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WORLD MARITIME UNIVERSITY

Shanghai, China

**OPERATING SYSTEM OPTIMIZATION
IN MULTIPURPOSE TERMINAL OF PALEMBANG PORT**

By

Dewa Cipta Hadi

Indonesia

A research paper submitted to the World Maritime University in partial fulfillment of
the requirements for the award of the degree of

MASTER OF SCIENCE

In

INTERNATIONAL TRANSPORT AND LOGISTICS

2014

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DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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ABSTRACT

Title of Dissertation : Operating System Optimization In Multipurpose Terminal of Palembang Port
Degree : Master of Science in International Transport and Logistics

Palembang Port is the busiest and the largest port in South Sumatera Province. The increased of economic in South Sumatera have any effect to the flow of ship and cargo. As the implications, management buy a number of cargo handling equipment especially in multipurpose terminal to speed up the cargo handling in terminal and high level of customer satisfaction. In addition, Palembang Port set the JCDT terminals where the operations specifically using Jib Crane. However, the main problem that arises with this terminal is the queue at certain hours because the ships came at the same time and handles a specific cargo by packaging of bag cargo. Therefore, the research is needed to determine the proper capacity and operating system taking into account existing infrastructure.

This research focuses on the utilization of facilities with the number of ship arrivals in terminal multipurpose and the waiting time by using queuing theory. The facilities analysis including analysis of gate, berth analysis, warehouse analysis and waiting cost analysis. Meanwhile, the calculations of ship arrivals rate and service rate pattern will be using the statistical distribution test. The total cost model will be calculated on all costs to be borne by the customer during the cargo handling activities to the gate and using existing operation system implemented in the terminal.

In the concluding chapter shows that the facilities in the terminal still accommodate the cargo throughput at least in the next 5 years. The total cost models using 2 operations model in terminal, they are truck losing and via warehouse. The results, application of cargo handling by using truck losing model more effective and efficient in term of cost.

Key words: **JCDT, forecasting model, KS-test, berth capacity, warehouse capacity, queuing theory, total cost model.**

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LIST OF ABBREVIATIONS

JCDT	Jib Crane Dedicated Terminal
TRT	Turn Round Time
WT	Waiting Time
UNCTAD	United Nations Conference on Trade and Development
MSE	Mean Square Error
GNP	Gross National Product
GDP	Gross Domestic Product
FIFO	First In First Out
LIFO	Last In First Out
WT	Waiting Cost
TC	Total Cost
KS Test	Kolmogorov-Smirnov Test
CV	Critical Value
CORREL	Correlation
CPO	Crude Palm Oil
SEA	South East Asia
STBA	Ship Time Between Arrival
LOA	Length of Overall
GT	Gross Tonnage
MPC	Move Per Cycle
CBM	Coal Bed Methane
ISPS Code	International Ship and Port Facility Security Code
IDR	Indonesia Rupiah
USD	US Dollar
BWT	Berth Working Time
NOT	Not Operation Time

Chapter 1 INTRODUCTION

1.3 Background

Indonesia is an archipelago country, that two-thirds of its territory is located on the waters and strategic location because it is located in the transit trade of the world. As an archipelago, the port's role is vital in the Indonesian economy. In this country, the presence of adequate port plays a major role in supporting the mobility of cargoes and people. Port is one of the most important trade chain of the entire trading process, both inter- island and international trade. As a meeting point between land and sea transportation, ports become very vital role in driving the growth of the economy. As part of the transportation system, the port plays an important role in the economy. As is known, In 2012 Indonesia's entry in the ranks of 40 countries in the world with a giant economy ranked 16th based on Gross Domestic Product, based on reports from Oppenheimer, United States & OECD Reports (2012); Mckinsey Global Institute Research (2012). This is one of the stage for Indonesia to achieve the ambition perch ranked 10th in the world in 2025 state by The Coordinating Ministry for Economic Affairs Republic Of Indonesia (2013); World in 2050 reports by Pwc Economics (2013).

In this research, the author will focus on one of the ports of total 12 ports managed by Indonesia Port II. The research will be conducted by author is the Palembang Port in South of Sumatera Province. The Southern Sumatran Province has such a wealth of diverse potential of natural resources (SDA), the wealth of art, culture and tourism potential. The whole of potential becoming South Sumatra is the richest province no. 5 in Indonesia (Statistics Indonesia Bureau, 2012). As the richest provinces no. 5 in Indonesia, South Sumatra natural richness is very large ranging from petroleum, natural gas, coal to geothermal is the main attraction for the entry of investors into South Sumatera. This province is also building a Gas and

Steam Power Plant at the mouth of the mine. South Sumatran became the largest supplier of electricity and gas for the Java and Singapore. The South Sumatran province's capital is in Palembang. Geographically, Southern Sumatra Province bordering Jambi province in the northern province of Bangka-Belitung in the east, in the southern province of Lampung and Bengkulu province in the west as described below :

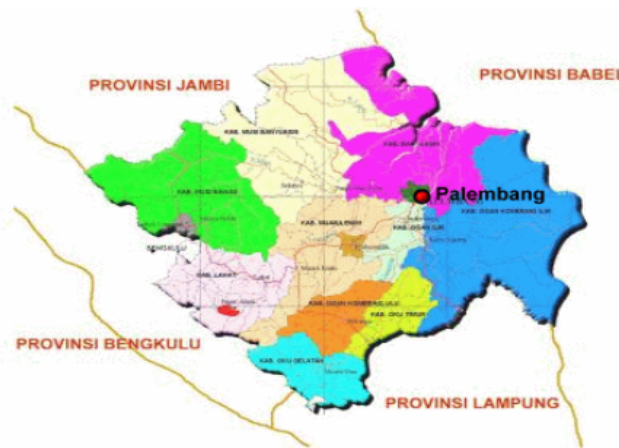


Figure 1.1. Southern Sumatran Province borders with the surrounding
Source: Bureau of Government Institutions in South Sumatra

Palembang, the capital of South Sumatera Province, in the last 5 years progressed rapidly. The facilities, infrastructure, investment booming, and economy continuous increase rapidly. This condition makes Palembang as one of the destinations in the country. Good for a visit and to seek business opportunities. In status, Palembang has become a metropolis city. The indicators are in terms of population density, the level of economy, availability of infrastructure and other supporting variables (Indonesia Shipping Gazzate, 2013). Some examples are the growth of this city held various events such as the implementation of National Sports Week XVI, Southeast Asian Games (SEA Games), various international conferences and meetings. This events impact the flow of cargo coming mainly materials for construction. It can be seen from the data high rate of flow of cargoes, especially general cargoes in multipurpose terminal.

In anticipation of traffic growth at the Palembang Port cargoes, the management of Indonesia Port II expanding the container yard and warehouse covering an area of 1 Ha is able to accommodate about 1320 TEUs. The expansion of the yard and warehouse is considered very appropriate because in addition to the anticipated increase in the flow of cargoes. Furthermore, the cargo handling equipment must also be taken into consideration in cargo operations.

1.4 The Research Problem

Due to the increased flow of cargoes, Palembang Port anticipated to increase productivity by purchasing four equipment cargoes handling namely Jib Crane. The purchasing of four jib cranes are implemented at the same time and used at berth in Multipurpose Terminal. The investment of cargo handling equipment is a response to improve customer service and provide customer satisfaction through increased productivity.

The utilization of Jib Crane is not optimally due to several factors. These factors include the persistence of the shipping companies that use the ship gear (Ship Crane), workers do not work 24 hours, there is no standard size packaging, etc. Furthermore, the Palembang Port applied one conventional berth with a Jib Crane Dedicated Terminal (JCDDT) for anticipating the low equipment utility. The JCDDT is planned at first is to maximize the performance of service operations and the productivity in the berth. In the terminal operations, efficient berth allocation is a vital factor for successful terminal operations and the equipment handling quantity and performance are the one of the key terminal productivity to provide service level to customer (Akio Imai, 2007). The Multipurpose Terminal also should provide loading and discharging cargo service with minimum waiting time and a maximum efficiency because those are the main indicator performance for Multipurpose Terminal (Kusmayadi, 2012).

However, The Effect of JCDT implementation leads to some new crucial issues. The several problems are the ship Turn Round time (TRT) in port and the waiting time (WT) is high. The concrete examples of the impact is the increased of ship waiting time effect for the ship queue, where the ship came at the same time with carry cargoes in large numbers. In terms of evaluating the ship waiting time, there are so many points that must be anticipated to solve the problems by terminal operators. The points that should be anticipated such as berth capacity, the number of trucks and warehouse capacity.

In providing service terminal with minimum waiting time and maximum efficiency, there are several things that can be used as a reference by the terminal operators in order to achieve proper terminal capacity. Things that should be used as a reference by the terminal operator with doing an analysis of the demand for cargo which will be served followed by a number of cargo handling equipment. The main purpose of this analysis is to determine whether the number of existing facilities and equipment to serve the demand. This needs to be done as a form of anticipation by terminal operators in order to avoid equipment handling inefficiencies and the amount of resources committed to the existing demand. Due to the technical side of the field operation, inefficient cargo handling will cause the length of time required for loading and unloading process and inefficient used cargo handling equipment. Another example that would be caused is the ship waiting time will be longer, then resulting in long queues. Appropriate time allocation will improve the performance and productivity of the terminal and make the next ship can be quickly served. Meanwhile, in customer side will incurred the higher cost it means there is more payment from customer to terminal operator.

In this research, the authors want to analyze the performance in multipurpose terminal by adequate number of berth, warehouse facilities with an optimal utilization in accordance with growing flow of cargoes in the

future and see whether the application of JCDT is better than other berth in multipurpose terminal in terms of productivity performance. Another thing is to provide minimum waiting time and efficiency. All this could be done by analyzing facility capacity, performance of cargo handling equipment and the utility of this equipment related to the cargo demand.

1.6 Limitation Problems

This research has some limitation in order to keep the research was not dilated, so that the author needs to provide some restrictions of the problem as follows:

- a. Object of analysis was limited in JCDT Terminal in multipurpose terminal of Palembang Port.
- b. The research will focused on cargo with packaging bag cargo.
- c. The terminal never handled transshipment operation.
- d. The research scope for operation was limited for ship arrival operation, loading and discharging activities, the operations are truck losing operation and loading discharging via warehouse.
- e. The facilities will be analyzed are berth and warehouse.
- f. The equipment handling will be analyzed are Jib Crane.
- g. The primary data will be collected from various sources in year 2012 and 2013.
- h. The forecasting of cargo traffic flow future demand for the next 5 (five) years.

1.7 The Expected Contribution

Contribution expected from the author of this research is to evaluate the performance of a Dedicated Terminal Jib Cranes in multipurpose terminal and the provision of adequate facilities as well as associated with their use in the future. In addition, this research supports the Palembang Port branch management to make strategic decisions in service multipurpose terminal

operations and investment decisions in the future. Meanwhile, the operational point of view, can aim to reduce the waiting time and the turn round time aboard ship while in port and use it to increase productivity at the terminal. Contributions that will be generated including the following:

- a. Forecast the cargo throughput some commodities with specialized by bag cargo, where it is useful to anticipate the amount of cargo loading and discharging will be done in the future.
- b. Determine the performance and capacity of the facilities with 2 operations aspects (Truck losing and using warehouse), whether existing facilities is proper related to cargo demand.
- c. Determine queuing system and handling equipment performance.
- d. Calculate the total cost model.

1.8 Research Structure

This research has a systematic structure which can be illustrated below:

a. Introduction

In this chapter will explain the research background, determining the research problem, limitation problems and the expected contribution of the research.

b. Literature Review and Conceptual Framework

In this chapter will explain about some of the literature and knowledge related to this research so that it can be used as a basis for the concept of the problem and the solution.

c. Research Methodology

In this chapter will explain a description of the research method: research materials, tools, research methodology, variables, and data to be collected. The purpose of this section is to give the reader information about the methods used to collect and analyze the data.

d. Data Collection

In this chapter will describe many data related of this research. It was collected from various sources in the form of primary and secondary data. The primarily it collected from Palembang Port and some data related to the operational activities. The authors also observed directly to the location of the research conducted by observing, studying and writing that can be the object research. Meanwhile, the secondary data collected from government institution, internet and others data related to this research.

e. Analysis

In this chapter describe about data analysis and discussion of research findings. Part of this chapter seeks to address issues that have been raised in the previous chapter. Some method will be implemented to determine the problems such as forecasting method, analysis ship arrival pattern, etc.

f. Conclusion and Recommendation

In this chapter will divide in two main subjects, conclusion and recommendation. The conclusion is brief statement of the results and discussion of the analysis that has been done in previous chapter. It contains answers to questions on the formulation of the problem. In Overall response focused on the scope of the question based on the previous chapter. Recommendation in this chapter means some advice given based on the findings of this research. It could be some personal opinion by authors.

Chapter 2 LITERATURE REVIEW

Literature review will present the relevant theory that can be used to explain some variables to be studied. Some of the various kinds of problem solving and analysis will be seen and supported by these theories. The previous literature and research topics related to the multipurpose terminal also support the research topic. The author, also incorporate some literature relating to operations in container terminals because in principle the use of patterns in the multipurpose terminal operations and container terminal has a lot in common.

2.2 Port and Terminal

2.8.4 Port

The main idea of port is handling of cargoes. This includes containerized cargo, break bulk cargo, bulk (palletized) cargo, dry bulk cargo, and liquid bulk cargo (Muller, 1995). The multipurpose terminal cargo operation is more difficult than single purpose ports. The high amount of cargo handling, optimization and improvement of efficiency is difficult to obtain.

Assigning special types of cargo for different berth groups or for specific types of port causes a loss of flexibility of port operations. Specialization of cargo handling loss the berthing capacity by dividing the port and the traffic before allocating berths, thus the loss of berthing flexibility and also loss of transit storage areas that maybe achieved by mixing complementary traffic. On the contrary, a specialized port gives a gain in service capacity in the berth facility by segregation of the different classes of traffic and also by separation of high and low average service times, large and small ships, there is a gain through greater consistency of demand (UNCTAD Hand Book, 1995).

2.8.5 Terminal

As mentioned above, the two kinds of terminals are single and multipurpose terminal. Gutzkow, 2013 divide types of marine ports by each location. It's describes in the chart below:

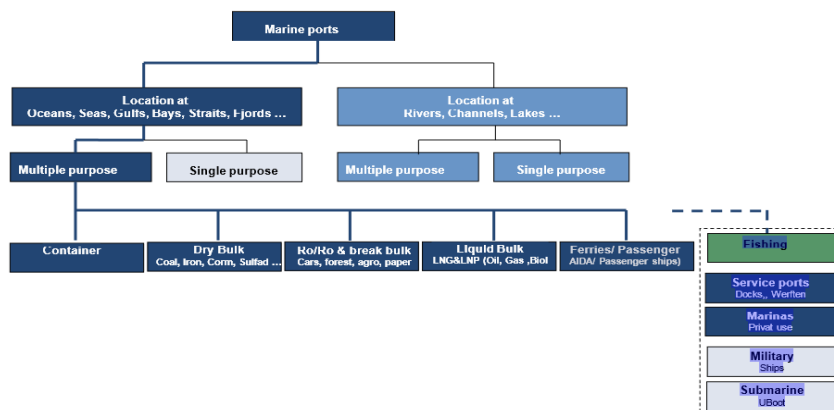


Figure 2.1: Marine Ports

The same as proposed by Faghri & Wahed (2002), the details will explain below:

a. Single purpose terminal

A single purpose terminal is a specialized terminal for handling unique cargoes. This type of terminal has unique economical appeal and uses special types of equipment for maximum throughput.

b. Multipurpose terminal

A multipurpose terminal is the terminal where general cargo vessel calling may carry a variety of cargoes transported in modern ways, such as containers, flats, pre slung cargoes, large units of iron and steel, large units of packaged timber, as well as cars and heavy machinery, together with basic load of palletized cargo, increasingly palletized (Unctad Hand Book, 1995). Multipurpose terminals ensure proper berth utilization for the seasonal fluctuation of specialized types of traffic by providing service to different types of traffic (Ramani K,V 1996).

The terminal's response is to be combined and flexible because the flexibility is provided within a specific spectrum of trade having identical generic characteristics (Caminos and Agos, 1991). This implies the terminals must be planned to accommodate heterogeneous cargoes, from general cargo in small consignments to containers.

2.9 Multipurpose Terminal Operation

2.9.1 The Operation Stage

Based on the prasetyo (2011), in optimizing the cargo handling activities to improve productivity performance in the multipurpose terminal is done by performing the following steps they are the planning stage, preparation stage, implementation stage, implementation phase (pay the cost).

However, the increased productivity of the work of cargoes loading and discharging cannot be separated from the existence of several factors such as commodities are dismantled, type of packaging, cargo handling equipment on berth, productivity of workers, transportation/truck, security around the terminals and weather condition.

Due to the operating system in multipurpose terminal, Gutzkow et al, 2013, saying that the process operations as illustrated below:

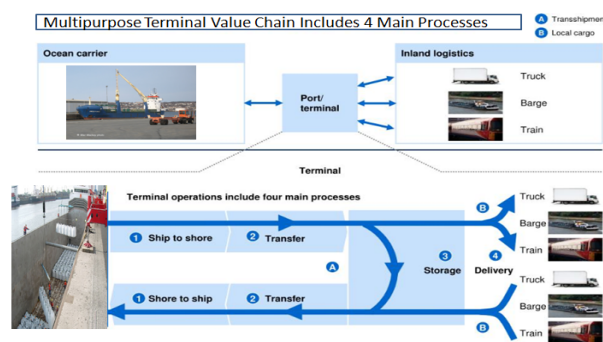


Figure 2.2: Process in Multipurpose Terminal

Meanwhile, Hennesey et al. (2003) explained that the operation of the terminal is divided into four systems, namely loading/unloading from/to ship to/from shore; transfer (from berth to storage area); storage; and delivery and receipt. The operation is depending on the kind of traffic/terminal being dealt with.

2.9.2 Shift in the Terminal

According to Presidential Instruction No. 3 of 1991 on Policy Flow of goods to support economic activity, the Indonesian government has set the schedule of the loading and discharging of cargoes are shift I (08.00-16.00), shift II (16.00-24.00) and shift III (24.00-08.00)

Due to the shift working in the loading and discharging of cargoes in terminals multipurpose, indicating government efforts (Ministry of Transportation) in order to improve the efficiency and effectiveness of the loading and discharging of

cargoes at the port, in addition to further improve service to the users of stevedoring services.

2.9.3 Receiving/Delivery Operation

The receiving/delivery is activity or delivering goods from and to port area. This activity is an activity that the end of the terminal operation. The handling equipment used in this operation by forklift and truck to the owner of the cargoes or warehouse. In general, the pattern of operation of the receiving / delivery at the terminal is divided into two kinds, namely:

a. Direct transport pattern / Truck losing

The direct pattern is commonly known as truck is Loading or discharging the cargoes using the truck directly from and to the vessel. In direct transport patterns, activity receiving / delivery is done by:

- The truck or conveyance is placed in a position directly next to the hull of a ship in the hold where loading and discharging is done by sling in the cargo handling equipment or ship gear (the crane in the ship).
- The cargoes in included in the hold or derived from the hold of the vessel from/to the truck.

b. Indirect transportation pattern

The indirect pattern is delivery or receipt of cargo after passing through a warehouse or yard. In the indirect transport patterns, activity receiving / delivery is done by:

- Placement of truck/forklift next to warehouse or door landline
- The transfer of cargoes from warehouse or yard.

