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Application of DEA and MPI Method on Indonesian Ports Marine Services Performance: A New Approach for Investments Decision Analysis

by

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Acknowledgements

Bismillahirrahmanirrahim
In the name of Allah, Most Gracious, Most Merciful

All praise and glory to Almighty Allah, the only God who gave me courage and patience to carry out this work. Peace and blessing of Allah be upon last prophet Muhammad (peace be upon Him).

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Abstract

Unlike most of the studies that measure Indonesian ports' performance from general aspects, this study measures the port's performance from a specific aspect: marine services. These services include pilotage and towage services.

By using Data Envelopment Analysis (DEA) and Malmquist Productivity Index (MPI) methods, this thesis intends to measure and benchmarks the technical efficiency (TE) and total factor productivity (TFP) of eight Indonesian ports' marine services' performance. The input variables used are the number of pilots, the number of pilot boats and harbour tugs. Meanwhile, the output variables used are the total amount of ship movements in GT and the total ship hours in GT as the product of pilotage and towage services.

Both methods are preferred because the methods allow the user to measure and benchmark the efficiency of various firms' performances simultaneously. More specifically, the MPI method enables the user to presents the productivity and efficiency change during a period of time. TE is the output of DEA method which in this thesis case shows the ability of a port to optimize the marine services' input to produce the output. Meanwhile, TFP is a result of MPI method which reflects the productivity and efficiency changes of marine services in a period of time.

The result of DEA analysis shows that in 2014, the port of Tanjung Perak scores the highest efficiency compared to the other ports studied. Meanwhile, the results of MPI indicate that the marine services' productivity over 2010 – 2014 in most of the observed ports are improved. Furthermore, in 2020, the ship calls in GT are predicted to increase by 66% on average, while the pilotage production in GT ship movements is projected to increase by 53% on average. The towage service production in GT ship hours are forecasted to growth by 64% on average.

With respect to the projected ship calls and marine services' productivity in 2020, the investments which have been planned to handle the ship traffic in that year also will have a positive impact on the productivity. The DEA analysis of marine services in 2020 also shows that the services in some ports will become less efficient while the port of Tanjung Perak remains the most efficient. It can also be concluded that the DEA and MPI are useful methods for analysing the TE and TFP of Indonesian ports' marine services and its can be used as a tool to analyse the future impact of Pelindo's investments plan on marine services equipment.

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List of Abbreviations

CPI	Customer Perception Index
DEA	Data Envelopment Analysis
EFFCH	Efficiency Change
IPC	Indonesia Port Corporation / PT Pelabuhan Indonesia II (Persero)
KP3EI	Komite Percepatan Pembangunan Ekonomi Indonesia *(Committee for Acceleration and Expansion on Indonesian's Economic Development)*
KPI	Key Performance Indicators
MP3EI	Master Plan Percepatan Pembangunan Ekonomi Indonesia *(Master Plan for Acceleration and Expansion on Indonesian's Economic Development)*
MPI	Malmquist Productivity Index
NOHT	Number of Harbour Tugs
NOP	Number of Pilots
NOPB	Number of Pilot Boats
Pelindo	PT Pelabuhan Indonesia (Persero)
SMG	Ship Movement in GT
SHG	Ship Hour in GT
TE	Technical Efficiency
TECHCH	Technical Change
TFPCH	Total Factor Productivity Change

1. Introduction

1.1. Problem Identification

As the biggest archipelagic country, Indonesia's economic activities rely on sea transportation that connects one island to the other islands. Therefore, there are many ports in Indonesia, scattered across Indonesia islands, either dedicated for passengers or goods. Recently, there are 1,241 existing ports which classified to commercial and non-commercial ports (Indonesian Ministry of Transportation 2014). For further development, those commercial ports are bestowed to PT Pelabuhan Indonesia (Pelindo) I, II[1], III and IV as the state-owned terminal operators. PT Pelindo I is given the rights to manage 21 ports in the western part of Indonesia while PT Pelindo II / IPC manages 22 ports in the mid-west part of Indonesia. Furthermore, 43 ports in mid-east part of Indonesia are run by PT Pelindo III. Meanwhile, PT Pelindo IV manages 22 ports in the eastern part of Indonesia[2]. However, as independent entities, these companies have their own policies to manage their ports. Later on, the term of "Pelindo" in this thesis will be used to mention all Pelindo I, II, III and IV.

source: own modification

Figure 1. The working region of PT Pelindo I, II, III and IV

As a port business entities, besides cargo services such as cargo handling, stevedoring and warehouse, Pelindo also have another services such as marine services that consist of berthing, pilotage, towage and mooring services. Different with the other ports such as some European ports which handed over the marine services management to the private sector, most of marine services activities in Indonesian ports are run by Pelindo as the port operator. Nevertheless, these marine services contribute considerably to the Pelindo's revenue and profit. In general, the revenue from marine services is the top three contributors of the total revenues. Therefore, marine services are play important role in Pelindo's ports activities. Figure 2 shows the share of Pelindo's revenue.

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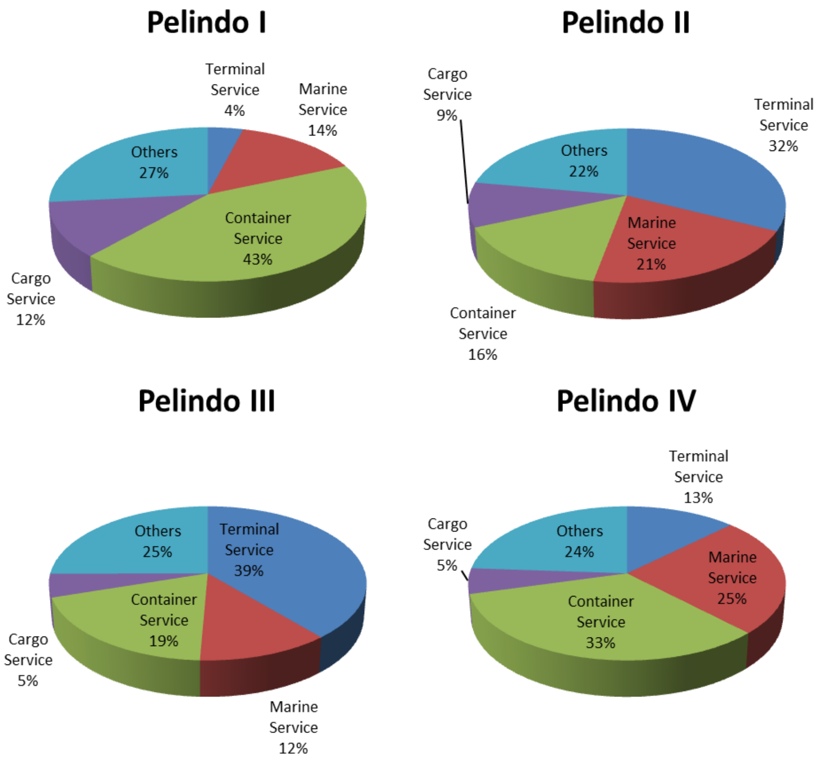
[1] also known as Indonesia Port Corporation - IPC

[2] according to Government Regulation 56/1961, 57/1961, 58/1961 and 59/1961



source: Pelindo I, II, III and IV

Figure 2. Share of Pelindo's revenues

As with cargo services, port marine services are also required to continuously improve. Two terms that are often used as a keyword in business process improvement are efficiency and productivity. With an increase of efficiency and productivity of the services, Pelindo's revenues and profit are expected to increase thereby improving their competitiveness with the other ports. Moreover, increased efficiency and productivity performance in the port activities can also reduce unnecessary effort and cost to perform a service.

In 2020, it is predicted that there will be an increase in ship calls due to Indonesia's economic growth. Hence, to anticipate a growing demand for port services, Pelindo planned several investments, for example, an addition to the number of pilot boats and harbour tugs as the equipment to support the marine services. However, during this time, the investments plans of harbour tugs and pilot boats which were carried out by Pelindo are not yet considering their efficiency and productivity level. Because of this reason, the primary goal of this thesis is to perform an efficiency and productivity measurement of the marine services in the future after the investments on the marine services equipment.

The majority of studies on the Indonesian port's performance measurement are concerned to the port's cargo services, rather than its marine services. A study conducted by (Purwantoro 2003) who was measure 24 Indonesian ports' performance using DEA analysis using four inputs and outputs. In 2010, there was also a study which measure 12 Indonesian container terminals by (Andenoworih

2010). Another study on Indonesian ports performance was also performed by (Sari 2014) who measure five container terminal operated by IPC. The inputs used are berth length, container yard area, number of quay crane, number of yard equipment and service time. On the outputs side are cargo throughput, over per hour and ship calls. Table 1 presents the studies on Indonesian ports' performance.

Table 1. Studies on Indonesian ports performance by Indonesian researchers

Reference	Research Object	Variables	
		Input	Output
Purwantoro (2003)	24 Indonesian ports	Infrastructure Marine services Terminal equipment Transport equipment	Ship calls in unit Ship calls in GT Cargo throughput in M^3 Container throughput in Teus
Andenoworih (2010)	12 Indonesian container terminal	Berth length Number of employee Number of gantry crane Yard are	Container throughput
Sari (2014)	5 IPC container terminal	Berth length Container yard area Number of quay crane Number of yard equipment Service time	Cargo throughput Mover per hour Ship calls

source: own collaboration from various sorces

Since there is no research on the port's marine services, this thesis will be addressed to shows the Indonesian ports performance in more specific scope: from its marine services. This analysis of marine services' efficiency can be used by port operators to compare the performance to the other ports. This enables the port operators to improve the marine services' planning and operations then produce as much as outputs with limited resources or the other way around, to optimize the input considering the output.

Usually, there are two methods which are carried out by Pelindo to measure their port marine services' performance. First, using the customer perceptions index (CPI) and second, using key performance indicator (KPI). CPI method uses a questionnaire to gather the perceptions of Pelindo's customers towards the marine services. Meanwhile the KPI method uses several set of targets as the indicator of how well the services can accomplish the targets. However these methods only measure the marine services' performance at individual port rather than comparing to the other ports.

Therefore, in this thesis, the efficiency and productivity of marine services' performance will be measured using Data Envelopment Analysis (DEA). DEA is a non-parametric method on linear programming system which can be used to obtain the performance among several ports. Meanwhile, Malmquist Productivity Index (MPI) also will be used to calculate the total factor productivity (TFP) of the marine service performance. By using MPI, the result of TFP will be decomposed into technology change (TECHCH) and efficiency change (EFFCH). In this case, The TECHCH is the ability of a port to improve new technology on its marine services such as ship's speed and power. Meanwhile the EFFCH reflects the port's managerial ability to allocate the optimum input given the actual or expected output. The efficiency and the productivity of marine services in this thesis will be measured using Input-Oriented and Constant Returns to Scale (CRS) approach.

The main reason underlying the selection of these methods is the fact that these methods allow to compare the efficiency of the marine services' performance of different Indonesian ports simultaneously. The other reason is to perform a complex technique of DEA and MPI methods to measure Indonesian ports' marine services which never been applied before.

1.2. Research Objective and Research Question

The main objective of this thesis is to analyse Pelindo's investments on marine services equipment based on the efficiency and productivity performance of the services. Before reaching the objective, the existing Technical Efficiency (TE) of marine services will be observed. Then, it will be followed by measuring the Total Factor Productivity (TFP) of the marine services on each port over five years. Prior to analysing the investments, the next step will predict the marine services output in the future. Afterwards, by considering the future situation and the addition of the number of pilot boats and harbour tugs, an analysis of the investments can be presented using Malmquist Productivity Index (MPI). Finally, the TE of the marine services' performance among the observed ports in 2020 will be obtained. To summarize the explanation above, the research question and sub-research questions of this thesis are as follows:

The research question:
"What is the impact of Pelindo's investment plan to the efficiency and performance level of their port's marine services?"

