus, the transport of goods using a container may allow it to be moved from a vehicle or a mode of transport to another without dismantling the contents first. The containers are made sturdy and strong and equipped with doors that are locked from the outside. All parts of the container including the door are united and cannot be removed or opened from the outside. Standard container sizes can be seen in the following table:

Table 5: Container Terminal Equipments

		20′ container		40′ container		40′ high-cube container		45′ high-cube container	
		imperial	metric	imperial	metric	imperial	metric	imperial	metric
external dimensions	length	19′ 10.5″	6.058 m	40′ 0″	12.192 m	40′ 0″	12.192 m	45′ 0″	13.716 m
	width	8′ 0″	2.438 m	8′ 0″	2.438 m	8′ 0″	2.438 m	8′ 0″	2.438 m
	height	8′ 6″	2.591 m	8′ 6″	2.591 m	9′ 6″	2.896 m	9′ 6″	2.896 m
interior dimensions	length	19′ 3″	5.867 m	39′ 5 45⁄64″	12.032 m	39′ 4″	12.000 m	44′ 4″	13.556 m
	width	7′ 8 19⁄32″	2.352 m	7′ 8 19⁄32″	2.352 m	7′ 7″	2.311 m	7′ 8 19⁄32″	2.352 m
	height	7′ 9 57⁄64″	2.385 m	7′ 9 57⁄64″	2.385 m	8′ 9″	2.650 m	8′ 9 15⁄16″	2.698 m
door aperture	width	7′ 8 ⅛″	2.343 m	7′ 8 ⅛″	2.343 m	7′ 6″	2.280 m	7′ 8 ⅛″	2.343 m
	height	7′ 5 ¾″	2.280 m	7′ 5 ¾″	2.280 m	8′ 5″	2.560 m	8′ 5 49⁄64″	2.585 m
internal volume		1,169 ft³	33.1 m³	2,385 ft³	67.5 m³	2,660 ft³	73.5 m³	3,040 ft³	86.1 m³
maximum gross weight		66,139 lb	30,400 kg	66,139 lb	30,400 kg	68,008 lb	30,848 kg	66,139 lb	30,400 kg
empty weight		4,850 lb	2,200 kg	8,380 lb	3,800 kg	8,598 lb	3,900 kg	10,580 lb	4,800 kg
net load		61,289 lb	28,200 kg	57,759 lb	26,200 kg	58,598 lb	26,580 kg	55,559 lb	25,600 kg

Source: Wikipedia, 2018

2.9 Container Terminal Facility

Container terminals have different characteristics than other conventional terminals or ports. Unlike other ports, this terminal serves only the loading and unloading of container vessels. The terminal is also equipped with facilities and equipment suitable for servicing container handling activities due to container vessels turnaround times are very high for ports or terminals, facilities and equipment for operational activities are very important to maintain loading and unloading speeds. Thus operational performance will become more efficient. Regarding the facilities required for a container terminal as follows:

2.9.1 Quay Wall

The container terminal quay wall is basically had no different from the other Ports, i.e., by using concrete construction and on the quay floor, there is a rail line to place quay cranes that will serve the loading and unloading of containers. There are several forms of quay wall design that is the deck on pile and caisson. This design depends on location, quay capacity and investment for the construction of container terminal.

The difference between the container terminal and the conventional port lies in the length and width of the quay. The container terminals have the larger quay dimensions required for loading and unloading activities and the mobility of the tools on it. Deeper depth design and ability to receive larger loads, as container vessels have a longer size and higher weight compared to other cargo vessels. Likewise, for the design of the dock floor, the larger container cranes that are above the quay required, the higher the bearing capacity of the quay floor.

2.9.2 Container Yard

At the seaside of the container terminal there is a quay wall, and on the ground side, there is a stack of containers that blend into the quay. The stacking area or Container Yard (CY) is required to stack and store the container and as a maneuvering area of the loading and unloading equipment operating on the ground. It also functions as the storage area of empty containers, transhipment, and dangerous cargo. For the efficient use of the container yard, there is a storage period for containers so that a container depot facility is located near the outside of the terminal in order to meet the demand for empty containers.

For the efficiency in handling containers in the container yard, the stacking area of the containers is divided into two blocks as follows:

a. Marshalling Yard Inbound is a block used to accommodate newly disassembled containers from container vessels and will be handled further.
b. Marshalling Yard Outbound is a block to accommodate export containers coming from outside the terminal and then loaded onto a container vessel.

2.9.3 Container Handling Equipment

To support the smooth activities of container loading and unloading at the terminal, particular equipment is needed to handle containers which will be explained as follows:

a. Waterside Equipment

An important function of waterside equipment is to serve the loading and unloading activities of container vessel from the vessel to the quay. The tools required for waterside are as follows:

1. Container Crane

Container handling equipment is on the quayside and permanently mounted using a rail so that it can move along the quay that works for loading and unloading containers and has a considerable range to pick up the container. Container crane or quay crane is the main equipment exposed to the sea that serves the loading and unloading directly from the ship to the land side. This tool has a large size to facilitate accessibility in container handling. The larger the size of the container vessel served the larger the size of the quay crane. When operating this tool takes the container from the stack on the boat and lifts it to a sufficient height, then the crane takes it along the portal from front to back toward the quay floor. The speed of the container crane for loading and unloading container is called Hook Cycle that runs fast enough in the range of approximately 3 to 4 minutes per box. Thus, the productivity of hook cycles in container cranes per hour ranges from 20 to 25 boxes per hour.

Hook Cycle is the time required by the container crane in the process of servicing the loading and unloading of the ship from the time the spreader is attached to the container, then removed and moved to the side of the quay or ship. Hook cycle speed is an indicator to measure container loading and unloading productivity at the terminal.

2. Container Spreader

In its operational activities container cranes require tools to lift and lower containers on loading and unloading activities. This tool is called the container spreader. This tool is rectangular made of a steel frame which is equipped with pins as a lock on all four corners and hung on a steel cable from the container crane. Container spreader has a locking mechanism in every corner that serves to hook and lock the container, so it can be lifted. It is also used in terminal ground equipment such as transtainers, RTGs, straddle carriers, and gantry cranes with construction adapted to their lift capacity.

b. Landside Equipment

On the land side, there is equipment that supports horizontal transport on land to distribute containers to and from other modes of transportation (sea, road, and rail). There are several types of equipment used on landside as follows:

1. Container Truck

Container truck is a container transport vehicle consisting of head truck and chassis where a container is placed on top (Wikipedia, 2018). This tool has a high intermodality because of the ability to maneuver when carrying containers that will facilitate the process of handling the loading and unloading of containers. In addition, this tool has higher security in carrying containers.

2. Reach Stacker

Reach Stacker is a vehicle used to handle intermodal containers in small container terminals or medium-sized ports. Generally, this tool is used for transhipment activities. Reach stacker is able to transport the container at short distances quickly and stack in a certain height, depending on the stack (storage area) access.

3. Straddler Carrier

Straddler carrier is a vehicle commonly used in terminals to move and stack containers from the side of the quay to the land side or the stacking area. This vehicle is a portal and has the ability to pick up, lift and then put the container in place. The way the straddle carrier works is by taking or lifting and carrying the container while straddling the load using a container spreader that functions as a lock when moving the container. This tool has the ability to stack containers up to 4 high (Wikipedia, 2018). The advantage of this vehicle is the ability to load and unload without the support of other loading and unloading equipment such as forklifts and cranes. In several terminals, this tool no longer has a driver, but already operated automatically or called with Automated Straddle Carrier (ASC).

4. Automated Guided Vehicle (AGV)

Automated Guided Vehicle (AGV) is a tool that has the same functionality and capability as a container truck. However, this tool has advantages because it can be operated automatically. This tool is widely used in container terminals that already use the automation system in container handling activities.

c. Container Stacking Yard

1. Rubber Tyred Gantry (RTG)

Rubber Tyred Gantry (RTG) is equipment which is used in intermodal operations in the container stacking area of container terminal (Wikipedia, 2018). This equipment has the ability to move within the stacking area that manages the stack of containers by raising or lowering the container from and to the top of the trailer or in accordance with the location of container placement according to block, slot, row, and tier.

2. Rail Mounted Gantry Crane (RMG)

Rail Mounted Gantry Crane (RMG) has the same function as RTG. However, this tool operates on different rails with RTGs that still use rubber tire. This equipment has the ability to stack container higher than RTG which reaches 8 containers high and has a longer span. This tool also has been using the electric power source for its operation and can be operated manually, semi-automatic and automatic.

3. Container Forklift

Container Forklift is a tool that can move and have a fork that is used to raise or lower the cargo or container in the area of the stacking area. This tool is used to lift and move the container at close range. This tool is generally used to load containers onto the trailer and stack containers in a narrow area because it has high maneuverability.

4. Side Loader

This vehicle has the same function as the Forklift, but the way it works is by lifting and lowering the Container from the side rather than from the front. Side Loaders are used to raise and lower the containers from and to the top of trailers or chassis.

d. Intermodal

The side of this terminal is the interface between the terminal and the rail network. This section links the loading and unloading activity of goods from train to land and vice versa. The tools used for this activity are as follows:

- Intermodal Container Cranes

This tool has capabilities that are not much different from RTG and RMG. Generally, the tool used has the same specifications as RMG. However, this tool is used for intermodal activity that serves to load and unload the container from road transport to train and vice versa.

2.10 Container Terminal Operational Performance

The operational activities of container terminals are to serve the container vessels berth and handle the loading and unloading activities of the container. The container terminal operational activities are to provide services to transfer cargo/containers between modes of transport and provide services to handle and control the loading and unloading of containers from vessels on the seaside to the landside and vice versa (Mpogolo, 2013). As a facility that encourages the acceleration of logistics and supply chain flow, terminal performance becomes important to improve efficiency and productivity continuously. The main activities in container terminal operations include operations for ship services, congestion, intermodal and gateway (Koh & Ng, 1994).

Regarding operations to serve the vessels while berthing, the container terminals have the main facility called quay equipped with quay crane to handle cargo/container from container vessels to quay. Planning for vessels arrival schedules and berth space allocation are the key to reduce the turnaround time of vessels while berthing because the container vessels have a high turnaround time.

Besides of berth service, cargo/container will be transferred using landside equipment to the stacking area. In the container yard, particular areas are provided to stack containers that are differentiated by cargo type, export-import, empty container, reefer container, transhipment and dangerous goods. There are several terminals that use warehouse facilities to load and unload cargo/containers or for additional logistics services. For inland services, there are truck and railway operating areas that have connections that connect the terminal to the land transportation system outside the terminal. Some terminals in the world have additional facilities that integrate deep-sea terminals with short-sea terminals or inland transportation systems.

Some ports in the world prefer to increase their productivity in order to anticipate the increasing volume of cargo/container in the future. This is important, given that the capacity of a terminal is heavily dependent on facilities and equipment to serve container loading/unloading activities. If the volume handled exceeds capacity, it will result in terminal jamming and inefficiencies that can result in terminal losses. This condition can be handled by the efficiency of terminal operational performance or investment for terminal infrastructure development.

2.11 Efficiency of Operational Performance in Container Terminal

The operational performance of the port terminals is generally measured from the speed in handling the loading/unloading of the cargo/container from the vessel to the stacking area which is subsequently taken out of the terminal gate, and so is the reverse process. From several port studies, the number of tonnes or containers per year is used as the main indicator to measure the operational performance of container terminals (Garcia-Alonso & Martin-Bofarull, 2007; Song & Yeo, 2004; Tovar & Trujillo, 2007). The variables which are used to measure the operational performance of the container terminals consider the container volume handled by the terminal in the TEU (twenty-foot equivalent unit) (Cheon, Dowall, & Song, 2010). Terminal performance can also be measured through efficiency in land use, terminal equipment and labor (Dowd & Leschine, 2001).

As a cargo shifting facility from land and sea transportation, efficiency is an important factor in container terminal operations, especially in the use of limited resources (Wang, Song, & Cullinane, 2002). For terminal operators, the main objective in terms of performance efficiency is to lower or stabilize costs in container handling per unit to maximize profits (Dowd & Leschine, 2001). In the short run, operational performance efficiency provides benefits for container terminals to enhance their ability to attract customers by offering competitive prices with optimal service.

Meanwhile, the long-term operational efficiency is needed to ensure the return of costs associated with investment in the development of container terminal (Wang & Cullinane, 2006). Efficiency also plays a role in encouraging regional development due to competition between ports (Merk & Dang, 2012). Therefore, the container terminals consider it important to make efficiency in its productivity.

The performance of container terminals has a complex structure composed of different variables, infrastructure and operational systems that exist in the terminal (Monteiro, 2015). There are two main concepts related to performance, namely efficiency and productivity in container terminals operational activities (Qianwen, 2010). The formula for measuring terminal productivity is measured in variable form as an example of the use of the number of resources required to perform certain service activities within a certain time to obtain operating performance efficiency. Therefore, the efficiency level can represent how fast the cargo/container can be handled and how fast the turnaround time of the ship is in the terminal.

The characteristics of the terminal strongly influence the performance of the container terminal. From several other studies, three factors were obtained to measure operational efficiency of container terminal operations; the first is customer satisfaction, the second is the efficiency and productivity of the port, and the third is the terminal activity that shows the smooth flow of container traffic in the terminal (Mpogolo, 2013). The higher throughput of the container in a terminal, the higher the efficiency level of the container terminals (Monteiro, 2015). Several other studies mention there are several complex factors that determine the success of container terminal performance. Factors that determine success include the company's ability to manage terminals, terminal productivity, terminal handling equipment, consumption forecasts, terminal accessibility, ship delivery services, supply chain and logistics integration, and land transportation networks (Tongzon & Heng, 2005).

Timeliness in cargo shipments is a major consideration for the owners and shippers of goods caused by the industrial sector requiring the product to be transferred to the market on time (UNCTAD, 2017). Therefore, terminal operators have an important role to ensure the smooth flow of logistics and supply chain with fast and efficient service; it can be described by the turnaround time of the ship and low dwelling time. (Tongzon, 2002). The higher the operational efficiency level of the container terminal, the more terminal users will choose the terminal for their logistic process needs; thus, the container terminal will gain more profit and market share (Tongzon & Heng, 2005).

2.12 Indicators of Efficiency Performance Measurement

Terminal operational performance can be used as a source of information to determine the level of terminal services to terminal users (Triatmodjo, 2009). Indicators for determining efficiency are applied based on the size and type of container terminals operations. The performance indicators based on container terminal types are determined by the terminal location and the surrounding economic conditions (Saanen, 2004). Performance indicators of the terminal are divided into four categories namely; ship operations, cargo handling, warehousing, and ground transportation. From these indicators, we can obtain information on the need to improve facilities or make new investments for terminal development (Mpogolo, 2013). Operational performance at the port is measured by the handling speed of loading/unloading cargo/container from ship to terminal. High terminal performance indicates that the terminal is able to provide good service to its users.

The function of performance measurement is to be able to evaluate the efficiency level of the production process at initial condition and during terminal activity. Performance measurement becomes an information source to provide recommendations for the steps or strategies needed to achieve better performance. Generally, port performance is evaluated with productivity in cargo handling at the quay and compares the realization of throughput with a business plan for operational activity over a period of time (Cullinane et al., 2004). Several studies have revealed that terminal performance evaluation consists of several variables. Terminal performance can illustrate terminal level efficiency, reliability, infrastructure conditions and cargo handling costs (Tongzon, 2004). Performance evaluation can also be done by comparing actual throughput with optimal throughput (Talley, 2006). The use of throughput as an indicator to determine terminal performance has been widely used. To find out the competitiveness of the container terminal to face the competition of container terminal business several indicators should be considered: efficiency, ship visits, terminal location, infrastructure, terminal costs and speed in responding to customers (Tongzon, 2002).