Guan (2009) stated that the yard operation it serves as a buffer to support both the quay side operation and receiving-delivery operation. It also provides the critical interface function between water transport and land transport. The objectives of the operation are two-fold: minimizing turnaround time and providing adequate support for vessel operation (high productivity) said Yuniarto (2013).

In order to provide a more detailed analysis and accurate, some researchers have focused their research is applied to the container terminal which can be used as

a reference in such multipurpose terminal such the terminal transfer operations by Cheng et al. (2005), Lee et al. (2007), Vis et al. (2005). The warehouse operations, by Erdemir (2003), Frankin & Johannesson (2013), Berntson & Holmstrand (2013), Gong (2009). The research focused in yard operations by Beaudoin, Lebel & Soussi (2013), King & Wong (2008), Kim and Hong (2006).

2.10 The Vessel Used in Multipurpose Terminal

2.10.1 General Cargo Vessel

Based on the study of Sasmito & Zain (2011) said that general cargo vessel is a vessel used to transport various types of goods. The vessel of this type using hatch cover, bulkheads twin decks in the holds if necessary. The vessel types of general cargoes are vessel with cargo gear, vessel without cargo gear and the vessel coastal trade liners.

2.10.2 Dry Bulk Cargo Vessel

Bulk carriers (dry bulk carrier) is a vessel that is intended to transport bulk cargo that is loaded into the vessel without the packaging in which the charge is only separated by a space restrictions and unloading, as well as liquid bulk carrier vessel (tankers). Bulk cargo vessel usually load/discharge using grabs, suction pipe, or use a self-unloading system of the vessel.

2.11 The Market

Notteboom & Vonck, 2012 said that the break bulk sector is very heterogeneous, but still some common evolutions and properties can be identified. The supply chain evolutions and macro-economic developments described into 5 affect all break bulk trades in a relatively similar fashion. They are, environmental regulation, markets characterized by consolidation (supply and demand side), the competitiveness is not only dependent on out of pocket cost considerations, the break bulk sectors can obtain major benefits from clustering and surrounding the core activities of each sector (Ports are becoming important distribution centre for chemicals, cars, forest products, etc).

The impact of containerization provides a significant effect on the flow of cargoes on general cargo. The containerization has significant impact not only on the

flow of cargoes, marine transportation system, but also with reference to the inland transport systems. Some influential researches dealing with inland container logistics topics have been conducted by Cappelli et al. (2007), China Intermodal Transport Services to the Interior Project (ITSIP) (2003), Dalla Chiara et al., (2002), ECMT (2001), Libardo and Nocera (2006), Notteboom (2001, 2004), Notteboom and Rodrigue (2005, 2007), Notteboom and Winckelmans (1999), Ocean Shipping Consultants (2007), Robinson (2002, 2005), and UNCTAD (1991).

2.12 Cargo Throughput Forecasting

Cargo throughput is very important for a port, it is not only the most basic production index for measuring the port development, but also a significant reference to organize its production, make its development plans and construction. In the mean time, the amount of the cargo throughput may reflect the economic situation and the development level of port city (Zhang, Huang & Zhao, 2012). The correctness and rationality of the forecast means various aspects in the development of ports including the scientific port layout, the scale of investment in infrastructure, business strategy & development, the collection and distribution of integrated transport plan.

2.12.1 Analysis Cargo Throughput Forecast Model

Through the use of statistical methods and mathematical models, quantitative forecast methods based on accurate, timely, systematic, comprehensive survey of statistical data and economic information can predict the future of the port in size, level, speed and other variables (Wang & Yang, 2007; Xu, 2010). It is closely related to statistics, so quantitative forecast methods also known as the statistical prediction depending on the different mathematical methods used, quantitative forecast methods can be divided into three categories: time series, causality analysis, and combined forecast method (Zhang, Huang & Zhao, 2012). This term of categories will explain below:

a. Time Series Method

The time series method is to find out the variation of the total port cargo throughput of historical data to establish a mathematical model to forecast (Zhang & Huang, 2012). Such methods include: moving average, exponential

smoothing, gray system, the seasonal changes, autoregressive method and time-independent variable regression analysis (Xu, 2006) method. Some research dealing with this method are Jiang and Lei (2009); Xu (2011); Guo, Song and Ye (2005). The time series method can be divided into many forms (Qun, 2013) such as: Trend prediction Models, Moving Average Method, Weight Moving Average, Exponential Smoothing Method.

In time series method, time is used as an independent variable. The trend prediction models can be divided into:

- a. Linear, the formula : $\text{Cargo } t = \alpha_0 + \alpha_1.t$
- b. Polynominal, the formula : $\text{Cargo } t = \alpha_0 + \alpha_1.t + \alpha_2.t^2$
- c. Exponential, the formula : $\text{Cargo } t = 10270e^{0.011t}$ (Mic. excel examples)

The moving Average Method is the simplest and one of the most frequently used extrapolation methods is the method of moving averages. To implement the moving averages method, first choose a span, the number of terms in each moving average. Chosen of a span of 3 months, then the forecast of next month value is the average of the previous 3 months. The formula: Average of y_{t-1} , y_{t-2} , $K y_{t-n}$

The last part is weight moving Average method. The weighting factors are often chosen to give more weight to the most recent terms in the time series and less weight to older data. Notice that this technique has the same disadvantage as the simple moving average technique and that it entails a more complicated calculation at each step of the smoothing procedure. The formula: $W_1.a_1 + W_2.a_2 + W_3.a_3$

b. Causality Analysis Method

Zhang and Zhao, 2012 said that causality analysis methods first identify the relationship between the cargo throughput and some hinterland economic indicators and establish the model based on these indicators. Such methods include regression analysis, the coefficient of elasticity, the system dynamics method and the method of neural network (Lin & Chen, 2008). Another reference used this methods are Huang, Cai and Yi (2010); Chen and Chen (2009); Xu,

Yan and Zhan ((2006). Based on Qun, 2013 said that, on many situations more than one independent variable is useful in predicting the value of a dependent variable. Then, we used the multiple regression. In other words, when we try to explain a dependent variable Y with regression, there are often a multitude of independent variables to choose from. In this method, the regression equation for Y includes a number of independent variables, the X's. The multiple regression formula: $Y = a + b_1X_1 + b_2X_2 + \dots + b_kX_k$

2.12.2 The mean Square Error (MSE)

In statistics, the mean squared error or MSE of an estimator is the expected value of the square of the "error." The error is the amount by which the estimator differs from the quantity to be estimated. The principle of choosing the best forecasting methods is forecast error. This is the important reason for choosing the best method to predict. In the mean square error, we have to find the forecast error as small as possible. Estimators (X) that have small MSE are considered good because their expected distance from θ is small (if the squared error is small then the actual distance will be small as well)(Lauritzen, 2004). The formula:

$$MSE = \frac{\sum (y_i - \hat{y}_i)^2}{n}$$

Table below is the example of comparing the amount of MSE with various forecasting method.

Regression (Y)	Time Series Regression			Moving Average	Weight Mov. Avg	Exponential Smoothing
	Linear	Polynomial	Exponential			
121,208	110,650	106,523	114,493	269,030	214,973	207,986

Table 2.1 Evaluation of Mean Square Error (MSE)

2.13 Variables Influencing Cargoes Throughput

To support the forecasting model by multiple regression method, many variables can be used for explain X as independent variables. In many situations more than one independent variable is useful in predicting the value of a dependent variable. In some literature can be found that some variables can be used as an independent variable will affect the dependent variable. According to Rigot (2012),

variables that affect cargo throughput are macroeconomic variables and the port variables.

2.13.1 Macroeconomics

The trade growth as one of the parameters to explain container growth for forecasting, therefore the port throughput is a part of the trade (Langen, 2003). As well as research conducted by Wiegman, et al (2007) who said that the demand total throughput of a port both export and import derived from global trade flows. We have to measure the port throughput. Therefore it is important to add the total value of the trade of a specific country (Fung, 2002) to measure the throughput of a port. Trade, in turn, depends on the economic activity of the country (de Langen, 2003; Behar and Vernables, 2010), the openness of the economy, the importance of the country as a trade nation (de Langen, 2003).

Products that have a high value, can be transported using a faster mode of transportation, as a result, the effect of the costs incurred will be higher. Whereas a product with low value, can be transported to a slower mode, as the effect of transport costs will be much cheaper but can be transported in a quantity greater. (Shah, 2009). The economic activity of a country can be measured by using Gross National Product (GNP) and Gross Domestic Product (GDP) of a country. Many studies that have used GDP as a measure for economic activity such as Jugovic, Hess, and Jugovic (2011), Gosasang, Chandraprakasul, and Kiattisin (2010), de Langen (2003), Vanoutrive (2010), Liu (2010). GDP is defined as the market value of the goods and services produced by labor and property located in a country (Marrewijk et al, 2007, p. 8). It therefore influences trade, e.g. high economic growth of a trading partner implies a larger market for domestic exports to satisfy foreign demand or for foreign production of goods such as commodities. Vanoutrive (2010) explored the link directly between GDP and port throughput, he concludes that the GDP of other countries also play an important role determining the port throughput.

2.13.2 Port Variables

Tongzon (1995) determines that cargo flow is dependent on the following factors. The first factors are the geographical location of a port, frequency of ship calls and terminal efficiency.

Another variables determining the port variables influencing cargo throughput is the performance of the port. For instance, the equipment handling and workers said Magomba, 2013. However, the variables is not only from the internal factors, another variables is the external variables (competition between transport chains said de Langen, 2010)

2.14 Queuing Theory

Queue analysis was first introduced by AK Erlang (1913) who studied the fluctuations in demand for telephone facilities and service delays. Currently queuing analysis are widely applied in the fields of business (banks, supermarkets), industry (automatic machines services), transportation (airports, sea ports, postal services) and others. Queuing analysis gives the probability information called operation characteristics, which can help decision makers in designing queuing service facilities to cope with fluctuating demand for services at random and keep a balance between the cost of service and waiting costs. Some examples of a queue that often encounter everyday are queues at supermarket checkout service, the queue to buy fuel, queue on red light (person or vehicle crossing), queue plane will land at an airport, queue care physicians, and others.

2.14.1 Basics Of Queuing System

The basic components of the queue are the arrival process, queue and service. These components are presented in the following figure:

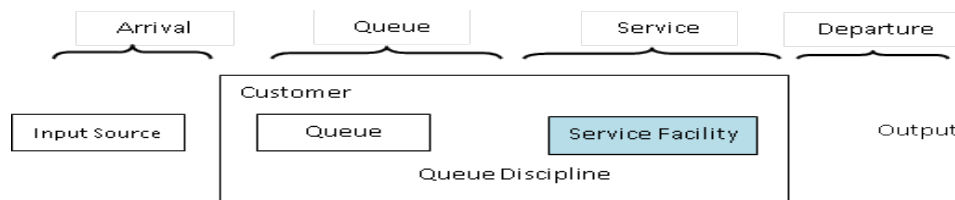


Figure 2.3: Basics of queuing system

Source: Moon, S. H. (2013). Port Logistics, *Unpublished LECTURE HANDOUT, WMU, Malmo, Sweden*

a. Arrival Process

Each problem involves the arrival queue, such as a person, a car, or a phone call to be served. This element is often called the input process. The process includes the input source or the regular arrival is calling population, and how the arrival of which is generally a random process. The arrival process is same like input source (Wang, 2009), the characteristics:

- One characteristic of the input source is its size. The size is the total number of customers. The size may be infinite (default one) or finite.
- When will each one arrive? Associate with a distribution—usually, Poisson distribution (the number of customers generated until any specific time) or Exponential distribution (inter arrival time).
- A customer may be balking, who refuses to enter the system and is lost if the queue is too long.

b. Queue

The core of the analysis of the queue is the queue itself. Incidence queue mainly depends on the nature of the arrival and service processes. Another important determinant is the discipline queuing. Queuing discipline is a decision rule that describes how to serve the queuing. If there is no queue means that the service idle or excess facilities. Wang, 2009 divided this term into 2 types, they are queue & queue discipline, the characteristics such as:

- Queue: The queue is where customers wait before being served and characterized by the maximum permissible number of customers that can contain. Queue may be infinite (default one) or finite.
- Queue Discipline : Refers to the order in which members of the queue are selected for service and first come first serve is normally used

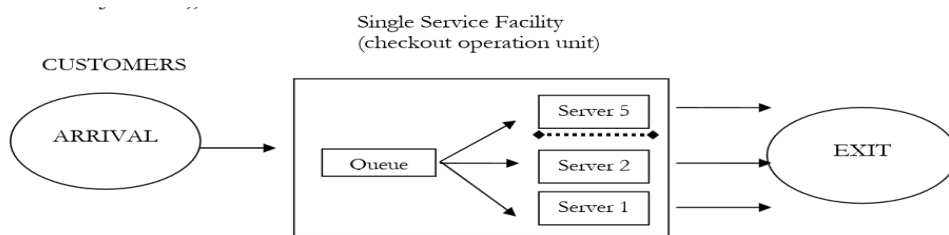
c. Service Mechanism

The service mechanism may consist of one or more service facilities. For example, at a check counter of a supermarkets sometimes there is only a server, but can also fill a cashier with aides to insert items into a plastic bag. The banks may employ one or many tellers. In addition, it is necessary known method of service was

completed, which is sometimes a process random. The service mechanism characteristics (Wang, 2009):

- Consists of one or more service facilities each of which contains one or more parallel service channels, called servers.
- At a given facility, the customer enters one of the parallel service channels and is served by that server.
- Most elementary models assume one service facility with either one or a finite number of servers.
- Service time is usually defined by a probability distribution.

Customers requiring service are generated over time by an input source. The required service is then performed for the customers by the service mechanism, after which the customer leaves the queuing system. We can have following two types of models: One model will be as Single-queue Multiple-Servers model and the second one is Multiple-Queues, Multiple-Servers model (Sheu, C., Babbar S, 1996).



Figure

2.4: Single Stage Queuing Model with Single Queue and Multiple Parallel Servers

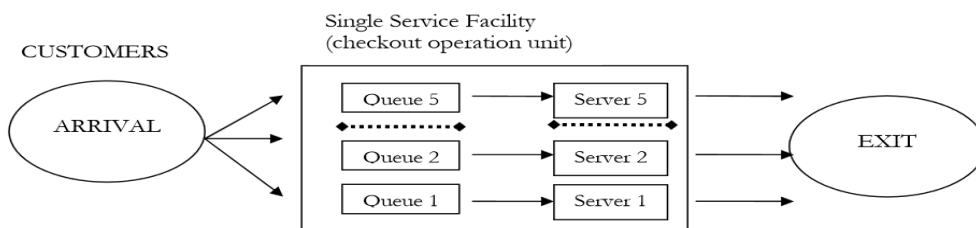


Figure 2.5: Single Stage Queuing Model with Multiple Queue and Multiple Parallel Servers

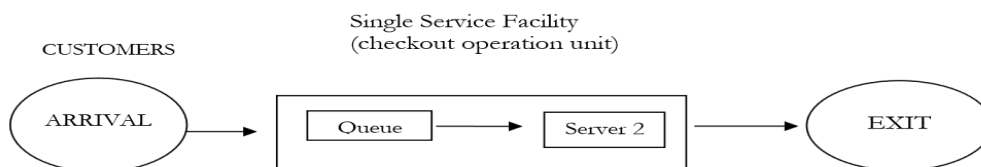


Figure 2.6: Single Stage Queuing Model with Multiple Queue and Multiple Parallel Servers

In these models, three various sub-processes may be distinguished:

- Arrival Process: includes number of customers arriving, several types of customers, and one type of customers demand, deterministic or stochastic arrival distance, and arrival intensity. The process goes from event to event, i.e. the event “customer arrives” puts the customer in a queue, and at the same time schedules the event “next customer arrives” at some time in the future.
- Waiting Process: includes length of queues, servers’ discipline (First in First Out). This includes the event “start serving next customer from queue” which takes this customer from the queue into the server, and at the same time schedules the event “customer served” at some time in the future.
- Server Process: includes a type of a server, serving rate and serving time. This includes the event “customer served” which prompts the next event “start serving next customer from queue”. (Troitzsch, 2006)

2.14.2 Arrival Distribution in Queuing Theory

Several disciplines related to queuing theory relating the number of services, the size of the waiting line (Willig, 1999). The arrival distribution is as follows:

- FIFO: (First in, First out), a customer that finds the service center busy goes to the end of the queue.
- LIFO: (Last in, First out), a customer that finds the service center busy proceeds immediately to the head of the queue. She will be served next, given that no further customer arrives.
- Random Service: the customers in the queue are served in random order.
- Round Robin: every customer gets a time slice. If her service is not completed, she will re-enter the queue.
- Priority Discipline: every customer has a (static or dynamic) priority, the server selects always the customers with the highest priority. This scheme cause preemption or not.

Nafas (2007) said that the Queuing model is commonly labeled as $M/M/c/K$, where first M represents Markovian exponential distribution of inter-arrival times, second M represents Markovian exponential distribution of service times, c (a

positive integer) represents the number of servers, and K is the specified number of customers in a queuing system. This general model contains only limited number of K customers in the system. However, if there are unlimited number of customers exist, which means $K = \infty$, then our model will be labeled as M/M/c (Hillier & Lieberman, 2001.)

One of the queuing models is used to analyze the performance of loading and unloading equipment that is by using the queuing model M / M / K. This means that the queuing system has Poisson arrival distribution and exponential service time unit k servers (Moon, 2011). So for this model, the operating characteristics are as follows:

- a. Probability with no customers in the system

Formula	:	$P_0 = \frac{1}{\sum_{n=0}^{k-1} \frac{1}{n!} \left(\frac{\lambda}{\mu}\right)^n + \frac{1}{k!} \left(\frac{\lambda}{\mu}\right)^k \left(\frac{k\mu}{k\mu - \lambda}\right)}$
---------	---	---

- b. The average time a customer spends in the queue

Formula	:	$W_q = \frac{\left(\frac{\lambda}{\mu}\right)^k \mu}{(k-1)! (k\mu - \lambda)^2} P_0 + \frac{1}{\mu}$
---------	---	--

- c. The average number of customers in the queue

Formula	:	$L_q = P_0 \frac{\left(\frac{\lambda}{\mu}\right)^k \rho}{k! (1 - \rho)^2}$
---------	---	---

- d. Utilization rate for each server

Formula	:	$\rho = \frac{\lambda}{k\mu}$
---------	---	-------------------------------

λ : Average rate of arrival (number of customers per unit time)

- e. Average number of customers in the system

Formula	:	$L = \lambda \left(W_q + \frac{1}{\mu}\right) = L_q + \frac{\lambda}{\mu}$
---------	---	--

μ : Average rate of service (number of customers per unit time)

k : Number of server

- f. Average time a customer spends in the system

Formula	:	$W = W_q + \frac{1}{\mu}$
---------	---	---------------------------

2.15 Total Cost Model

Most analysis of queuing problems finally come to the question how to design a server facility or how the level of service that should be provided. If the decision variable is the level of service, then the model must identify the relationship between the level of service with parameters and variables relevant. The evaluation decision criteria of this model are the total expected cost. The relationship decision variables (level of service) evaluation criteria (total expected cost) shown in the graph below :



Figure 2.7: Total Cost

As seen in the graph the total expected cost is the sum of two different costs: (1) cost of services and (2) the cost of waiting. So, it is clear that the level of service that is recommended is that causes the lowest total expected cost. However, this does not mean this analysis can determine precisely the lowest total cost because operating characteristic obtained is only an average figure and so is uncertain. Thus, the analysis of queues is not an optimization technique, but only information provider.