The sub-research questions are:

- *What is the current efficiency level of marine services in each port managed by Pelindo?*
- *What is the productivity level of the marine services over five years (2010-2014)?*
- *What is the expected marine services' output in 2020 for each port?*
- *How much is the change in the productivity level of planned investment with respect to the expected marine services' output in 2020?*
- *What is the expected efficiency level of marine services in each port managed by Pelindo in 2020?*

1.3. Scope and Limitation of the Research

The research will be limited only to eight Indonesian ports under the management of Pelindo I, II, III and IV that consisting of four primary-class ports and four first-class ports spreaded in eight provinces. These ports are: the port of Belawan (North Sumatera), port of Dumai (Riau), port of Tanjung Priok (DKI Jakarta), port of Palembang (South Sumatera), port of Tanjung Perak (East Java), port of Tanjung Emas (Central Java), port of Makassar (South Sulawesi) and port of Balikpapan (East Kalimantan). The reason behind this selection is because these ports are the important nodes of Indonesian logistics network. The limited access to collect the data from the other ports also contributes to the reason why there are only few number of the ports which observed.

Despite the port marine services are consist of berthing, pilotage, towage and mooring, this thesis limited only to the pilotage and towage service which in the later only mentioned as “marine services”. The data used in this thesis also limited only from 2010-2014 which collected from each Pelindo’s annual report.

Even though there are many indicators to measure the performance of a service, this thesis will only focused on measuring the marine service performance based on the non-financial and non-technical indicator. The factors of the distance from the pilot station to the navigation buoy where the pilot should on board to the piloted ship will not be considered. Therefore, the input and output variables used are only considering the number of equipment which used in marine services activity.

1.4. Research Methodology

To draw a conclusion of this thesis, a well-known performance analysis method called Data Envelopment Analysis (DEA) and Malmquist Productivity Index (MPI) will be utilized. The DEA method is preferred because it is a common method to measure the efficiency of a process on various services by considering several input and output factors. In addition, Malmquist Productivity Index (MPI) will be deployed to presents the productivity and efficiency change of Pelindo’s marine services over five years.

To running the analysis, DEA and MPI methods require some inputs and outputs variables which associated with marine services. In this thesis, several input and output variables are selected, such as the number of pilot, the number of pilot boats and the number of harbour tugs for the input variables. On the other side, ship movement in GT and ship-hour in GT are selected as the output variables.

With respect to the research method, this thesis will combine both qualitative and quantitative methods. Literature review in this thesis is a part of the qualitative method. Since there is no reference on DEA application in marine services, therefore some literature review will discuss the DEA application in port performance in general.

As for the quantitative method, an analysis technique using the DEA and MPI method will be conducted. The data will be collected from Pelindo’s annual report as well as the company’s long term plan.

1.5. Thesis Structure

After describing the background, research objectives and methodology in chapter one, chapter two presents some literature reviews related to the thesis topic. It consists of the definition and the rules regarding the pilotage and towage service in Indonesian ports. The basic theory of efficiency and productivity will be covered in this chapter. The literature review will also discuss the researches which have been conducted to measure Indonesian ports’ performance as well as some applications of DEA and MPI method. Afterwards, chapter three provides the research sequences as well as the approaches of each sequence. Next, chapter four describes the case study of Indonesian port marine service. Chapter five will discuss the process of the analysis which divided into several steps according to the thesis methodology. The result of the analysis of each step also will be discussed here. Finally, chapter six summarizes the key findings of the research as well as the limitation of the study. Furthermore, the suggestions for further research are also will be explained here.

2. Literature Review

At this chapter, the discussion of the literature reviews will start from the notion of pilotage and towage service as well as the related rules which applied in Indonesian ports. Next, reviewing some literatures regarding the efficiency and productivity in general. Afterwards, the discussion will touch upon the research of Indonesian port performance. The last part of this chapter will discuss the DEA and MPI methods in general and in specific to the port related services.

2.1. Indonesian Pilotage and Towage Services

2.1.1. Pilotage and Towage Service Definition

One of the activities that have a significant role in the operations at the port is pilotage and towage services. According to the Minister of Transportation Decree 53/2011, pilotage is a pilot activity in guiding, helping and giving advice and information to the captain about the important state of local waters. Therefore, the voyage navigation and ship manoeuvre can be carried out safely, orderly and smoothly for the safety of the ship and the environment (Kementerian Perhubungan [Ministry of Transportation] 2011). While the pilot itself is a sailor, who has expertise in the nautical field that has qualified to carry out pilotage service.

In mandatory pilotage waters, a ship which has minimum 500 gross tonnage (GT) must use the pilotage service. While in exceptional pilotage waters, pilotage services performed at the request of captain. Upon consideration of the safety of shipping from harbour master and the request from the captain, a ship which has less than 500 GT, which voyage in the mandatory pilotage waters can be given pilotage services.

Meanwhile, harbour towage is a part of the pilotage activities include pushing, pulling/towing or guiding/holding the ship motion, for berthing to or unberthing from a dock, jetty, trestle, pier, buoy, dolphin, another ship and other mooring facilities by using tugboat/harbour tug. A pilot officer can use harbour tug to assist ship navigation in a certain size to keep the safety and security and the smooth pilotage operation.

2.1.2. Pilotage and Towage Service Provider

Refers to the Minister of Transport Decree 53/2011, the pilotage services shall be performed by the Port Authority and the Port Operator Unit under the Ministry of Transportation. In the case of the Port Authority and the Port Operator Unit pilot cannot provide the pilotage services required in the mandatory pilotage waters, exceptional pilotage waters and a specific terminal, then the execution may be delegated to Port Business Entity that meet the requirements for obtaining permission from the Minister.

Therefore, Pelindo as a Port Business Entity has given a right to provide a pilotage and towage service. According to the Ministry Decree, Pelindo as Port Business Entity which delegated to give a pilotage services have the following obligations:

1. Provide some pilot officer who meets the requirements in accordance with the number of ships movements per day;
2. Provide some pilotage facility and infrastructure that responds to the requirements in accordance with the size and the number of ships movements per day;
3. Provide a proper and appropriate pilotage services according to the specified systems and procedures;
4. Report to harbour master in the event of constraints in the implementation of pilotage service;
5. Report to the Directorate General of Sea Transportation regarding the pilotage activity report every 1 (one) month.

2.2. Efficiency and Productivity

Up to now, there is no studies related to the efficiency and productivity measurement of marine services. Due to lack of the relevant references that can be used as comparison to this thesis, the topic of efficiency and productivity will be discussed in general. In addition, the discussion will also adapated from the case studies in other sector such as manufacturing.

In general, productivity can be defined as the utilization of existing resources (e.g.: human resources, machinery, and others) in producing goods and services. Productivity improvement is one of the steps taken by a company to increase the production by improving the potential resources in the production activities, either in the form of goods or services. In order to provide and maintain a service excellence, a company must have high productivity level. Therefore, the company should always measure its level of productivity by setting a productivity standard indicator. A standard indicator can be defined as something that is considered as a fixed value so that it can be used as a reference.

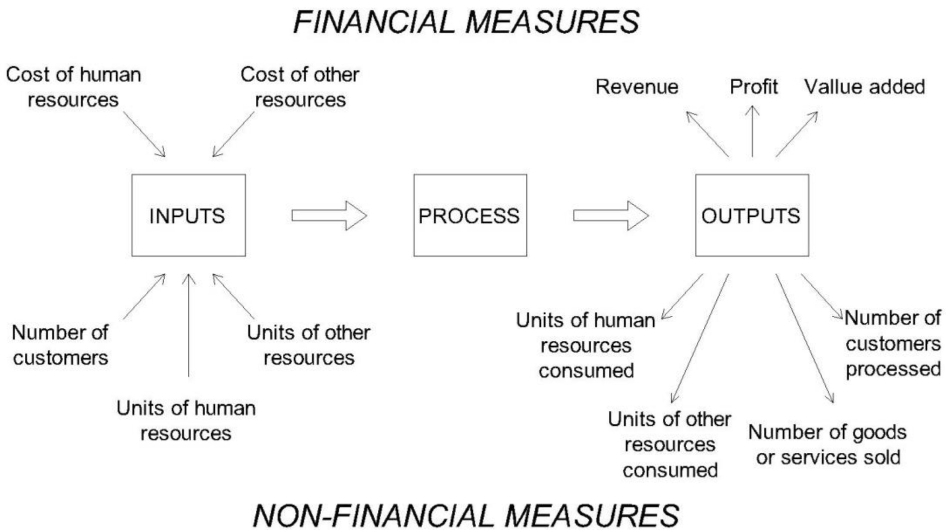
In his research, (Tangen 2002) mentioned that productivity is the relationship between the output to the input in a production process. Therefore, productivity is very closely related to the use and availability of production resources. On the other hand, productivity is also closely associated with the creation of a final value of a product.

Consistent with the earlier definition of productivity, (Gummesson 1998) also mentioned that productivity is the ratio between output and input. However, he added that the more we reduce the input and still maintain the output, then the productivity will increase. Moreover (Gummesson 1998) argued that in the future, an increase in earnings (output) is more focused than cost reduction. This approach can be done by increasing the output at a faster rate than the input, so it can provide increased profits at the same time with the increase in costs.

However, based on the argue from (Mahoney 1988), (Johnston & Jones 2004) expressed in his research that there is a different understanding in interpreting and understanding the concept of services productivity. For example, the concept of productivity is often used as the main concepts including efficiency, quality, effectiveness, utilization. Therefore, (Johnston & Jones 2004) detailing some of the definitions of these terms.

Utilization is the ratio between the actual output of a process or an operation towards its design capacity. In fact, there is no process or operation that reached 100% with its design capacity due to maintenance or malfunction. Efficiency is the ratio between the actual output and the effective capacity (Slack et al. 2001). While productivity is the ratio between the actual output towards its inputs required to produce the output. An example of input, among others: material, employees, equipment, and customers, while the output is goods and services (Slack et al. 2001).

Moreover (Johnston & Jones 2004) also emphasize that to find the productivity value may be complicated due to three reasons: first, the outputs are sometimes expressed in different units than the inputs. The output is usually measured in physical terms such as units, tonnes, kilowatts or value. While the input is presented in different sizes, including people and costs. Second, the resulting ratio cannot describe clearly the performance or productivity until the value of the ratio is compared to the previous period as a benchmark. Third, many different ratios can be used to describe the productivity. The picture shows some examples of input and output variables in terms of both financial and non-financial that can be used to determine the productivity ratio.



Source: (Fitzgerald et al. 1991)

Figure 3. Example of the input and output variables for creating productivity ratio

2.3. Port Performance Measurement

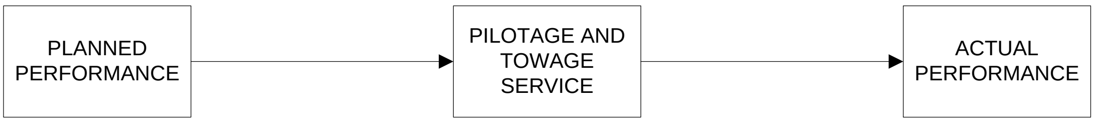
To develop the organization, conducting a performance measurement is essential for a firm. In the country level, performance measurement has a significant role in evaluating the production at the country's current and the future (Dyson 2000). If the performance measurement can be done correctly, the firm can be directed to the desired direction. This aim can be done by analysing the behavioural responses and understand the impact of various measures of performance on the port efficiency. However, if it is done incorrectly, then the firm can move to the wrong direction and will lead to unintended negative consequences.

The economic growth of a region is strongly influenced by the performance of the port because the port connects sea transportation and land transportation. In addition, a port also act as a major provider of various ship activities, cargo and land transportation. A port can also contribute positively to the economic development of a region if the port can well performed and able to provide a satisfactory and efficient services to ships and goods. Conversely, if the port operates inefficiently, it will cause a waste of resources. Therefore, the analysis of the efficiency of the port is important to carried on to provide port operators with a clear idea about the extent to which port's resources works and help them to compare their advantages and disadvantages (Lu 2014). Moreover, the measurement of the performance of the port can increase port development while maintaining competitiveness in an increasingly competitive commercial environment. Therefore, it is crucial to do a comprehensive study to identify any performance indicators that are relevant to the activities of the ship, cargo and terminal. Therefore, by analysing the efficiency of a port using several indicators can provide a snapshot of the comparison of port performance on an international level.

In general, as mentioned earlier, measuring the performance of a service or the production process is critical in order to know how much the productivity level of the service. Just like the other services, port services performance should also be measured. In addition, port services performance measurement such as marine services also required as an input to improve the quality of the services. It also can be used as a basis for planning operational strategies and the determination of appropriate investment program.