The performance indicators of UNCTAD terminals (1976) reveal two categories used as performance indicators for terminals, namely financial and operational indicators shown in the table as follows:

Table 6: Performance Indicator

Financial Indicator	Operational Indicator
Tonnage works	Arrival rate
Berth occupancy revenue per ton of cargo	Waiting time
Cargo handling revenue per ton of cargo	Service time
Labor expenditure	Turn-around time
Capital equipment expenditure per ton of cargo	Tonnage per ship
Contribution per ton of cargo	Fraction of time berthed ships worked
Total contribution	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

Bichou & Gray (2004) revealed that port efficiency consists of three categories of indicators, physical indicators, productivity, and economy. Physical indicators used for efficiency analysis are indicators that have a relationship with measuring the time of the vessel during berthing such as ship waiting time, turnaround time, berth occupancy rate, service time and dwell time (Bichou & Gray, 2004). Productivity indicators in measuring performance efficiency have relation with the labor involved in terminal operational activities and operational costs incurred in service and handling of goods or containers (Syafaaruddin, 2015). Furthermore, economic indicators focus on total expenditure and revenue from the operational side of the port (Bichou & Gray, 2004).

Kasyfi & Shah (2007) revealed that productivity indicators serve as a basic indicator used to measure the efficiency level of the container terminal operating performance. Descriptions of productivity indicators applied in their research are as follows:

Table 7: Performance Indicator

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 Turnaround Time	Truck cycle time in terminal
	Gate Throughput	Container per hour per lane

Source: Kasypi & Shah, 2007

From another study, Chung (2005) revealed that port performance as a combination of terminal operational performance such as ship speed, cargo handling time and cargo rates for optimization in asset utilization and financial performance. The indicators used in the study are shown in the table as follows:

Table 8: Port Performance Indicator

No	Indicators
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: UNCTAD, 1976

In carrying out its operational activities, Belawan International Container Terminal has an indicator that is used to assess terminal performance. Key Performance Indicator (KPI) at Belawan International Container Terminal is as follows:

Table 9: Key Performance Indicator at BICT

No	Key Performance Indicator (KPI)
1	Container Loading / Unloading Productivity (B/S/H)
2	Level of Berthing Effectiveness (ET/BT)
3	Container Dwelling Time - Import (Day)
4	Readiness of loading and unloading Equipment (%)
5	SeaPort Capacity Utilization Rate / Yard Occupancy Ratio (YOR) (%)
6	Container Productivity (TEUs)

Source: Pelindo I, 2018

The operational performance of container terminals cannot depend only on productivity factors since the terminal function is the provider of services for vessels, cargo, and connectivity by inland transportation (Cullinane et al., 2004). The benefit of defining the port or terminal performance indicators is to evaluate port performance by comparing performance indicators at actual and optimum conditions (Syafaaruddin, 2015). In line with economic aspects, port or terminal management can control variables which are referred to as a port or terminal performance indicators to optimize operating objectives and targets. To maximize organizational benefits, port or terminal management must choose the value of the variable that provides the maximum gain for the port or terminal. Thus, the values in that variable will be used as a benchmark indicator.

2.13 Sustainable Development

Ports or terminals play a key role in the maritime transport industry by integrating land and sea transportation systems. Ports or terminals also serve as trade gateway and supply chains by bringing goods and services to everyone around the world (Mpogolo, 2013). As the key to regional economic growth and job opening, sustainable development of the terminal becomes an important factor in terminal operational activities. Sustainability in terminal operations becomes a critical issue involving socio-economic and environmental factors.

Sustainable development is a development that is held in order to meet current needs and also for future generations. The sustainability of a terminal can also be defined as a situation in which the terminal must meet its own needs for the present and the future without compromising the needs of future generations (Abbott, 2008). Therefore, for sustainability terminals, it suggests a strategy to meet the operational needs of current and future terminals and to meet the needs of the company and its shareholders. On the other hand, this strategy also has the purpose of protecting natural resources and humanity (Hiranandani, 2012). This means the terminals must balance their roles, trade and transport facilitators and all the communities in their environment (Goulielmos 2000).

To achieve operational and sustainable development of the terminal becomes a complex issue to be solved involving complex organizational structures. Hence the need for collaboration between stakeholders, government, community members and parties involved in ports or terminals to achieve sustainable operations at ports or terminals (Kang & Kim, 2017). The expected result of this collaboration is the increased efficiency and competitiveness of the terminal. On the same side, the concept of sustainability in terminal operations combines the four main perspectives that serve as a unified operating strategy plan as follows:

1. Economic Perspective in terms of return on investment capital, efficiency in the use of facilities and tools, optimization of land use and provision of new facilities to maximize operational performance (Oecd, 2018)
2. The competitive perspective serves to ensure the capability to improve the operational performance and terminal business to remain competitive in the increasingly sophisticated terminal competition (Cheon & Deakin, 2010)
3. The social environment which has a direct contribution to employment, scientific development, environmental development in the area around the port or terminal and members of the community (Cheon & Deakin, 2010).
4. Management of environmental conditions related to the terminal activity (Oecd, 2018)

Strategy and business activities at the terminal operator are deemed necessary to accommodate the operational needs of the terminal at present and in the future. These strategies include efficiency of operational performance, safety, and security in terminals, environmental management systems, improvement of terminal facilities, cooperation, technology and communications. Therefore, success in achieving sustainable development, terminals need to regulate the balance between land, facility, equipment, labor, and technology applied to operational activities and terminal business that will ultimately provide added value to the terminal and regional economic growth (Low, Lam, & Tang, 2009; Wang, & Cheng, 2010). Development planning and efficiency in port operational performance will benefit the ongoing development of terminals that will enhance business competitiveness, innovation and market share (Tan, Shen, & Yao, 2011). Thus, integrating all ongoing activities within the terminal and in the area around the terminal is part of the goal of becoming an efficient and sustainable terminal operator.

2.14 Theoretical Analysis

2.14.1 Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) is a programming application or mathematical calculation methodology used to analyze and estimate productivity efficiency in a unit. Basically, DEA is a non-parametric approach of linear programming techniques to measure the relative performance of organizational units (Deazone, 2018). Roll & Hayuth (1993) was the first to apply Data Envelopment Analysis (DEA) in the port industry to measure port efficiency and performance. They assume that the port is a service organization that has a complex structure. With the complexity being the factor affecting the efficiency of port performance. This complexity then becomes a difficult factor in determining the level of efficiency and the extent to which port or terminal resources have been fully utilized to achieve the target. Roll & Hayuth (1993) revealed that DEA is one of the most suitable tools for measuring port or terminal performance efficiency. From the research conducted shows that DEA can show the relationship between input and output in terms of performance efficiency and able to show the potential for improvement and efficiency improvement.

Valentine & Gray (2002) revealed that the DEA method is very useful for testing the efficiency of ports or terminals. Testing using this method was applied in his research at the time of efficiency testing of 31 ports in Europe and North America that used inputs such as total berth length and berth length for container and output using total throughput containers. Emperor et al. (2006) conducted research to analyze port productivity also by using DEA method. This study assumes that container terminals depend on the use of information technology and equipment and with competition between container terminals, the main purpose of their research is to minimize the use of inputs such as the total length of the berth and the number of gantry cranes and to maximize the output value of container throughput.

Applications in the DEA method work by identifying the units to be evaluated which consist of the Decision-Making Unit (DMU) determination, followed by determining input and output variables. The input contains the required data, while the output is the result of the analysis of the data. DEA will compare input and output data from DMU with other input and output data on similar DMUs. Then form the efficiency of the available data to calculate the efficiency value of the inefficient units then determine the efficiency targets for the unit to be more efficient. This comparison is made to obtain efficiency value.

Figure 6: DMU Production Process
Source: Kim And Harris, 2008

Productivity and efficiency are important in performance evaluation. Wang et al. (2005) revealed the DMU productivity as the ratio of the relationship between output and input, and efficiency as a comparison value. Performance evaluation is an important tool used for organizational development. The evaluation conducted aims to improve the efficiency level in the operating system and can define the company's strategy for current and future conditions, in the context of achieving and maximizing the results obtained.

2.14.2 DEA for Container Terminal Operational Performance

DEA analysis is applied by measuring the level of efficiency of the decision-making unit by comparing the best results available in the sample to obtain a comparison of production efficiency. Cooper & Rhodes (1978) revealed that the DEA methodology as a mathematical model application program was applied to observe data that has relationships such as production function and production efficiency. DEA methodology was initiated and developed by Edward Rodes who used this method to complete his thesis to obtain a doctorate under the supervision of WW Cooper in 1978 (Monteiro, 2015). Charnes, Cooper & Rhodes (1978) define the DEA methodology as a mathematical program applied to observational data to derive empirical estimations of relationships-between production functions and possible efficiency in production. This methodology analyzes the optimal combination of input and output. The use of DEA can also be used to generate subjective measurements in operational efficiency, comparing them to each other through sample units which then form the performance curve as a result of observation.

Cullinane et al. (2004) exposed DEA as a non-parametric linear programming methodology to measure and evaluate the relative efficiency of decision-making units (DMUs), by determining inputs and outputs as production factors to assess the efficiency. Talley (2006) also applied DEA as a non-parametric mathematical programming technique to obtain relative efficiency for DMUs for multiple ports. The number of container throughput determines the DMU value in this study. The DEA methodology aims to analyze the optimal combination of inputs and outputs, based on performance on decision-making units (DMUs).

Data Envelopment Analysis (DEA) has two types of approaches CCR and BCC Model, shown in figure 7. The CCR model was first developed by Charnes, Cooper, and Rhodes (CCR) in 1978. CCR allows for the assessment of the relative efficiency of DMUs by providing a measure of productivity and pointing to efficiency indicators based on the constant return to scale (CRS). This is done by measuring the ratio of the number of outputs to the number of inputs (Kasypi & Shah, 2007). Kasypi & Shah (2007) revealed that the weights of the two input and output variables can be optimized to maximize the relative efficiency score of the DMU provided that no DMU has a relative efficiency score of more than one. Figure 7 (a) a set of DMUs is classified with the DEA-CCR model, where point C denotes the value considered efficient.

The DEA approach with the BCC model (variable returns to scale) is the result of the development of the CCR model developed by Banker, Charnes, and Cooper (BCC) in 1984. The BCC model allows that decision-making units are evaluated to identify increased return to scale (IRS) and decline return-to-scale (DRS) or constant which is then called Variable Return to Scale (VRS) (Kasypi & Shah, 2007). In figure 7 (b) shows the DEA-BCC model, where points A, C, and F indicate values considered efficient. Based on the observed performance of each DMU, the combination of output and input will form the limits of efficiency and determine the degree of relativity and efficiency. The expected result, DMU on the curve is an efficient DMU in distributing inputs and generating output. Meanwhile, DMUs that are outside the curve are considered inefficient.

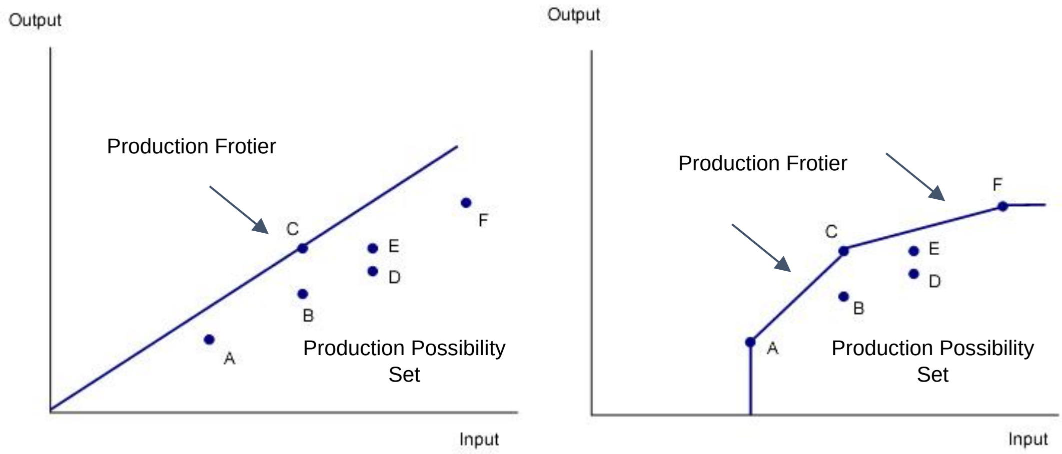

Figure 7: Production Frontiers Curve Example (A) DEA-CCR Model (B) DEA-BCC Model
Source: Kim And Harris, 2008

Cullinane et al. (2004) in the study reveals an evaluation of the efficiency rate of major container seaports in the world over time using DEA window analysis using cross-sectional data and panel data. In addition, Min and Park (2005) used the same method to evaluate the performance efficiency of 11 container terminals within four years. The applied DEA window analysis makes it possible to observe the efficiency of container terminals over time.

Cullinane & Wang (2006) revealed a significant inefficiency from a study of 69 container terminals in Europe using the DEA cross-sectional method. Research conducted proves that the average efficiency of container terminals located in different locations or regions, both for large and small. The input used is the terminal length, equipment, and size of the terminal area while the output uses container throughput.

From the above explanation, DEA explained that the efficiency could be calculated by measuring the ratio of the actual number of inputs to the actual number of outputs of DMU, where efficiency is part and sourced from productivity (Kasypi & Shah, 2007). Furthermore, the following equation will show the terms of productivity and efficiency.

$$Performance(Efficiency, Productivity) = \frac{Output}{Input}$$

Equation 1

Equation 1 and Equation 2 apply only for simple data evaluation. For more complex measurements, the solution in measurement will involve some inputs and outputs converted by the weight cost approach as shown in equation 3 (Kasypi & Shah, 2007).

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

Equation 2

Assumed that all weights are uniform, in mathematical equations, it can be written as follows:

$$Efficiency = \frac{\sum_{r=1}^{n} \mathrm{u_r y_r}}{\sum_{i=1}^{n} \mathrm{v_i x_i}} = \frac{\mathrm{u_1 y_1 + u_2 y_2 + \ldots + u_n y_n}}{v_1 \mathrm{x_1} + v_1 \mathrm{x_1} + \ldots + v_n \mathrm{x_n}}$$

Equation 3

Where:

y_r = quantity of output *r*

u_r = weight attached to output *r*

x_i = quantity of input *i*

v_i = weight attached to input *i*

Efficiency indicator will be obtained if the efficient result is equal to 1. Hence the efficiency unit is set as 0 < efficiency <1.