2.15.1 Cost of Service/Queuing System

The simple example of implementation the cost service, we can see in the supermarket. The adding of checkout counters can effect to the finance because the supermarket have add the cost for all equipment and new waitress counter. This means that if the level of service improves, the cost of service will increase also.

The cost of the service can also be seen from another point of view. If the service level increases, idle time maid is also expected to increase, which means an increase in the opportunity cost for not allocating the waiter to other productive

activities. The method used to calculate the service charge can be different for different cases. Any means used should give the same amount. In order to apply a queuing theory, it gives an approach to minimize the following objective function of operating costs (Yuniarto, 2013). Below is the formula:

Formula	:	$Z = Cq + Cw$
---------	---	---------------

Z = total costs (total costs of the system); Cq = service cost and Cw = waiting cost.

2.15.2 Waiting Cost

Generally there is an inverse relationship between the level of service and waiting times. But sometimes it is difficult to explicitly declare the cost of waiting per unit time. The cost of waiting to be expected simply as the cost of lost profits for company or the cost of the decline in productivity for workers. The waiting cost in the multipurpose terminal for example: waiting for cargo, waiting truck, productivity of workers not optimal, etc.

2.15.3 Total Cost

The total cost means that similar to the cost of services, which determination may be different from one case to another case. Thus, the problem is a conflict between the decision wait for queuing cost against the cost of the service. And decision models formulated as queuing problems:

Formula	:	Minimize: $TC(S) = I \cdot C1 + W \cdot C2$
---------	---	---

$TC(S)$ = total system cost based on the service level

$(S), I$ = service provider's total hours during a specific period,

$C1$ = cost per unit hour in the hours,

W = total waiting hours during a specific period and

$C2$ = cost per unit hour in the waiting hours.

Chapter 3 RESEARCH METHODOLOGY

This research will be analyzed using quantitative methods. The used of quantitative methods chosen by the author in order to obtain more accurate results and detailed. Further details of the research problem will be solved by using the queuing theory. The research data used by author include two things: the primary and secondary data. The use of data sourced from a variety of sources both internal and external. The internal data from Indonesia Port Group, Palembang Port branch and the external data from government institution, customers and related company to this research. In addition, data collection is also using qualitative methods is by conducting interviews with company management, service users and other interested parties in order to research more valid. Some of the data and methods used by author to analyze and solving the problem can be seen in the figure below:

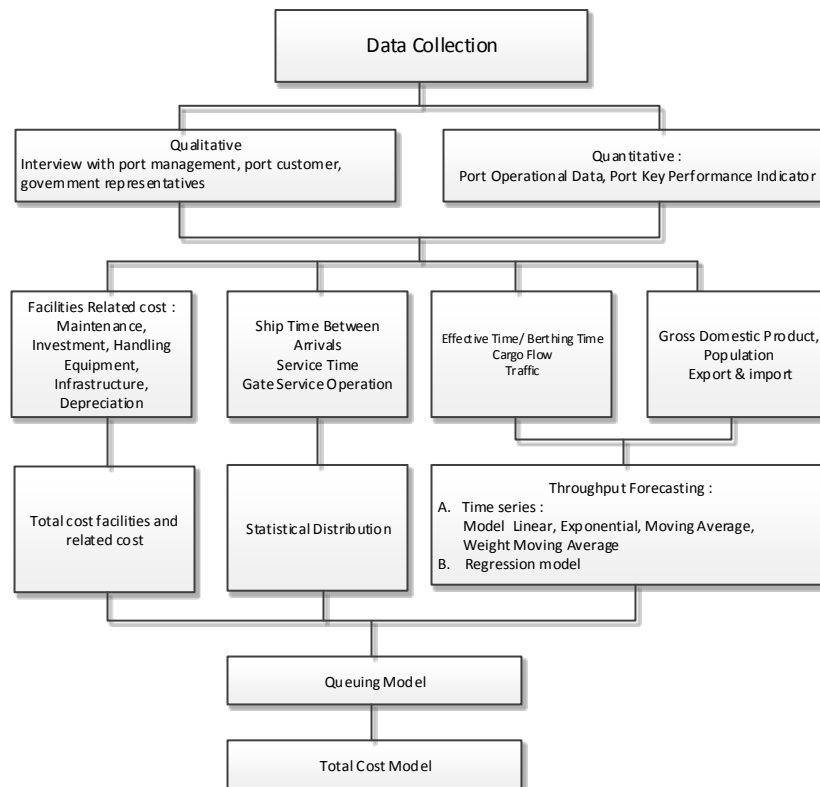


Figure 3.1: Research Methodology
Source: Author

3.1 Research Method

The research methodology consists of four major objectives:

- a. Forecast the cargo throughput some commodities with specialized bag cargo, where it is useful to anticipate the amount of cargo loading and discharging will be done in the future.
- b. Determine the capacity of the facilities, whether existing facilities is proper related to cargo demand.
- c. Determine queuing system and handling equipment performance.
- d. The total cost models by using two cargo handling models in terminal.

3.2 Data Requirement

The data needed to solve this problem as follow:

- a. The Operational data such as the jib crane, berth, warehouse productivity and others operational data will be observed and collected at Palembang Port.
- b. Time between arrivals of ship in the terminal will be observed and collected at Palembang Port.
- c. The volume of export and import cargo will be collected from Bureau of Government Institutions in South Sumatra and Statistics Indonesia Bureau.
- d. The numbers of truck by vendors.

3.3 Ship Arrival Pattern

Several ways that can be used to obtain information about the performance of the ship is to evaluate the ship arrival pattern by using the tool in statistics. Statistical tool that can be used is as described below:

3.3.1 Histogram

In general, there are many ways to present the data in statistics, one of which is by using the histogram. The histogram consists of a rectangle whose base is the length of the class interval, whereas a high frequency of the class interval. The usefulness of the histogram is to determine the distribution / dissemination of data

thus obtained more information from the data and will make it easier to obtain conclusions from these data. The histogram is ideal to use for:

- a. Establish whether the process runs stable or not
- b. Get information about current performance or process variations
- c. Test and evaluate the repair process for improvement

Based on Calyampudi et al., 2005 (as cited in Yuniarto, D.2013), the width of each bar in histogram is always constant and reflect the data range i.e bin. The steps to create a histogram graph as follows:

- a. By reference of the Sturges Rule, the formula can be expressed as :

Formula : $h = \frac{X(n) - X(1)}{k}$
--

X (1): X minimum

X (n): X maximum

- b. Some formula can be used to determine the number of bins (k). The formula is as follows :

Formula : $k = 1 + \log_2 (n)$

n: Number of data observation

3.3.2 Kolmogorof-Smirnov Goodness of Fit Test

Kolmogorov-Smirnov test (KS test) is a non-parametric statistical tests are the most basic and most widely used. It's first introduced by Andrey Nikolaevich Kolmogorov. KS test is used for one sample test that allows the comparison of a frequency distribution. The basic concept of the KS test is similar to other normality test, which measures the ratio of the empirical data with the theoretical normal distribution of data has a mean and standard deviation equal to the empirical data.

In this research, the frequency of ship arrival distribution and service time is one of evaluation to determine the ship arrival pattern for a queue model. The first thing to do is to test the frequency distributions of ship arrival and service time, so it can be determined the queue model for the next step (Bagus D, 2011, 20).

Below is a brief explanation of frequency distribution test using Kolmogorov Smirnov Goodness of Fit Test (K-S test) by Rajagopalan et al., 2006 (as cited in Prayogi, Y. 2013):

a. Aim

The aim is to test the population distribution $F(x)$ be regarding as $F_0(x)$, based on random sample.

b. Source

Let X_i , ($i = 1, 2, \dots, n$) a random sample of n observations be drawn from a population and $F_0(x)$ be the cumulative distribution function (CDF) of a specified (given) population.

c. Hypothesis

H_0 : the population distribution $F(x)$ is $F_0(x)$, $F(x) = F_0(x)$

H_1 : the population distribution $F(x)$ is not $F_0(x)$, $F(x) \neq F_0(x)$

d. Critical Value (D_α) and Level Of Significance (α)

The following is a table of critical value for a significance level using a sample size of more than 35:

Sample Size (n)	Level of Significance ; for $D = \max F_0(X) - F_n(X) $				
	0.2	0.15	0.10	0.05	0.01
Over 35	$\frac{1.07}{\sqrt{n}}$	$\frac{1.14}{\sqrt{n}}$	$\frac{1.22}{\sqrt{n}}$	$\frac{1.36}{\sqrt{n}}$	$\frac{1.63}{\sqrt{n}}$

Table 3.1. Level of Significance

Source: Prayogi, Y. (2013). Selected Statistical Tests

e. Method

- Calculate the cumulative distribution $F_0(x)$ base on the sample observations and the specified (given) population distribution.
- Obtain the cumulative distribution of the sample, $F_n(x)$ be the empirical distribution function, $F_n(x) = (\text{Number of observations } X_i \leq x) / n$.
- Find the absolute difference $|F_0(x) - F_n(x)|$

f. Test Statistic

$$D = \max |F_0(x) - F_n(x)|$$

g. Conclusion

If $D \leq D_{\alpha}$, accept H_0 and If $D > D_{\alpha}$, reject H_0 or accept H_1

3.4 Forecasting Method

In this research, the forecasting is used as a tool to predict future cargo throughput, especially for packaged goods (bag cargo). The forecasting in this research using two methods, namely data time series and multiple regression. In term of forecasting with time series data using linear forecasting, moving average and weight moving average. As for the multiple regression is to look at the relationship between two different variables. The data used in the multiple regression by using economic data such as population, GDP and export-import cargo flows. Prior to forecasting, mapping will be done by CORREL. This is done in order to avoid overlap between one variable with another variable. After the forecasting result between time series data and multiple regression, each will be compared with each other by using MSE (Mean Square Error). MSE is one method to evaluate the forecasting method. This approach set the forecasting errors with a large range of values . Typically use more useful for calculating MSE forecast error as a percentage rather than number. In an evaluation using MSE, find a number with the smallest value, then elected the best forecasting method.

3.5 Queuing Theory

The main thing to determine the queuing model is ensures that the hypothesis is accepted as an exponential distribution. To obtain the exponential distribution is to calculate the ship arrival pattern and service time. The main purpose using queuing model is to analyze the behavior of the ship. In this research, researcher using M/M/1 model because in the implementation using First In First Out (FIFO) service system that is composed of a single server. M/M/1 system usage to assume the arrival process is poisson distribution. This is in line with the rules stated by Moon, D (2012) in the arrival process on a real system is expressed as follows:

- a. Use of the number of customers in a very large system
- b. Single customer impact on the performance of the system is very small

- c. In this system said that all independent customer means a customer's decision to use the system is independent from other users.

Chapter 4 DATA COLLECTION

The research data used by author include two things: the primary and secondary data. The use of data sourced from a variety of sources both internal and external. The internal data comes from Indonesia Port II Group, Palembang Port branch and the external data from government institution, customers, and related company to this research. In addition, data collection is also using qualitative methods is by conducting interviews with company management, service users and other interested parties in order to research more valid.

4.1. Company Overview

Palembang Port is one of the total 12 ports managed by Indonesia Port II. Indonesia Port II classified the port into three main classes. The classes are main port, first class port and second class port. Palembang Port include into first class port. One of the uniqueness of Palembang Port is a river port. There are three branches of the river port of all ports managed by the Indonesia Port II, they are Palembang Port, Pontianak Port and Jambi Port.

Palembang Port has two operated two ports, Boom Baru Port and Lais River Port. The Boom Baru Port on the Musi River in Palembang is the largest river port in Sumatra and the lifeblood of economic growth in South Sumatra province. Meanwhile, the port area has bright prospects for future development, including through investment in the Lais River area which provides ample space for industrial activities.

The growth of this port is closely tied to the development of the hinterland industries of agriculture, mining and manufacturing. One of the local commodities whose production is expected to boom over the coming years in crude palm oil (CPO), in line with the vast expanses of oil palm plantations across South Sumatra. This makes agribusiness a prime investment opportunity.

The Boom Baru Port management is preparing to handle this surge in commodities shipments by providing a terminal with all the modern equipment necessary to guarantee good service for ships and cargo.

4.1.1. Geography

a. Geographical Location

The Palembang Port is located on the Musi River in Palembang. The geographical location is 020 - 58' - 48' latitude and 1040 - 46' - 36 ET with an average height of 8 meters above sea level.

b. Season & wind speed

Season contained in Palembang as general which occurs in all parts of Indonesia, namely the rainy season and dry season. Wind speed in nearly all regions of Palembang evenly each month ranging from 2 knots to 4 knots with average rainfall ranging between 14.6 mm³ (in September) to 392.4 mm³ (March), while the average humidity is 77% (September) to 87% (January-April and December).

c. Geology

Shape and state of Palembang region has alluvial layer of soil types, clay and sandy, lies in the young layers, many contain petroleum which is also known as the valley of Palembang - Jambi. Land is relatively flat and low, places a rather high located in the northern part of town. Palembang partially flooded, especially if it rains continuously.

4.1.2. Facilities and Equipments

Currently, The Palembang Port facilities and infrastructure will be sufficient to serve the export / import and also a gate south Sumatran province's economy and its environment, and has been equipped with a wide range of cargo handling equipment that is ready to serve freight transportation system as well as accommodating to the development of technology transport and information in the future.

The port located on the River Musi Palembang, South Sumatera. The distance from upstream to the port basin is about 55 miles, or 101 km. The travel time required between eight and nine hours. The inland areas work consisted of Boom

Baru and Lais River. The total areas for Boom Baru Port around 24 hectares and has a basin depth of -9 up to -12 LWS and have many facilities and cargo handling equipment such as warehouse, container yard, conventional yard and cargo handling equipments. Meanwhile, the River Lais are has an open warehouse area of 230 m², 16700 m² yard, berth around 280 m and the basin depth approximately -1 up to -1 LWS. More detailed information about the facility and handling equipment Palembang Port can be seen in table 1-5 below.

The Boom Baru Port has 4 main terminals in anticipation of the flow of goods and passengers in and out through this post. The fourth terminals are passenger terminal, conventional terminal, container terminal and bulk terminal (CPO terminal). Each commodity and packaging (loading and discharging) adapted to the facilities and cargo handling equipment in each terminal. Below is a general overview of the terminals in Boom Baru Port:

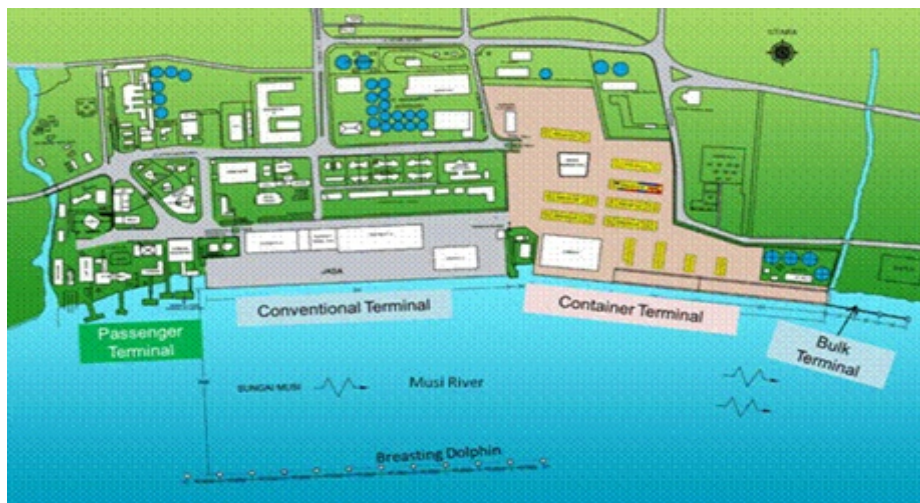


Figure 4.1: Layout of berthing facilities
Source: Palembang Port

The information details about the facilities and equipments are described in the table below:

a. Facilities :

No	Facilities	Descriptions	Remarks (Unit)
1	Main Facilities	Land Area	722.5 Ha
2	Vessel Service Facilities	Dock Length	1126 m
		Flow Depth	-6.5 mLWS
		Berth Depth	-7 to -10 mLWS
		Holding Boats	3 vessels
		Pilot Boats	5 vessels
		Water Boat 100 Ton	2 unit
		Fire Boat	1 unit

Table 4.1: Facilities
Source: Palembang Port

b. Yard

No	Yard	Designated Yard	Long (m)	Width (m)	Area Coverage (m ²)
1	Ex Pilots	Stuffing Business Terminal Div	40	30	1200
2	A, B-C - Front - Rear	Multipurpose	135	20	2700
		Stuffing Business Terminal Div	86	10	860
3	DE - Front	Multipurpose	105	20	2100

	- Rear	Stuffing Business Terminal Div	105	10	1050
4	H (Rear)	Stuffing Business Terminal Div	103	10	1030
5	Ex Telkomsel Tower	Multipurpose	57.07	31	1769.17
6	Passenger Terminal (Front)	Multipurpose	46.53	29.03	1350.77
7	Ex Immigration	Car Terminal	59.39	28.66	1702.12
8	Ex BNI & VTP	Car Terminal	40.06	44.48	1781.87

Table 4.2: Yard

Source: Palembang Port

c. Warehouse

No	Warehouse Location	Long (m)	Width (m)	Area Cov.(m2)	Capacity (Ton)
1	Warehouse A	26	24.5	637	700
2	Warehouse B	47	24.5	1151.5	1260
3	Warehouse C	36.4	24.5	891.80	980
4	Warehouse D – E	105	26	2730	3000
5	Warehouse H	55	25	1375	1520

Table 4.3: Warehouse

Source: Palembang Port

d. Equipments:

No	Area Coverage	Descriptions	Remarks (Unit)
1	Business Terminal Div.	Forklift	12 unit

		Jibcrane	4 unit
		Head Truck	5 unit
2	Container Terminal Div	Forklift	4 unit
		Side Loader	2 unit
		Head Truck	9 unit
		Chassis	12 unit
		Reach Stacker	2 unit
		Container Crane	2 unit
		RMGC	4 unit

Table 4.4: Equipments
Source: Palembang Port

Other Tools Support:

No	Equipments	Descriptions	Remarks (Unit)
1	Motorcycle	All Division	14 unit
2	Car	All Division	14 unit
3	Genset	All Division	4 unit