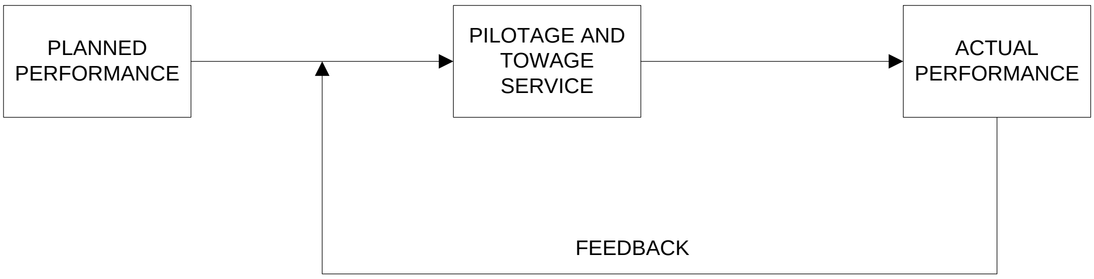
Similar with other areas, measuring the performance of marine service also requires such indicators which could be used as a benchmark. (UNCTAD 1976) mentioned that the performance indicators could be used as: first, the comparison of real operational performance with the targets set and second, to observe the trend in operational performance. Furthermore, (UNCTAD 1976) also suggest that performance indicators of port services can also be used as an input or the basis for tariff negotiations.

To be able to control an operational process, a company or organization needs to take notice of its performance or the outcome of the service. Feedback from outcome either from performance or production report can be used to improve the input in order to adjust the next outcome in accordance with the plan (UNCTAD 1976). Figure 1 illustrates an operational scheme without using a feedback process (open loop). While Figure 2 illustrates an operational scheme using a feedback process (closed loop).



source: (UNCTAD 1976)

Figure 4. Operational scheme with open loop process



source: (UNCTAD 1976)
Figure 5. Operational scheme with closed loop process

According to (Bichou 2006), research on port performance measurement has shifted from the dimensions of utilization and effectiveness of port performances towards the dimension of efficiency due to the lack of standard indicators used to measure the productivity. Efficiency can be defined as the ratio between the actual quantity of output to the actual quantity of input. There are two aspects of efficiency measurement, financial aspect and physical aspect. A financial aspect measurement usually focuses on the cost or profit generated from port throughput. The financial performance indicator may include price per twenty-foot equivalent (TEU), total income and expenses related to the ship's size in net registered tonnes (NRT) or gross registered tonnes (GRT). While the physical performance indicator focus on the quay transfer operations and concerned with ship-related parameters such as ship turn-round time (TRT), berth occupancy ratio (BOR) or working time (WT) (Bichou & Ray 2004).

2.3. Study on Indonesian Port Performance

Due to a large number of ports and the existing problems in Indonesian ports, hence, many studies that makes Indonesian ports as the research subject. To date, there are several studies on Indonesian port performance conducted either by Indonesian or foreigner researchers. While Indonesian researchers only study on Indonesian ports performance among national ports such as the study by (Purwantoro 2003; Sari 2014), foreigner researchers (Seo et al. 2012; Merk & Dang 2012) compare Indonesian ports with international ports. All of these studies were using DEA to analyse the port performance. However, among these studies, there is no research which focused on the Indonesian port marine service performance.

Table 2. Research on Indonesian port performance

Reference	**Research Object**	**Variables**	
		Input	**Output**
Purwantoro (2003)	24 Indonesian ports	Infrastructure Marine services Terminal equipment Transport equipment	Ship calls in unit Ship calls in GT Cargo throughput in M^3 Container throughput in Teus
Andenoworih (2010)	12 Indonesian ports	Berth length Number of employee Number of gantry	Container throughput

		crane Yard Area	
Sari (2014)	5 IPC container terminal	Berth length Container yard area Number of quay crane Number of yard equipment Service time	Cargo throughput Mover per hour Ship calls
Seo et al. (2012)	30 ASEAN ports including 4 Indonesian ports: Belawan, Tanjung Priok, Tanjung Perak, Makassar	Number of berth Berth length Container yard area Number of cranes	Container throughput (Teus)
Merk & Dang (2012)	42 world container terminal including Tanjung Priok	Berth length Yard area Reefer point Quay cranes Yard cranes	Container throughput (Teus)
Merk & Dang (2012)	35 world coal bulk terminal including Balikpapan and Tanjung Bara	Berth length Storage area Load / unload capacity	Cargo throughput (M^3)

source: own collaboration derived from various sources

2.4. Data Envelopment Analysis and Malmquist Productivity Index

According to (Summanth 1984), productivity is a simple ratio between output and input from the business processes of a firm. There are several methods proposed by the experts to explain this ratio. Some of them are Mundel models, The American Productivity Centre (APC) model, and the Objectives Matrix models. (Summanth 1984) also proposed his productivity measurement model that later on in some literature referred to Summanth method. However, the models above can only measure the productivity of the single firm, so it is less appropriate if it is used to compare and rank the productivity of many firms simultaneously.

According to (Quanling 2001), Data Envelopment Analysis (DEA) is a new tool that integrate operations research, management science and econometrics. DEA was introduced by Charnes, Cooper and Rhodes (Charnes et al. 1978). DEA commonly used because it can measure, compare and rank the productivity of some firms simultaneously. Because of the advantages offered by the DEA, the DEA method utilized in this research in the processing and analysis of data provided. Data Envelopment Analysis (DEA) method commonly used because it can measure, compare and rank the productivity of several firms simultaneously. Because of the advantages offered by DEA method, this research will deploy the method in the processing and analysis of provided data. Besides, the use of DEA method does not have always to use the cost function or profits, so that financial data which are often hard to get may not be included.

There are two main models in the DEA method, which are Constant Return to Scale (CRS) model and Variable Return of Scale (VRS) model which is the developed model of CRS (Osman et al. 2008)). The use of CRS method is usually selected if the firm is developed enough and quite stable so that the concept of returns to scale is a priority in its business process. In addition, CRS model also more appropriately used in a business process which if the value the input increases, the output value also increases. In another sense, the efficiency value is always fixed every time there is an additional input value. Meanwhile, the VRS method used in a firm that is still in the process of development, so it has not been able to adopt the concept of a return to scale. So, if the input value increases, the output value might be decreased.

Malmquist Productivity Index (MPI) was proposed by Sten Malmquist in 1953, a Swedish economist and statistician. Then, in 1992, this method was firstly used by Caves et al. This method is an effective way to measure total factor productivity (TFP) change between the certain periods and able to disintegrate the source of the efficiency change (Coelli et al. 2005; Cook & Zhu 2005; Fare et al. 1994). The basic concept of MPI is that the efficiency and temporal changes in efficiency can be measured by the distance estimation function consisting of the input and output of the production system (Farrell 1957). In conducting the analysis, this method does not use the assumption of production efficiency, but rather identifying how best is the production scheme. Moreover, MPI also shows the frontier of the efficient production, which measures the output of the firms relative to the frontier

The changes of TFP index in MPI represent the firm's productivity. If the value of the TFP index shows a value greater than one (TFP>1), then there is an increase of firm's productivity from the (t) period to the (t+1) period. If the value is equal to one (TFP=1) indicates there is no change in firm's productivity. If the value less than one (TFP<1) then there is a decrease in firm's productivity. In this thesis, the TFP index in marine services indicates the productivity in pilotage and towage service in a period of time. The result of the index is calculated from the changes of the marine services inputs and outputs on each year.

(Estache et al. 2004) mentioned that the changes of TFP can be attributed to two main sources of the management and the business environment: the catch-up effect and the frontier-shift effects. The catch-up effect, which also referred to the total change of efficiency change (EFFCH), is represented by the port's movement along the production frontier of marine services , and can happen in a relatively short time. If the value of efficiency change is greater than one (EFFCH>1), it indicates an increase in the firm's efficiency compared to the previous year. In the opposite, if the value is less than one (EFFCH<1), indicates that the firm's efficiency is decrease. The term catch-up effect is given because the concept implies a managerial capacity of the port to follow best practices in order to operate its marine services in the frontier border at any point in time. The effect of catch-up is determined by the managerial capacity of the port to be able to: first, maximize the output of marine services product by utilizing the given inputs, or timely adjust input factors given the level of output which also known as pure efficiency changes (PECH) and second, respond to marine services demand by flexibly adjust the production scale of marine services which also known as scale efficiency changes (SECH). Figures in the PECH reflect whether an organization is working on a suitable level, resulting in appropriate scale. If there is a decrease in the value of PECH (PECH<1), then it indicates a distortion managerial competence. Likewise, the decline in SECH (SECH<1) reflects a scale problem.

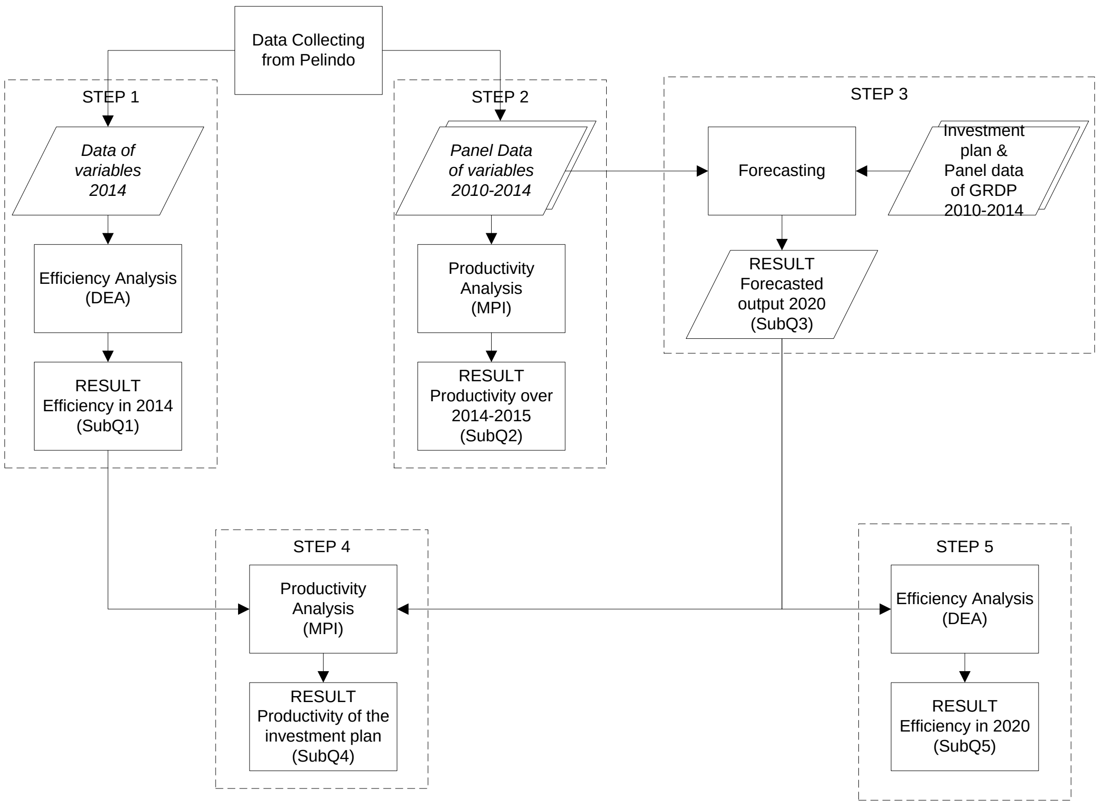
Meanwhile, the frontier-shift effects, is represented by a shift of the productive efficiency frontier in the marine services production. The effects might happen because of a significant change as technological or technical changes (TECHCH). If the value of technology change is greater than one (TECHCH>1), it indicates an increase in the firm's technology compared to the previous year. In the opposite, if the value is less than one (TECHCH<1), indicates that the firm's technology is decrease. By keeping up the latest technology in marine services such as using better pilot boats and harbour tugs' performance can increase the TFP from the frontier-shift effect. However, to follow the development of new technologies requires effective planning long-term strategic.

3. Research Methodology and Data

3.1. Efficiency and Productivity Measurement Steps

To create a well-organized analysis process, there are five steps that are addressed to answer the research question and sub-research questions. The methods that will be used in this thesis are: Data Envelopment Analysis (DEA) and Malmquist Productivity Index (MPI). These methods will be conducted using a statistical computer program STATA.