2.14.3 DEA Linear Programming and Modelling

The productivity of a company can be measured by comparing the actual volume of production with production frontier. With the DEA method, we can create value for an efficient DMU to know and indicate the level of each inefficient DMU. Currently, DEA programs are media or program applications used to measure the level of decision-making units (DMU). According to Mokhtar (2013), constant measurement of constant return to scale (CRS) model is obtained with N linear programming issue under Charnes et.al.1978 as follows:

$$Min_{\psi\lambda} \psi_j$$

$$\sum_{i=1}^{N} \lambda_i y_{ri} \geq y_j; \qquad r = 1, \ldots, R$$

$$\sum_{i=1}^{N} \lambda_i x_{si} \geq \psi_j x_j; \quad s = 1, \ldots, S$$

$$\lambda_i \geq 0; \quad \forall i$$

Equation 4

Where:

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

$x_i = x_{1i}, x_{2i}, \ldots, x_{Si}$ is the input vector

To solve the above equation, we get the value of N from the samples from each terminal for weight N then the optimal solution N will be found. Each optimum solution is an efficiency indicator for the container terminal ψ^*j and with the determination of $\psi^*j \leq 1$. Thus, it can be determined that container terminals with values ψ^*j <1 are considered inefficient container terminals, and container terminals with $\psi^*j = 1$ are considered terminals efficient container. Charnes et al. (1978) revealed that the constant returns to scale (CRS) model modified further by Banker et al. in 1984 by adding the additional constraint $\sum_{i=1}^{N} ë_i = 1$, which then resulted as variable return to scale (VRS). The model modified as follows:

$$Min_{\vartheta\lambda}\vartheta_j$$

$$\sum_{i=1}^{N} \lambda_i y_{ri} \geq y_j; \qquad r = 1, \dots, R$$

$$\sum_{i=1}^{N} \lambda_i x_{si} \geq \psi_j x_j; \quad s = 1, \dots, S$$

$$\sum_{i=1}^{N} \lambda_i = 1; \; \lambda_i \geq 0; \; \forall i$$

Equation 5

Charnes et al. (1978) through the DEA-CCR model can find an overall efficiency evaluation to identify relative efficiency and identify resources that then estimate the number of identified inefficiencies. The DEA-CCR model is then called a return to scale (CRS). Banker et al. (1984) reveal DEA-BCC by adding restriction $\sum_{i=1}^{N} ë_i = 1$ capable of distinguishing between technical inefficiency and given scale from the operation. DEA-BCC model is then called the variable return to scale (VRS). In conclusion, for the DEA-CCR model, efficient DMUs are called efficient and economically efficient, while for the DEA-BCC model, efficient DMUs can be categorized as efficient which are technically only technically efficient (Mokhtar & Shah, 2013).

In terms of measuring the efficiency of terminal performance has many studies conducted. Studies undertook concentrate on production efficiency at the terminal level (Wang et al., 2002). The research was conducted by using DEA-CCR model or DEA-BCC model by utilizing some input variables as examples of quay length, quay crane and container yard and with output variable that is throughput container. However, other studies indicate the need for more input variables with the restriction of asset use as inputs to obtain identical ratios (R. Gray & V.F. Valentine, 2000).

in using the DEA-CCR method or DEA-BCC model, two model orientations are the orientation on input and output. Mokhtar (2013), measured terminal efficiency and container movement of 6 major container terminals in the Malaysian Peninsular exploitation panel data from 2003 to 2010 using DEA-CCR and DEA-BCC. The orientation of the model used in the research is to use an output-oriented model. Mokhtar (2013) tries to develop DEAs that use relatively new inputs compared to previous studies. Using input variables are the terminal area, draft, quay length, quay crane index, stacking yard index, vehicle and gate path number and exploit output with throughput value. DEA-CCR is considered to be more comprehensive because it handles scale and technical efficiency while DEA-BCC focuses only on technical efficiency (Syafaaruddin, 2015). The main results obtained from the study indicate that there is no substantial relationship between the size of the container yard and the efficiency. Hence, the efficiency cannot be determined only from the size of the terminal but also on the allocation of resources that exist at the terminal.

In terms of measuring the efficiency of terminal performance has many studies conducted. Studies undertook concentrate on production efficiency at the terminal level (Wang et al., 2002). The study is conducted by using DEA-CCR model by utilizing some input variables as examples of quay length, quay crane and container yard and with output variable that is throughput container. However, other studies indicate the need for more input variables with the restriction of asset use as inputs to obtain identical ratios (R. Gray & V.F. Valentine, 2000).

DEA model types (Cooper et al., 2004)

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

Figure 8: DEA Model Types
Source: Sharma and Yu, 2009

From figure 8, there are two orientation models while using DEA: input and output orientation. Mokhtar (2013), measured terminal efficiency and container movement of 6 major container terminals in the Malaysian Peninsular exploitation panel data from 2003 to 2010 using DEA-CCR and DEA-BCC. The orientation of the model used in the research is to use an output-oriented model. Mokhtar (2013) tries to develop DEAs that use relatively new inputs compared to previous studies. Using input variables are the terminal area, draft, quay length, quay crane index, stacking yard index, vehicle and gate lane number and exploit output with throughput value. DEA-CCR is considered to be more comprehensive because it handles scale and technical efficiency while DEA-BCC focuses only on technical efficiency (Syafaaruddin, 2015). The main results obtained from the study indicate that there is no substantial relationship between the size of the container yard and the efficiency. Hence, the efficiency cannot be determined only by the size of the terminal but also on the allocation of resources that exist at the terminal.

2.14.3 DEA Applications for Benchmarking Container Terminal

DEA analysis has been widely used in evaluating performance for various types of activities or operations. In its the application, this method is conducted to determine the level of efficiency by using benchmarking towards companies or organizations. Efficiency score is determined by the ratio between the output and input weights as shown in the equation 1. Input variables are defined from all the resources utilized for activities/operations which called as input or production factors while the output variable is the result of input. To evaluate the productivity or efficiency of operations at the terminal is conducted by considering multiple outputs and inputs related to terminal production characteristics. Both variables need to be taken into account to obtain an efficiency score.

The frontier statistical model is used as a model to evaluate the performance efficiency of a terminal or DMU, where throughput as an output and utilization of terminal resources as input (Talley, 2006). In this study, the terminal is called Decision Making Units (DMU). As explained above about performance indicators, terminal performance cannot rely only on a single productivity factor because the terminal does not only function as connecting facility of land and sea transportation of goods/containers but also as berth facility and container handling (Cullinane et al., 2004). Thus, Data Envelopment Analysis (DEA) is used to analyze terminal performance involving several input variables and outputs in the calculation.

Performance indicators that determine the level of efficiency are evaluated by comparing the performance of several terminals as benchmarking. Benchmarking is a measuring tool or activity used to compare the performance of several activities which have the same function to determine the performance with the best value or results (Rankine, 2013). It requires a value as factors to analyze and measure terminal performance. Performance efficiency can be identified by the efficiency score obtained from a comparison of among competitors.

Benchmarking on a terminal is determined by the following factors:

1. Type of trade and size of the container terminal
2. Terminal characteristics which include terminal shape, linkage, navigation, hinterland, and inland transport network
3. Measurement of resource utilization such as labor productivity, service levels, and capital.

This research is conducted with an approach using qualitative and quantitative analysis methods. Quantitative analysis is held to analyze the efficiency of terminal operating performance using throughput as a productivity or output target and resource utilization as input. This study will perform DEA analysis as a method for benchmarking container terminals. Qualitative Analysis is used to measure the efficiency achieved by a literature review of academic journals and articles from various sources that are in line with this study.

From the explanation of the two basic models of DEA namely DEA-CCR and DEA-BCC which these models are commonly used to measure efficiency oriented to Constant Return to Scale (CRS) and Variable Return to Scale (VRS) (Sharma & Yu, 2009). This study uses a CRS model by applying an input-oriented DEA-CCR model as a measurement of the number of terminals or DMU by minimizing input to satisfy the level of output since the DEA always measures the weighted output to the weighted input. Thus, obtained efficiency scores ranging from 0 to 1. With the provision of a value of 1 means efficient and less than 1 means inefficient. DEA analysis is conducted by using the Stata program to analyze the performance of container terminal efficiency with a frontier statistical model which is used as a model to evaluate the efficiency of multi-terminal operating performance where throughput as output and use of resources as input (Talley, 2006).

Chapter 3 – Research Methodology

3.1 Research Framework and Design

This study will describe the analysis of potential factors affecting the performance and productivity of container terminals. The methodology framework describes the methods applied in the study. Consider that the performance of container terminals has different levels depending on the characteristics of the terminals. Thus, to be able to measure the operational performance of a terminal requires different input variables according to the characteristics of the terminal.

In this section will explain the process of how the research is done. The descriptive survey design is conducted to analyze the factors that affect the operational efficiency of Container terminals operation. The method of this research applies qualitative and quantitative methods, where qualitative analysis aims to examine information in the form of an analysis framework of factors that influence the efficiency of the terminal conducted with the literature review of studies related to the research. Meanwhile, quantitative analysis to analyze the data between the utilization of equipment, facilities, and throughput of container terminals. The methodology developed in this study serves to measure the efficiency level of the container terminal operational performance and the factors affecting the efficiency level. Operational performance efficiency is considered an element capable of generating competitiveness and influencing terminal operations (Song & Han, 2003)

The study design contains guidance in the process of collecting data, analysis, and interpretation of observations. The problems that exist in this study aims to test the functions and activities that exist in the Belawan International Container Terminal (BICT). As a terminal operator, BICT requires various facilities to perform its function as a container terminal. The facilities required by a container terminal to perform its functions and activities is the infrastructure, equipment, labor, and technology system as the input for the production of the container terminal. From several studies conducted revealed that the appropriate method in analyzing the efficiency of container terminals operational performance is by doing a direct observation of terminal activities and conducting interviews or quantitative surveys using a questionnaire on the people involved in the activity. The strategy used in this research uses several methods for obtaining and collecting related data. The data obtained came from various sources, literature studies, interviews, questionnaires and observations used as a method for data collection (Fisher, 2010). This is the most common research methodology used in many studies.

The operational performance analysis of container terminal uses data obtained from the Belawan International Container Terminal (BICT) management. The data used as the observation material will be taken from 2017 to analyze the performance efficiency based on the throughput of the container terminals. This data will then be analyzed using the DEA quantitative analysis. Quantitative methods using Data Envelopment Analysis (DEA) as a non-parametric mathematical method are used to analyze and estimate productivity efficiency in a unit. This program will work by identifying the units to be evaluated which consists of determining the Decision-Making Unit (DMU), then continued with the determination of input and output variables. DEA analysis used will serve as input to test and define container terminals performance efficiency (Talley, 2006). The indicator used as input consist of variables that have influence on container terminal operational performance system as follows:

Table 10: Input and Output Efficiency Performance Indicators

DMU	Year	Input		Year	Ouput	
		Variable	Abbreviation		Variable	Abbreviation
4 Container Terminal	2017	Quay Length (M) Quay Crane (Unit) Container Yard (M^2) Yard Equipment (Unit)	(QL) (QC) (CY) (YE)	2017	Container Throughput (TEUs)	(T)

Source: Own elaboration

In this section, there is also a brief description of the profile and performance of BICT that will be used to support the descriptive analysis in this study.

3.2 Study Area

The study area for this study will be conducted at the Belawan International Container Terminal (BICT) located in Belawan Port, North Sumatra, Indonesia. This terminal is chosen due to Belawan Port is the Main Port in North Sumatra and the third largest port in Indonesia. As a container terminal operator, BICT handles many container traffic for national and international trade contributions. Furthermore, this study will examine the performance indicators of BICT compared to three major container terminals in Indonesia, namely Terminal Peti Kemas Koja (TPK Koja), Terminal Peti Kemas Semarang (TPKS) and Terminal Petikemas Surabaya (TPS), with throughput as projections.

3.3 Research Data Sampling

Research Data Taking focuses on sampling representing the entire population. Mugenda & Mugenda (2003) define a population is a group of objects or individuals that have common characteristics that can be observed on the object or individual. Keller (2009) revealed that the sample is a set of data containing information taken from the total population. Sampling for the entire population is not possible due to limited resources and time.

Respondents identified as involved in the research list are people who are considered to have characteristics or have interests and have direct involvement in terminal operations. Respondents who become the target population in the study are those who are directly involved in the operation activity of the terminal at Belawan International Container Terminal (BICT). Thus it is assumed that the total number of respondents is 50 respondents from senior staff at Belawan International Container Terminal (BICT) who will represent the entire selected population and the data obtained will be further managed.

3.4 Data Collection Methods

Methods of data collection are done systematically. This process begins by asking permission from the Belawan International Container Terminal (BICT) for ease of conducting surveys and collecting valid data. Followed by the selection of samples based on the structure and function in responsibility for terminal operational activities. Then ask the consent of the respondent to take part in the observation by answering the questions in the interview or questionnaire given to the respondent. Existing questions are designed to be responded and answered flexibly with oral or written which will save time from respondents in giving answers. The survey is conducted using an online questionnaire distributed directly to respondents. Likert scale is used as a parameter to measure survey response in this study. On the other hand, secondary data is collected from documents and data information through existing literature studies related to this research. Documents and data information are obtained from various sources of print or internet media, such as libraries, port or terminal websites, manuals, literature or scientific journals, maritime magazines, news reports and annual performance reports of container terminals.

The legality and validity of the data are assured since the data is obtained and collected from internal sources of Pelindo I as BICT container terminal operators. However, the data is categorized as confidential data and may be published pursuant to the permits and regulations of Pelindo I since the data is collected from various sources mainly from management reports or by directly contacting the parties responsible from the operation of container terminals. There are also some data collected from the BICT website and the annual report of Pelindo I.

3.5 Reliability and Validity

Reliability refers to the extent to which analytical procedures or data collection techniques will result in consistent findings (Mark et al., 2007). Reliability can be measured with indications of consistency and stability in assessing or measuring data or information. Therefore, it is necessary to have a structured observation strategy in order to increase the level of reliability when collecting data or information through interviews or questionnaires.

Validity relates to the truth about the data or information obtained. Validity leads to the extent to which the empirical measure of the truth of a data or information. To ensure the validity of this research, data or information is obtained from Pelindo I internal management and documents related to this research. To test the validation level of this data is to refer to the literature related to the study used in this research.

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Chapter 4 – Data Processing and Analysis

4.1 Data Processing and Analysis

Data analysis is defined as a way of analyzing the information gathered by focusing on the various questions raised in the study (Kothari, 2004). Data collected from the field is analyzed qualitatively and quantitatively. Qualitative analysis involves the analysis of information from literature studies, communication with container terminal operator and distributing questionnaire to several stakeholders. The data and information obtained are then compiled and summarized to recognize the relationship between the research question and subsequently put into a logical conclusion. For quantitative analysis is done with the data collected from the variables used to determine the input variables that are clearly described in the Research and Design Framework. The Stata software will be used in this study to determine the methodology approach with quantitative analysis. Respondents are asked to provide responses and answers or arguments for each service related to the operational performance of container terminals. The results obtained are then evaluated and analyzed to obtain an interest level on the terminal operational performance efficiency.

The following data is related to container throughput from 2015 to 2017 at BICT showing an increase in average container throughput of 3.7% / yr, 2017 throughput recorded at 526,039 TEUs, with the composition of 47.2% import and 52.8% export. Table 2.3 below shows the development of container traffic in BICT:

Table 11: Container Throughput at BICT 2015 - 2017

No.	Description	Unit	Year		
			2015	2016	2017
1	Import	Teus	203,559	218,813	248,194
2	Eksport	Teus	231,980	244,651	277,845
3	Transhipment	Teus	0	0	0
	Total	Teus	435,539	463,464	526,039

Source: Pelindo I

Dwell Time (DT) is defined as the total time spent by a container in one or more stacks on a stacking area starting from being unloaded from the ship to the container coming out of the terminal (Ottjes et al., 2007). Dwell time is the key factor in determining the required stack capacity in container terminal (Saanen, 2004). (Rakt, 2002) Revealed that in some terminals several containers are staying more than six months, however typical dwell time varies between 2 to 6 days for imports and 3 to 7 days for export. The better the performance on the stacking area and will reduce congestion in the container terminals.