Table 4.5: Other Tools Support
Source: Palembang Port

Below is a Master Plan of Short Term Development for the Palembang Port from 2009 – 2013:

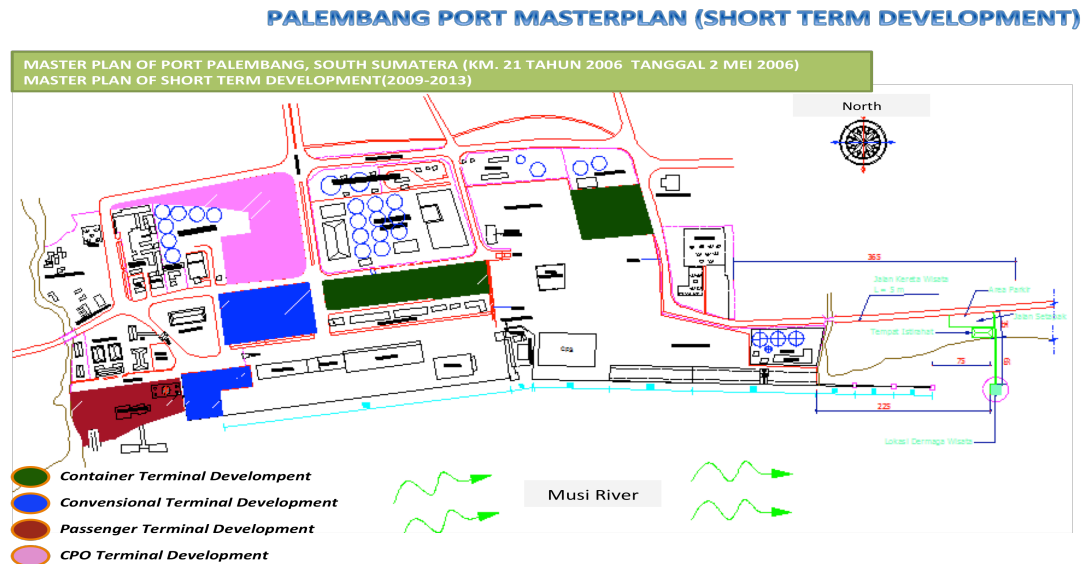


Figure 4.2: Short Term Development of Palembang Port
 Source: Palembang Port

The realization for short term development has been done in particular to the expansion of the yard and warehouse in container and conventional terminal. One of the examples of expansion in the terminal is destroying the warehouse I become the yard. The radical expansion made by management Palembang Port on conventional terminals (multipurpose terminal). This is done because of necessity flow of goods and to avoid bottlenecks on the land side due to the new investment tools (Jib Crane) and the presence of Jib Crane Dedicated Terminal (JCDT). The multipurpose terminal expansion done by destroying a few buildings like ex pilot, ex Telkomsel tower, passenger terminal (front), etc. The objective is to get enough space for multipurpose terminal operations such as stuffing. The business expansion is also performed by multipurpose terminal is made the car terminal. The expansion is done by using the former building area of immigration, BNI and VTP.

Below is a Master Plan of Long Term Development for the Palembang Port from 2013 – 2028:

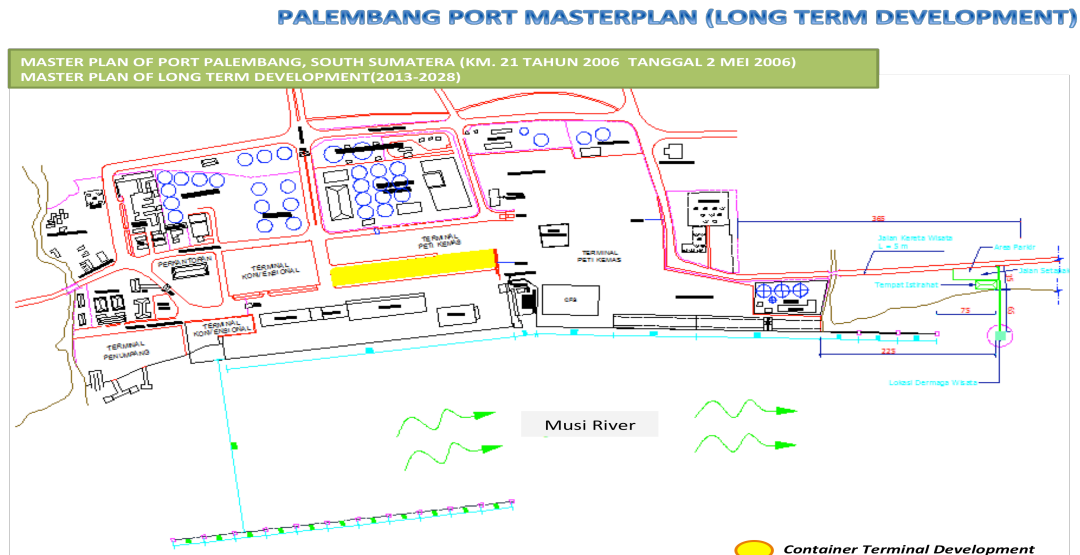


Figure 4.3: Long Term Development Of Palembang Port
Source: Palembang Port

Long term development will be focused on the west side of the port. The area is close to the bulk terminal (CPO Terminal). The expansion is more difficult because the west side directly adjacent to the neighborhood residents. The only way out is liberating the land surrounding residents. Although difficult, but this should be done by the Palembang Port management in cooperation with local governments.

4.2. Operational Data

4.2.1. Cargo Throughput & Ship Call

The authors divided the operational data in terms of traffic into two parts. The two parts are cargo throughput and ship call. The term of cargo throughput means the number of cargoes in and out during the period (per 1 year). The cargo throughput through Palembang Port are classified into 5 packaging, they are general cargo, bag cargo, liquid cargo, dry bulk cargo and container. The implementation of the use in JCDT Terminal more use of packaging by using Bag Cargo. Meanwhile, the other classification is ship calls, which means the number of ship through Palembang Port during the period (per 1 year).

4.2.1.1.Cargo Throughput

The table below represents the amount of cargo through Palembang Port for the last 10 years. The cargo throughput described as follows:

		Tons (000)										
No.	Cargo Flows	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1	General Cargo	275	276	804	526	211	230	306	397	446	807	1648
2	Bag Cargo	609	589	672	999	1000	687	645	658	923	730	912
3	Liquid Cargo	6097	6239	4196	4772	5008	5986	178	436	1110	1092	858
4	Dry Bulk	3522	3199	3585	2907	3339	2897	3617	4034	3684	3271	3446
5	Container	606	706	805	906	1181	1082	1142	1286	1706	1776	1855

Table 4.6: Cargo Throughput
Source: Palembang Port

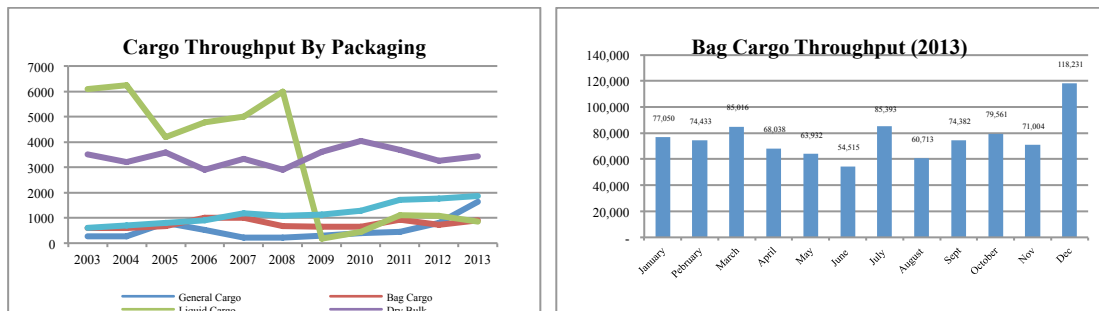


Figure 4.4: Cargo Throughput by Packaging & Bag Cargo Throughput 2013
Source: Palembang Port

Due to the research, the author will focused in packaging with Bag Cargo. As shown in the chart above, packaging by bag cargo occur volatile during the last 10 years. Sharp decline occurred in 2008, where the economic crisis is not only in Indonesia, but also around the world. However, with response by Indonesia government regulation, the country was able to get out of the crisis. This can be seen through the increase of cargo throughput data starting from years of 2009 to 2013. Meanwhile, the significant rise occurred especially in 2011 due to the incidental events that occurred not every year. The international sporting event held in 2011 is the implementation of SEA (South East Asia) Games in Palembang. In 2011, the cargo throughput for bag cargo packaging rose significantly. The increase is due to the need for very large bag of cement are needed for the construction of sport facilities and infrastructure such as physical construction of sport building, venue, etc.

Meanwhile, if the look of the bag cargo traffic data for year 2013 also happens to fluctuate but still within the normal level. The significant increase in cargo occurred in December due to a target given by the government of South Sumatera Province for one year which must be met by each region, especially for fertilizer and flour goods.

4.2.1.2.Ship Call

The table below represents the ship calls through Palembang Port for the last 10 years. The ship calls described as follows:

No	Year	Ocean Going		Domestic		Total	
		Unit	GT (000)	Unit	GT (000)	Unit	GT (000)
1	2003	677	3,274	3,134	8,482	3,811	11,756
2	2004	828	4,005	3,223	7,782	4,051	11,787
3	2005	789	3,639	3,470	7,670	4,259	11,309
4	2006	995	5,189	3,096	5,976	4,091	11,165
5	2007	1,338	6,384	2,568	4,317	3,906	10,701
6	2008	1,016	3,889	2,296	4,182	3,312	8,071
7	2009	674	1,997	1,870	3,476	2,544	5,473
8	2010	649	2,238	1,776	4,183	2,425	6,421
9	2011	692	2,184	2,251	4,817	2,943	7,001
10	2012	820	2,782	2,790	5,280	3,610	8,062
11	2013	835	2,521	3,019	5,684	3,854	8,205

Table 4.7: Ship Call
Source: Palembang Port

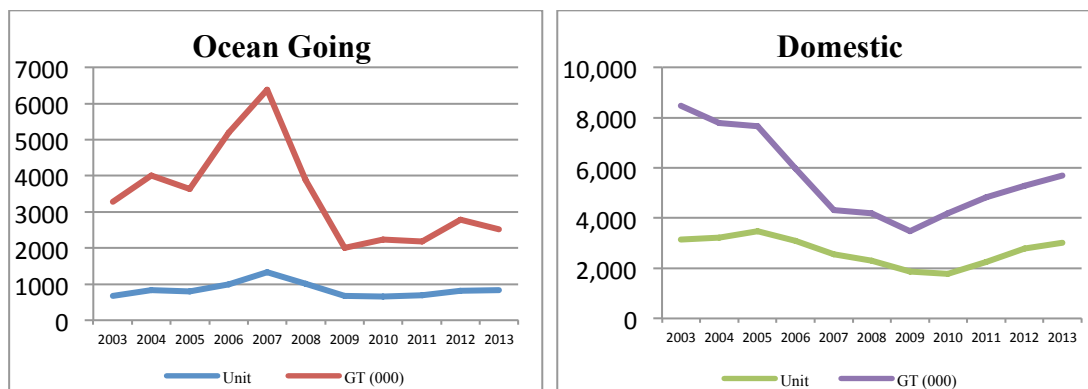


Figure 4.5: Ship Call by Ocean Going & Domestic
Source: Palembang Port

Ship calls data through Palembang Port over the last 10 years in tune with the cargo throughput, where data in 2008 is significant decline due to the global economic crisis. However, along with Indonesia and world economic recovery, the

ship calls increasing from year to year. Meanwhile, in the year 2013, the ship calls in JCDT is fluctuate. It can be seen in the table below. Even though the end of the year, the ship calls was decrease, however the bag cargo throughput is increase because of chasing the target of cargo by the provincial government.

No.	Terminal	Month	Unit
1	JCDT	January	16
2		February	16
3		March	21
4		April	20
5		May	20
6		June	13
7		July	19
8		August	12
9		September	17
10		October	22
11		November	18
12		December	16
Total			210

Table 4.8: JCDT Ship Call
Source: Palembang Port

4.2.2. Ship Time Between Arrival (STBA)

In this term, determine the time distance required between one ship arrive to the other ships. The Focus of STBA is to evaluate ship arrival pattern. Based on the terminology created by Sturges, the formulation used to search for K is as follows:

$$h = \frac{X(n) - X(1)}{k} \quad \text{and } k = 1 + 3.3 \times \log(n)$$

where, k is number of bins and n is number of data.

Using operational data, the number of ship calls in the year 2013 is 210 ships. So, n = 210. Steps to make the distribution pattern between ship arrivals using Sturges rule as follows:

a. Making a bins (k)

Firstly, we determine the number of bins k by using the formula Sturges Rule which calculated by formula $k = 1 + 3.3 \log N$. To find the data ship between arrivals by calculating $n - 1 = 210 - 1 = 209$. Based data in year 2013, the number of ship arrival:

$$k = 1 + 3.3 \times \log (n)$$

$$k = 1 + 3.3 \times \log (209)$$

$$k = 8.65$$

- b. The next step is determining the h. Determination h is by difference the maximum and minimum value of ship time between arrivals. The data shows that maximum value of ship between arrivals is 34.21 and minimum value is 0.43. By using the formula $h = \frac{X(n) - X(1)}{k}$, so obtained $h = \frac{(34.21 - 0.43)}{9} = 3.90 = 4$
- c. Distribution of Ship Time Between Arrivals (STBA)

Based on the above calculation, the distribution of ship time between arrival shows to the table below:

Bin	Interval			Frequency
	(hours)			
1	-	-	4.00	57
2	4.00	-	8.00	47
3	8.00	-	12.00	40
4	12.00	-	16.00	30
5	16.00	-	20.00	16
6	20.00	-	24.00	9
7	24.00	-	28.00	5
8	28.00	-	32.00	3
9	32.00	-	36.00	2
Average Interval		9.48	Total	209

Table 4.9: Distribution of STBA

Source: Author Elaboration

- d. Histogram graph

The next step is to make a histogram graph using data distribution frequency. The histogram graph as illustrated below:

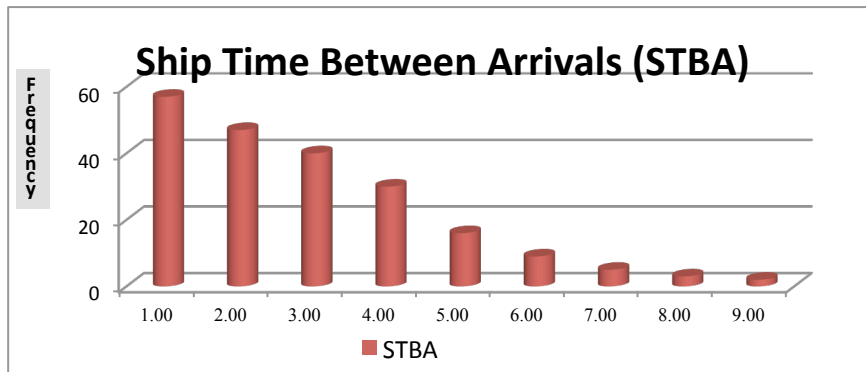


Figure 4.6: Ship Call by Ocean Going & Domestic Histogram
Source: Author Elaboration

4.2.3. Ship Length Overall

The ship length of overall (LOA) is the length of ship berthing in JCDT. The data of LOA it shown on the table below:

Bin	Interval			Frequency
	Start	End	Midpoint	
1	26.00	-	35.35	1
2	35.35	-	44.70	0
3	44.70	-	54.05	10
4	54.05	-	63.40	11
5	63.40	-	72.75	42
6	72.75	-	82.10	42
7	82.10	-	91.45	36
8	91.45	-	100.80	48
9	100.80	-	110.15	20
Average Interval	81.78		Total	210

Table 4.10: Distribution of LOA
Source: Author Elaboration

By using the table above, the histogram graphs can be described as follows:

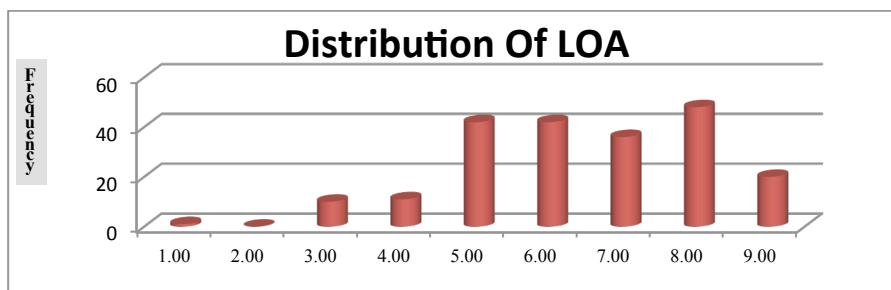


Figure 4.7: LOA Histogram
Source: Author Elaboration

4.2.4. Gross Tonnage Distribution (GT)

Bin	Interval			Frequency
1	93.00	-	790.42	16
2	790.42	-	1487.85	68
3	1487.85	-	2185.27	21
4	2185.27	-	2882.69	44
5	2882.69	-	3580.11	34
6	3580.11	-	4277.54	11
7	4277.54	-	4974.96	12
8	4974.96	-	5672.38	2
9	5672.38	-	6369.81	2
Average Interval		2,230.36	Total	210

Table 4.11: Distribution of GT

Source: Author Elaboration

By using the table above, the histogram graphs can be described as follows:

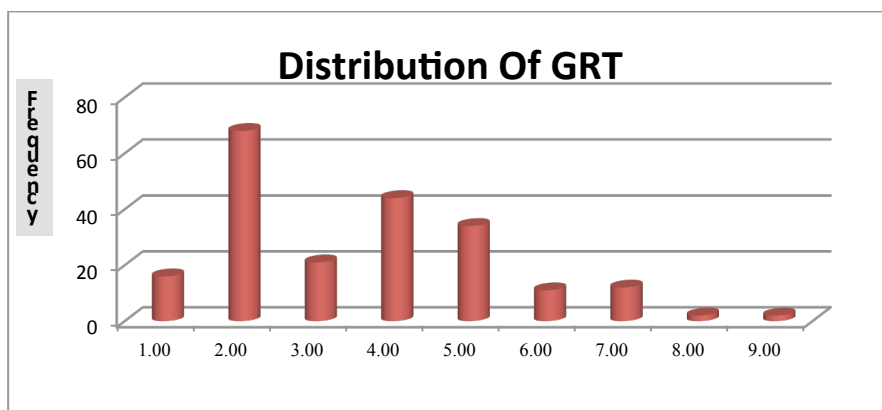


Figure 4.8: GT Histogram

Source: Author Elaboration

4.2.5. Move Per Cycle (MPC)

Move per cycle means the jib crane production. The jib crane movement at the first time raised the cargo from the ship to the land and return back to the ship or otherwise. It said 1 cycle. In one cycle, the cargo movement describe on the table below:

Bin	Interval			Frequency
	Hours			
1	58.98	-	399.24	31
2	399.24	-	739.50	25

3	739.50	-	1079.76	49
4	1079.76	-	1420.02	18
5	1420.02	-	1760.28	19
6	1760.28	-	2100.54	42
7	2100.54	-	2440.80	14
8	2440.80	-	2781.06	11
9	2781.06	-	3121.32	1
Average Interval		1,228.20	Total	210

Table 4.12: Distribution of MPC

Source: Author Elaboration

By using the table above, the histogram graphs can be described as follows:

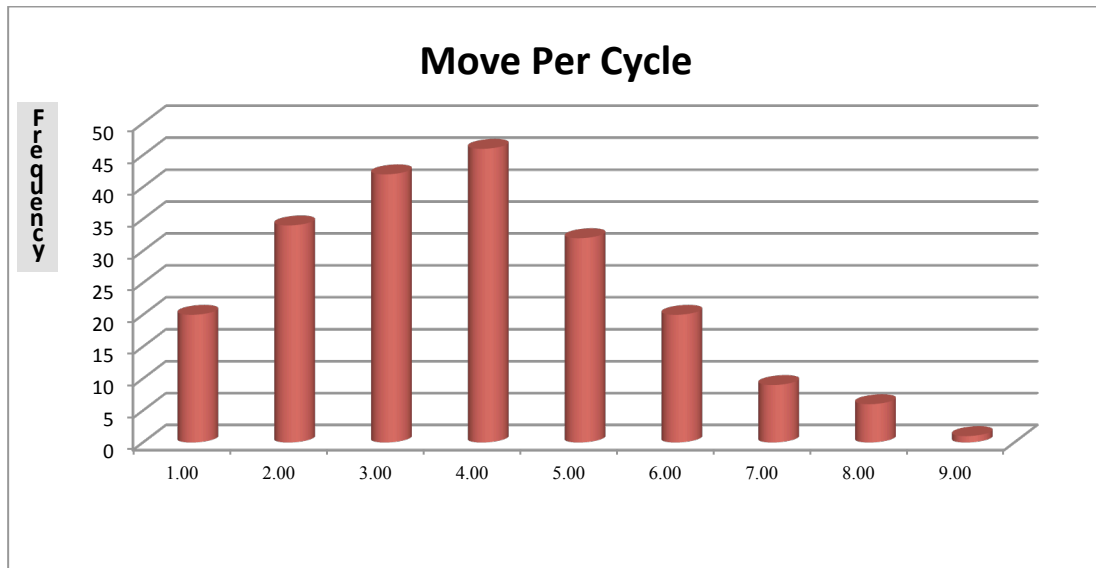


Figure 4.9: Move per Cycle Histogram

Source: Author Elaboration

4.2.6. Cargo Handling Service Time

Cargo handling service time is the effective time of service provided at the time of loading and unloading cargo by using a jib crane. The cargo handling service time describe on table below:

Bin	Interval			Frequency
	Hours			
1	11.30	-	38.62	22
2	38.62	-	65.94	49
3	65.94	-	93.27	49
4	93.27	-	120.59	39
5	120.59	-	147.91	25

6	147.91	-	175.23	17
7	175.23	-	202.55	5
8	202.55	-	229.88	3
9	229.88	-	257.20	1
Average Interval		92.12	Total	210

Table 4.13: Distribution of Cargo Handling Service Time

Source: Author Elaboration

By using the table above, the histogram graphs can be described as follows:

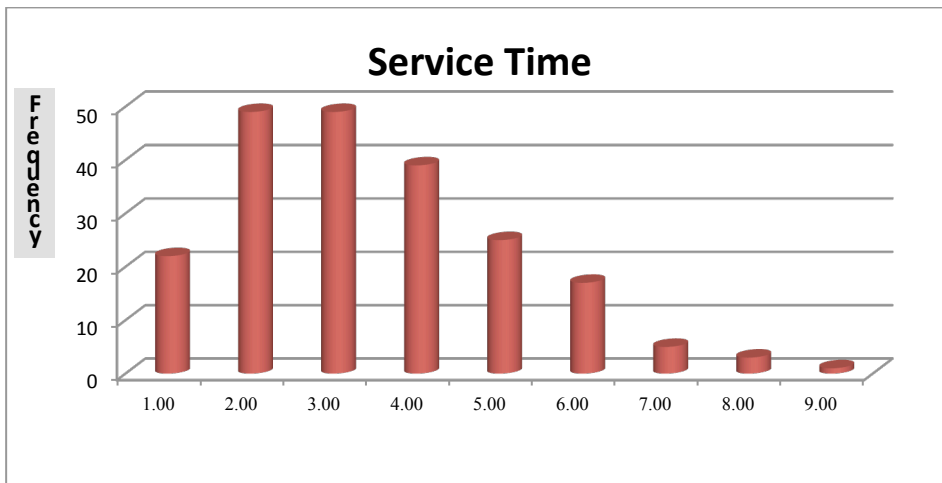


Figure 4.10: Cargo Handling Service Time Histogram

Source: Author Elaboration

4.2.7. Gate Operation

Gate operation means service provided to customers who pass through the terminal gate. The gate service time describe on table below:

Bin	Interval			Frequency
	Hours			
1	0.017	-	0.023	22
2	0.023	-	0.029	41
3	0.029	-	0.035	61
4	0.035	-	0.041	15
5	0.041	-	0.047	16
6	0.047	-	0.053	23
7	0.053	-	0.059	2
8	0.059	-	0.065	20
9	0.065	-	0.071	10
Average Interval		0.038	Total	210

Table 4.14: Distribution of Gate Service Time

Source: Author Elaboration

By using the table above, the histogram graphs can be described as follows:

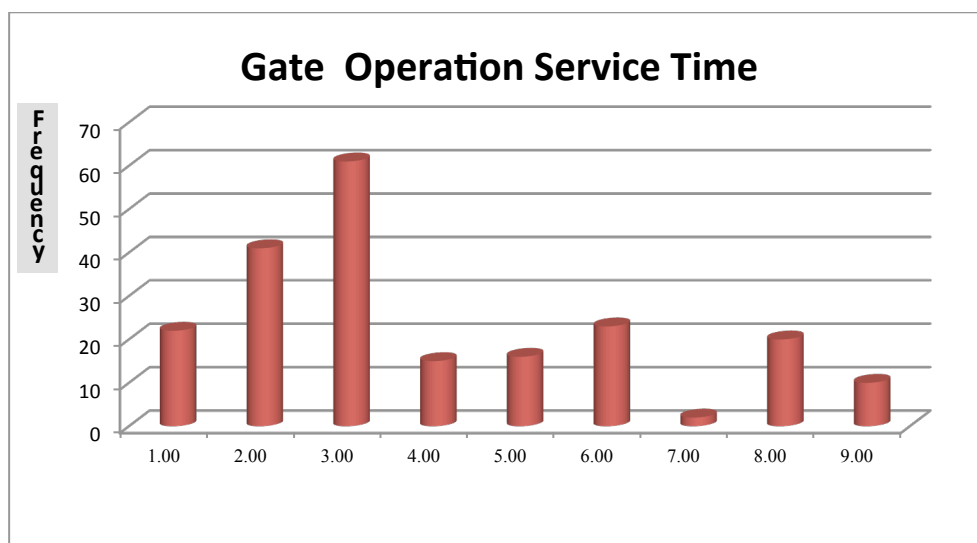


Figure 4.11: Gate Operation Service Time Histogram
Source: Author Elaboration

4.3. Economic Indicators

4.3.1. Hinterland

Like the other provinces of Indonesia, the province of South Sumatra is currently also working to develop the potential of its energy resources. South Sumatra Province has considerable energy resources such as oil abundant, coal, natural gas, CBM gas, micro-hydro and biomass. The magnitude of the potential diversity of energy resources owned by the province of South Sumatra until it is no exaggeration if the nickname as "The Central National Energy" attached to this province. Careful planning, development and management of energy resources currently being pursued not only by the provincial government of South Sumatra, but all elements of society are also entrepreneurs.

Based on data from the provincial government related, potential energy resources owned by the province covers, with a total petroleum reserves estimated at 5.034.082 MSTB, 7.238 BSCF gas reserves spread over three counties and coal reserves at 18.13 billion tons. The potential energy by Mater Plant South Sumatra province, namely, the potential for unexpected Coal Bed Methane (CBM) of 120 tcf, the potential energy of water under 10.238 kilowatt capacity. As for the broad

premises forest biomass reaches 53 %, 28 % and agricultural estates which accounted for 7.5 % of the waste biomass potential is estimated at 16034.24 GWh.

In addition to the natural resources that have been mentioned above, several kinds of resources from agriculture also contributed and important part of South Sumatra's Economy, making a significant contribution to the province's exports and GRDP and providing the largest of jobs. Production per hectare has steadily risen since 2007. Main products of South Sumatra agriculture industry include rubber, palm oil, fruits, rice, vegetables, coffee, and sugarcane. The following details about the biggest plantation of South Sumatra commodities such as rubber and palm oil:

a. Rubber

The South Sumatra Province is rich in rubber. South Sumatra has the largest rubber plantations in Indonesia. Rubber production is dominated by crumb rubber, with most of its natural rubber exported to international markets. Only a small portion is used domestically by the Indonesian tire industry. Farmers typically produce two categories of rubber. Class A is the higher quality rubber, which has a water content of around 9% by weight per block, while class B rubber contains 11% water by weight. The rubber industry is dominated by small producers. Opportunities exist to produce crumb rubber and rubber products on a large scale. The industry is dominated by small landholders and farmers that produce crumb rubber and small businesses producing rubber products but lack access to capital to produce on a large scale or produce industrial and technical rubber products that require high technology. The local investors present in the rubber industry in South Sumatra include state-owned Perkebunan Negara (PTPN) VII, Sampoerna Agro Tbk, owned by the Sampoerna family, and London Sumatra Indonesia Tbk, an Indonesian stock exchange listed company. PTPN VII has 65,800 hectares of rubber plantations. Sampoerna Agro has a 183 hectare rubber plantation. London Sumatra Indonesia is involved in plant breeding, planting, harvesting, processing, and selling rubber as well as palm and palm oil seeds, crude palm oil, cocoa, tea, coconut and coffee.

b. CPO (Crude Palm Oil)

South Sumatra plans to make available an additional 350,000 hectares available for CPO production. CPO production has grown 6-7% annually the last few years and is expected to continue to grow due to rising demand from China and India. Hindoli, which was acquired by Cargill in 1995, is one of the major CPO producers in South Sumatra. Hindoli has 16,000 hectares and another 17,600 hectares of micro mills, with an annual output of 150,000 tons. They plan to increase palm oil production by 20% in 2012 through intensification and expansion of its plantations. The majority of CPO production in South Sumatra is exported to foreign markets. Opportunities exist at each phase of the production process including plantations, refining, improving capacity, production, and efficiency of micro-mills and small plantation holders, and creating value -added products such as ole-chemical and bio-fuel.

4.3.2. Gross Domestic Product (GDP)

GDP is one of indicator that determined to measure the throughput of the port by measuring the level of a country's economy or the economy of the region. So, it can be said that port economy is an indicator of the region economy. It is certainly in harmony with the words of Bin Liu and Xiaoyu (2012) as saying that port economy and GDP have correlation.

The importance of GDP is calculating the growth rate of the port because it is considered as a measure of how far the port economy has been growing or shrinking. Generally speaking, if the GDP of a region increases, the port economy is strengthening. Conversely, when the GDP shrinking or negative, then the economics of the port would tend to weaken. Therefore, it is important to know how much the growth of a port by using the GDP indicator. Below is the data on GDP for the southern Sumatran region that was launched by Indonesia's statistics Bureau over the last 10 years:

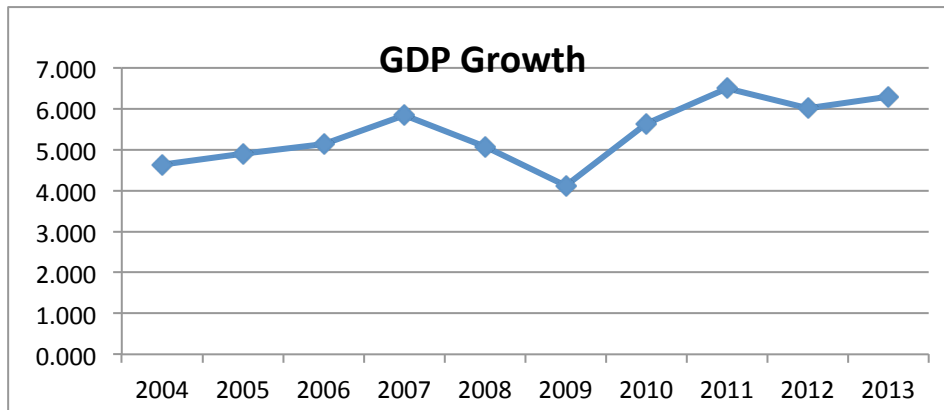


Figure 4.12: GDP Growth
Source: Author Elaboration

(000)

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
GDP	47,344	49,663	52,215	55,262	58,065	60,453	63,859	68,008	72,094	76,637

Table 4.15: Southern Sumatran GDP
Source: Indonesia's Statistics Bureau

4.3.3. Population

The population growth in the southern Sumatran province from year to year is increasing with the average movement for nearly 10 years at 2:28%. The highest population over 10 years occurred in 2012 with a growth rate of nearly 6%. Table 4.16 will explain the southern Sumatran province's population growth.

No	Year	Population	Growth
		(000)	%
1	2003	6519	
2	2004	6625	1.60
3	2005	6756	1.94
4	2006	6900	2.09
5	2007	7020	1.71
6	2008	7122	1.43
7	2009	7223	1.40
8	2010	7446	2.99
9	2011	7576	1.72
10	2012	8054	5.93
11	2013	8215	1.96

Table 4.16: Southern Sumatran Population
Source: Indonesia's Statistics Bureau

4.4. Cargoes Export Import

Foreign trade have main important role in the economy and development. The activity of foreign trade, especially exports is one of the biggest sources of foreign exchange earnings. Through the exchange, the province can buy imported goods needed to support the industrial sector. Overview of the development of the Southern Sumatran Province exports has fluctuated from year to year. The data on the development of the Southern Sumatran import export trade during the last 10 years is reflected in the table below:

No.	Years	Export	Import	Balance Of Trade	Growth
					(%)
	1	2	3	4	5
1	2000	925,288.20	245,530.40	679,757.80	-
2	2001	520,909.20	112,215.70	408,693.70	(39.88)
3	2002	626,918.00	154,824.30	472,093.70	15.51
4	2003	903,646.50	112,369.60	791,276.90	67.61
5	2004	1,156,241.00	85,877.90	1,070,363.10	35.27
6	2005	1,241,052.70	192,405.80	1,048,646.90	(2.03)
7	2006	2,390,576.90	283,962.80	2,106,614.10	100.89
8	2007	2,725,871.40	167,698.70	2,558,172.70	21.44
9	2008	3,471,835.90	225,741.30	3,246,094.60	26.89
10	2009	2,015,510.40	224,827.30	1,790,683.10	(44.84)
11	2010	3,516,895.90	365,850.60	3,151,045.30	75.97
12	2011	5,057,407.48	553,906.61	4,503,500.87	42.92
13	2012	4,371,655.37	506,686.77	3,864,968.60	(14.18)
14	2013	3,915,682.12	565,994.38	3,349,687.74	(13.33)

Table 4.17: Foreign Trade Balance of South Sumatra

Source: Ministry of Foreign Trade Republic of Indonesia

In the table above, describe that in year 2012 and 2013 has decreased growth, however non-oil exports still have an important role in the export of South Sumatra province. This can be seen in the graph below for the last 2 years are 2012 and 2013.

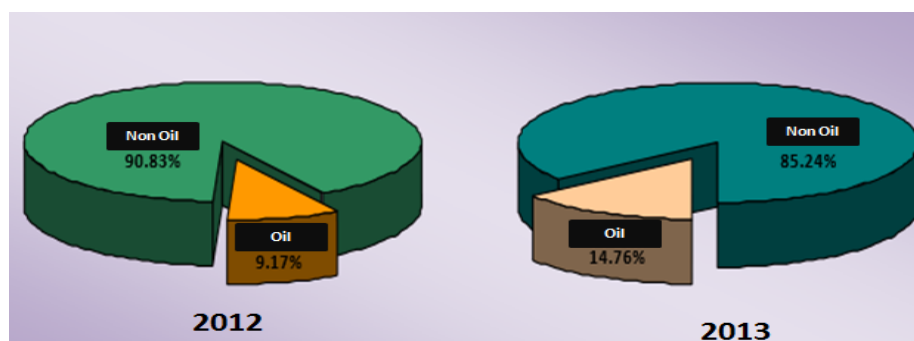


Figure 4.13: Oil & Non Oil Export

Source: Ministry of Foreign Trade Republic of Indonesia

The decline in non-oil commodities from 2012 to 2013 due to several mainstay commodities such as coal, wood / wood products decreased significantly. Nevertheless, the rubber market share still dominates the Southern Sumatran Province mainstay commodities for export. The transportation packing used for export for rubber is using bag. With the high demand for rubber exports this certainly increases the economic port itself.

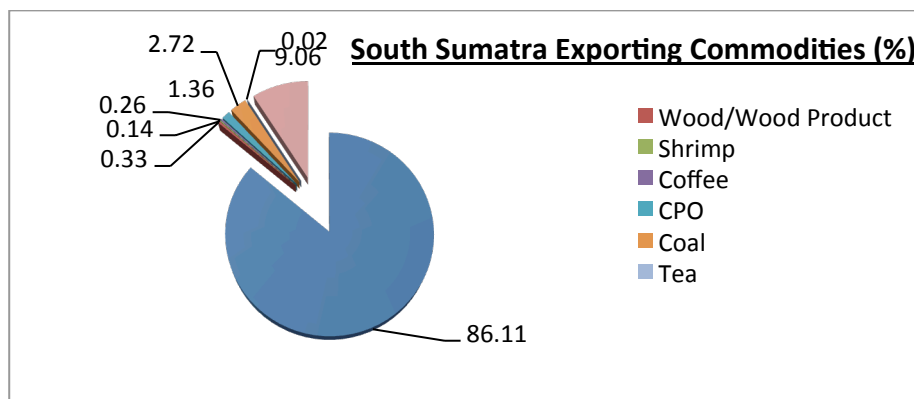


Figure 4.14: South Sumatra Exporting Commodities
Source: South Sumatra Statistics Bureau

The most important loading port is the port through a Boom Baru, followed by Plaju Port and Kertapati Port. The market share of exports through the port of a Boom Baru is the largest in the province of South Sumatra. It can be seen from a market share figure below:

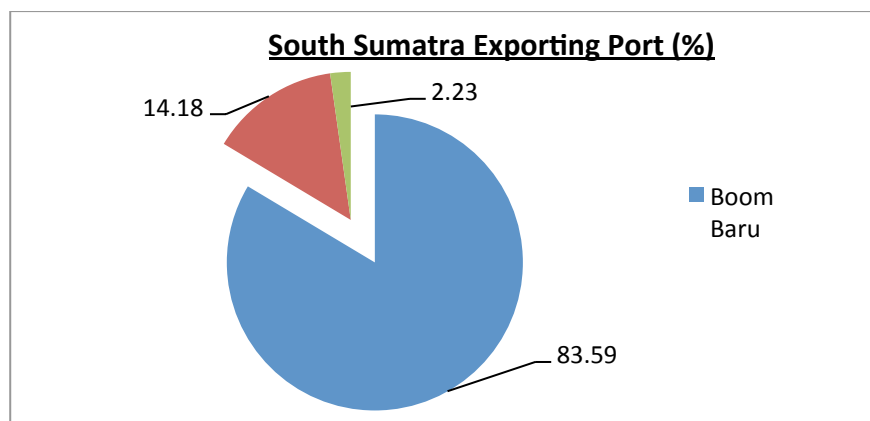


Figure 4.15: South Sumatra Exporting Port
Source: South Sumatra Statistics Bureau

4.5. Cost in the Terminal

Various types of cost incurred as a result of cargo handling activities at the terminal, such as the cost of providing facilities, infrastructure and cargo handling equipment and various kinds of service charged to customers. The cost incurred in cargo handling at terminal will be explained further below.