The first step of the research analyse the initial efficiency level of the marine services of each port in 2014 using DEA. After that, the second step analyse its productivity index over five years (2010 – 2014) using MPI. Next, the third step forecast the marine services' variables in 2020 which are: the number of ship calls in GT, the ship movements in GT and ship hours in GT based on the ship calls in GT. This step is aimed to determine the output for marine services in 2020. Considering the change of marine services output in 2020, the fourth step will analyse the investments plan using MPI to determine the total factor productivity (TFP) in 2020 compared to 2014. Lastly, the fifth step analyses the efficiency level of the services among observed ports after the investments in 2020. Figure 6 shows the methodology flowchart.



Source: own modification

Figure 6. Methodology flowchart

3.2. Data Envelopment Analysis (DEA) Approach

The DEA method commonly used because it can measure, compare and rank the productivity of several firms simultaneously using multiple inputs and outputs. Because of the advantages offered by DEA method, this thesis will use the method in the processing and analysing the provided data.

In addition, the DEA model that will be used in this thesis is the CRS model because the business process in marine services is developed enough and quite stable. In addition, the marine service business model also adopts the concept of returns to scale where an increasing of (i.e. the number of pilot boats) will also proportional to the increase in output (i.e. shipmovement in GT). The orientation of DEA approach is input orientation in order to show the inefficient aspect from the input side.

In chapter 2, it is also mentioned that productivity is a concept that describes the relationship between the input which may quantitatively such as the number of workers, numbers of equipment, etc. with the output such as the amount of goods or services generated as the result of a production process. With respect to the subject of this thesis, therefore, the productivity which will be analysed is the Indonesian port marine services, specifically its pilotage and towage service.

The major components required in the DEA method are Decision Making Unit (DMU), input and output. DMU can be interpreted as the object of research, such as firms or organization. In this thesis, the DMU are eight ports which operated by Pelindo I, II, II and IV. Table 3 shows the DMU selection:

Table 3. DMU / Ports selection

No	Name of Port	Port Class	Managed by
1	Belawan	Primary Class	Pelindo I
2	Dumai	First Class	Pelindo I
3	Tanjung Priok	Primary Class	Pelindo II / IPC
4	Palembang	First Class	Pelindo II / IPC
5	Tanjung Perak	Primary Class	Pelindo III
6	Tanjung Emas	First Class	Pelindo III
7	Makassar	Primary Class	Pelindo III
8	Balikpapan	First Class	Pelindo IV

source: own colaboration

This DEA approach will use the non-financial performance indicators. So that, the efficiency and productivity of the services will be measured from the tangible production factors such as the number of pilots, the number of pilot boats and the number of harbour tugs as well as the marine service products such as the total ship movements in GT and the total ship hours in GT. Pilotage and towage services are taken as one entity. Table 4 presents the input and output variables.

Table 4. Input and output variables

No	Variable	Code	Explanation
Input			
1	Number of pilots	NOP	The number of marine pilots who performed pilotage activity

2	Number of pilot boats	NOPB	The number of pilot boats which is available and used to transport the pilot to a ship
3	Number of harbour tug	NOHT	The number of harbour tug which is available and used to assist the pilot to move a ship
Output			
1	Ships movements in GT	SMG	The number of ship movement (in GT) produced in pilotage service
2	Ships hours in GT	SHG	The number of ship hour (in GT) produced in towage service

source: own colaboration

A number of the pilots (NOP) represent the total number of pilots in a port who authorized to perform pilotage duties. A number of pilot boats (NOPB) and number of harbour tugs (NOHT) represent the total number of pilot boats and harbour tugs used in a port within a certain period. However, this input is not considering the technical specifications of the equipment such as speed and power. Meanwhile, The output of marine services are separated into two categories, in a number of the ships movement in GT, which is the pilotage service product and in the ship hour in GT which is the towage service product. In the production report, the marine service products are distinguished into two categories: in the unit and GT. This distinction is due to the different tariff applied. The ship movement in the unit will be charged a basic tariff. Meanwhile, the GT ship movement in GT will be charged a variable tariff due to the ship size in GT.

This input and output variables also applied to the latest step in this thesis which measures the efficiency of the marine service among observed port in year 2020. However, the difference with the first step is on the value of the input and output variable which already considering the growth in year 2020.

3.3. Malmquist Productivity Index (MPI) Approach

A set of panel data consisting of data reported in 2010 up to 2014 will be used to run MPI. The input and output variables for efficiency measurement in the first step also applied here. The MPI method will be set to the input orientation to show the inefficient aspect from the input side.

3.4. Forecasting Approach

According to (Jung 2011), ports seem to have an effect on the local and national economic development because ports play a significant role in domestic and international trade. In addition (Wildenboer 2015) mentioned that the port activity have an impact on the economy in terms of GDP or other measures. Therefore, to predict the number of port activities in the next period could refer to the predicted growth of the local economy within the same period. In macroeconomics, the local economic indicator is usually presented in term of Gross Regional Domestic Product (GRDP). To provide a clear explanation, for example, port of Tanjung Perak as the trade and logistics node in the province of East Java is predicted to serve around 78 million ship calls in 2020 due to the prediction of an increase of 7% growth in GRDP of East Java province.

This method could be analogous to the term of the multiplier in macroeconomics, where the multiplier itself is a proportional factor that measures the change in a variable due to changes in other variables. Therefore, in this study, the growth factor of the activities of a port will be measured in proportion to changes in economic growth in the area where the port is located, with reference to the GRDP growth.

There are several methods that are often used to predict the growth of value within a certain time. One of these methods is the Compound Annual Growth Rate (CAGR). This method is usually used by business investors to predict an annual growth rate on investment regarding the initial value and its final value of an investment period as well as the number of years. The formula of the CAGR is as follows:

$$CAGR(t_0, t_n) = \left(\frac{V(t_n)}{V(t_0)}\right)^{\frac{1}{t_n - t_0}} - 1$$

Where:
$V(t_0)$ = initial value
$V(t_n)$ = final value
$t_n - t_0$ = number of years

In this thesis, the annual growth rate of GRDP, as well as the marine service variables, will be calculated using the CAGR method.

3.5. Investments Plan Analysis Approach

Besides measuring the efficiency and productivity of Indonesian ports' marine services, the other objective of this thesis is to analyse the Pelindo's investments plan for their marine services equipment. The approach of this step is to compare the performance of marine services in the year 2014 to the projected output in the year 2020 by considers the addition of the number of the pilots, pilot boats and harbour tugs in 2020. Then, the data will be analysed with MPI to show the change in the total factor productivity over 2014 – 2020.

Usually, Pelindo's investments plan was carried on based on the utilization rate of the equipment or a facility. For example, if the utilization rate of the pilot boat is high within a certain period, then an addition in the number of the pilot boat will need. Otherwise, if the utilization is relatively low, then there will be no addition in the number of pilot boat. In other words, Pelindo will keep the existing number of pilot boats to perform the marine services. However, when determining the utilization rate, Pelindo also considers the spare time required to carry out technical maintenance. It means that in a period of time, for example one year, the pilot boat should be given spare time to take annual maintenance such as annual docking repair which is an obligation from the ship classification.

3.6. Data

The main data which is required in this thesis is the set of panel data consisting of marine service variables data in 2010 – 2014 as well as the data of the change in number of pilot, the number of pilot boats and the number of harbour tug. To forecast the ship calls and marine service production in 2020, the data of GRDP of each province also required. The GRDP of each province will be taken from the Indonesian Centre Bureau of Statistics (BPS). As for the reference in forecasting approach, the forecasted data of GDP will be required. This forecasted GDP is based on the International Monetary Fund (IMF) economics forecast. Meanwhile, the marine services variables in 2010-2014 will be extracted from the management report of each port.

4. Case Study: Indonesian Port Marine Services

4.1. Port of Belawan Profile

Port of Belawan is the third largest port in Indonesia. This port is of the main class category and is managed by Pelindo I. The port is located in the city of Medan, the capital city of North Sumatra province. Among the other provinces in Sumatra Island, North Sumatra has the highest GDRP. In 2013, the GRDP of this province was 142,537 billion Rupiahs (in constant prices) which is 5.36% of the total Indonesian GRDP. The following Table 5 and Table 6 respectively show ports traffic profiles and its elasticity.

Table 5. Port of Belawan's traffic profile (in hundreds)

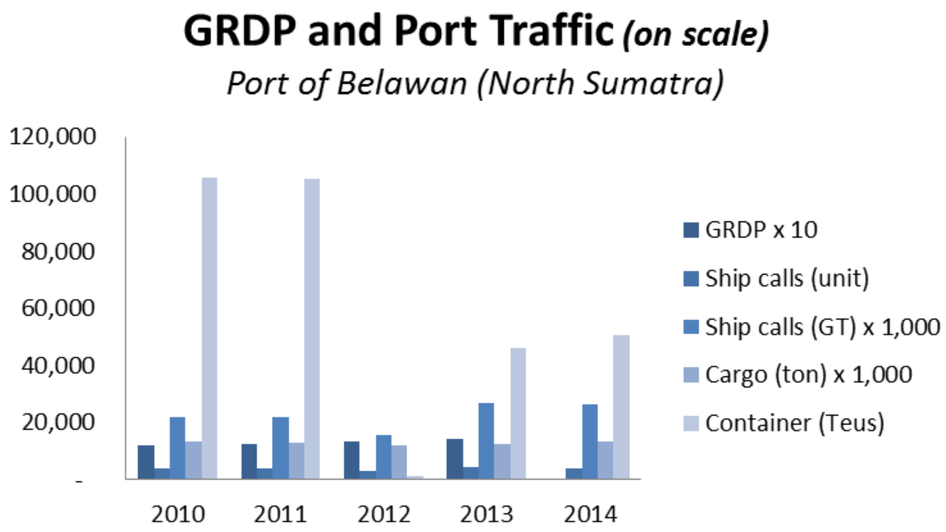
	2010	2011	2012	2013	2014
GRDP **(constant prices)**	1,187	1,266	1,345	1,425	-
Ship calls (unit)	40	39	29	44	41
Ship calls (GT)	219,670	220,173	157,412	269,184	261,686
Cargo traffic (Ton)	132,237	126,651	120,965	124,354	131,482
Cont'r traffic (Teus)	1,056	1,052	13	460	505

source: derived from BPS and Pelindo I Annual Report

Table 6. Port of Belawan's variables elasticity

	Elasticty (with respect to GRDP in constant prices)
Ship calls (unit)	0.10
Ship calls (GT)	0.73
Cargo traffic (Ton)	(0.02)
Cont'r traffic (Teus)	(2.74)

source: own calculation



source: own modification

Figure 7. GRDP and port traffic of Belawan

From the Table 5 and the Figure 7, it can be seen that GRDP of the North Sumatera province over 2010 – 2013 is increasing. That also reflected in the number of ship calls (in GT) which also increasing over the same period. It also presents that the rise in the number of ship calls (in GT) is in line with the increasing number of ship calls (in Unit). The cargo traffic also increases, even though there is a slight drop on 2012. Meanwhile, the number of container throughput in the port of Belawan is decreasing because the container handling has been switched to Belawan International Container Terminal.

In addition, Table 7 presents the marine service variables in the port of Belawan over 2010 – 2014.

Table 7. Panel data of Belawan port's marine services variables (in thousand)

	2010	2011	2012	2013	2014
Number of pilot	15	22	22	26	27
Number of pilot boat	4	5	5	6	6
Number of h'bor tug	2	3	3	4	4
Ship movement (GT)	30,627	35,330	25,494	35,939	32,485
Ship hour (GT)	41,466	46,099	40,149	44,766	44,340

source: derived from Pelindo I Annual Report

4.2. Port of Dumai Profile

Unlike ports in the other provinces which are located in the capital city of the province, port of Dumai is situated in the town of Dumai, in the province of Riau. The capital city of this province is Pekanbaru. This port categorized in first class port which operated by Pelindo I. In 2013; the province has the GRDP of 109,703 billion Rupiahs (in constant prices), which shares 4.10% of the total Indonesian GRDP. This port has a high potential to be developed due to its location in the trade traffic of Malacca Strait. The activity in this port is dominated by liquid bulk cargo transfer such as crude palm oil (CPO) as well as crude oil due to many oil companies are located here such as PERTAMINA and Chevron. Besides that, this port is supported by several hinterlands such as oil palm plantation. Table 8 and Figure 8 below respectively present that the increase in GRDP has a positive correlation with the number of ship calls (in Unit and GT) as well as with the cargo traffic. However, the number of container throughputs in the port is low because many cargoes are handled in the form of general cargo such as bags and pallets. Meanwhile,

Table 9 presents the port's variables elasticity.