The following data related to dwelling time from 2015 to 2017 at BICT showed an increase in performance in the container yard (CY) with a decrease in the dwell time from 4.1 days in 2015 to 2.7 days in 2017 or a reduction of 1.4 days. It is also related to the arrangement of documents ready before the container enters the terminal. Table 12 below shows the dwell time at BICT:

Table 12: BICT Dwell Time 2015 – 2017

No.	Description	Unit	Year		
			2015	2016	2017
1	Import	day	5.9	4.6	3.7
2	Export	day	2.3	1.9	1.7
Average		day	4.1	3.3	2.7

Source: Pelindo I

The operational performance of BICT ship and goods services from 2015 to 2017 data shows an increase. Berthing time in 2017 is 25.5 hours/vessel increased compared to the year 2016 of 27.6 hours/ship. It is due to the acceleration of the clearance out process by the ship agency. Likewise, the productivity of loading and unloading increased from 33.5 BSH in 2015 to 49.0 BSH in 2017. It is influenced is influenced by the improved ratio of equipment utilization and better planning and managing container handling activities. However, Berth Occupancy Ratio (BOR) in 2017 decreased by 1.2% from 2016, while for container yards the value of Yard Occupancy Ratio (YOR) in 2017 increased by 1.2% from 2016. The realization of Ships Turnaround Time in 2017 is 1.7 day/ship or an increase of 0.2 day/ship from 2016, this is due to increased waiting time, postpone time, approach time and berthing time. Details of the operational performance of BICT can be seen in Table 4 as follows:

Table 13: BICT Operational Performance 2015 – 2017

No.	Description	Unit	2015	2016	2017
A.	Ship arrivals	Call	503.0	568.0	563.0
	Box per Ship	Box/Ship	693.5	716.2	797.8
B.	Service Time				
	1. Waiting Time (WT)	hour/ship	1.6	2.3	1.1
	2. Aproach Time (AT)	hour/ship	2.2	2.4	2.3
	3. Berthing Time (BT)	hour/ship	27.8	27.6	25.5
	a. Berth Working Time (BWT)	hour/ship	21.3	21.3	18.2
	Idle Time (IT)	hour/ship	1.8	1.7	0.8
	Efective Time (ET)	hour/ship	18.7	19.5	17.4
	b. Non Operating Time (NOT)	hour/ship	7.3	6.3	7.4
	4. Turnaround Time (TRT)	hour/ship	31.6	34.0	41.0
	Turnaround Time (TRT)	day/ship	1.3	1.4	1.7
C.	Utilization				
	1. Berth				
	a. Berth Occupancy Ratio (BOR)	%	46.5	51.4	49.6
	b. Berth Through Put (BTP)	Teus/M	802.8	929.9	1019.2
	2. Container Yard				
	a. Yard Occupancy Ratio (YOR)	%	31.2	27.4	28.6
	b. Yard Through Put (YTP)	Teus/GS	132.6	153.6	168.3
D.	Produktivity	B/C/H	20.8	21.7	22.5
		B/S/H	33.5	35.8	49.0

Source: Pelindo I

Several container terminals in Indonesia are still fully operated under Pelindo management, while some have been privatized. Belawan International Container Terminal (BICT) and Semarang Container Terminal (TPKS) are fully operated under Pelindo 1 and Pelindo III. Container terminals such as TPK Koja container terminal and Semarang Container Terminal (TPS) are joint operations between Pelindo and foreign companies. Koja Container Terminal is a joint operation between Indonesia Port Corporation (IPC) or Pelindo II and Hutchinson Port Hong Kong (Tpkkoja, 2018), while Surabaya Container Terminal (TPS) is a joint operation between Pelindo III and Dubai Port World (Pelindo, 2018).

The following table shows that TPK Koja and TPS are the busiest container terminal in Indonesia with higher throughput results. In 2017 was the highest achievement in the operation of the TPK Koja container terminal since they have successfully exceeded the target and reached throughput of 1 million TEUs. TPK Koja container terminal experienced a significant increase in international container traffic from 2016 to 2017 with an increase of 32.4%. While BICT, TPS, and TPKS also experienced a gradual increase from 2015 to 2017. This research will focus on observing container terminal efficiency performance based on container throughput in 2017. Details of throughput between the major international container terminals In Indonesia can be seen in Table 14 as follows:

Table 14: Throughput of Major International Container Terminals in Indonesia

No.	Container Terminal	Throughput (TEUs)		
		2015	2016	2017
1	Belawan International Container Terminal (BICT)	435,539	463,464	526,039
2	Terminal Petikemas Koja (TPK Koja)	975,438	827,198	1,095,000
3	Terminal Petikemas Semarang (TPKS)	608,199	615,132	634,265
4	Terminal Petikemas Surabaya (TPS)	1,198,483	1,241,227	1,306,878

Source: Compiled from various sources

4.2 DEA Analysis

Data obtained from observations will be processed using the DEA analysis method. From the explanation above that DEA is a non-parametric mathematical program used to measure the performance efficiency of organizational units. This methodology is conducted by analyzing the optimal combination of inputs and outputs. Thus, several indicators are used to accommodate the evaluation of the container terminal efficiency. The indicator will be described as an input variable which consists of quay length, quay crane, container yard and yard equipment and uses throughput as output.

The table below will provide a description of each variable consisting of input and output. The variable is assessed based on the unit of measurement that will be shown in the following table:

Table 15: Input and Output Variable Definition

Input Variables	Description	Unit
Quay Length	The total quay length in the container terminal dedicated for container vessels berthing	Meter
Quay Crane	Number of Seaside Equipment which supports handling loading and unloading at the quay (e.g. (e.g., CC, QC, HMC, and mobile crane)	Unit
Container Yard	The total area for stacking containers and maneuvering of the loading and unloading equipment operating on the ground	m2
Yard Equipment	Number of Landside Equipment which supports handling loading and unloading at container yard (e.g., RTG, Reach Staker, Side Loader, Sky Stacker, Forklift, Translifter, and Truck)	Unit
Output Variables		
Throughput	The total number of containers handled at the container terminal in a year period. It's the total number of imports, export, and transhipment.	TEUs

Source: Own elaboration based on various source

4.3 Data for Container Terminal Efficiency Performance Measures

The data of the input and output variable that will be used in the DEA analysis is shown in Table 16. Thus, cross-section data from several container terminals used as benchmarking will be exploited to obtain results from the DEA analysis model. The cross-section data displayed is the result of a combination of various sources originating from the internal of Pelindo and other sources that have been explained in the research and methodology chapter. Details of the data collected will be presented in Appendix 1 in this study report.

This study uses four major container terminals in Indonesia namely Koja Container Terminal (TPK Koja), Terminal Peti Kemas Semarang (TPKS) and Terminal Petikemas Surabaya (TPS) as Decision Making Unit (DMU). Since each container terminals used as the material of research which has different characteristics such as quay length, container yard, and other facilities. Therefore, all data is collected and presented in table 16 which shows the total number of facilities and equipment for each terminal. The equipment used in every terminal is the sum of the entire equipment used for container handling activities at the container terminal. As previously mentioned, the detail of facilities and equipment data from every terminal can be seen in Appendix 1.

The following Table 16 describes four existing container terminals in Indonesia that are used as the material of study. The table also shows that some terminals have the same characteristics. In the container terminals industry, handling facilities and equipment used for operational activities vary from one terminal to another. It is following the objective of the study that sets benchmarking as the basis for efficiency analysis by comparing terminals in terms of operational performance. From the data collected then the input and output variables are used to test the DMU from each terminal. The input and output values are presented according to the observations and characteristic data of each terminal. Each input and output will be abbreviated as follows quay length (QL), quay crane (QC), container yard (CY), and yard equipment (YE).

Table 16: DEA Analysis Data Input and Output

No.	Container Terminal	Quay Length (M) (QL)	Quay Crane (Unit) (QC)	Container Yard (M^2) (CY)	Yard Equipment (Unit) (YE)	Throughput (TEUs) (T)
1	Belawan International Container Terminal (BICT)	550	6	158,464	43	526,039
2	Terminal Petikemas Koja (TPK Koja)	650	7	257,200	76	1,095,000
3	Terminal Petikemas Semarang (TPKS)	531	7	195,386	80	634,265
4	Terminal Petikemas Surabaya (TPS)	1000	11	350,000	142	1,306,878

Source: Own modification based on various source

The unit used to measure the value of each input uses a matric system and throughput using the TEUs measurement unit. The capacity of the quay and field shown from each terminal has a size that is not much different. However, we can see that the number of equipment used on land side or yard equipment (YE) has a significant amount of difference. The DEA method applied in the study uses Stata software to analyze data for models and generate efficiency values from operational performance at the container terminal. The Stata Program is an application that can measure the performance of a DMU using the DEA Technique. The DEA data flow in Stata as follows:

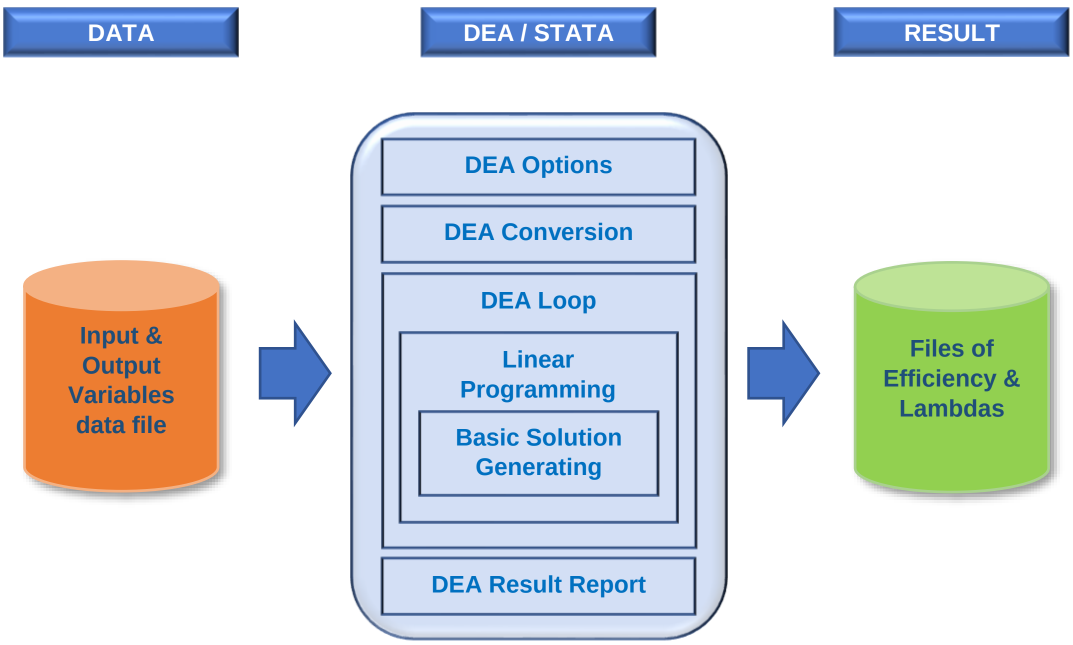

Figure 9: Diagram of Data Flow in Stata
Source: Lee & Ji, 2009

Stata program also provides a nonparametric tool to analyze productivity or efficiency with DEA. Stata requires the initial data set of input and output variables which are used to observe the unit or DMU. This program can accommodate and evaluate the unlimited numbers of inputs and outputs and the unlimited numbers of DMUs (Lee & Ji, 2009). DEA makes it possible to analyze multiple inputs and outputs at the same time. This study uses input variables which are terminal resources for the production process namely quay length, the quay crane, container yard and yard equipment with throughput as output. The decision-making units (DMU) consist of four terminals which are evaluated in this study. The results of the DEA-CCR analysis with constant return to scale (CRS) state that the DMU is efficient if the DMU obtains a DEA score equal to 1 and all slacks are 0.

Cullinane et al., (2006) revealed that to obtain output by minimizing input is recommended by using the basis of the DEA model on the input oriented. The implementation of the DEA model is based on general input oriented of DEA-CCR with CRS to obtain the efficiency score since resources utilization influences the terminal operation.

The summary of DEA analysis procedures using the Stata program as follows:

- Step 1. Determine the number of input and output variables.
- Step 2. List the initial data set from input and output variables (Table 16).
- Step 3. Establish the observed DMUs.
- Step 4. Running Linear programming in Stata to complete each DMU by executing the program to achieve optimal solutions.
- Step 5. Determine the optimal solution for efficiency from variables that are statistically significant.
- Step 6. Define the efficient score from the results of the DEA analysis.

Table 17 presents descriptive statistics from Stata for input and output variable data. The table above also presents data which indicates the number of observations, average, standard deviation of input and output, minimum and maximum values. There are four container terminals observed in the study. From these observations obtained values from descriptive statistics for input and output variable. The maximum and minimum of quay length (QL) are 1,000 m and 532 m respectively. The average and standard deviation of quay length (QL) are 682.8 m and 217.8 m respectively. The maximum and minimum quay cranes (QC) are 11 units and 6 units respectively with an average, and standard deviation are 7.8 units and 2.2 units. The maximum and minimum of container yard (CY) are 350,000 m2 and 158,464 m2 respectively with average, and standard deviation are 240,626.5 m2 and 83,733.9 m2. The maximum and minimum of equipment yards (YE) are 142 units and 43 units respectively with an average, and standard deviation are 85.3 units and 41.3 units. As for output, the maximum and minimum of throughput (T) are 1,306,878 TEUs and 526,039 TEUs respectively. The average and standard deviation of throughput (T) are 890,545.5 TEUs and 371,339.5 TEUs respectively. Descriptive statistics in table 17 show the diversity of results since container terminals in Indonesia have different sizes of facilities, equipment, and throughput values.

Table 17: Descriptive Statistic on Input and Output Data

Variable	Obs	Mean	Std. Dev.	Min	Max
QL	4	682.8	217.8	531.0	1,000.0
QC	4	7.8	2.2	6.0	11.0
CY	4	240,262.5	83,733.9	158,464.0	350,000.0
YE	4	85.3	41.3	43.0	142.0
T	4	890,545.5	371,339.5	526,039.0	1,306,878.0

Source: Own calculation

The following table 18 will show the correlation between input and output variables. The function of determining the correlation between input and output variables is to measure the strength and direction of the linear relationship between these variables. As shown in table 18 that the highest correlation is the relationship between yard equipment (YE) and quay crane (QC) of 1.0 and between quay crane (QC) and quay length (QL) of 1.0, while the lowest correlation is shown by the relationship between throughput (T) and yard equipment of 0.8 and between throughput (T) and quay crane (QC) of 0.8. However, the relationship still shows a positive number. All variables presented can be accepted since no negative correlation is generated. In addition, there is no weak correlation since all input and output variables provide strong correlation value with the value of the relationship between variables is in the range of 0.8 to 1. Thus, it proves that the existing variables can be used for further analysis to obtain efficiency scores of operational performances in the container terminals.

Table 18: Correlation Between Input and Output Variables

	QL	QC	CY	YE	T
QL	1.0				
QC	1.0	1.0			
CY	0.9	0.9	1.0		
YE	0.9	1.0	0.9	1.0	
T	0.9	0.8	1.0	0.8	1.0

Source: Own calculation

4.4 DEA Result

From data collection for each container terminal and testing from descriptive statistics on input and output variables, the data will be processed using the DEA method with the Stata program to obtain an efficiency score. DEA analysis observes that there is only one terminal, Koja Container Terminal (TPK Koja) which has achieved an efficiency score equal to 1, while the other three terminals receive less than 1. The efficiency score of DMUs could be categorized as very strong or absolutely efficient if all slack generated tend to be zero, and less efficient or inefficient if several slacks have values more than zero (Sharma and Yu, 2009). The DEA test results do not provide absolute efficiency values since these values will change along with changes in the initial data set. The study uses DEA-CCR model by applying an input-oriented as a measurement of DMU. DEA is determined by measuring the weighted output to the weighted input. Thus, an efficiency score is obtained from 0 to 1. With the provision of a value of 1 means efficient and less than 1 means inefficient. Talley (2016) revealed that the achievement of technical efficiency is when the throughput reaches the maximum value of the certain utilization resources. Therefore, the number of resources in the container terminal is considered as input should be exploited entirely to achieve the maximum value of the efficiency score.