4.5.1. Berth Facilities Cost

Berth facilities cost consist of two kinds, they are for investment and maintenance. In term of berth facilities investment, the data collected is in unit price. Meanwhile, the maintenance cost is assumed as the proportion of investment cost. The total cost for berth investment is USD 1,250 /m². For the cargo handling equipment, a Jib crane investment is around USD 4.5 million with total investment is 4 jib cranes. By using assumption economic usage is around 25 years and interest (r) 9%. The maintenance cost is approximately 5% from annual cost. The data relating to the berth facilities cost will more detail described in the table below:

No.	Berth Area	Size		Area	Investment
		Length	Width	Coverage (m2)	Cost (USD)
1	A, B - C	135	20	2700	3,375,000
2		86	10	860	1,075,000
3	DE	105	20	2100	2,625,000
4		105	10	1050	1,312,500
5	H	103	10	1030	1,287,500
Total				7740	9,675,000

Table 4.18: Berth investment cost
Source: Author Elaboration

No.	Berth Labor	1 shift	3 shift	Labor Salary (IDR)
1	Operator 1	1	3	2,500,000
2	Operator 2	1	3	2,500,000
3	Checker	1	3	2,000,000
4	Administrator	1	3	1,900,000

Table 4.19: Berth labor cost
Source: Palembang Port

4.5.2. Warehouse Facilities

Warehouse facilities cost consist of two kinds, they are for investment and maintenance. In term of warehouse facilities investment, the data collected is in unit

price. Meanwhile, the maintenance cost is assumed as the proportion of investment cost. The total cost for warehouse investment is USD 1,400 /m². By using assumption economic usage is around 25 years and interest (r) 9%. The maintenance cost is approximately 5% from annual cost. The employee salary is in table below:

No.	Berth Labor	1 shift	3 shift	Labor Salary
1	Administrator 1	1	3	2,200,000
2	Administrator 2	1	3	2,200,000

Table 4.20: Warehouse labor cost

Source: Palembang Port

4.5.3. Gate Operation Service

The total cost for gate investment is IDR 1,850,000,000 by using assumption economic usage is around 25 years and interest (r) 9%. The maintenance cost is approximately 5% from annual cost. Currently the officer on duty at the gate is 1 person. Meanwhile throughout a full day there are 3 shifts, so there are total officer of full day is 3 persons. The salary for one officer is IDR 2,100,000 per month

4.5.4. Waiting Cost

Waiting costs are the costs incurred as a result of service during cargo handling at the terminal. The main customer of the terminal is shipping company. So, the cost incurred as a result of cargo handling activities will have an impact to the shipping company and the cargo itself. Waiting cost in this research, divided into two kinds, they are ship waiting cost and cargo waiting cost.

4.5.4.1. Ship Waiting Cost

In this study, the ship waiting cost calculation using data from shipping company that ships using the berth in the JCDT. The data illustrated in the table below:

No.	Ship Name	GT	Revenue (USD)	Sailing Day	Cost/GT/Day
1	KM.LINTAS SEGARA	1580	496,151	171	1.84
2	KM.CARAKA JN.III-21	3257	1,142,173	218	1.61
3	MV.NGOC HA	2498	876,381	203	1.73
4	KM.AL FALAH 1	4859	1,618,540	215	1.55
5	KM.TRADISI 8	1312	309,180	169	1.39
6	KM.SENANG JAYA	2367	873,417	215	1.72
7	KM. RIMBA SATU	3951	1,209,111	230	1.33

8	TEK GLORY I	3401	1,172,217	226	1.53
9	MV. HODASCO 09	2546	996,177	191	2.05
10	MV.HODASCO 19	4675	1,451,971	245	1.27
11	KM. ANUGRAH BUANA VI	2302	1,043,105	214	2.12
12	KM.KARANA SEMBILAN	6135	1,752,281	242	1.18
13	MV.MARITIME 36	2999	1,053,362	210	1.67
14	KM. NIAGA 62	3208	1,252,287	191	2.04
Average					1.64

Table 4.21: Ship Waiting Cost
Source: Palembang Port

4.5.4.2. Cargo Waiting Cost

Cargo waiting cost calculation method is by using the data cargo value, by finding the opportunity cargo and its depreciation. Here is the data that describes the cargo value for one year in 2013 presented in the table below:

No.	Month	Value Of Discharging	Value Of Loading
		(in million USD)	(in million USD)
1	January	352.41	41.98
2	February	293.86	81.34
3	March	327.01	35.47
4	April	285.03	38.67
5	May	263.10	62.73
6	June	286.10	44.24
7	July	286.16	32.58
8	August	268.91	31.08
9	September	240.24	69.15
10	October	297.83	31.51
11	November	305.72	32.58
12	December	288.82	57.72
Total		3495.19	559.05

Table 4.22: Cargo Value
Source: Indonesia Bureau Statistics

Chapter 5 ANALYSIS

In this chapter will be presented various calculations and analysis consisting of forecasting bag cargo throughput for the next five years (2014-2018), analysis of ships arrival, service time pattern and gate operation service. Other evaluation in this chapter is to analyze the capacity of each facility such as berth and warehouse, calculation of service cost and waiting cost in the terminal and calculating total cost model.

5.1. Bag Cargo Throughput Forecasting

In determining the bag cargo throughput forecasting divided into two kinds, namely by using time series models and regression models. Among all the existing models, the best result will be selected for bag cargo throughput forecasting.

5.1.1. Time Series Model

In this analysis, the author used three kinds of models in time series model in order to obtain a specific result. The time is used as an independent variable. The three models are as follows:

a. Trend Prediction (Linier)

Below is the graph by linear method:

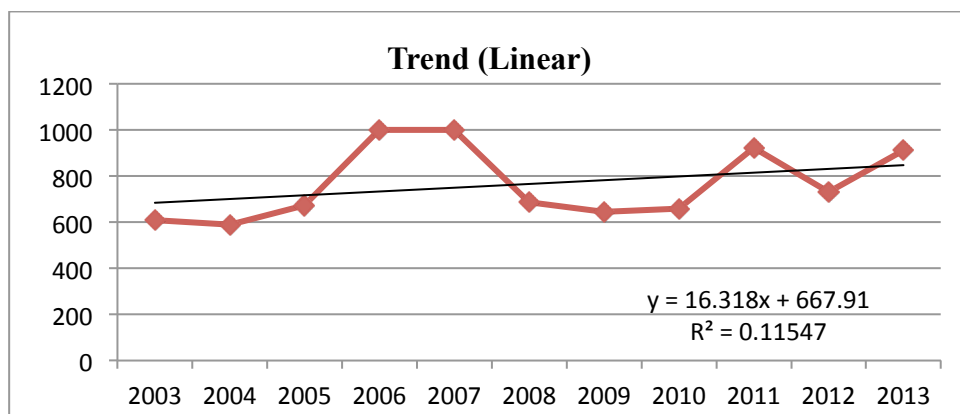


Figure 5.1: Trend (Linier)

Source: Author elaboration

Based on author calculation using trend (linier) model, obtained $Y = 16.31x + 667.9$ and $R^2 = 0.115$.

Formula	:	$BC_t = \alpha_0 + \alpha_1 \cdot t$
BC_t	:	Throughput t
t	:	Time series
α_i	:	Regression coefficient for I from 0 to

By using the formula as described above, the result for forecasting of bag cargo throughput year 2014 – 2018 will present in table below:

No	Year	Throughput	Trend (Linear)
			Forecasting
1	2003	609	684.21
2	2004	589	700.52
3	2005	672	716.83
4	2006	999	733.14
5	2007	1000	749.45
6	2008	687	765.76
7	2009	645	782.07
8	2010	658	798.38
9	2011	923	814.69
10	2012	730	831.00
11	2013	912	847.31
12	2014	?	863.62
13	2015	?	879.93
14	2016	?	896.24
15	2017	?	912.55
16	2018	?	928.86

Table 5.1: Trend (Linear) forecasting Calculation

Source: Author elaboration

b. Moving Average

The moving average calculation models by using the average of the three previous years.

Formula	:	Average of y t-1, y t-2, K y t-n
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By using the formula as described above, the result for forecasting of bag cargo throughput year 2014 – 2018 will present in table below:

No	Year	Throughput	Moving Average
			Forecasting
1	2003	609	
2	2004	589	
3	2005	672	
4	2006	999	623.33
5	2007	1000	753.33
6	2008	687	890.33
7	2009	645	895.33
8	2010	658	777.33
9	2011	923	663.33
10	2012	730	742.00
11	2013	912	770.33
12	2014	?	855.00
13	2015	?	832.33
14	2016	?	866.44
15	2017	?	851.26
16	2018	?	850.01

Table 5.2: Moving Average forecasting Calculation
Source: Author elaboration

c. Weight Moving Average

Based on author calculation using weight moving average model, obtained $w_1 = 0.201$; $w_2 = 0.011$; $w_3 = 0.788$.

Formula : $W_1.a_1 + W_2.a_2 + W_3.a_3$

By using the formula as described above, the result for forecasting of bag cargo throughput year 2014 – 2018 will present in table below:

No	Year	Throughput	Weight Moving Average	w1	0.201
			Forecasting	w2	0.011
1	2003	609		w3	0.788
2	2004	589			
3	2005	672			
4	2006	999	623.33		
5	2007	1000	753.33		
6	2008	687	890.33		

7	2009	645	895.33
8	2010	658	777.33
9	2011	923	663.33
10	2012	730	742.00
11	2013	912	770.33
12	2014	?	855.00
13	2015	?	832.33
14	2016	?	866.44
15	2017	?	851.26
16	2018	?	850.01

Table 5.3: Weight Moving Average forecasting Calculation

Source: Author elaboration

5.1.2. Regression Model

In the regression model, variable Y as bag cargo and variable X as variable that support for variable Y, they are GDP, Export Import and population. Judging from the correlation table 5.4, the relationship between variables is so high, so the author used GDP as the X factor. The correlation and forecasting results can be seen in the table below:

Formula	:	$Y = a + b_1X_1 + b_2X_2 + \dots + b_kX_k$
----------------	----------	--

	<i>GDP</i>	<i>EXIM</i>	<i>POPULATION</i>
<i>GDP</i>	1		
<i>EXIM</i>	0.8506007	1	
<i>POPULATION</i>	0.9918227	0.816757025	1

Table 5.4: Correlation table

Source: Author elaboration

No	Year	Throughput	GDP	FORECASTING
			(00000)	
1	2003	609	453.14	775.76
2	2004	589	473.44	765.34
3	2005	672	496.63	808.58
4	2006	999	522.15	978.92
5	2007	1000	552.62	979.44
6	2008	687	580.65	816.39
7	2009	645	604.53	794.51

8	2010	658	638.59	801.28
9	2011	923	680.08	939.33
10	2012	730	720.94	838.79
11	2013	912	766.37	933.60
12	2014	?	774.86	908.40
13	2015	?	805.69	916.89
14	2016	?	836.52	925.39
15	2017	?	867.35	933.88
16	2018	?	898.18	942.38

Table 5.5: Multiple Regression Model Calculation

Source: Author elaboration

5.1.3. The Mean Square Error (MSE)

The principle of choosing the best forecasting methods is forecast error. This is the important reason for choosing the best method to predict. In the mean square error, we have to find the forecast error as small as possible. The formula of mean square error as is shown in table below:

$$MSE = \frac{\sum (y_i - \hat{y}_i)^2}{n}$$

From the formula, the mean square error of each Method as can be seen in the table:

	Trend(Linear)	Moving Average	Weight Moving Average	Regression
MSE	14,023	31,374	24,830	9,411

Table 5.6: Mean Square Error Calculation

Source: Author elaboration

The smallest forecast error used regression models. So, the author used regression model as the best model for forecasting. The cargo bag forecasting throughput for the next five years (2014-2018) are as follows:

No	Year	Throughput	Forecasting
1	2014	?	908.40
2	2015	?	916.89
3	2016	?	925.39
4	2017	?	933.88
5	2018	?	942.38

Table 5.7: Forecasting Result

Source: Author elaboration

5.2. Distribution Analysis

5.2.1. Ship Time Between Arrivals

The following distribution analysis, the authors use the KS test (Kolmogorov Smirnov goodness of fit test), which is to analyze ship arrival patterns and service time pattern are assumed to follow the exponential distribution. As one example, the author will be more detailed discussion of ship arrival distribution. The test of ship time between arrivals distribution uses several steps. The steps are as follows:

a. Propose a hypothesis

Ho : The distribution of ship time between arrivals $F(x)$ is the same as $F_0(x)$, the model accepted and follow the exponential distribution

H₁ : The distribution of ship time between arrivals $F(x)$ is not the same as $F_0(x)$, the model is not accepted and not follow the exponential distribution.

b. Selection critical value D_α

The second step is selection critical value D_α . By a significance level 95% and number of sample for ship time between arrivals is 209 data. So the results D_α as follow:

$$D_{0.95} = \frac{1.36}{\sqrt{209}} = 0.0940$$

c. Calculate the frequency probability

The calculation frequency probability for each sample as follows:

- Interval 0 – 4	= $F(0 < x \leq 4)$	= 57/209	= 0.27
- Interval 4 – 8	= $F(4 < x \leq 8)$	= 47/209	= 0.22
- Interval 8 – 12	= $F(8 < x \leq 12)$	= 40/209	= 0.19
- Interval 12 – 16	= $F(12 < x \leq 16)$	= 30/209	= 0.14
- Interval 16 – 20	= $F(16 < x \leq 20)$	= 16/209	= 0.08
- Interval 20 – 24	= $F(20 < x \leq 24)$	= 9/209	= 0.04
- Interval 24 – 28	= $F(24 < x \leq 28)$	= 5/209	= 0.02
- Interval 28 – 32	= $F(28 < x \leq 32)$	= 3/209	= 0.01
- Interval 32 – 36	= $F(32 < x \leq 36)$	= 2/209	= 0.01

- d. Calculate probability density factor

The calculation of probability density function is assumed follow exponential distribution as shown previously. The formula as follows:

$$f(t < x \leq T) = \left| e^{-\left(\frac{t}{m}\right)} - e^{-\left(\frac{T}{m}\right)} \right|$$

Where: $f(t < x \leq T)$ = probability density between t and T

Meanwhile, m = average time between arrivals

The average time between arrivals calculated from all data (209) is 9.48. Based on the formula above, the following is the calculation:

$$f(0 < x \leq 4) = \left| e^{-\left(\frac{0}{9.48}\right)} - e^{-\left(\frac{4}{9.48}\right)} \right| = 0.34$$

$$f(4 < x \leq 8) = \left| e^{-\left(\frac{4}{9.48}\right)} - e^{-\left(\frac{8}{9.48}\right)} \right| = 0.23$$

$$f(8 < x \leq 12) = \left| e^{-\left(\frac{8}{9.48}\right)} - e^{-\left(\frac{12}{9.48}\right)} \right| = 0.15$$

$$f(12 < x \leq 16) = \left| e^{-\left(\frac{12}{9.48}\right)} - e^{-\left(\frac{16}{9.48}\right)} \right| = 0.10$$

$$f(16 < x \leq 20) = \left| e^{-\left(\frac{16}{9.48}\right)} - e^{-\left(\frac{20}{9.48}\right)} \right| = 0.06$$

$$f(20 < x \leq 24) = \left| e^{-\left(\frac{20}{9.48}\right)} - e^{-\left(\frac{24}{9.48}\right)} \right| = 0.04$$

$$f(24 < x \leq 28) = \left| e^{-\left(\frac{24}{9.48}\right)} - e^{-\left(\frac{28}{9.48}\right)} \right| = 0.03$$

$$f(28 < x \leq 32) = \left| e^{-\left(\frac{28}{9.48}\right)} - e^{-\left(\frac{32}{9.48}\right)} \right| = 0.02$$

$$f(32 < x \leq 36) = \left| e^{-\left(\frac{32}{9.48}\right)} - e^{-\left(\frac{36}{9.48}\right)} \right| = 0.01$$

- e. Cumulative probability $F_0(x)$

The cumulative probability $F_0(x)$ can be calculated by adding frequency of probability density per interval.

- f. Calculate the difference

We calculate the difference between $F_0(x)$ and $F_n(x)$

To clear the overall distribution ship time between arrivals results, will be presented in the following table:

Class	Interval			Empirical Distribution			Specified Distribution		Different
				Frequency	Probability	Cum Probability Fn (X)	Probability	Cum Probability Fo (X)	D
I	0.00	-	4.00	57	0.27	0.27	0.34	0.34	0.0716
II	4.00	-	8.00	47	0.22	0.50	0.23	0.57	0.0725
III	8.00	-	12.00	40	0.19	0.69	0.15	0.72	0.0292
IV	12.00	-	16.00	30	0.14	0.83	0.10	0.82	0.0173
V	16.00	-	20.00	16	0.08	0.91	0.06	0.88	0.0302
VI	20.00	-	24.00	9	0.04	0.95	0.04	0.92	0.0316
VII	24.00	-	28.00	5	0.02	0.98	0.03	0.95	0.0282
VIII	28.00	-	32.00	3	0.01	0.99	0.02	0.97	0.0246
IX	32.00	-	36.00	2	0.01	1.00	0.01	0.98	0.0224
Total				209	1				0.0940

Table 5.8: Distribution Ship Time between Arrivals Result

Source: Author elaboration

g. Determine the maximum value in column Different (D)

The maximum value is 0.0725

h. Decision making stage

If the D value \leq critical value $D\alpha$, it means H_0 accepted. The hypothesis said:

H_0 : The distribution of ship time between arrivals $F(x)$ is the same as $F_0(x)$, the model accepted and follow the exponential distribution

H_1 : The distribution of ship time between arrivals $F(x)$ is not the same as $F_0(x)$, the model is not accepted and not follow the exponential distribution.

The calculation is $0.0725 \leq 0.0940$. So, it means H_0 accepted. The model accepted and followed the exponential distribution.