Compare to the port of Belawan, it can be seen that port of Dumai has a higher number of ship calls (in GT) due to many oil tankers or CPO carriers in significant size which load and unloading its cargo in this port.

Table 8. Port of Dumai's traffic profile (in hundreds)

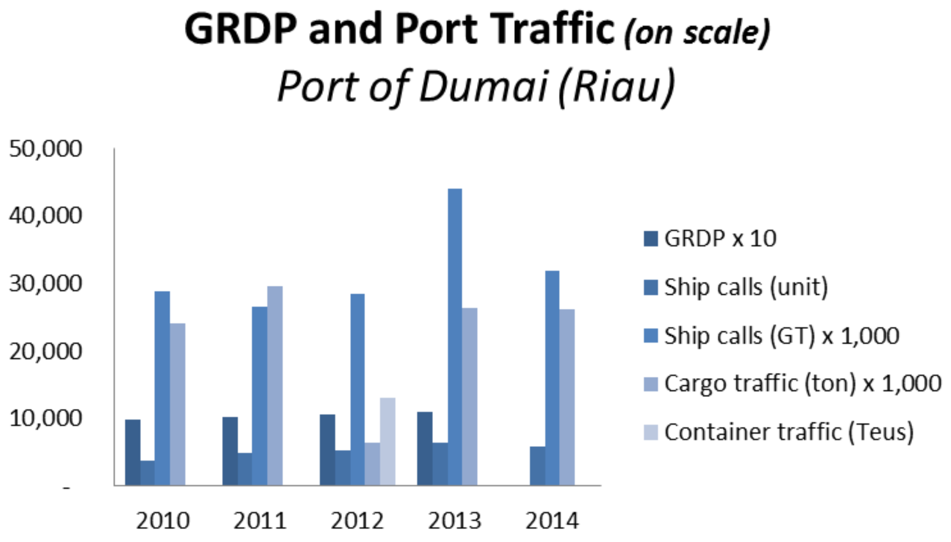
	2010	2011	2012	2013	2014
GRDP (constant prices)	977	1,027	1,063	1,091	-
Ship calls (unit)	38	48	53	63	58
Ship calls (GT)	287,374	264,793	283,825	439,496	318,940
Cargo traffic (Ton)	240,407	294,733	64,515	262,699	262,411
Cont'r traffic (Teus)	-	-	130.42	0.58	0.24

source: derived from BPS and Pelindo I Annual Report

Table 9. Port of Dumai's variables elasticity

	Elasticty (with respect to GRDP in constant prices)
Ship calls (unit)	3.48
Ship calls (GT)	0.81
Cargo traffic (Ton)	0.68
Cont'r traffic (Teus)	(2.74)

source: own calculation



source: own modification

Figure 8. GRDP and port traffic of Dumai

Moreover, the Table 10 presents the marine service variables in the port of Dumai over 2010 – 2014.

Table 10. Panel data of Dumai port's marine services variables (in thousand)

	2010	2011	2012	2013	2014
Number of pilot	22	27	30	33	33
Number of pilot boat	8	8	8	8	8
Number of h'bor tug	6	6	6	7	7
Ship movement (GT)	35,945	35,612	37,886	44,240	39,766
Ship hour (GT)	45,536	42,981	46,418	53,136	50,443

source: derived from Pelindo I Annual Report

4.3. Port of Tanjung Priok Profile

Port of Tanjung Priok is the biggest port in Indonesia. This port is located in the capital city of Indonesia, Jakarta. This port is operated by Indonesian Port Corporation (IPC) or more commonly known as Pelindo II. As the largest trade centre in the region of western Indonesia, Jakarta has the country's largest GRDP with the number of 477.285 billion Rupiahs (in constant prices) or around 17.94% of the total Indonesian GRDP.

Table 11. Port of Tanjung Priok's traffic profile (in hundreds)

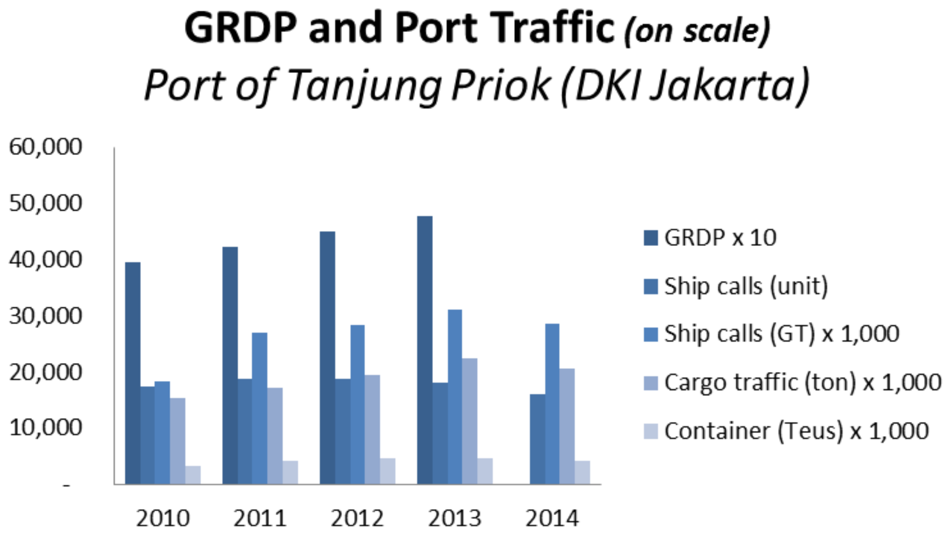
	2010	2011	2012	2013	2014
GRDP **(constant prices)**	3,956	4,222	4,498	4,773	-
Ship calls (unit)	175	189	188	182	161
Ship calls (GT)	184,037	269,679	283,825	312,537	286,289
Cargo traffic (Ton)	153,959	172,987	194,368	225,381	207,450
Cont'r traffic (Teus)	33,774	41,928	46,397	46,503	41,987

source: derived from BPS and IPC Annual Report

Table 12. Port of Tanjung Priok's variables elasticity

	Elasticty (with respect to GRDP in constant prices)
Ship calls (unit)	(0.32)
Ship calls (GT)	1.86
Cargo traffic (Ton)	1.23
Cont'r traffic (Teus)	0.89

source: own calculation



source: own modification

Figure 9. GRDP and port traffic of Tanjung Priok

From Table 11 and Figure 9 above, it can be seen that the GRDP of DKI Jakarta province is continuous to show an increase. The ship traffic in the port also displays an increase over 2010 – 2013. However in 2014, most of port traffic indicators such as the number of the ship (in Unit and in GT), the number of cargo and container throughput are drop compare to the previous year in 2013. This situation due to fewer ship calls which carrying some commodities such as rice, sugar and cattle feed. It is also because the there is a reducing number of the ship calls carrying export goods from Jakarta such as cement and building materials. The small growth of Indonesian economic is the reason behind the decreasing number of some indicators in Tanjung Priok. Meanwhile the Table 12 shows the port's variables elasticity.

Even though there is a declining number of the cargo throughput, this does not occur in container throughput. From the Table 11, it can be seen that the container throughput is stay increasing over five years. The figures of container throughput in Table 11 only present the throughput from a conventional terminal in the port of Tanjung Priok, not from dedicated terminals such as TPK Koja and JICT.

The following Table 13 presents the marine service variables in the port of Tanjung Priok over 2010 – 2014.

Table 13. Panel data of Tanjung Priok port's marine services variables (in thousand)

	2010	2011	2012	2013	2014
Number of pilot	65	65	75	75	81
Number of pilot boat	5	5	6	7	7
Number of h'bor tug	13	13	14	15	15
Ship movement (GT)	110,474	126,568	132,119	133,332	134,651
Ship hour (GT)	179,564	186,394	200,010	203,264	235,878

source: derived from IPC Annual Report

4.4. Port of Palembang Profile

Palembang port is also called the port of New Boom which run by IPC or Pelindo II and categorized as first class port. This port is located on the banks of the Musi River in the city of Palembang, the capital city of South Sumatra province. This port is the largest river port on the Sumatra Island. This port is supported by some hinterland such as agriculture, mining and industry. Meanwhile, the main commodity of this port is CPO.

As can be seen in the Table 14 and Figure 10, the GDRP of this province in 2013 is 76,409 billion Rupiahs (in constant prices) or 2.87% of the total Indonesian GRDP. Compare to the port of Tanjung Priok, this port shows significance increase in all indicators over 2010 – 2014 such as the number of ship calls in GT and cargo throughput. Compare to 2013, the number of container throughput decrease by 200 Teus. The Table 15 reflects the variables elasticity with respect to the GRDP.

The statistic results also show that even though the number of ship calls (in Unit) is declining, the number of ship calls (in GT) is increasing due to the average size of the arrived ships become larger. The cargo capacity of the ships is also bigger than the previous years which reflected the increased number of the cargo throughput.

Table 14. Port of Palembang's traffic profile (in hundreds)

	2010	2011	2012	2013	2014
GRDP (constant prices)	639	680	721	764	-
Ship calls (unit)	33	29	29	28	26
Ship calls (GT)	100,152	144,957	157,412	152,103	159,708
Cargo traffic (Ton)	118,430	133,067	149,514	145,134	157,114
Cont'r traffic (Teus)	82	86	88	86	84

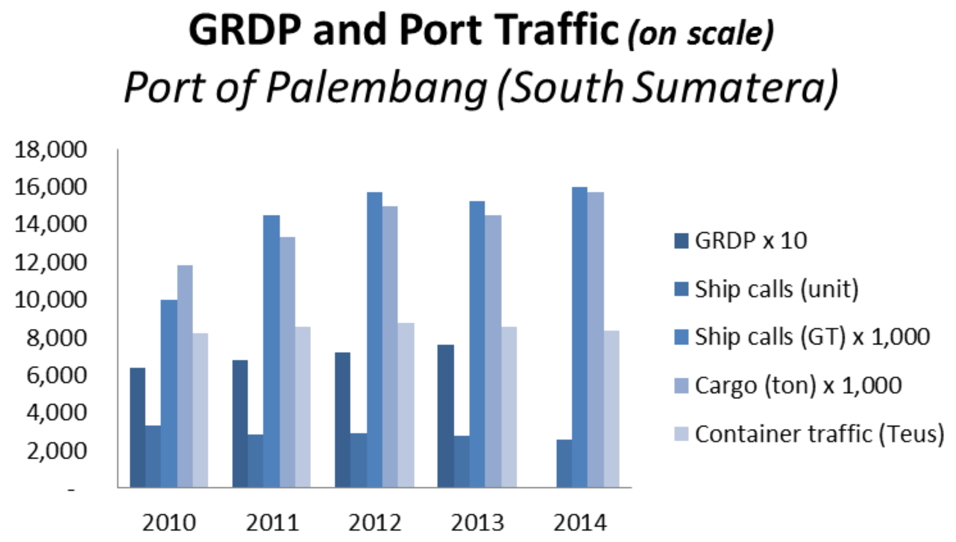
source: derived from BPS and IPC Annual Report

Table 15. Port of Palembang's variables elasticity

	Elasticty (with respect to GRDP in constant prices)
Ship calls (unit)	(0.98)
Ship calls (GT)	2.02

Cargo traffic (Ton)	1.20
Cont'r traffic (Teus)	0.07

source: own calculation



source: own modification

Figure 10. GRDP and port traffic of Palembang

The Table 16 below presents the marine service variables in the port of Palembang over 2010 – 2014.