From table 19, it shows that in 2017 the Koja Container Terminal (TPK Koja) is considered as an efficient container terminal. With a certain level of utilization of resources indicates that the input on the TPK Koja is able to generate the maximum output value expressed by the throughput value in the output variable. After looking at the other terminals, Surabaya Container Terminal (TPS) on the second rank after TPK Koja, and the next position is occupied by Belawan International Container Terminal (BICT), while Semarang Container Terminal (TPKS) is the lowest ranked among the four terminals.

The following table 19 shows that the Belawan Container Terminal (BICT) which is the objective of this study, only utilize 84.9% of the input provided. In order to achieve the maximum score of the efficiency, all inputs should be reduced by 15.1%. In addition, table 21 shows that the operational performance of BICT can be improved by reducing three inputs, namely 154.7 units from QL, 1,7 units from QC and 10,989.6 units from CY. The three input slacks can be reduced if BICT reduces all inputs by 15.1%. Table 20 presents that efficient production as a reference peers from BICT is DMU 2, namely the Koja Container Terminal (TPK Koja) with a linear combination weight of 100%.

Table 19: DEA Efficiency Scores

No.	DMU Container Terminal	Rank	Efficiency Score
1	Belawan International Container Terminal (BICT)	3	0.8
2	Terminal Petikemas Koja (TPK Koja)	1	1.0
3	Terminal Petikemas Semarang (TPKS)	4	0.8
4	Terminal Petikemas Surabaya (TPS)	2	0.9

Source: Own calculation

Surabaya Container Terminal (TPS) obtained an efficiency score of 87.7% higher than BICT. To achieve the maximum score of efficiency, TPS should reduce all input by 12.3%. The efficiency of TPS operational performance will be increased by reducing three inputs, namely 101.3 units from QL, 1.3 units from QC and 33.8 units from YE. On the other hand, Semarang Container Terminal (TPKS) obtained the lowest efficiency score among the four terminals analyzed in this study which is 76.3%. Efforts to reach the maximum value, TPKS should reduce input by 23.7%.

Thus, the efficiency of the TPKS operational performance will be increased by reducing three inputs, namely 28,4 units from QL, 1,3 units from QC and 17.0 units from YE. From table 22 shows that the reference peers from TPS and TPKS are Koja Container Terminal (TPK Koja) with linear combination weights of 57.9% and 119.4% respectively.

Table 20: Reference Peers of DMU

No.	DMU Container Terminal	Reference (l)			
		1	2	3	4
1	Belawan International Container Terminal (BICT)	.	0.5	.	.
2	Terminal Petikemas Koja (TPK Koja)	.	1.0	.	.
3	Terminal Petikemas Semarang (TPKS)	.	0.6	.	.
4	Terminal Petikemas Surabaya (TPS)	.	1.2	.	.

Source: Own calculation

Table 21: DEA Input and Output Slack

No.	DMU Container Terminal	Input Slack				Output Slack
		QL	QC	CY	YE	T
1	Belawan International Container Terminal (BICT)	154.7	1.7	10989.6	.	.
2	Terminal Petikemas Koja (TPK Koja)	0.0	0.0	0.0	.	.
3	Terminal Petikemas Semarang (TPKS)	28.4	1.3	.	17.0	.
4	Terminal Petikemas Surabaya (TPS)	101.3	1.3	.	33.8	.

Source: Own calculation

4.5 Questionnaire Results and Descriptive Analysis

This section will discuss empirical findings and the results of collecting questionnaires which are distributed to senior staff at Belawan International Container Terminal (BICT). Fill out the questionnaire online using the online form provided by https://erasmusuniversity.eu.qualtrics.com. The respondents is asked to fill out the online questionnaire form by accessing the website. The data presented from the online questionnaire includes background information of the respondents and questions related to the purpose of the study to determine the level of efficiency of operational performance at the container terminal.

Respondents taken as samples are employees who worked at Belawan International Container Terminal (BICT). In accordance with the target population, 50 employees have filled out the online-questionnaire form provided through the website mentioned above. Respondents are employees in charge of various divisions with different status/positions and years of service in the BICT Container Terminal. The respondents will receive an online questionnaire link that is distributed by sending the link through e-mails and mobile applications to facilitate the respondents in completing the questionnaire. The duration of filling the questionnaire starts on 30 July 2018 to 8 August 2018. This study uses the Likert scale as a parameter to measure survey response with ranges from 1 to 3, 1 to 4 and 1 to 5 respectively. Then the results of the questionnaire are collected and analyzed according to the objectives of the study.

4.6 Response Rate

From the data collected through the online-questionnaire, 50 questionnaires are obtained which showed a 100% response rate. This response rate is considered very good since it has a response value above 70% (Mugenda & Mugenda, 2003). It shows that the response in filling out the questionnaire covers the entire targeted population.

4.7 Data Respons and Findings

4.7.1 General Information

The purpose of this study is to determine the background of respondents based on the following parameters: education level, the name of division/unit section, position/status in the organization and number of years the respondent has worked in the company. Furthermore, the collected data will be presented in the description of statistics to obtain a response from the respondents.

Table 22: Education Level

What is your education level?		
Level of Education	**Frequency**	**Percentage**
High School	3	6%
Diploma's Degree	3	6%
Bachelor's Degree	41	82%
Master's Degree	3	6%
Doctorate	0	0%
Total	**50**	**100%**

Source: Own calculation

Table 22 above shows the distribution of respondents based on the level of education which from descriptive research statistics reported that 6% of respondents reported having a High School education level, 82% of respondents reported are holders of a bachelor’s degree, 6% are holders of a Diploma degree, 6% are holders of a master’s degree, while Doctorate holders contribute 0%. From the survey results, it can be concluded that the majority of employees who work at Belawan International Container Terminal (BICT) have a high level of education and understand the important factors that affect the efficiency of operational performance in the container terminal.

Based on the results of the survey, the master's degree education level is dominated by the leaders in Belawan International Container Terminal (BICT) who hold the position/status as manager. Moreover, the bachelor's degree education level is dominated by employees serving as staff and others as assistant managers and managers. Meanwhile, the level of diploma and high school education comes from employees serving as staff and operators. It shows that there is a tight relationship between the level of education of employees in occupying certain positions/status in the organization. The higher the level of education, the chance to occupy a higher position/status within the organization.

Table 23: Division/Unit

What is your division/unit?

Division / Unit	**Frequency**	**Percentage**
Management System	4	8%
Operation	16	32%
Engineering	13	26%
Finance	5	10%
Human Resources	6	12%
Information Technology	6	12%
Total	**50**	**100%**

Source: Own calculation

The descriptive statistics shown in Table 23 above presents that the respondents who participated more in answering the questionnaire came from the operation division by 32%, 16% came from the Engineering division, 6% came from the Human Resources division and Information Technology respectively, while the other 4% comes from the Management System division. It implies that the majority of the respondents came from the Operation division. The Operation division is a division that has a direct influence on operational activities at Belawan International Container Terminal (BICT). While in the second position is occupied by engineers who have direct responsibility for the utilization and maintenance of facilities and equipment at BICT.

Table 24: Respondents Position/Status

What is your position/status in the organization?

Position / Status	**Frequency**	**Percentage**
Operator	4	8%
Staff	29	58%
Assistant Manager	11	22%
Manager	6	12%
General Manager	0	0%
Total	**50**	**100%**

Source: Own calculation

The findings from Table 24 above shows that 12% of respondents hold positions as staff, 22% of respondents hold positions as assistant managers, 58% of respondents hold positions as staff, while 8% hold positions as operators. It indicates that the majority of respondents hold positions as staff.

Table 25: Number of Years Respondents Have Worked in the Company

How long have you worked at this company?		
Year	**Frequency**	**Percentage**
Less than 2 years	2	4%
3 - 5 years	15	30%
6 - 9 years	15	30%
Over 10 years	18	36%
Total	**50**	**100%**

Source: Own calculation

The findings from Table 25 above show that 36% of respondents have worked in their respective divisions/units over 10 years, 30% of respondents have worked between periods of 6-9 years, 30% of respondents have worked between 3 - 5 years while working less than 2 years contributed 4%. It indicates that the majority of respondents have worked in each division at the Belawan International Container Terminal (BICT) for more than 10 years.

4.7.2 Efficiency of Operational Performance in Container Terminal

The efficiency of the container terminal operating performance can be measured by several indicators such as the increased level of container throughput and resources utilization (quay, cranes, yards, etc.), reducing handling time and minimize congestion?

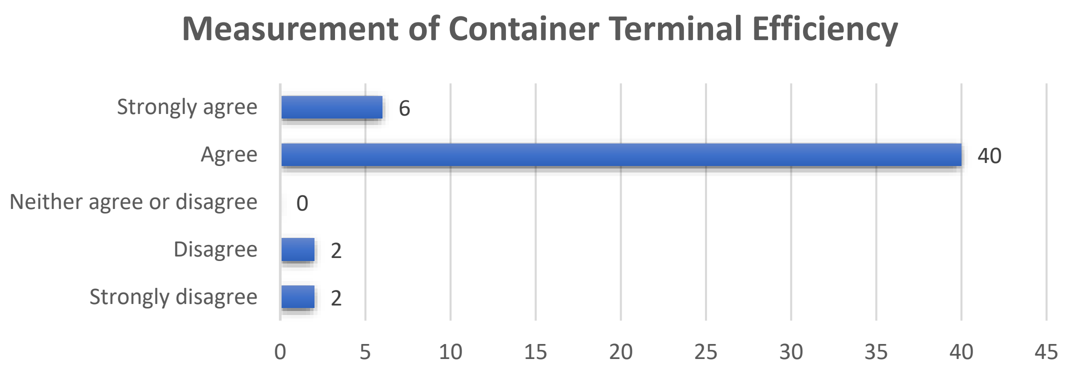

Figure 10: Measurement of Container Terminal Efficiency
Source: Own calculation

This study attempts to find out the response of the respondent regarding the extent of the agreement or disagreement regarding whether several indicators can measure the efficiency of the container terminal operating performance as mentioned in the above question. As Figure 9 above, indicates, 4% of respondents strongly disagree, 4% of respondents disagree, 0% of respondents agree or disagree, 80% of respondents agree, while 12% of respondents strongly agree. This finding shows that most of the container level of input and resource utilization (quay, cranes, yards, etc.), reducing handling time and minimizing congestion in container terminals can determine the efficiency score of operational performance in the container terminal.

From the above assessment indicators, it can be seen that there are still respondents who respond not to agree. However, this assessment proves that the majority of the respondents have the knowledge and understanding of the indicators used to measure the efficiency of operational performance in the container terminal very well. It shows that an increase in the input and output variables determines the level of efficiency of the operational performance at the container terminal.

How do you assess the resources utilization such as quay, cranes, yards, and equipment to the current container throughput at Belawan International Container Terminal (BICT)?

As the question is mentioned above, this study aims to determine the response of respondents regarding how to assess the use of resources such as the quay, crane, yard, and equipment for the current container throughput at Belawan International Container Terminal (BICT). As shown in Figure 10 below that 0% of respondents rated very low, 8% of respondents rated low, 42% of respondents rated moderate, 42% of respondents rated high, while 8% of respondents rated very high. This finding shows that the majority of respondents expressed the utilization resources are high and moderate, where the two assessment criteria have the same weight of 42%. On the other hand, there are answers from respondents who state that the utilization of resources in BICT is still low.

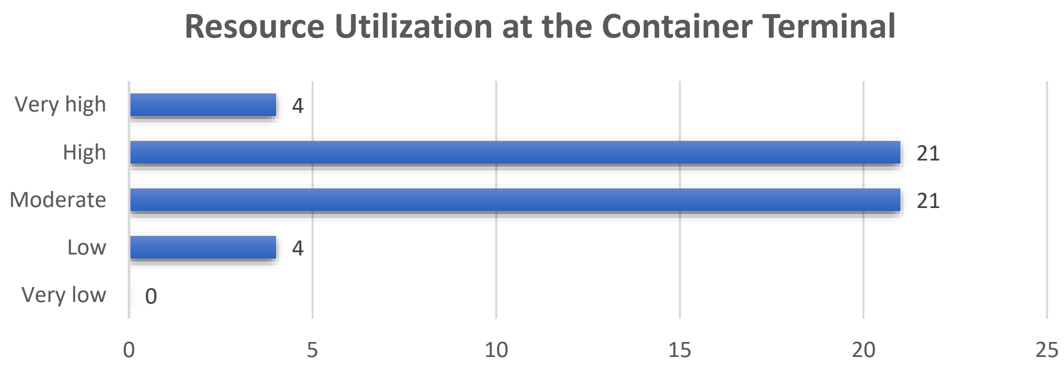

Figure 11: Resource Utilization at the Container Terminal
Source: Own calculation

Assessment of resources utilization such as quay, cranes, yards, and equipment has a relationship to the assessment of efficiency scores using the DEA analysis method. DEA results show that BICT is inefficient with an efficiency score of 84.91%. To achieve the maximum efficient score BICT should reduce the input variable by 15.09%. It indicates that resources utilization in BICT has not been optimally managed in order to achieve efficient performance and maximum throughput.

How would you rate the current operating performance at Belawan International Container Terminal (BICT)?

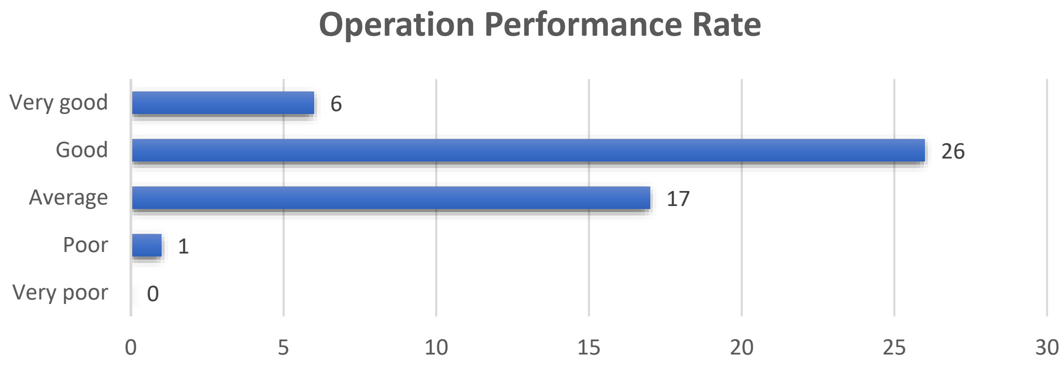

Figure 12: Operation Performance Rate
Source: Own calculation

This study sought to find out how respondents rated the current operating performance at Belawan International Container Terminal (BICT). As shown in Figure 11 above presents 0% of respondents rated very poor, 2% of respondents rated poor, 34% of respondents rated average, 52% of respondents rated good, while 12% of respondents rated very good. This finding shows that the majority respondents considered that the operational performance in BICT is in a good category. However, there are still some answers from respondents who stated that the operating performance of BICT is still low. It reveals that the performance of BICT needs to be improved to achieve the efficiency of operational performance.

The value of operational performance at BICT as shown in figure 11 above has a relationship to the assessment of efficiency scores using DEA analysis. DEA results show that BICT is inefficient with an efficiency score of 84.9%. To achieve the maximum efficient score BICT must reduce the input variable by 15.1%. It indicates that current operational performance at BICT is inefficient and needs to be improved.

How important is the efficiency of operational performance at Belawan International Container Terminal (BICT)?