The following is a diagram of cumulative probability distribution and cumulative density distribution:

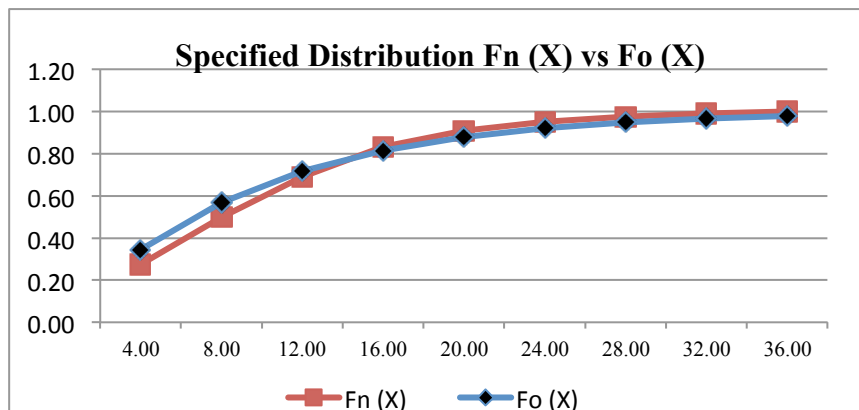


Figure 5.2: Diagram specified Distribution $F_n(x)$ vs $F_o(x)$
 Source: Author elaboration

5.2.2. Service Time

The steps that will be performed in service time distribution are the same steps as above with a few differences such as the determination of the number of data samples. In service time distribution analysis, the total data sample is 210 data. So, D

$$D_{0.95} = \frac{1.36}{\sqrt{210}} = 0.0938$$

If the D value \leq critical value D_{α} , it means H_0 is accepted. The hypothesis is:

H_0 : The distribution of ship time between arrivals $F(x)$ is the same as $F_o(x)$, the model is accepted and follows the exponential distribution

H_1 : The distribution of ship time between arrivals $F(x)$ is not the same as $F_o(x)$, the model is not accepted and does not follow the exponential distribution.

The results of the service time test can be shown in the table as follows:

Class	Interval			Empirical Distribution			Specified Distribution		Different D
				Frequency	Probability	Cum Probability Fn (X)	Probability	Cum Probability Fo (X)	
I	11.30	-	38.62	22	0.10	0.10	0.23	0.23	0.0122
II	38.62	-	65.94	49	0.23	0.34	0.17	0.40	0.0058
III	65.94	-	93.27	49	0.23	0.57	0.13	0.52	0.0502
IV	93.27	-	120.59	39	0.19	0.76	0.09	0.61	0.0143
V	120.59	-	147.91	25	0.12	0.88	0.07	0.68	0.0192
VI	147.91	-	175.23	17	0.08	0.96	0.05	0.74	0.0222
VII	175.23	-	202.55	5	0.02	0.98	0.04	0.77	0.0207
VIII	202.55	-	229.88	3	0.01	1.00	0.03	0.80	0.0193

IX	229.88	-	257.20	1	0.00	1.00	0.02	0.82	0.0177
			Total	210	1				0.0938

Table 5.9: Distribution of Service Time Result

Source: Author elaboration

Decision: In the calculation $0.0502 \leq 0.0938$. So, it means H_0 accepted. The model accepted and followed the exponential distribution.

5.2.3. Gate service

The steps that will be performed in gate service distribution are same steps as above with a few differences such as the determination of the number of data samples. In gate service distribution analysis, the total data sample is 210 data. So, D

$$D_{0.95} = \frac{1.36}{\sqrt{210}} = 0.0938$$

If the D value \leq critical value D_{α} , it means H_0 accepted. The hypothesis said:

H_0 : The distribution of ship time between arrivals $F(x)$ is the same as $F_0(x)$, the model accepted and follow the exponential distribution

H_1 : The distribution of ship time between arrivals $F(x)$ is not the same as $F_0(x)$, the model is not accepted and not follow the exponential distribution.

The results of gate service test can be shown in table as follows:

Class	Interval			Empirical Distribution			Specified Distribution		Different D
				Frequency	Probability	Cum Probability Fn (X)	Probability	Cum Probability Fo (X)	
I	0.02	-	0.02	22	0.10	0.10	0.09	0.09	0.0011
II	0.02	-	0.03	41	0.20	0.30	0.08	0.17	0.0126
III	0.03	-	0.03	61	0.29	0.59	0.07	0.24	0.0347
IV	0.03	-	0.04	15	0.07	0.66	0.06	0.30	0.0360
V	0.04	-	0.05	16	0.08	0.74	0.05	0.35	0.0386
VI	0.05	-	0.05	23	0.11	0.85	0.04	0.39	0.0453
VII	0.05	-	0.06	2	0.01	0.86	0.04	0.43	0.0426
VIII	0.06	-	0.06	20	0.10	0.95	0.03	0.46	0.0490
IX	0.06	-	0.07	10	0.05	1.00	0.03	0.49	0.0511
			Total	210	1				0.0938

Table 5.10: Distribution of Gate Service Result

Source: Author elaboration

Decision: In the calculation $0.0426 \leq 0.0938$. So, it means H_0 accepted. The model accepted and followed the exponential distribution.

5.2.4. KS Distribution Test

The following will be described in the table below the distribution test performed using the Kolmogorov Smirnov:

No	Description	Unit	Sample	Average	D	D _{0.95}	Distribution
1	Ship arrivals	Hours	209	9.48	0.0725	0.0940	Exponential
2	Service Time	Hours	210	42.29	0.0502	0.0938	Exponential
3	Gate Operation Service	Hours	210	0.038	0.0426	0.0938	Exponential

Table 5.11: KS Test Distribution Result

Source: Author elaboration

As shown by the table 5.11 above, all of distribution test using Kolmogorov Smirnov test follow the exponential distribution.

5.3. Analysis of Facilities

5.3.1. Gate Analysis

Currently, the exit and entry gate to the terminal using only one entrance and one exit. The background of the application of one entrance and exit, in addition to high effectiveness, also in terms of security is preserved. Moreover, with the implementation of the ISPS Code requires that custody be tightened either for vehicles or unauthorized persons forbidden entry into the terminal area. One of the obstacles that occur in the gate, especially when the ships were unloading queues is sometimes caused by the arrival of the truck at the same time. This constraint occurs because the officer at the gate only one person.

5.3.1.1. Gate Facilities Cost

The gate facilities cost is calculated of the area of the gate operation. The area gate operation divided into two kinds, they are the investment cost and maintenance cost. The investment cost including the infrastructure and facilities. The gate investment and facilities has been adjusted to the appropriate location and design of the implementation of the ISPS Code. The total cost for gate investment is IDR 1,850,000,000 by using assumption economic usage is around 25 years and interest

(r) 9%. The maintenance cost is approximately 5% from annual cost. In determining the cost of the gate, the calculation using the following steps:

a. Determining Annual Cost, the formula is as follow :

$$\text{Annual Cost} = \text{investment} \frac{r (1 + r)^{25}}{(1 + r)^{25} - 1}$$

Based on the formula, the calculation:

$$\text{Annual Cost} = \text{IDR } 1,850,000,000 \frac{0.09 (1 + 0.09)^{25}}{(1 + 0.09)^{25} - 1}$$

$$= \text{IDR } 1,850,000,000 \frac{0.776077259}{7.62308066}$$

$$= \text{IDR } 188,341,563/\text{year}$$

b. Determining Maintenance Cost

$$= 5 \% * \text{IDR } 188,341,563$$

$$= \text{IDR } 9,417,078/\text{year}$$

c. Calculate total cost, The formula : Annual cost + Maintenance cost

$$= \text{IDR } 188,341,563 + \text{IDR } 9,417,078$$

$$= \text{IDR } 197,758,641 / \text{year} = \text{IDR } 541,804 \text{ per day}$$

$$= \text{USD } 51.60 (1 \text{ USD} = \text{IDR } 10,500)$$

5.3.1.2. Gate Labor Cost

Currently the officer on duty at the gate is 1 person. Meanwhile throughout a full day there are 3 shifts, so there are total officer of full day is 3 persons. The salary for one officer is IDR 2,100,000 per month. The calculation of gate labor cost as follows: Total person per day * salary

$$= 3 * \text{IDR } 2,100,000 = \text{IDR } 6,300,000 / \text{month}$$

$$= \text{IDR } 210,000 \text{ per day}$$

$$= \text{USD } 20 (1 \text{ USD} = \text{IDR } 10,500)$$

5.3.2. Berth Analysis

The berth in Conventional Terminal Palembang Port is currently one of the busiest terminals in the South Sumatra Province. Moreover, the presence of the utilization of equipment handling (Jib Crane) can speed up the cargo handling

process become faster. The quality of the berth, need to do regular maintenance which is certainly an impact on costs.

5.3.2.1. Berth Capacity

The berth capacity is determined by the longest ship berthing at the berth. Based on data length overall (LOA) in table 4.10 states that the average ship LOA is 81.78 m. By adding 10 meter front and back for safety is equal 101.78 meter. Meanwhile, the length of berth is around 343 meter. Thus, the ship can berthing at berth is about 3 ships at the same time. The second thing that can be used as reference is based on data in table 4.10, there are 20 frequencies ship within 1 year by having longest LOA with interval 100.80 – 110.15 m. there were 10 ships with the same LOA. If the ship LOA of 110.15 adding 20 m as security side, the maximum LOA of the ship is 130.15 m. It means enough 2-3 ships berthing simultaneously.

5.3.2.2. Berth Facilities Cost

The area berth facilities cost divided into two kinds they are the investment cost and maintenance cost. The investment cost including the infrastructure and facilities. The total cost for berth investment is USD 1,250 /m². By using assumption economic usage is around 25 years and interest (r) 9%. The maintenance cost is approximately 5% from annual cost. In determining the cost of the berth, the calculation using the following steps:

- a. Determining Annual Cost, the formula is as follow :

$$\text{Annual Cost} = \text{investment} \frac{r (1 + r)^{25}}{(1 + r)^{25} - 1}$$

The total berth coverage based on table 4.2 as follows:

No.	Berth Area	Size		Area	Investment
		Length	Width	Coverage (m2)	Cost (USD)
1	A, B - C	135	20	2700	3,375,000
2		86	10	860	1,075,000
3	DE	105	20	2100	2,625,000
4		105	10	1050	1,312,500
5	H	103	10	1030	1,287,500
Total				7740	9,675,000

Table 5.12: Berth Investment Cost Calculation

Source: Author elaboration

Based on the formula, the calculation:

$$\text{Annual Cost} = \text{USD } 9,675,000 \frac{0.09 (1 + 0.09)^{25}}{(1 + 0.09)^{25} - 1}$$

$$= \text{IDR } 9,675,000 \frac{0.776077259}{7.62308066}$$

$$= \text{USD } 984,975/\text{year}$$

b. Determining Maintenance Cost

$$= 5 \% * \text{USD } 984,975.$$

$$= \text{USD } 49,249/\text{year}$$

c. Calculate total cost, The formula : Annual cost + Maintenance cost

$$= \text{USD } 984,975 + \text{USD } 49,249$$

$$= \text{USD } 1,034,224 / \text{year} = \text{USD } 2,844 \text{ per day}$$

5.3.2.3. Berth Equipment Handling Cost

The total equipment handling at berth is 4 jib cranes. The investment cost for a Jib Crane USD 4.5 million. By using assumption economic usage is around 25 years and interest (r) 9%. The maintenance cost is approximately 5% from annual cost. In determining the cost of berth equipment handling, the calculation using the following steps:

a. Determining Annual Cost, the formula is as follow :

$$\text{Annual Cost} = \text{investment} \frac{r (1 + r)^{25}}{(1 + r)^{25} - 1}$$

Based on the formula, the calculation:

$$\text{Annual Cost} = \text{USD } 18,000,000 \frac{0.09 (1 + 0.09)^{25}}{(1 + 0.09)^{25} - 1}$$

$$= \text{USD } 18,000,000 \frac{0.776077259}{7.62308066}$$

$$= \text{USD } 1,832,512/\text{year} = \text{USD } 458,128 / \text{year} / \text{Jib crane}$$

b. Determining Maintenance Cost

$$= 5 \% * \text{USD } 458,128.$$

= USD 22,906 /year / Jib crane

c. Calculate total cost, The formula : Annual cost + Maintenance cost

= USD 458,128 + USD 22,906

= USD 481,034 / year = USD 1,318 per day

5.3.2.4. Berth Labor Cost

Currently the officer on duty at the gate is 4 persons. Meanwhile throughout a full day there are 3 shifts, so there are total officer of full day is 12 persons. The salary for labor cost as shown on the table 5.13.

No.	Berth Labor	1 shift	3 shift	Labor Salary	Total Labor Salary (IDR)	USD
1	Operator 1	1	3	2,500,000	7,500,000	714.29
2	Operator 2	1	3	2,500,000	7,500,000	714.29
3	Checker	1	3	2,000,000	6,000,000	571.43
4	Administrator	1	3	1,900,000	5,700,000	542.86
					Total	2,542.86
					Average	635.71

Table 5.13: Berth Labor Cost Calculation

Source: Author elaboration

Total labor cost = USD 2542.86 / month

= USD 85 per day (1 USD = IDR 10500)

5.3.3. Warehouse Analysis

The implementation of JCDT, where the mandatory use of jib cranes, began in 2013, there were significant a shift towards the use of the three warehouse. The cargoes owner used a truck losing model rather than having to go via warehouse. This is intended to avoid double handling of the cargo handling, which ultimately led to the cost. However, some owners still use warehouse at the terminal though only slightly for several reasons such as:

- a. The cargo owner doesn't have a warehouse Line II.
- b. Warehouse receiver is closed, so had to use warehouse in the terminal as a temporary storage.

5.3.3.1. Warehouse capacity

Currently, the terminal has 5 warehouses it shown in table 4.3 whether it is used by the terminals themselves and who have cooperated to a third party. However,

from the five warehouses, from 2011, the three warehouses (A, B and C) are used exclusively for cargo bag.

No	Warehouse Location	Size		Area	Capacity
		Long (m)	Width (m)	Coverage (m2)	(Ton)
1	Warehouse A	26	24.5	637	700
2	Warehouse B	47	24.5	1151.5	1260
3	Warehouse C	36.4	24.5	891.8	980
		Total		2680.3	2940

Table 5.14: Warehouse Capacity
Source: Author elaboration

Based on the result table 5.7, the warehouse capacity still available to accommodate the bag cargo throughput forecasting for the next 5 years (2014-2018). This can be inferred from the available empty space in the warehouse to be used as cargo storage for bag cargo. This can be seen in the figure below:

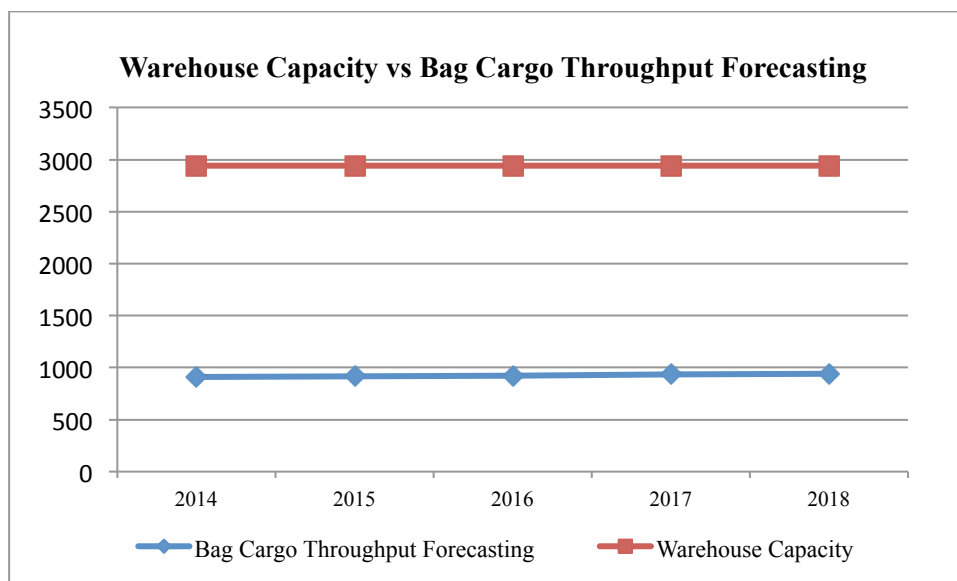


Figure 5.3: Warehouse capacity vs Bag Cargo Throughput Forecasting
Source: Author elaboration

5.3.3.2. Warehouse Facilities Cost

The total cost for warehouse investment is USD 1,400 /m². By using assumption economic usage is around 25 years and interest (r) 9%. The maintenance cost is approximately 5% from annual cost. In determining the cost of warehouse, the calculation using the following steps:

- a. Determining Annual Cost, the formula is as follow :

$$\text{Annual Cost} = \text{investment} \frac{r(1+r)^{25}}{(1+r)^{25} - 1}$$

The total warehouse coverage based as follows:

No	Warehouse Location	Size		Area	Capacity	Investment
		Long (m)	Width (m)	Coverage (m2)	(Ton)	Cost (USD)
1	Warehouse A	26	24.5	637	700	891,800
2	Warehouse B	47	24.5	1151.5	1260	1,612,100
3	Warehouse C	36.4	24.5	891.8	980	1,248,520
Total				2680.3	2940	3,752,420

Table 5.15: Warehouse Investment Cost Result

Source: Author elaboration

Based on the formula, the calculation:

$$\text{Annual Cost} = \text{USD } 3,752,420 \frac{0.09(1+0.09)^{25}}{(1+0.09)^{25} - 1}$$

$$= \text{USD } 3,752,420 \frac{0.776077259}{7.62308066}$$

$$= \text{USD } 382,020/\text{year}$$

b. Determining Maintenance Cost

$$= 5\% * \text{USD } 382,020.$$

$$= \text{USD } 19,101/\text{year}$$

c. Calculate total cost, The formula : Annual cost + Maintenance cost

$$= \text{USD } 382,020 + \text{USD } 19,101$$

$$= \text{USD } 401,121 / \text{year} = \text{USD } 1,099 \text{ per day}$$

5.3.3.3. Warehouse Labor Cost

Currently the officer on duty at the warehouse is 2 persons. Meanwhile throughout a full day there are 3 shifts, so there are total officer of full day is 6 persons. The salary for labor cost as shown on the table below:

No.	Berth Labor	1 shift	3 shift	Labor Salary	Total Labor Salary (IDR)	USD
1	Administrator 1	1	3	2,200,000	6,600,000	628.57
2	Administrator 2	1	3	2,200,000	6,600,000	628.57
Total						1,257.14
Average						628.57

Table 5.16: Warehouse Labor Cost Calculation

Source: Author elaboration

Total labor cost = USD 1,257.14 / month
 = USD 42 per day (1 USD = IDR 10,500)

5.3.4. Waiting cost analysis

5.3.4.1. Ship waiting cost

The following is the data used to calculate the ship waiting costs are based on average GRT ships using the terminal and the average cost incurred by shipping companies per GT/day.