Table 16. Panel data of Palembang port's marine services variables (in thousand)

	2010	2011	2012	2013	2014
Number of pilot	15	15	15	17	17
Number of pilot boat	3	3	4	4	4
Number of h'bor tug	2	2	2	2	2
Ship movement (GT)	13,809	15,821	16,515	16,666	16,749
Ship hour (GT)	22,445	23,299	25,001	25,408	29,121

source: derived from IPC Annual Report

4.5. Port of Tanjung Perak Profile

Port of Tanjung Perak is the second busiest and largest port in Indonesia after the port of Tanjung Priok. This port is operated by Pelindo III, categorized as the main class port. This port is located in the city of Surabaya which also the capital city of the province. The GRDP of East Java province is also the second largest after the province of DKI Jakarta. In 2013, the GRDP of the province is 419,428 billion Rupiahs, shares 15.76% of the total Indonesian GRDP. This port is the main trade gateway to the eastern part of Indonesia.

Table 17. Port of Tanjung Perak's traffic profile (in hundreds)

	2010	2011	2012	2013	2014
GRDP (constant prices)	3,423	3,670	3,937	4,194	-
Ship calls (unit)	142	141	148	142	140
Ship calls (GT)	632,482	727,306	731,222	762,937	755,592

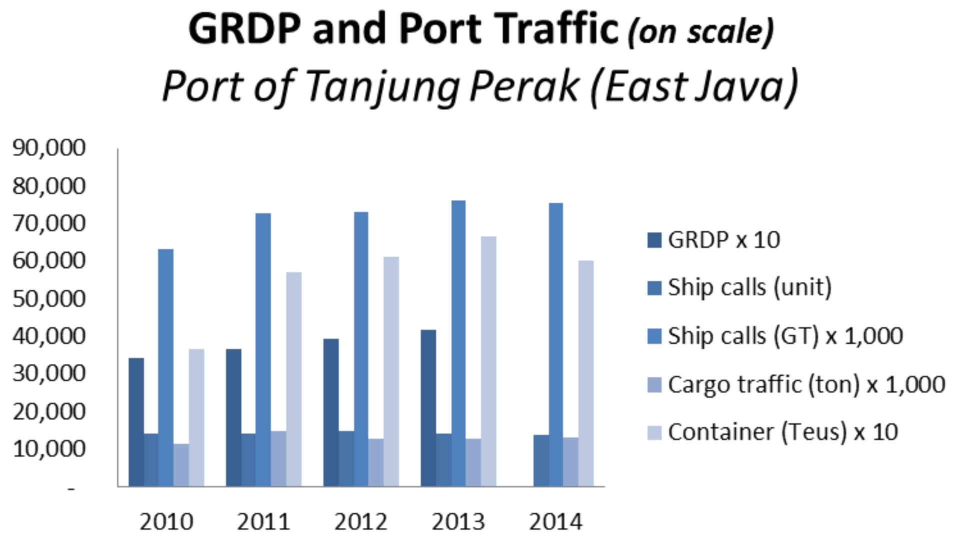
Cargo traffic (Ton)	116,332	149,249	130,044	127,260	130,435
Cont'r traffic (Teus)	3,654	5,700	6,114	6,651	6,019

source: derived from BPS and Pelindo III Annual Report

Table 18. Port of Tanjung Perak's variables elasticity

	Elasticty (with respect to GRDP in constant prices)
Ship calls (unit)	(0.04)
Ship calls (GT)	0.68
Cargo traffic (Ton)	0.43
Cont'r traffic (Teus)	1.97

source: own calculation



source: own modification

Figure 11. GRDP and port traffic of Tanjung Perak

Similar to the port of Palembang, despite the number of ship calls (in Unit) is decreasing, the number of ship calls (in GT) is increasing over the past five years. This increase does not only happen on the number of ship calls (in GT) but also the rest of port traffic indicators such as cargo throughput and container throughput.

As same as the port of Tanjung Priok, the figure of the container throughput is only reflected the throughput from the conventional terminal within the port of Tanjung Perak area. However, beside this port who handle the container, there are Terminal Petikemas Surabaya (TPS), Berlian Jasa Terminal Indonesia (BIJT) and the newest and the first green port in Indonesia, Terminal Teluk Lamong (TTL).

In addition, Table 19 presents the marine service variables in the port of Tanjung Perak over 2010 – 2014.

Table 19. Panel data of Tanjung Perak port's marine services variables (in thousand)

	2010	**2011**	**2012**	**2013**	**2014**
Number of pilot	55	55	55	60	65
Number of pilot boat	4	5	6	6	6
Number of h'bor tug	10	10	12	12	12

Ship movement (GT)	168,293	166,812	223,067	253,887	240,257
Ship hour (GT)	344,656	354,037	345,238	487,457	562,568

source: derived from Pelindo III Annual Report

4.6. Port of Tanjung Emas Profile

This port is managed by Pelindo III, categorized as first class port. This port is situated in Central Java Province, in the capital city of the province, Semarang. The GRDP of this province in 2013 is 223,099 billion Rupiahs (in constant prices), which shares 8.38% of the total Indonesian GRDP. This port is the gateway of export and import activities for Central Java and its surrounding regions. Because of the location of the port is in the middle position of Java Island that connects the provinces in Java. Hence, this port's role is crucial. The hinterland of this port scattered not only in Central Java and Yogyakarta but also reached Banjarmasin, which is located in South Kalimantan. The main commodities that are passing through this port are food products and furniture.

Table 20 and Figure 12 show the statistical report of the port traffic. In 2014, the number of ship calls (in Unit) is declined compare to 2013, while the number of ship calls (in GT) increases compared to the previous year. This is due to the larger size of ships which arrived at the port. The cargo throughput in 2014 is also decrease. Most of the containers cargo is handled in Terminal Peti Kemas Semarang (TPKS) so that the figure of container throughput in Port of Tanjung Emas is relatively small. Meanwhile, the Table 21 presents the port’s variables elasticity with respect to the GRDP.

Table 20. Port of Tanjung Emas traffic profile (in hundreds)

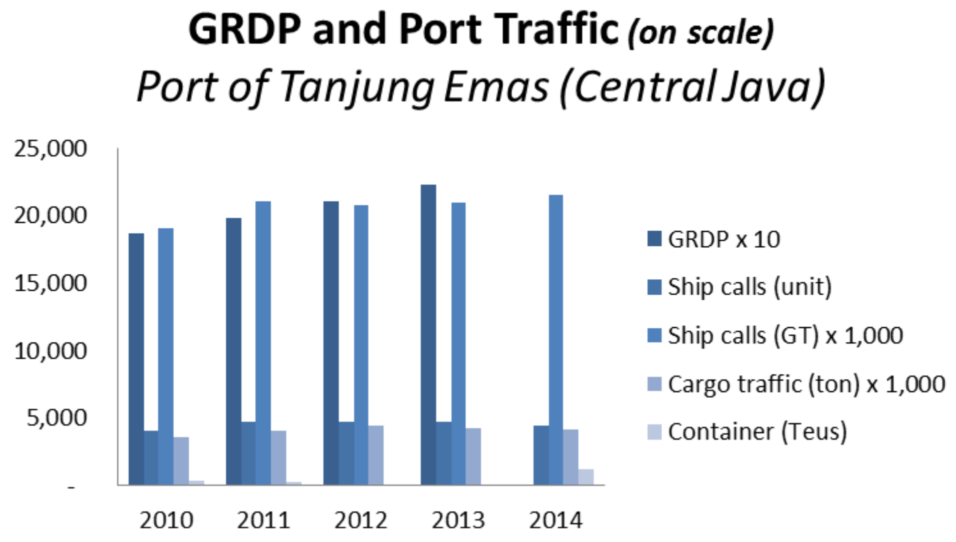
	2010	2011	2012	2013	2014
GRDP (constant prices)	1,870	1,983	2,108	2,231	-
Ship calls (unit)	40	47	47	48	44
Ship calls (GT)	191,042	210,759	207,668	209,533	215,008
Cargo traffic (Ton)	35,960	40,101	44,074	42,543	41,314
Cont’r traffic (Teus)	3.38	2.81	0.97	0.14	11.95

source: derived from BPS and Pelindo III Annual Report

Table 21. Port of Tanjung Emas’s variables elasticity

	Elasticty (with respect to GRDP in constant prices)
Ship calls (unit)	0.39
Ship calls (GT)	0.51
Cargo traffic (Ton)	0.60
Cont’r traffic (Teus)	6.32

source: own calculation



source: own modification

Figure 12. GRDP and port traffic of Tanjung Emas

The following Table 22 presents the marine service variables in the port of Tanjung Emas over 2010 – 2014.

Table 22. Panel data of Tanjung Emas port's marines service variables (in thousand)

	2010	2011	2012	2013	2014
Number of pilot	18	20	21	21	24
Number of pilot boat	2	2	2	2	2
Number of h'bor tug	2	2	2	2	2
Ship movement (GT)	30,040	31,671	34,596	31,092	37,296
Ship hour (GT)	39,208	42,641	42,788	44,867	48,870

source: derived from Pelindo III Annual Report

4.7. Port of Makassar Profile

Port of Makassar is the largest port on the Sulawesi Island. The official name of this port is port of Soekarno – Hatta. It is located in the city of Makassar, province of South Sulawesi. The port location is very strategic because it is situated at the entrance of the Sulawesi Island. The city of Makassar is located in the southern part of Sulawesi. This port is adjacent to the main shipping lanes in Indonesia. This port is managed by Pelindo IV and categorized as the main class port.

As stated in Table 23 and Figure 13 below, the GRDP of South Sulawesi province is 64,284 billion Rupiahs (in constant prices), shares 2.42% of the total Indonesian GRDP. This number is the highest among another province on Sulawesi Island. The GRDP of South Sulawesi indicates a positive trend during the past five years. However, this positive trend also impacts to the port and cargo activities in the port. It can be seen from the statistics of the ship calls (in Unit and in GT) as well as the cargo throughput and container throughput

In 2014, the number of ship calls (in Unit and GT) decreased compared to the previous year. Nevertheless, this declining number of ship calls does not affect the cargo throughput and container throughput. Meanwhile, the Table 24 presents the port's variables elasticity with respect to the GRDP.

Table 23. Port of Makassar's traffic profile (in hundreds)

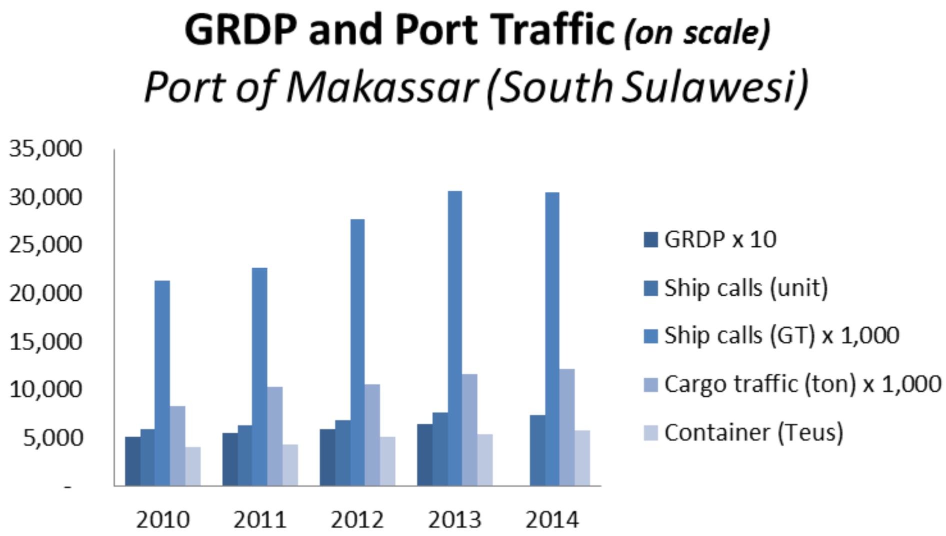
	2010	2011	2012	2013	2014
GRDP (constant prices)	512	551	597	643	-
Ship calls (unit)	59	63	68	77	74
Ship calls (GT)	213,589	227,572	277,306	306,170	305,579
Cargo traffic (Ton)	82,968	103,710	106,536	116,153	121,660
Cont'r traffic (Teus)	41	43	51	55	57

source: derived from BPS and Pelindo IV Annual Report

Table 24. Port of Makassar's variables elasticity

	Elasticty (with respect to GRDP in constant prices)
Ship calls (unit)	0.74
Ship calls (GT)	1.22
Cargo traffic (Ton)	1.31
Cont'r traffic (Teus)	1.15

source: own calculation



source: own modification

Figure 13. GRDP and port traffic of Makassar

Table 25 below presents the marine service variables in the port of Makassar over 2010 – 2014.