This study attempts to find out how respondents respond to the importance of the efficiency of operational performance at Belawan International Container Terminal (BICT). Figure 12 below, indicates 0% of respondents rated not at all important, 2% of respondents rated slightly important, 24% of respondents rated important, 8% of respondents rated fairly important, while 66% of respondents rated very important. This finding shows that the majority of the respondents reported that the efficiency of operational performance at BICT is very important. It proves that respondents who are employees at BICT realize that increasing the efficiency of operational performance at BICT is a very important factor to be continuously improved in order to improve competitiveness and market share.

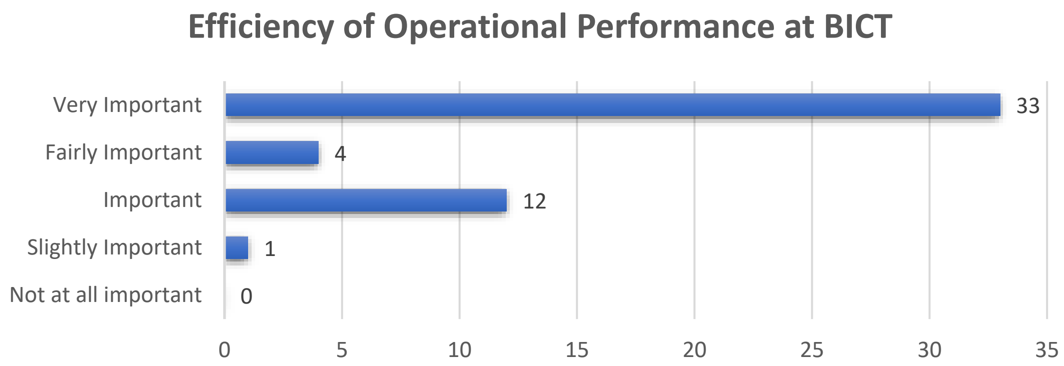

Figure 13: Efficiency of Operational Performance at BICT
Source: Own calculation

From your perspective, how to improve the efficiency of operational performance in Belawan International Container Terminal (BICT)?

This study attempts to find out how the perspectives of the respondents about how to improve the efficiency of operational performance in Belawan International Container Terminal (BICT). This question is an open question, and the respondents can freely provide their views and opinions. There are many answers given by respondents, and these answers have similarities and relationships between one another. Thus, this study summarizes all the responses and opinions provided by the respondents in order to obtain a clear understanding of the efficiency of operational performance at Belawan International Container Terminal (BICT).

The study found that the majority of the respondents thought that to improve the efficiency of operational performance is by implementing proper operation management and increase the utilization of facilities and equipment to enhance the speed of loading and unloading. There is another opinion that states it can be improved by optimizing resource utilization, optimizing the performance of quay cranes and yard equipment. Determination of the ideal composition in the loading and unloading process, both from vessel to truck and vice versa, container yard, receiving and delivery so that it can be a reference for performance improvement and efficiency that can be applied in Belawan International Container Terminal (BICT).

Operating systems and service procedures based on performance by utilizing information technology advances can improve the efficiency of operational performance. It can also be supported by making careful planning and better operational control and the most important with the support of a modern Terminal Operating System (TOS). From the responses collected revealed that the respondents have a good understanding of the indicators used to measure the efficiency of operational performance. The perspectives of the respondents emphasized the statement that performance efficiency can be achieved by optimizing the utilization of resources owned such as quay length, quay crane, container yard and yard equipment. The optimization should be done optimally to improve service quality and higher throughput. Efficiency will increase terminal competitiveness and market share and eventually it will provide benefit to the company development.

4.7.3 Quay Length

How is the quay capacity for berthing and loading and unloading activity?

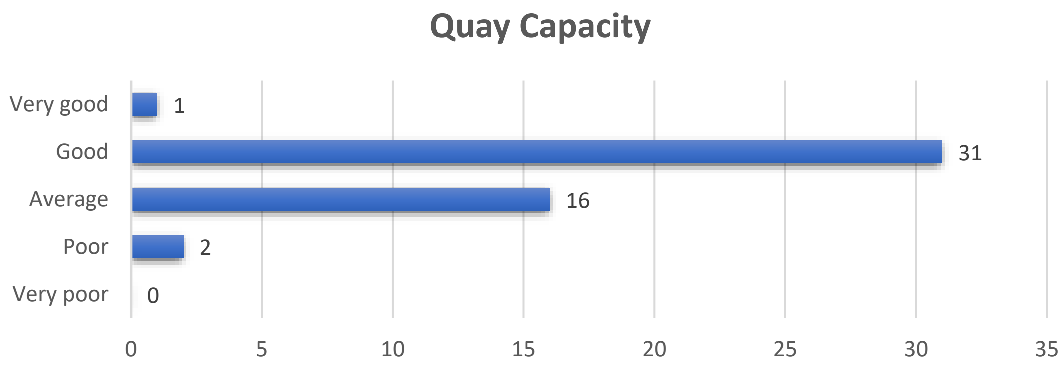

Figure 14: Quay Capacity
Source: Own calculation

The above question aims to find out how respondents assess the quay capacity for berthing and loading and unloading activity. As figure 13 above, indicates that 0% respondents rated very poor, 4% respondents rated poor, 32% respondents rated average, 62% respondents rated good, while 2% respondents rated very good. This finding shows that the majority of the respondents considered that the quay capacity for berthing and loading activities is in a good category. On the other hand, some respondents stated that quay capacity is in the average category. These results reveal that BICT still has to optimize quay capacity to achieve efficient operational performance. Following the results of the DEA analysis in table 21 above shows that the operational performance of BICT can be increased by reducing three input variables namely quay length (QL), quay crane (QC) and container yard (CY). Of the three inputs, one of them is quay length (QL) which functions for berthing container vessels. The DEA results revealed that to achieve performance with an efficient QL score must be reduced by 154,734 units.

How often do you find no berth available upon vessel arrival?

This study attempts to find out how often the respondents found that there is no berth available upon vessel arrival at the Belawan International Container Terminal (BICT). As shown in Figure 14 below that 16% of respondents rated hardly ever, 44%of respondents rated occasionally, 36% of respondents rated sometimes, 4% of respondents rated frequently, while 0% of respondents rated almost always. These findings show that the majority of the respondents expressed that there is no berth available upon vessel arrival at BICT in the occasional category and others judge sometimes.

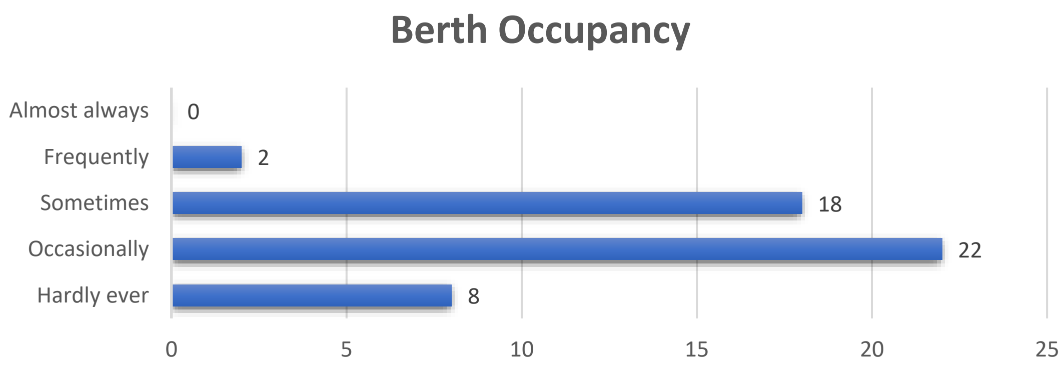

Figure 15: Berth Occupancy
Source: Own calculation

Berth Occupancy Ratio (BOR) is the ratio of time berth is occupied by container vessels from the total time available at the terminal to carry out loading and unloading activities (UNCTAD, 2018). BOR uses measurements based on percentages. Mwasenga (2012) revealed that high berth occupancy if BOR > 70% indicates that the terminal condition is in congestion while low berth occupancy if BOR < 50% indicates a lack of utilization of resources in the terminal. However, most container terminals try to maintain Berth Occupancy Ration (BOR) below 60-65% in order to maintain the safety margin for the early and late arrival of the container vessels (Saanen & Rijsenbrij, 2018).

In addition to table 13 above shows that in 2017 Berth Occupancy Ratio (BOR) at BICT was 49.6% which decreased from 2016 which is 51.4% or decreased by 1.8%. It reveals that the berth occupancy ratio (BOR) in BICT is still low. This condition is also in line with the results of the DEA which reveals that there is an excess in the variable input quay length (QL) and should be reduced to achieve the maximum efficiency score. To achieve higher BOR, BICT should increase the number of ship calls and the utilization of facilities and equipment in the terminal. It means that BICT should be more efficient in utilizing resources in order to increase competitiveness and market share.

4.7.4 Quay Crane

How do you assess Quay Crane performance in container loading and unloading activities to a ship or truck at Belawan International Container Terminal (BICT)?

This study sought to find out how respondents assessed the performance of quay crane in container loading and unloading activities to ships or trucks at Belawan International Container Terminal (BICTAs shown in Figure 15 below that 0% respondents rated very poor, 0% respondents rated poor, 26% respondents rated average, 60% respondents rated good, while 14% respondents rated very good. This finding shows that the majority of the respondents stated that quay cranes performance in loading and unloading containers for BICT to a ship or truck activities is in a good category. It indicates that quay crane performance can be improved to achieve more efficient performance. Following the results of the DEA analysis in table

21 above shows that there is an input slack on the input variable quay crane (QC) of 1.7 units. By reducing the input weight, the performance of the quay crane will be efficient.

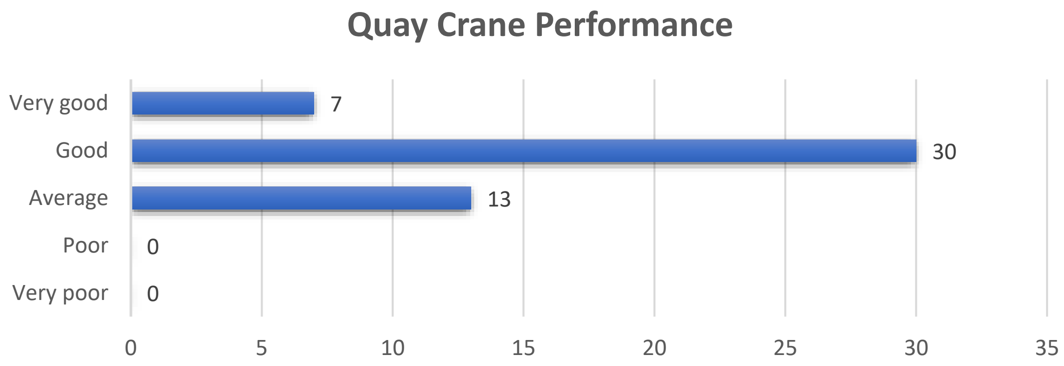

Figure 16: Quay Crane Performance
Source: Own calculation

How do you asses the operational performance effectiveness of the current quay crane at BICT?

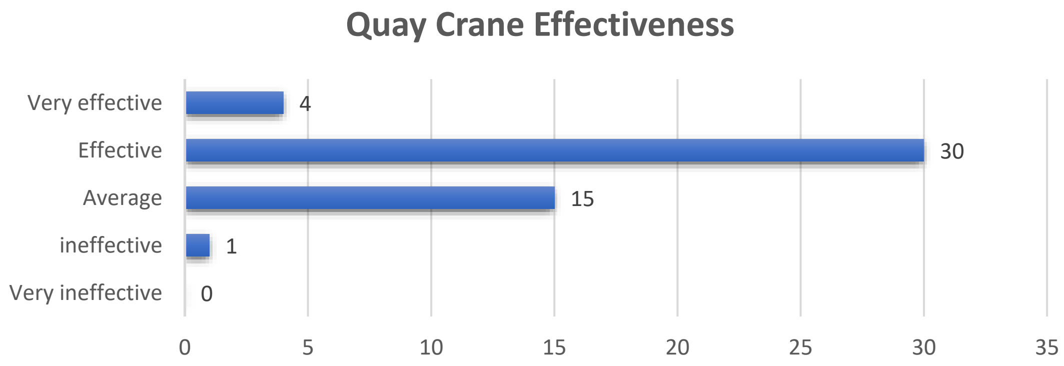

Figure 17: Quay Crane Effectiveness
Source: Own calculation

This study attempts to find out how respondents assess the effectiveness of the operational performance of the quay crane at BICT. Figure 16 above presents that 0% of respondents rated very ineffective, 2% of respondents rated ineffective, 30% of respondents rated average, 60% of respondents rated effective, while 8% of respondents rated very effective. These results show that the majority of the respondents stated that the operational performance effectiveness of the current quay cranes at BICT is in the effective category. It indicates that the current performance of quay cranes is good and still allow to be improved to achieve more effective and efficient performance.

4.7.5 Container Yard

How would you assess the yard capacity for container stacking in the terminal?

The above question aims to find out how the respondents assess the yard capacity for container stacking at Belawan International Container Terminal (BICT). From Figure 17 shows that 0% of respondents rated much less than required, 18% of respondents rated less than required, 30% of respondents rated at capacity, 50% of respondents rated capacity available, while 2% of respondents rated much capacity available. This finding shows that the majority of the respondents rated that the yard capacity for container stacking at BICT in the capacity available category. It means there is still available capacity which can be used to stack more containers in the container yard.

Yard Occupancy Ratio (YOR) is a ratio or size of available capacity or utilization of a container yard that can be used for container stacking in the certain period, for example per day, per week, per month or per year (Country, 2018). There are two factors influence the increase and decrease of YOR values namely the increase in container throughput and dwelling time at the container terminal.

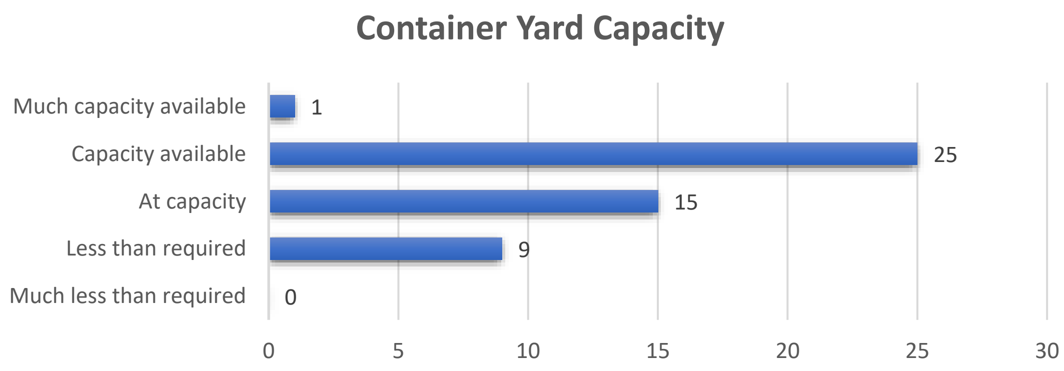

Figure 18: Container Yard Capacity
Source: Own calculation

YOR is measured by percentage. The indicator used as a YOR measurement if YOR <50% indicates that the operation of the container terminals has not developed, and the utilization of stacking area is not optimal, YOR 60% - 69% indicates that the operation of container terminals is developing, and the utilization of stacking area is optimal, YOR > 70% of stacking area utilization is optimal and needs to be maintained to prevent congestion in the terminal.

In addition to table 13 above shows that Yard Occupancy Ratio (YOR) 2017 in BICT is 28.6% which has increased from 2016 at 1.8%. This reveals that the Yard Occupancy Ratio (YOR) on BICT is still low. This condition is also in line with the results of the DEA which revealed that there is an excess in the input variable of container yard (CY) and should be reduced to achieve a maximum efficiency score of 10,989.6 units from CY. To achieve high YOR, BICT should optimize the utilization of the container yard.