No	Types	Value	Units
1	Average GT	2230.46	GT
2	Ships average cost	1.64	USD/GT/Day

Table 5.17: Ship Waiting Cost

Source: Author elaboration

The total of ships waiting cost = 2230.46 GT x USD 1.64 USD/GT/Day
 = USD 3,658 per ship/day
 = USD 153 per ship/hour

5.3.4.2. Cargo waiting cost

The first thing to do to determine cargo waiting cost is calculating the ratio of cargo discharging: loading in the terminal. From the calculation the ratio is 0.947: 0.053. The second step is calculating the cargo value per tonnage. The calculation of cargo value per tonnage by dividing value cargo and volume of the cargo as shown by the table below:

No.	Trade	Cargo Value (USD)	Volume (Tonnage)	Value per Tonnage
1	Discharging	3495.19	3,915,682.12	892.61
2	Loading	559.05	565,994.38	987.73

Table 5.18: Cargo value per tonnage

Source: Author elaboration

The third step is calculating the good value:

Goods value = (0.947 * USD 892.61) + (0.053 * USD 987.73)
 = 845.30 + 52.34
 = USD 898 per tonnage

With an average cargo handling per call is 239.376 ton, so total cargo value is USD 214,960 (USD 898 x 239.376). After obtained the result of goods value, then calculate the cargo waiting cost with the interest rate (9%):

$$\begin{aligned}
 \text{Waiting cost} &= \text{Goods value} \times \text{interest rate} \\
 &= \text{USD } 214,960 \times 9 \% \\
 &= \text{USD } 19,346.4 \text{ tonnage per year} \\
 &= \text{USD } 53 \text{ per tonnage per day (1 year = 365 day)} \\
 &= \text{USD } 2.208 \text{ per tonnage per hours}
 \end{aligned}$$

The following table is a summary of all costs as a result of cargo handling activities at the terminal:

No.	Types	Cost (USD)	Unit
1	Gate Facilities	51.6	per day
2	Gate Labor	20	per day
3	Berth Facilities	2844	per day
4	Berth Equipment	1318	per day
5	Berth Labor	85	per day
6	Warehouse	1099	per day
7	Warehouse Labor	42	per day
8	Ship Waiting Cost	153	per hour
9	Cargo waiting cost	2.208	per hour

Table 5.19: Summary cargo handling cost
Source: Author elaboration

5.4. Queuing Model Calculation

In this research, the queuing model that will be analyzed are queue model calculation of ship arrivals, queuing model calculation of service time and queuing model calculation at gate. The test based on the previous analysis using the analysis distribution such as ship arrivals, service time and gate service follow exponential distribution. It is means that the data is the poison distribution, which means that the model can be used to queuing theory model is the M/M/K model.

5.4.1. Berth Queuing Model Analysis

The following data and the steps needed to calculate the queuing model as follows:

a. Ship arrival Rate (λ)

Based on table 4.9 above, the average ship between arrivals is around 9.48 hours. While, the data sample for full year is 209 ships.

b. Ship service rate (μ)

We can called ship service rate as berthing time in the terminal, means the berthing time during loading and discharging cargo. In the implementation, the berthing time consist of Berth Working Time (BWT) and NOT (Not Operation Time). The BWT means when time allocated for working to serve in the berth. Meanwhile NOT is the time is allocated for doesn't work in the Berthing Time periods. NOT assumed additional time in 30 minutes before and after cargo handling consisting of the preparation phase. All cargo consists of cargo packaging by bag cargo consisting of fertilizer, flour and cement. The tonnage per call is 2359.38 and average berthing time is 54 hours, so average ships spending time in the berth is 43.10 hours (2359.38/54). By adding 30 minutes before and after loading/discharging for preparation phase, the time is 44.10 hours or 198.64 ships per year (365*24/44.10).

c. The server

Because ship service rate (μ) 198.64 ships per year is $<$ 210 ship per year, it should be have more than one server. By using the number of server $k = 3$, the requirement of the queuing model have been met.

d. Queuing model

By using model M/M/3, the following are the steps in using queue calculation:

- Utilization rate

The formula is as follows:

$$\rho = \frac{\lambda}{k\mu} = \frac{210}{3 (198.64)} = \frac{210}{595.92} = 0.35$$

- Probability there is no ship in the queue

The formula is as follows:
$$P_0 = \frac{1}{\sum_{n=0}^{k-1} \frac{1}{n!} \left(\frac{\lambda}{\mu}\right)^n + \frac{1}{k!} \left(\frac{\lambda}{\mu}\right)^k \left(\frac{k\mu}{k\mu - \lambda}\right)}$$

Calculation using formula:

$$P_0 = \frac{1}{\sum \frac{1}{0!} \left(\frac{210}{198.64}\right)^0 + \frac{1}{1!} \left(\frac{210}{198.64}\right)^1 + \dots + \frac{1}{3!} \left(\frac{210}{198.64}\right)^3 \left(\frac{3(198.64)}{3(198.64) - (210)}\right)}$$

$$= \frac{1}{1+1.057+0.5588+0.196927+(0.196927*1.5441)} = \frac{1}{3.11680198}$$

$$= 0.3208$$

- Average time a ship spends in the queue

The formula is as follows: $W_q = \frac{\left(\frac{\lambda}{\mu}\right)^k \mu}{(k-1)!(k\mu-\lambda)^2} P_0 + \frac{1}{\mu}$

Calculation using formula:

$$W_q = \frac{\left(\frac{210}{198.64}\right)^3 198.64}{(3-1)!(3(198.64)-210)^2} 0.3208 + \frac{1}{198.64}$$

$$= 0.00529$$

- Average number of ship in the queue

The formula is as follows: $L_q = P_0 \frac{\left(\frac{\lambda}{\mu}\right)^k \rho}{k!(1-\rho)^2}$

Calculation using formula: $L_q = 0.3208 \frac{\left(\frac{210}{198.64}\right)^3 0.35}{3!(1-0.35)^2}$

$$= 0.0523$$

- Average time ship spends in the terminal:

The formula is as follows: $W = W_q + \frac{1}{\mu}$

Calculation by using formula: $W = 0.0529 + \frac{1}{198.64} = 0.00556$

$$= 48.73 \text{ hours}$$

- Average number of ship, the formula is as follow :

$$L = \lambda \left(W_q + \frac{1}{\mu}\right) = L_q + \frac{\lambda}{\mu}$$

Calculation by using formula:

$$L = 0.0523 + \frac{210}{198.64} = 1.10940$$

The example above calculation is queuing theory models using the number of servers 3. The following is the result of the calculation of other queuing models using

a server with number servers 2 and 4 by using the same calculation steps. The table is as follows:

No	Models Name	Characteristics	Number Of Server		
			2	3	4
1	Number of Berths	k=	2	3	4
2	Arrivals Rate (Ships/Year)	λ=	210.00000	210.00000	210.00000
3	Service Rate of Each Berth	μ=	198.64000	198.64000	198.64000
4	Average Utilisation	ρ=	0.52859	0.35240	0.26430
5	Probability No Ships In The system	P_0=	0.26300	0.32080	0.34060
6	Average ship Waiting in the Queue	Wq =	0.00055	0.00053	0.00051
7	Average ship in the queue	Lq =	0.14850	0.05230	0.01237
8	Average Spends Time in the terminal	W =	0.00559	0.00556	0.00554
9	Average number of ship	L =	1.20560	1.10940	1.06950

Table 5.20: Characteristics of Queuing Model Result

Source: Author elaboration

5.4.2. Gate Queuing Model Analysis

The following data and the steps needed to calculate the queuing model as follows:

- a. Truck arrival Rate (1)

The truck arrival is 1264 truck/year.

- b. Truck service rate (μ)

The truck service rate is 3792 truck/year

- c. The server

Since truck arrival rate (1) 1264 ship per year is less than truck service rate (μ) 3792 trucks per year, it should be have not more than one server.

- d. Queuing model

By using model M/M/1, the following are the steps in using queue calculation:

- Utilization rate

The formula is as follows:

$$\rho = \frac{\lambda}{k\mu} = \frac{1264}{1(3792)} = \frac{1264}{3792} = 0.33$$

- Probability there is no truck in the queue

The formula is as follows:
$$P_0 = \frac{1}{\sum_{n=0}^{k-1} \frac{1}{n!} \left(\frac{\lambda}{\mu}\right)^n + \frac{1}{k!} \left(\frac{\lambda}{\mu}\right)^k \left(\frac{k\mu}{k\mu - \lambda}\right)}$$

Calculation using formula:

$$P_0 = \frac{1}{\sum \frac{1}{0!} \left(\frac{1264}{3792}\right)^0 + \frac{1}{1!} \left(\frac{1264}{3792}\right)^1 \left(\frac{1(3792)}{1(3792) - (1264)}\right)}$$

$$= 0.6669$$

- Average time a truck spends in the queue

The formula is as follows: $W_q = \frac{\left(\frac{\lambda}{\mu}\right)^k \mu}{(k-1)!(k\mu-\lambda)^2} P_0 + \frac{1}{\mu}$

Calculation using formula:

$$W_q = \frac{\left(\frac{1264}{3792}\right)^1 3792}{(1-1)!(1(3792-1264))^2} 0.6669 + \frac{1}{3792}$$

$$= 0.0003956$$

- Average number of truck in the queue

The formula is as follows: $L_q = P_0 \frac{\left(\frac{\lambda}{\mu}\right)^k \rho}{k!(1-\rho)^2}$

Calculation using formula: $L_q = 0.6669 \frac{\left(\frac{1264}{3792}\right)^1 0.33}{1!(1-0.33)^2}$

$$= 0.16342$$

- Average time truck spends in the terminal:

The formula is as follows: $W = W_q + \frac{1}{\mu}$

Calculation by using formula: $W = 0.0003956 + \frac{1}{3792} = 0.0006593$ years

$$= 5.77 \text{ hours}$$

- Average number of truck, the formula is as follow :

$$L = \lambda \left(W_q + \frac{1}{\mu}\right) = L_q + \frac{\lambda}{\mu}$$

Calculation by using formula:

$$L = 0.16342 + \frac{1264}{3792} = 0.4967 = 1 \text{ truck}$$

The existing number of gate operation is one gate, so the analysis queuing characteristic only for $k = 1$ number of server

5.5. Total Cost Model Calculation

The total cost model analysis is used to determine both the optimal number of facilities and cargo handling equipment that is required in order to support customer satisfaction. Analysis of total cost model can be calculated by the following formula:

$$Z = I. C1 + W. C2$$

Where, z = total cost (total cost in the system)

I = Service provider during specific periods

C1 = Cost per unit

W = Total waiting cost

C2 = Cost per unit

The total cost calculation result as shown in the table below:

No	Number Of Server	2	3	4
1	Cost Of Service	8,494.00	9,859.62	11,225.24
	a. Berth Facilities	5,688.00	5,688.00	5,688.00
	b. Berth Equipment	2,636.00	3,954.00	5,272.00
	c. Berth Labor	170.00	217.62	265.24
2	Cost Of Warehouse	1,141.00	1,141.00	1,141.00
	a. Warehouse Service	1,099.00	1,099.00	1,099.00
	b. Warehouse Labor	42.00	42.00	42.00
3	Cost Of Gate	71.60	71.60	71.60
	a. Gate Facilities Service	51.60	51.60	51.60
	b. Labor Gate Service	20.00	20.00	20.00
	Wq (year)	0.00055	0.00053	0.00051
	Wq (hour)	4.82	4.64	4.47
4	Cost Of Waiting	747.79	720.60	693.41
	a. Ship waiting cost	737.15	710.35	683.54
	b. Cargo waiting cost	10.64	10.25	9.86
5	Total Cost			
	Service by Truck Losing	9,313.39	10,651.82	11,990.25
	Service via warehouse	10,454.39	11,792.82	13,131.25

Table 5.21: Ships Total Cost

Source: Author elaboration

The table above explained the costs incurred due to cargo handling services activity in the terminal. As shown in the table above, the increase occurs when cargo handling activities using a number of different equipment handling facilities. Based

on the table above it can be seen that the total cost for cargo handling using server (jib crane) with the number 2 is the amount of USD 10,454.39 consisting of USD 8,494 for cost of service , cost of warehouse USD 1,141, USD 71.60 cost of gate and USD 747.79 cost of waiting . When the number of jib crane added into 3 units, the cost of service become \$ 9,859.62. The addition of the cost of the equipment costs are incurred, while berth facilities cost is same. Meanwhile, the waiting cost is decreased to USD 720.60. However, the cost of gate is the same cost even the server changing with 2 and 3 server because there is no adding server in the gate service operation. The significant differences occurred in the total cost for using the service truck losing models, which in terms of time more quickly and costs more efficient. As seen in the table that the cost of using 2 jib cranes of \$ 9,313.39 which consists of the cost of service is USD 8.494 and costs of waiting is USD 747.79. While the decline in the cost of waiting, occur if the amount of jib crane was increased to 3 units and 4 units. The total cost of using 3 jib cranes is USD 10,651.82 and using 4 jib cranes is USD 11,990.25. However the difference between the total costs used the truck losing model and cargo handling through warehouse very significant.

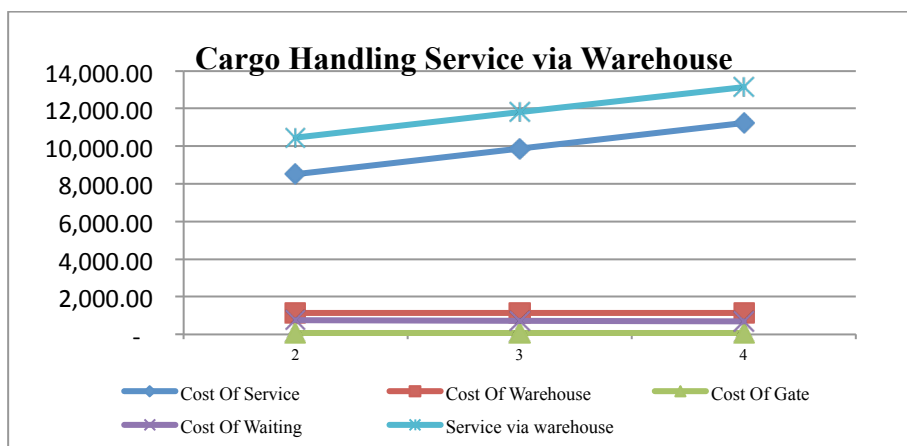


Figure 5.4: Cargo Handling Service via Warehouse
Source: Author elaboration

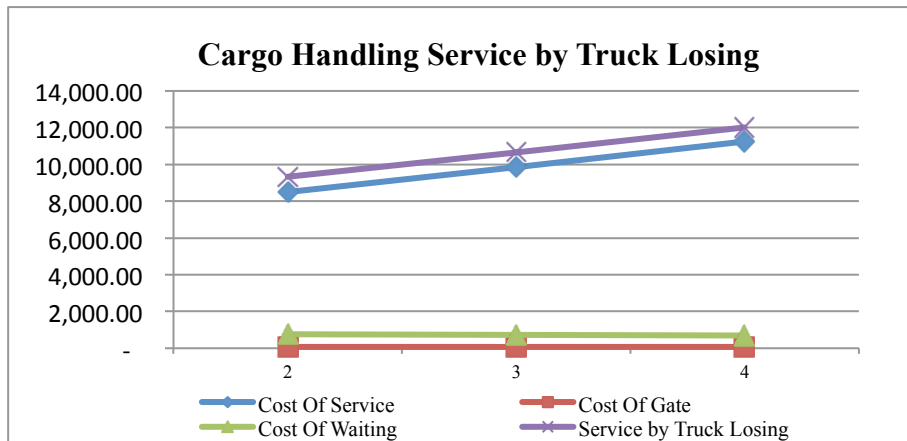


Figure 5.5: Cargo Handling by Truck Losing

Source: Author elaboration

The table below will be apparent difference or ratio of each cost incurred as a result of cargo handling at the terminal either by using a truck losing model or via warehouse.

Service By Truck Losing

Ratio of each service cost to total cost

No	Service	Number of server		
		2	3	4
1	Cost of service	91.20	92.56	93.62
2	Cost of gate	0.77	0.67	0.60
3	Cost of waiting	8.03	6.77	5.78

Table 5.22: Ratio each service to total cost A

Source: Author elaboration

Service via warehouse

Ratio of each service cost to total cost

No	Service	Number of server		
		2	3	4
1	Cost of service	81.25	83.61	85.48
2	Cost of warehouse	10.91	9.68	8.69
3	Cost of gate	0.68	0.61	0.55
3	Cost of waiting	7.15	6.11	5.28

Table 5.23: Ratio each service to total cost B

Source: Author elaboration

Chapter 6 CONCLUSIONS & RECOMMENDATION

In this chapter will divided into two main subjects, they are conclusion and recommendation. Based on the previous evaluation and analysis, the research obtained some conclusion and recommendation.

6.3.Conclusions

- a. In determining the forecasting bag cargo throughput using four forecasting models, they are trend (linier), moving average, weighted moving average and regression. The regression model using GDP as the independent variable. In all four forecasting models are used, regression models selected as the best model because has the smallest forecast error by the Mean Square Error. The bag cargo forecasting throughput for the next 5 years (2014-2018) are 908.40, 916.89, 925.39, 933.88 and 942.38.
- b. Conducting frequency distribution test by using Kolmogorov Smirnov (KS) for ship arrivals, service time and gate operation service. The results for KS distribution test are followed the exponential distribution for ship arrivals, service time and gate operation system. Thus, the method used to analyze queuing models is to use the model M/M/K.
- c. The maximum LOA for the longest ship berthing at the terminal is 130.15 m. Thus, the berth capacity is still available to serve the ship with the longest LOA. Meanwhile, the warehouse capacity is 2940 tonnage. The warehouse capacity still available to accommodate the bag cargo throughput for the next 5 years (2014-2018).
- d. The cost analysis shows that the cost result for cargo handling is divided into 3 kinds. They are cost of service, cost of warehouse, cost of gate operation service and cost of waiting. The cost of service, cost of warehouse and cost of gate operation service consist of the facilities, equipment and labor. The gate facilities cost is USD 51.6, gate labor is USD 20, berth facilities is USD 2844, berth equipment is USD 1318, berth labor is USD 85, warehouse facilities cost is USD

1099, warehouse labor is USD 42, ship waiting cost is USD 153 and cargo waiting cost is USD 2.208.

- e. A significant difference to the total cost generated for the application of 2 models of cargo handling at JCDT terminal, they are truck losing and handling via warehouse. The application of truck losing using 2 servers is USD 9313.3, 3 and 4 servers is USD 10,651 and USD 11,990. While, the application of cargo handling via warehouse using server 2,3 and 4 respectively were USD 10454, USD 13,131 and USD 11,792. Based on the these result it can be concluded that the application of cargo handling by using models of truck losing more effective and efficient in term of cost.

6.4.Recommendation

- a. Based on this research, author wanted to provide recommendations to the management Palembang Port that need to maximize the existing warehouse functions. The changes in the application model of cargo handling at the terminal by using model truck losing, resulting in an empty warehouse into a function that can be maximized for use as another cargo warehouse or other commodities. The maximize warehouse functions add to the company earnings result.
- b. Besides strengthening cooperation with third parties, the company requires a truck investment as a new business. Thus, it can make more effective an efficient in terms of time and cost. So, cargo handling in terminal as one stop logistics to customers.

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