Table 25. Panel data of Makassar port's marine services variables (in thousand)

	2010	2011	2012	2013	2014
Number of pilot	32	32	32	37	42
Number of pilot boat	3	3	3	3	3
Number of h'bor tug	4	4	4	4	4
Ship movement (GT)	22,916	24,831	28,323	32,769	32,148
Ship hour (GT)	56,823	60,946	69,274	98,244	87,110

source: derived from Pelindo IV Annual Report

4.8. Port of Balikpapan Profile

Similar to the port of Dumai, the port of Balikpapan is also located not in the capital city East Kalimantan province. This port is situated in Balikpapan city. This port is managed by Pelindo IV and categorized into a first class port. The cargo traffic in the port is dominated by coal which will be exported abroad. In the second place, crude oil cargo is also dominating the port cargo traffic. As same as the city of Dumai, there are some oil companies which operating in Balikpapan. Besides coal and petroleum, Balikpapan port also serves the export of wood chips, plywood and general cargo.These many numbers of activities and many type of goods that are served by this port is also reflected in the fairly high GRDP of East Kalimantan province. Compared to other provinces in Kalimantan Island, the province of East Kalimantan has the highest GRDP, which is 121,990 billion Rupiahs (in constant prices). It is 4.58% of the total Indonesian GRDP.

Table 26. Port of Balikpapan's traffic profile (in hundreds)

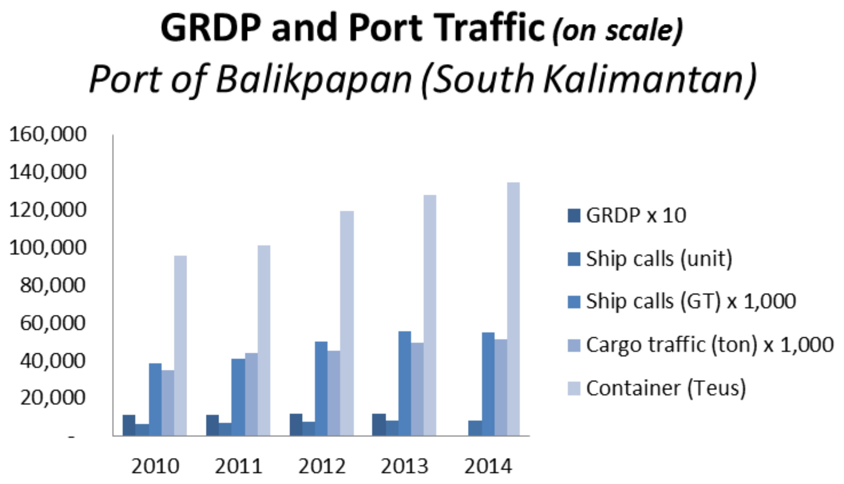
	2010	2011	2012	2013	2014
GRDP (constant prices)	1,110	1,155	1,201	1,220	-
Ship calls (unit)	65	69	75	84	81
Ship calls (GT)	387,130	412,474	502,616	554,934	552,575
Cargo traffic (Ton)	352,614	440,768	452,777	493,649	517,054
Cont'r traffic (Teus)	960	1,012	1,193	1,281	1,345

source: derived from BPS and Pelindo IV Annual Report

Table 27. Port of Balikpapan's variables elasticity

	Elasticty (with respect to GRDP in constant prices)
Ship calls (unit)	0.74
Ship calls (GT)	1.22
Cargo traffic (Ton)	1.31
Cont'r traffic (Teus)	1.15

source: own calculation



source: own modification

Figure 14. GRDP and port traffic of Balikpapan

From the Table 26 and Figure 14 above, it presents that an increasing number of GRDP is linear to the increase in both cargo and container throughput. However, the traffic statistics also indicates that in 2014, there are some decreases in the number of ship calls in GT and Unit. Table 28 below presents the marine service variables in the port of Balikpapan over 2010 – 2014.

Table 28. Panel data of Balikpapan port's marine services variables (in thousand)

	2010	2011	2012	2013	2014
Number of pilot	34	39	44	47	47
Number of pilot boat	3	4	5	5	5
Number of h'bor tug	5	5	6	6	6
Ship movement (GT)	40,833	42,674	51,124	57,386	58,927
Ship hour (GT)	68,188	73,135	83,129	94,243	96,885

source: derived from Pelindo IV Annual Report

5. Data Process, Result and Analysis

5.1. The Efficiency of Pelindo's Port Marine Services in 2014

The efficiency of marine services' performance in 2014 can be done by using DEA method. The input and output data were using the marine variables in 2014. The following Table 29 and Table 30 show the data from each port which then used as the input and output variables.

Table 29. Input variables (data of 2014)

DMU	INPUT		
	NOP	NOPB	NOHT
Bela'wan	27	6	4
Dumai	33	8	7
Tanjung Priok	81	7	15
Palembang	17	4	2
Tanjung Perak	65	6	12
Tanjung Emas	24	2	4
Makassar	42	3	4
Balikpapan	47	5	6

source: derived from Pelindo's Annual Report

Table 30. Output variables (data of 2014)

DMU	Output *(in thousand)*	
	SMG	SHG
Belawan	32,485	44,340
Dumai	39,766	50,443
Tanjung Priok	134,651	235,878
Palembang	16,749	29,121
Tanjung Perak	240,257	562,568
Tanjung Emas	37,296	48,870
Makassar	32,148	87,110
Balikpapan	58,927	96,885

source: derived from Pelindo's Annual Report

To explain the relation between the input and output of DEA in marine services, the following Table 31 presents the benchmarks of marine services for each port in 2014.

Table 31. Benchmarks of marine services variables per port (2014)

DMU	NOP/NOPB	SMG/NOPB (in thousand)	SHG/NOHT (in thousand)
Belawan	4.50	5,414	11,085
Dumai	4.13	4,971	7,206
Tanjung Priok	11.57	19,236	15,725
Palembang	4.25	4,187	14,560
Tanjung Perak	10.83	40,043	46,881
Tanjung Emas	12.00	18,648	12,217
Makassar	14.00	10,716	21,778
Balikpapan	9.40	11,785	16,148

source: own calculation

Among the ports, the port of Makassar has the highest ratio in term of ratio between the number of pilot per pilot boat (14). It means that one pilot boat is used to transport 14 marine pilots. Meanwhile, the lowest ratio is the port of Dumai (4.13) which means that one pilot boat able to serves four marine pilots. However, the numbers of pilots in each port are determined by each Pelindo based on the ship traffic and there is no standard rule regarding the minimum number of pilot required in port.

From the table, it is also observed that some ports have high ratio of the number of pilot per boat, such as the port of Tanjung Perak, port of Tanjung Emas, port of Tanjung Priok and port of Makassar. However, there is no further scientific reason behind the difference ratio between those ports since the ports have independency to provide the number of pilot and pilot boats.

In term of ratio between the number of ship movements in GT to the number of pilot boats, the port of Tanjung Perak has the highest ratio (40,043) which means that per unit of pilot boat has output of 40,042,912 ship movements pilotage. Meanwhile, the port of Belawan has the lowest ratio (5,414) which means that one pilot boat has theoutput of 5,414,197 ship movements pilotage.

The port of Tanjung Perak also has the highest ratio ship hours in GT per the number of harbour tugs (46,881) which means that a single harbour tug has output of 46,880,628 ship hours towage. Whereas, the port of Dumai has the lowest ratio (7,206) meaning that a single harbour tug has output of 7,206,182 ship hours towage.

Afterwards, these input and output data then will be processed with DEA method using STATA software. The result of the analysis can be seen in the following Table 32.

Table 32. Efficiency result of Pelindo's port marine service in 2014

Rank	Port	Technical efficiency score
1	Tanjung Perak	1
2	Balikpapan	0.490533
3	Tanjung Priok	0.480382
4	Tanjung Emas	0.465701
5	Makassar	0.464531
6	Palembang	0.418277
7	Belawan	0.405628
8	Dumai	0.326013

source: DEA analysis results

From Table 32 above, it can be seen that port of Tanjung Perak has the highest efficiency compared to the other ports. This results reflect the marine services's efficiency on each port according to the optimization of their marine services' input such as the number of marine pilots, the number of pilot boats and harbour tugs to obtain the marine services' output such as the total ship movements in GT and the total ship hours in GT.

Meanwhile, the second rank is the port of Balikpapan (0.490). The third rank is port Tanjung Priok (0.480). The fourth rank is the port of Tanjung Emas (0.465).

Meanwhile, the fifth and sixth rank is the port of Makassar (0.464) and Palembang (0.418). Port of Belawan and port of Dumai placed in seventh rank (0.405) and eighth rank (0.326) respectively. Therefore, in general it can be concluded that most of the ports are have overcapacity on their marine services equipment.

A considerable difference between the efficiency of port of Tanjung Perak and the other ports also raises a big question, why it happened. By looking back at the input and output of each port, the difference results happen due to high efficiency obtained by the port of Tanjung Perak, while the other ports only achieved less than half the value. The high efficiency in the port of Tanjung Perak due to the output of the port is high enough compared with the available input.

Table 33. Input slack of the efficiency analysis

Rank	Port	i-slack NOP	i-slack NOPB	i-slack NOHT
1	Tanjung Perak	0	0	0
2	Balikpapan	7.11273	0.981066	0
3	Tanjung Priok	2.48197	0	0.480382
4	Tanjung Emas	1.08664	0	0
5	Makassar	9.44545	0.464531	0
6	Palembang	2.57938	1.25483	0
7	Belawan	2.16335	1.62251	0
8	Dumai	0	1.61502	0.29592

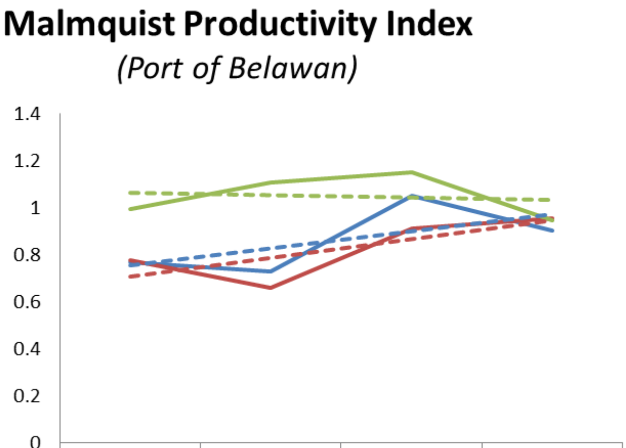
source: DEA analysis results

Table 33 shows the slack of the efficiency analysis. A slack can be described as the amount of either input or output value which should be reduced to make the DMU more efficient. For example, marine service in the port of Palembang can be more efficient if the number of pilots reduced by two persons as well as the number of pilot boat also should be reduced by one unit.

It can be observed that most of the ports have overcapacity of their input especially in the number of pilot. This situation might arise because of the different policy in each port to provide and organize their pilotage operation. The entire report of DEA analysis on efficiency measurement of marine services in 2014 presented in Appendix A.

5.2. The Productivity of Marine Service over 2010-2014 period

To find the productivity of marine service throughout 2010 - 2014, a set of panel data consisting of the marine services variables within observation period should be prepared. Next, these panel data processed with MPI method using STATA software.