Do you agree or disagree that dwell time is an indicator to measure the efficiency of container terminal?

This study aims to determine the response of the respondent regarding the extent to which the agreement or disagreement over whether the dwell time is an indicator to measure the efficiency of the container terminals. As figure 18 above, indicates, 2% of respondents strongly disagree, 22% of respondents disagree, 18% of respondents neither agree or disagree, 54% of respondents agree, while 4% of respondents strongly agree. This finding shows that the majority of the respondents agree that time is an indicator to measure the efficiency of container terminals. From the above assessment indicators, it can be seen that there are still respondents who respond not to agree. However, the results of this assessment prove that the majority of the respondents have the knowledge and understanding of dwell time as an indicator to measure the efficiency of operational performance in the container terminal very well. Looking at table 12 above presents that the dwell time at BICT from 2015 to 2017 experienced to increase with a decrease in dwell time from 4.1 days in 2015 to 2.7 days in 2017 or a reduction of 1.4 days. It means that handling containers in the container yard has been done optimally to reduce congestion in the terminal.

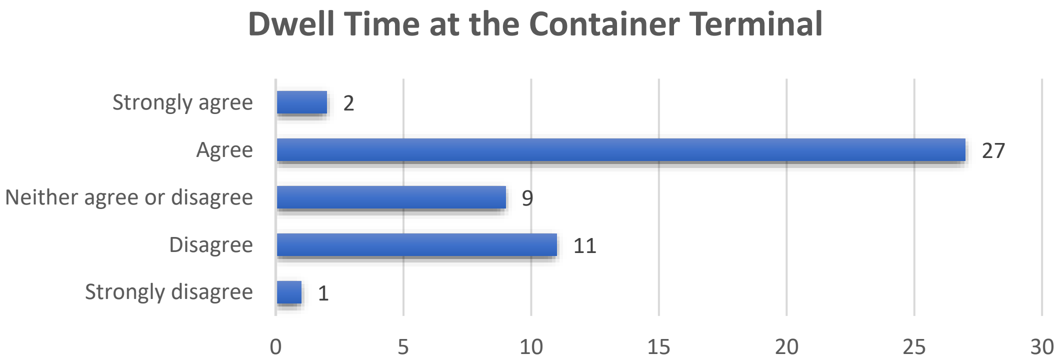

Figure 19: Dwell Time at the Container Terminal
Source: Own calculation

4.7.6 Yard Equipment

Does the Belawan International Container Terminal (BICT) have enough and reliable yard equipment to improve the productivity and speed of loading and unloading activities?

The design of the questions shown above aims to find out whether the Belawan International Container Terminal (BICT) have enough and reliable yard equipment to improve the productivity and speed of loading and unloading activities. As presented in Figure 15 below that 0% of respondents rated not enough but reliable, 18% of respondents rated reliable but enough notes, 30% of respondents rated neither enough nor reliable, while 50% of respondents rated enough and reliable. These findings show that the majority of the respondents rated that the Belawan International Container Terminal (BICT) has enough and reliable yard equipment. It means there are still many available capacities which can be used to stack more containers in the container yard. Looking at the DEA results, it shows that the input variables for equipment yard (YE) on BICT has been optimally utilized with the input slack of YE is zero. It indicates that the performance of the yard equipment at BICT has been used efficiently.

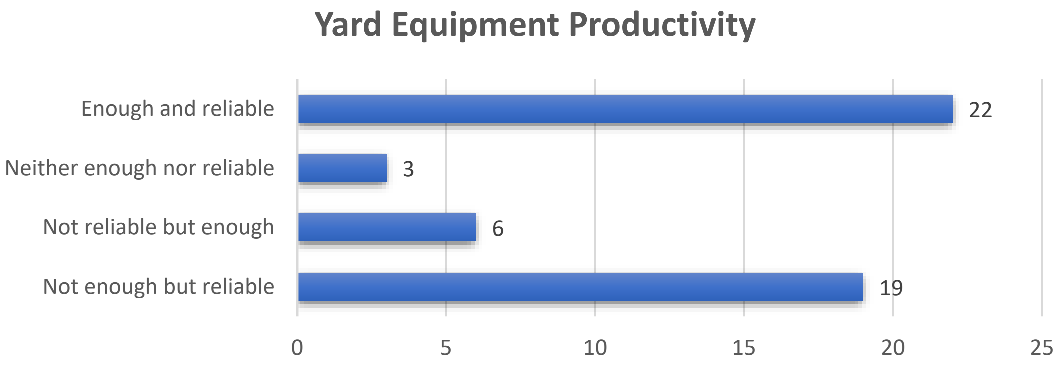

Figure 20: Yard Equipment Productivity
Source: Own calculation

How do you measure the efficiency of the yard equipment deployment in the container terminal?

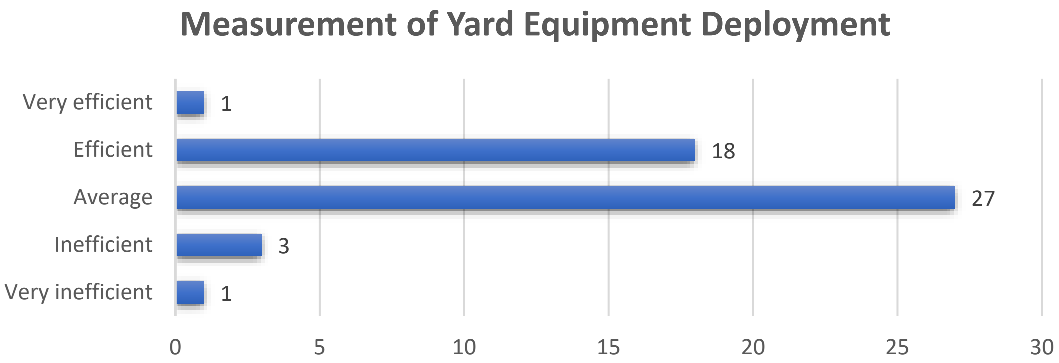

Figure 21: Measurement of Yard Equipment Deployment
Source: Own calculation

This research attempts to find out how respondents measure the efficiency of the yard equipment deployment in the container terminal. Figure 20 above presents that 2% of respondents rated very inefficient, 6% of respondents rated inefficient, 54% of respondents rated average, 36% of respondents rated efficient, while 2% of respondents rated very efficient. These results show the majority of the respondents rated that the yard equipment deployment in the container terminal is in the average category. On the other hand, 36% of respondents rated that the deployment of yard equipment is efficient. It indicates that currently the deployment of equipment at BICT is good but still needs to be improved.

4.7.7 Sustainable Development of Container Terminal

By extending the current terminal the service quality and container throughput will increase?

This study aims to determine the response of respondents regarding the extent of agreement or disagreement about whether by extending the current terminal the service quality and container throughput will increase. As shown in figure 21 that 0% of respondents strongly disagree, 2% of respondents disagree, 16% of respondents neither agree nor disagree, 76% of respondents agree, while 6% of respondents strongly agree. This finding shows the majority of the respondents agree that by extending the current terminal the service quality and container throughput will increase. From the above assessment indicators, it can be seen that 16% of the respondents gave neither agree or disagree responses. The difference in statements among respondents is due to the relationship between expanding the terminal will improve service quality, and throughput depends on the market share owned by the BICT container terminal. A large market share will require a greater terminal capacity to handle container loading and unloading activities and transportation of goods from sea to land and vice versa.

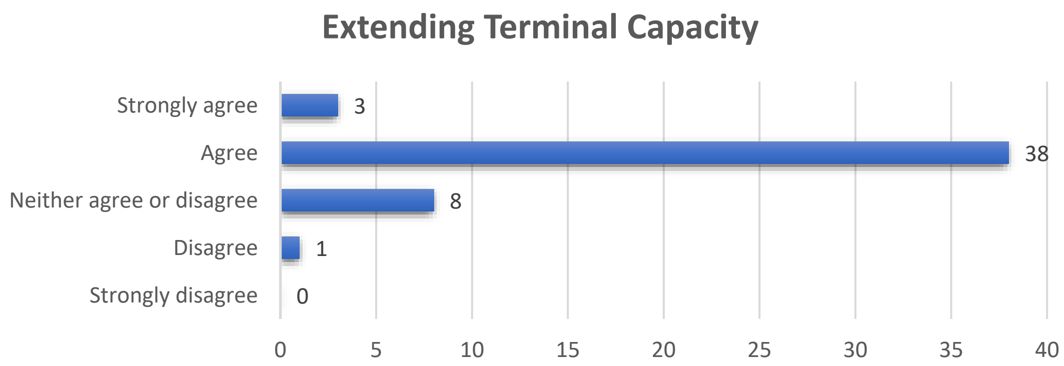

Figure 22: Extending Terminal Capacity
Source: Own calculation

DEA analysis result shows that the BICT efficiency score is still below one which means inefficient. Efforts to achieve an efficient score, BICT should reduce the weight of input variable to achieve the maximum efficiency score. Currently, BiCT terminal capacity is still lower than its capacity which means there is still many capacities available at the terminal. Therefore, efforts to meet the available capacity are carried out by optimizing the utilization of resources owned by BICT.

The appropriate answer to the question above is if the container terminal has a large market share and has reached its design capacity. By expanding the terminal, the quay and container yard capacity will increase and can accommodate large quantities of containers and serve higher ship calls as well. Eventually, by extending the terminal, it will increase the service quality and container throughput.

Do you think that the upgrading terminal facilities and equipment will improve sustainability in terminal operations?

The above question aims to find out the opinions of respondents on terminal facilities and equipment whether the upgrading terminal facilities and equipment will improve sustainability in terminal operations. Figure 22 indicates that 2% of respondents answered no, 10% of respondents answered maybe, 88% of respondents answered yes. These findings indicate that the majority of the respondents answered yes. It means that respondents agree that by upgrading facilities and equipment will improve sustainability in terminal operations. Sustainable development of the terminal is an important factor in terminal operations. With competition, it will encourage the terminal to ensure efficiency of terminal operational performance to remain competitive by upgrading facilities and equipment and applying modern technology in the terminal.

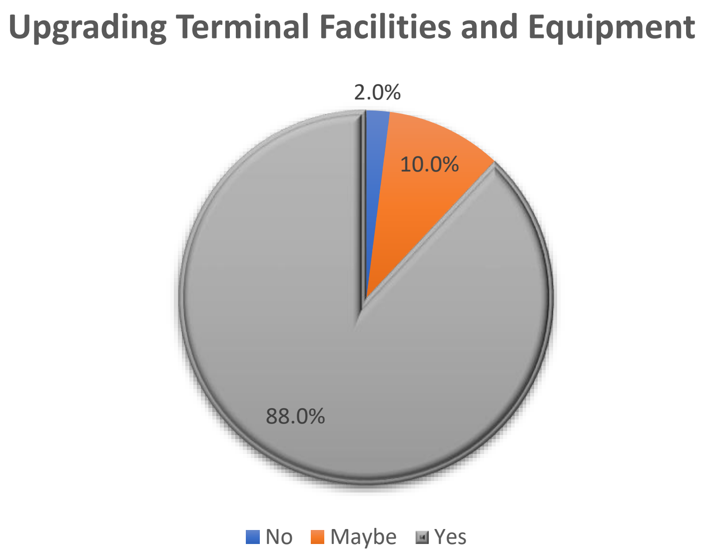

Figure 23: Upgrading Terminal Facilities and Equipment
Source: Own calculation

Do you agree that by conducting the sustainable development will improve the competitiveness and market share of container terminal?

This study attempts to find out the response of respondents regarding the extent to which the agreement or disagreement on whether by conducting sustainable development will improve the competitiveness and market share of container terminals. As shown in figure 23 that 0% of respondents answered strongly disagree, 0% of respondents answered disagree, 2% of respondents answered neither agree or disagree, 66% of respondents answered agree, while 33% of respondents answered strongly agree. This finding shows that the majority of the respondents agree that by conducting the sustainable development will improve the competitiveness and market share of container terminals. Moreover, some other respondents strongly agree.

Sustainable development of the terminal is an important factor in improving the competitiveness and market share of container terminals. The existence of competition will encourage the terminal to improve the operational and business performance of the terminal to be more efficient. Thus, it will provide benefits for container terminal users and operators. Development planning and efficiency in operation will provide benefits for sustainable development. For this reason, innovation and investment in environmental technology are needed to increase the sustainable development in the terminal.

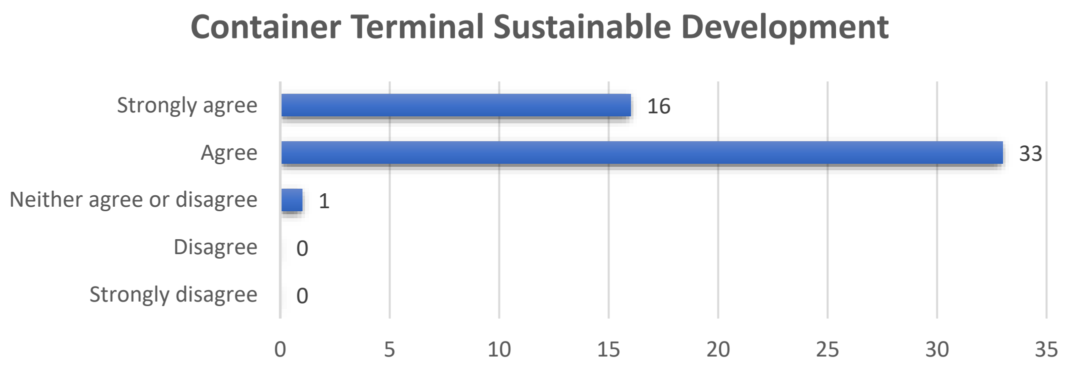

Figure 24: Container Terminal Sustainable Development
Source: Own calculation

From your perspective, how to improve the sustainable development in Belawan International Container Terminal (BICT)?

This purpose of this study is to find out the perspectives of the respondents about how to improve the sustainable development in Belawan International Container Terminal (BICT). This question is an open question, and the respondents can freely provide their views and opinions. There are many answers given by respondents, and these answers have similarities and relationships between one another. Thus, this study summarizes all the answers and opinions given by the respondents in order to obtain a clear understanding of the strategy to improve the sustainable development in BICT container terminal.

The study found that majority of the respondents thought that to improve sustainable development by expanding the terminal which included the addition of the quay length, container yard expansion, additional equipment, and the use of new technology to achieve optimal service. Many things need to be considered in the container terminal sustainable development such as we need to evaluate the current terminal capacity and resources utilization. Therefore, BICT needs to know and analyze market share to ensure sustainable development in BICT.

Sustainable development of the container terminal is essential to be held in order to meet the needs and smooth flow of goods transportation at this time and also for future generations. Sustainability in the terminal should be organized with planning to endanger the needs of future generations. Therefore, it is necessary to have a strategy in the sustainable development plan of the container terminal to meet the terminal operational needs at present and in the future.

Sustainable development strategies and business activities for terminal operators are necessary to accommodate the operational needs at present and in the future. This strategy includes operational performance efficiency, terminal safety, and security, environmental management systems, improvement of terminal facilities and equipment, cooperation, modern technology, and communication. Therefore, success in achieving sustainable development, the terminal needs to regulate the balance between land, facilities, equipment, labor, and technology that is applied to conduct operational activities and terminal business which will ultimately provide added value to the terminal and regional economic growth.

4.8 Summary of Findings

The purpose of this study is to analyze and measure the efficiency level of operational performance at Belawan International Container Terminal (BICT). The method in this study uses a qualitative and quantitative analysis approach. This study assesses the indicators that affect the efficiency of operational performance at the container terminal. There are two methods used in this study, namely the DEA analysis method using the Stata program and the online questionnaire which is used as the main instrument to obtain primary data from BICT. The DEA method is held to measure performance efficiency based on input and output variables. Input variables consist of the quay length, the quay crane, container yard, and yard equipment and throughput as output variables.

Meanwhile, the questionnaire is designed using the Likert scale ranging from 1 to 3, 1 to 4 and 1 to 5, respectively. The sample size used in this study is 50 respondents from BICT employees. Findings revealed that all respondents participated in the survey. Distribution, data collection, and analysis are facilitated with the use of an online questionnaire provided by Erasmus University Rotterdam through the website link of http://erasmusuniversity.eu.qualtrics.com/. Through this website, the questionnaire is designed and distributed to respondents by sending website links via email and mobile applications.

The findings reveal that there is an era relationship between the results of the DEA and the responses collected from the respondents. It shows that there are consistency and stability in assessing or measuring data or information. Surveys are conducted to test the truth about the testing of data or information obtained. From the results of observations and calculations carried out found that the current performance of Belawan International Container Terminal (BICT) is inefficient. The DEA results show that the efficiency score of BICT is 0.8 or still below 1. From testing the four large container terminals in Indonesia, BICT is in the third position under the TPK Koja and TPS while TPKS occupies the lowest position.

The survey results revealed that respondents considered that the current performance of BICT is inefficient. It is shown from survey result that measures by four input variables that are used in research. Respondents considered that the category of quay length capacity is good but not utilized optimally and caused the lower ratio of BOR. A lower BOR ratio reveals that berth availability is often found on the quay when the vessels arrive. Most respondents considered the performance of quay cranes in good category and others rated on average. Respondents considered that there are still many capacities available in the container yard. It causes inefficient performance of BICT operations. For yard equipment, most of the respondents agreed that the utilization of the equipment is in the sufficient and reliable category. The survey results also show that respondents have a good understanding of indicators that affect the efficiency of operational performance at the container terminal from the perspective of the respondents, it is considered that in order to improve competitiveness and market share, the terminal should improve the efficiency and put an investment in order to realize sustainable development in BICT. Finally, the findings indicate that the operational performance of BICT is inefficient. It is caused by three input variables namely quay length, quay crane and container yard. The three variables should be reduced by optimizing the resources in the container terminal to achieve the efficiency score.

Chapter 5 – Conclusions and Recommendations

5.1 Conclusion

The objective of the study is to analyze the efficiency of operational performance at Belawan International Container Terminal (BICT) using DEA analysis. The results of this study answer the Main Research Questions and sub-research questions. The measurement of efficiency in this study uses the DEA method with the Stata program and the distribution of an online questionnaire. Factors that influence performance efficiency are used as measurement indicators that are exploited to evaluate the efficiency score. The indicators consist of input variables including quay length, quay crane, container yard and yard equipment and the output variable is throughput. Input and output variables are held to test the efficient score of the DMU or terminal unit. It also presents recommendations and suggestions that include achieving targets by optimizing the resources indicated by the result of the test.

The findings revealed that the operational performance of BICT is identified as inefficient using only 84.9% of the input provided. To achieve the maximum efficiency score, BICT should reduce all inputs by 15.1%. The efficiency of operational performance can be achieved by reducing three input slacks, namely 154.7 units from QL, 1.7 units from QC and 10,989.6 units from CY. By observing the four terminals as DMU, BICT occupied the third position under the Koja TPK and TPS while the TPKS in the lowest position.

Responses from respondents collected from an online questionnaire indicate that there are consistency and stability in assessing or measuring data or information. The survey is conducted to test the validity of data examination or information obtained. The results of observations of the online questionnaires revealed that respondents considered the current performance of BICT is inefficient. The study found that four input variables, namely quay length, the quay crane, container yard and yard equipment are not utilized optimally. It will be improved by optimizing the utilization of resources in the terminal.

Respondents considered that the quay length capacity is not used optimally which then led to a lower BOR ratio. It reveals that berth availability is often found on the quay while the vessels arrive. For quay crane variables, the survey results show that the current quay crane performance is good, and it is still possible to be upgraded to achieve more effective and efficient performance. Respondents consider that there are still many capacities available in the container yard which can be used to stack more containers in the container yard. The low YOR ratio is an indicator that the performance of container yards at BICT is inefficient. For yard equipment, most respondents agree that the yard equipment is in the sufficient and reliable category. It is following the DEA result which shows that the input variable for equipment yard has been utilized optimally with the weight of input slack is zero. It indicates that the performance of the yard equipment at BICT is efficient.

The survey results also show that respondents have a good understanding of indicators that affect the efficiency of operational performance in container terminals. Most of the respondents thought that to improve the efficiency of operational performance is by implementing proper operation management and increase the utilization of facilities and equipment to enhance the speed of container handling activities. From the perspective of respondents, it is considered that to improve competitiveness and market share; the terminal should increase productivity and efficiency, and conduct investments for development.

The study also reveals that sustainable development strategies and business activities for terminal operators are considered very important to accommodate current and future operational needs. Therefore, to achieve the success of sustainable development, BICT needs to regulate the balance between land, facilities, equipment, labor, and technology provided to carry out terminal operations and business activities. Eventually, it will provide added value to the terminal and economic growth.

The application of the DEA analysis and online questionnaire held in this study is expected to help stakeholders, especially in the BICT to measure the efficiency and strategies to improve the efficiency of operational performance at the container terminal. Optimization should be conducted optimally to enhance service quality and higher throughput. Efficiency will improve terminal competitiveness and market share and eventually will benefit the company development.

5.2 Suggestions for Further Research

Due to several constraints during the study, such as time and data limitations, the DEA analysis only examine several initial datasets of input and output variables. DEA only analyzes the efficiency level of operational performance at BICT based on the relative efficiency between several DMUs used in the sample. The DEA results do not provide absolute efficiency values since these values will change along with changes in the initial data set. Further research can be conducted by observing more DMUs with the addition of output and input variables to obtain the precise efficiency scores.

Remembering the importance of evaluating the efficiency of operational performance at the terminal; efficiency can be observed further by using several DEA models such as DEA-CCR and DEA-BCC. The precise initial data set can support the accurate level of efficiency. Therefore, DEA analysis is an important tool for Belawan International Container Terminal (BICT) to know and understand how efficient their performance and position compared to other container terminals in Indonesia regarding efficiency performance. Eventually, it will present solutions for container terminals to improve the operational performance in order to enhance competitiveness, market share, and customer satisfaction.

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Appendices

Appendix 1

Facilities and Equipment

Belawan International Container Terminal (BICT)

No.	Facility	Unit	Volume
1	**Quay Length**	m	550
2	**Quay Crane**	Unit	6
3	**Container Yard**	m2	158,464
4	**Yard Equipment:**		
	a. RTG	Unit	11
	b. Reach Staker	Unit	2
	c. Side Loader	Unit	1
	d. Truck	Unit	29
	Total	Unit	43

Sources : Own elaboration from various sources

KOJA Terminal

No.	Facility	Unit	Volume
1	**Quay Length**	m	650
2	**Quay Crane**	Unit	7
3	**Container Yard**	m2	257,200
4	**Yard Equipment:**		
	a. RTG	Unit	25
	b. Reach Staker	Unit	3
	c. Truck	Unit	48
	Total	Unit	76

Sources : Own elaboration from various sources

Terminal Petikemas Semarang (TPKS)

No.	Facility	Unit	Volume
1	**Quay Length**	m	531
2	**Quay Crane**	Unit	7
3	**Container Yard**	m2	195,386
4	**Yard Equipment:**		
	a. RTG	Unit	23
	b. Reach Staker	Unit	3
	c. Side Loader	Unit	2
	d. Top Loader	Unit	1
	e. Forklift	Unit	8
	f. Truck	Unit	43
	Total	Unit	80

Sources : Own elaboration from various sources

Terminal Petikemas Surabaya (TPS)

No.	Facility	Unit	Volume
1	**Quay Length**	m	1000
2	**Quay Crane**	Unit	11
3	**Container Yard**	m2	350,000
4	**Yard Equipment:**		
	a. RTG	Unit	28
	b. Reach Staker	Unit	6
	c. Sky Stacker	Unit	3
	d. Truck	Unit	80
	e. Translifter	Unit	7
	f. Forklift	Unit	18
	Total	Unit	142

Sources : Own elaboration from various sources

Appendix 2

DEA-Stata Result

```
      name:  dealog
       log:  C:\Users\Riky Armadi\Documents\MEL Thesis\Run Stata\dea.log
  log type:  text
 opened on:  12 Aug 2018, 16:25:35

options: RTS(CRS) ORT(IN) STAGE(2)
CRS-INPUT Oriented DEA Efficiency Results:
                             ref:     ref:     ref:     ref:  islack:  islack:  islack:  islack:  oslack:
          rank    theta         1        2        3        4       ql       qc       cy       ye        t
dmu:1        3  .849081         .  .480401        .        .  154.734  1.73168  10989.6        .        .
dmu:2        1        1         .        1        .        .        0        0        0        .        .
dmu:3        4   .76249         .  .579237        .        .  28.3778  1.28277        .  16.9772        .
dmu:4        2  .877049         .   1.1935        .        .  101.277  1.29307        .  33.8353        .
      name:  dealog
       log:  C:\Users\Riky Armadi\Documents\MEL Thesis\Run Stata\dea.log
  log type:  text
 closed on:  12 Aug 2018, 16:25:35
```

Source: Own elaboration

Appendix 3

Online Questionnaire Form

Efficiency Analysis of Operational Performance in Container Terminal: A Case Study in BICT

Start of Block: Introduction

Dear Respondent,

Thank you for your willingness to participate in this survey. The survey is undertaken as part of the existing requirements in research to obtain a Master of Science (MSc) in Maritime Economics and Logistics at Erasmus University Rotterdam.

Currently, I am conducting research on "**Efficiency Analysis of Operational Performance in Container Terminal: A Case Study in BICT Container Terminal, North Sumatera, Indonesia**." This study aims to evaluate the efficiency of operational performance in container terminals in order to improve productivity and sustainable development in BICT. As a respondent, you will be asked to answer some questions related to this research.

The survey will take about 10 minutes. The answers you provide will be used for academic purposes and will be kept confidential. The survey is available in English and Bahasa Indonesia. If you have any concerns, please feel free to contact me at 489144ar@eur.student.nl.

Best Regards,

Riky Armadi

End of Block: Introduction

Start of Block: Part A. General Information - Jul 28, 2018

1 What is your education level?

- ◯ High School (1)
- ◯ Diploma's Degree (6)
- ◯ Bachelor's Degree (2)
- ◯ Master's Degree (3)
- ◯ Doctorate (4)

---

2 What is your division/unit?

- ◯ Management System (1)
- ◯ Operation (2)
- ◯ Engineering (3)
- ◯ Finance (4)
- ◯ Human Resources (5)
- ◯ Information Technology (6)

---

3 What is your position/status in the organization?

- Operator (1)
- Staff (2)
- Assistant Manager (3)
- Manager (4)
- General Manager (5)

---

4 How long have you worked at this company?

- Less than 2 years (1)
- 3 - 5 years (2)
- 6 - 9 years (3)
- Over 10 years (4)

---

5 Please fill in your email address (you can decide to leave this empty):

____

End of Block: Part A. General Information - Jul 28, 2018

Start of Block: Part B: Efficiency of operational performance at the container terminal - Jul 28, 2018

6 The efficiency of the container terminal operating performance can be measured by several indicators such as the increased level of container throughput and resources utilization (quay, cranes, yards, etc.), reducing handling time and minimize congestion.

- Strongly disagree (1)
- Disagree (2)
- Neither agree or disagree (3)
- Agree (4)
- Strongly agree (5)

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7 How do you assess the resources utilization such as quay, cranes, yards, and equipment to the current container throughput at Belawan International Container Terminal (BICT)?

- Very low (1)
- Low (2)
- Moderate (3)
- High (4)
- Very high (5)

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8 How would you rate the current operating performance at Belawan International Container Terminal (BICT)?

- Very poor (1)
- Poor (2)
- Average (3)
- Good (4)
- Very good (5)

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9 How important is the efficiency of operational performance at Belawan International Container Terminal (BICT)?

- Not at all important (1)
- Slightly Important (2)
- Important (3)
- Fairly Important (4)
- Very Important (5)

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10 From your perspective, how to improve the efficiency of operational performance in Belawan International Container Terminal (BICT)?

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End of Block: Part B: Efficiency of operational performance at the container terminal - Jul 28, 2018

Start of Block: Part C: Quay Length - Jul 28, 2018

11 How is the quay capacity for berthing and loading and unloading activity?

- Very poor (1)
- Poor (2)
- Average (3)
- Good (4)
- Very good (5)

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12 How often do you find no berth available upon vessel arrival?

- Hardly ever (1)
- Occasionally (2)
- Sometimes (3)
- Frequently (4)
- Almost always (5)

End of Block: Part C: Quay Length - Jul 28, 2018

Start of Block: Part D: Quay Crane - Jul 28, 2018

13 How do you assess Quay Crane performance in container loading and unloading activities to a ship or truck at Belawan International Container Terminal (BICT)?

- Very poor (1)
- Poor (2)
- Average (3)
- Good (4)
- Very good (5)

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14 How do you asses the operational performance effectiveness of the current quay crane at BICT?

- Very ineffective (1)
- ineffective (2)
- Average (3)
- Effective (4)
- Very effective (5)

End of Block: Part D: Quay Crane - Jul 28, 2018

Start of Block: Part E: Container Yard - Jul 28, 2018

15 How would you assess the yard capacity for container stacking in the terminal?

- Much less than required (1)
- Less than required (2)
- At capacity (3)
- Capacity available (4)
- Much capacity available (5)

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16 Do you agree or disagree that dwell time is an indicator to measure the efficiency of container terminal?

- Strongly disagree (1)
- Disagree (2)
- Neither agree or disagree (3)
- Agree (4)
- Strongly agree (5)

End of Block: Part E: Container Yard - Jul 28, 2018

Start of Block: Part F: Yard Equipment - Jul 28, 2018

17 Does the Belawan International Container Terminal (BICT) have enough and reliable yard equipment to improve the productivity and speed of loading and unloading activities?

- Not enough but reliable (1)
- Not reliable but enough (2)
- Neither enough nor reliable (3)
- Enough and reliable (4)

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18 How do you measure the efficiency of the yard equipment deployment in the container terminal?

- Very inefficient (1)
- Inefficient (2)
- Average (3)
- Efficient (4)
- Very efficient (5)

End of Block: Part F: Yard Equipment - Jul 28, 2018

Start of Block: Part G: Sustainable Development of Container Terminal - Jul 28, 2018

19 By extending the current terminal the service quality and container throughput will increase?

- ◯ Strongly disagree (1)
- ◯ Disagree (2)
- ◯ Neither agree or disagree (3)
- ◯ Agree (4)
- ◯ Strongly agree (5)

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20 Do you think that the upgrading terminal facilities and equipment will improve sustainability in terminal operations?

- ◯ No (1)
- ◯ Maybe (2)
- ◯ Yes (3)

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21 Do you agree that by conducting the sustainable development will improve the competitiveness and market share of container terminal?

- ○ Strongly disagree (1)
- ○ Disagree (2)
- ○ Neither agree or disagree (3)
- ○ Agree (4)
- ○ Strongly agree (5)

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22 From your perspective, how to improve the sustainable development in Belawan International Container Terminal (BICT)?

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End of Block: Part G: Sustainable Development of Container Terminal - Jul 28, 2018