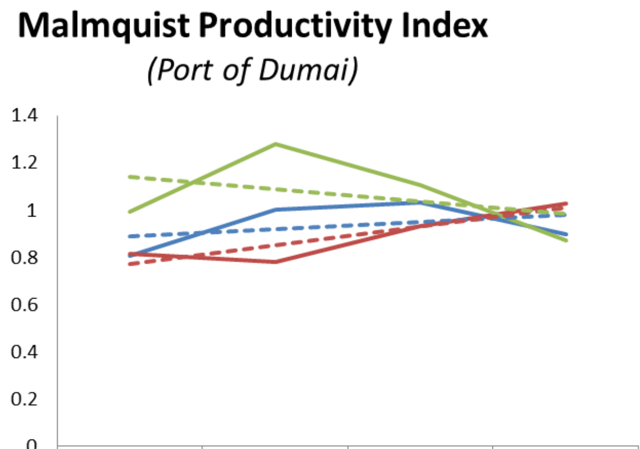
	2010-2011	2011-2012	2012-2013	2013-2014
Belawan tfpch	0.769038	0.727899	1.04812	0.903893
Belawan effch	0.775866	0.658902	0.912916	0.955171
Belawan techch	0.9912	1.10471	1.14811	0.946315

source: MPI analysis result

Figure 15. MPI result of Belawan port

The Figure 15 shows the MPI result of the port of Belawan. In general, the marine services' productivity in the port of Belawan over 2010 – 2014 showing a fluctuative productivity change. The highest productivity change which indicated in TFPCH was occured in the period 2012-2013 (1.048).

In this period, the high TFPCH is due to an increase in technology change (TECHCH) which also means that there is an upgrading in pilot boats and harbour tugs speed and power. However the marine services' productivity over 2010 – 2014 show a positive trend which indicated from the trendline of the total factor productivity factor (TFPCH).



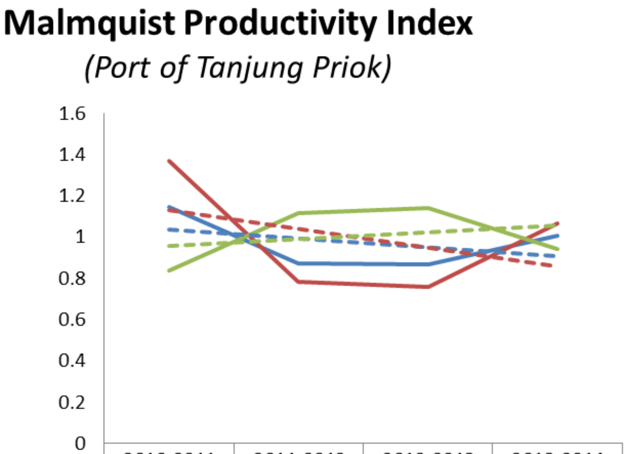
	2010-2011	2011-2012	2012-2013	2013-2014
Dumai tfpch	0.807266	1.00004	1.03078	0.89887
Dumai effch	0.814433	0.781098	0.932693	1.02902
Dumai techch	0.9912	1.28031	1.10517	0.873521

source: MPI analysis result

Figure 16. MPI result of Dumai port

The Figure 16 shows that the TFPCH in the port of Dumai also fluctuative. The TFPCH was gradually increased in the year 2010 until reach the highest figure in the year 2013 (1.030) then it decline in the year 2014. The highest TFPCH was occurred due to an improvement in marine services technology change (TFPCH) (1.105). However, over the period 2010 – 2014, the EFFCH and TECHCH move in the opposite direction.

In the other words, despite the marine services experienced decreased in technology changes, the efficiency changes were still increased. The ability of the port marine services to utilize its input to obtain greater output might be the reason why the EFFCH were increased gradually. In addition, the trendline of TFPCH over past five years showing that the productivity of marine services in the port of Dumai is increase.



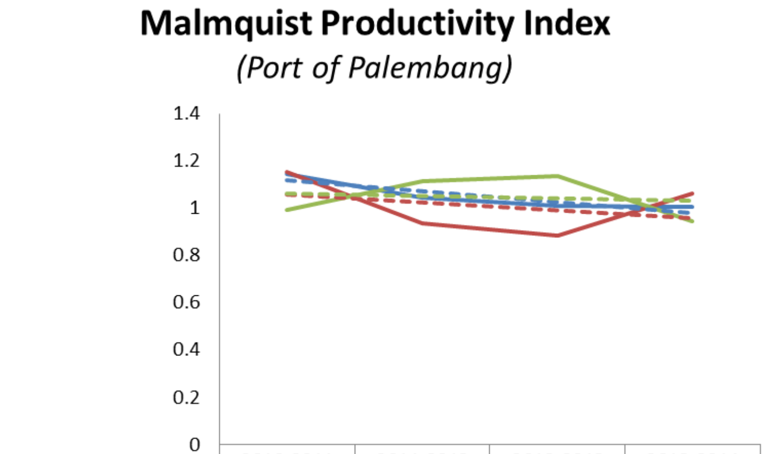
	2010-2011	2011-2012	2012-2013	2013-2014
Tanjung Priok tfpch	1.14568	0.869882	0.865012	1.00433
Tanjung Priok effch	1.36601	0.780609	0.760006	1.06718
Tanjung Priok techch	0.838708	1.11436	1.13816	0.941101

source: MPI analysis result

Figure 17. MPI result of Tanjung Priok port

The Figure 17 above shows that in 2014, the productivity of marine services in the port of Tanjung Priok was better than the previous year (1,004). This is due to the increasing in efficiency changes than in 2013 (1.067) where production of marine services more optimally by utilizing the existing input.

However, the technology changes in the same year has decreased (0.941). From these results, it can be also known that in general, the trendline of the productivity of marine services during the period 2010 - 2014 was declined.

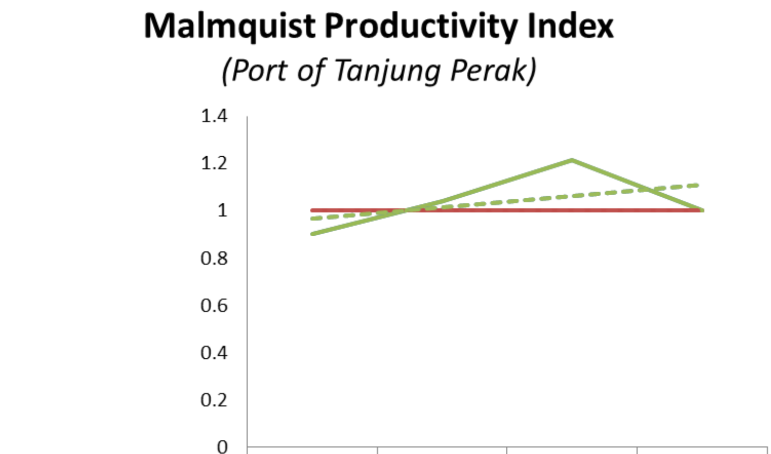


	2010-2011	2011-2012	2012-2013	2013-2014
Palembang tfpch	1.1457	1.04387	1.00914	1.00498
Palembang effch	1.15587	0.936737	0.886641	1.06199
Palembang techch	0.9912	1.11436	1.13816	0.946315

source: MPI analysis result

Figure 18. MPI result of Palembang port

Figure 18 shows that during the period 2010-2014, the rate of productivity of marine services at the port of Palembang continue to decline although it still shows positive productivity. In the last year of observation also indicates that the productivity of marine services is increased by 1.004. This was due to the increased efficiency changes (1.061) in the form of utilization of the existing number of inputs to produce more output. Meanwhile, the technological changes in the same year was decreased (0.946).



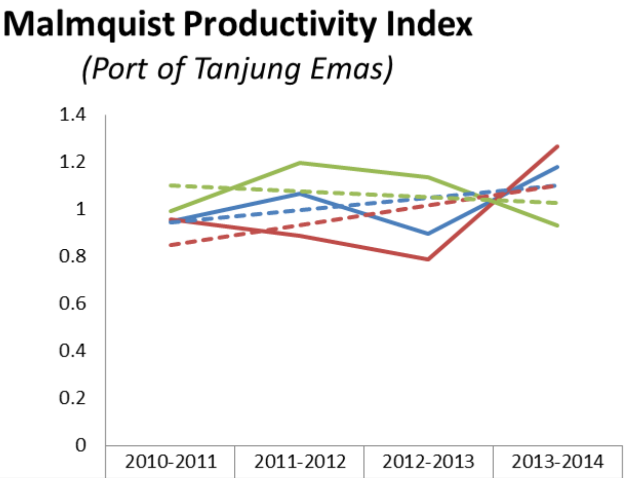
	2010-2011	2011-2012	2012-2013	2013-2014
Tanjung Perak tfpch	0.90252	1.04243	1.21372	1.00405
Tanjung Perak effch	1	1	1	1
Tanjung Perak techch	0.90252	1.04243	1.21372	1.00405

source: MPI analysis result

Figure 19. MPI result of Tanjung Perak port

Figure 19 displays the productivity of marine services in the port of tanjung perak during the period 2010 - 2014. In general, the productivity of the services in this period was fluctuated, where the highest productivity was achieved in the period 2012-2013 (1.213). This was also due to the increasing in technology changes (1.213).

Meanwhile, the efficiency changes in in the period 2010 - 2014 remained unchanged (1), so that it can be concluded that the productivity of marine services in the port of Tanjung Perak was affected by the technology changes such as improvement in the ships' speed and power.



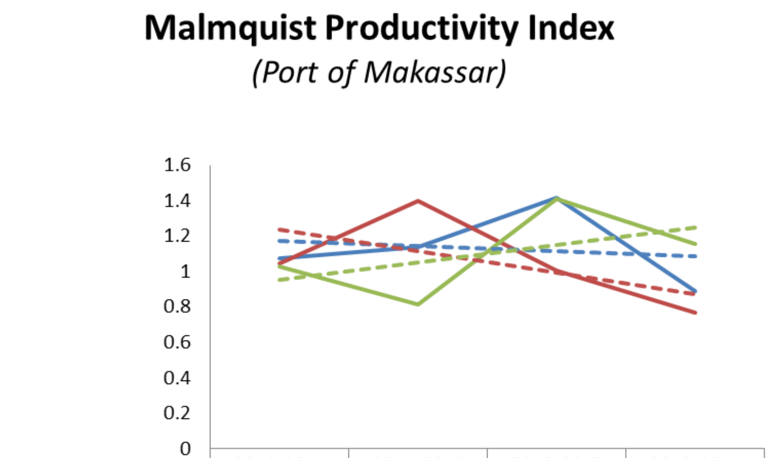
	2010-2011	2011-2012	2012-2013	2013-2014
Tanjung Emas tfpch	0.948865	1.06603	0.898717	1.18094
Tanjung Emas effch	0.957289	0.891137	0.789619	1.26759
Tanjung Emas techch	0.9912	1.19626	1.13816	0.931642

source: MPI analysis result

Figure 20. MPI result of Tanjung Emas port

From Figure 20, it can be seen that in 2014, the productivity of marine services at the port of Tanjung Emas has increased compared to the previous year (1.180). The improvements in the efficiency changes was a cause of the increased productivity of marine services during the year.

Meanwhile the technology changes in the same year was decreased compared to 2013 (0.931). However, during the period 2010 - 2014, the productivity of marine services in the port have a positive trendline.

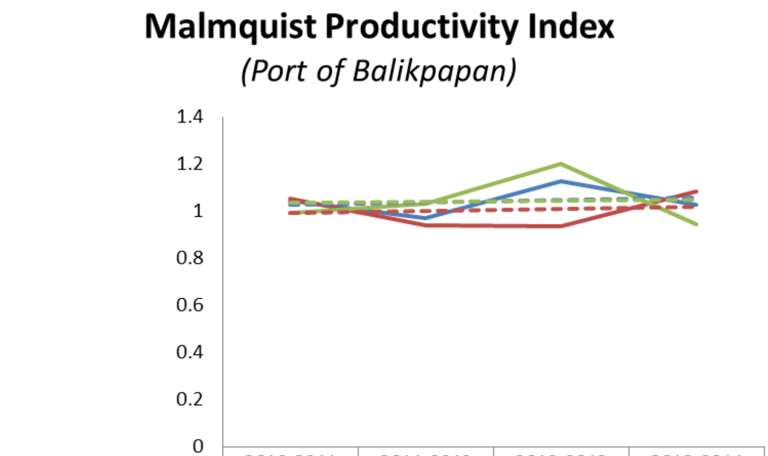


	2010-2011	2011-2012	2012-2013	2013-2014
Makassar tfpch	1.07256	1.13665	1.41819	0.88667
Makassar effch	1.04414	1.39874	1.00443	0.768287
Makassar techch	1.02722	0.812622	1.41194	1.15409

source: MPI analysis result

Figure 21. MPI result of Makassar port

Figure 21 shows that the productivity of marine services in the port of Makassar was fluctuated with the highest value in the period of 2012 - 2013 (1.418). This increase was due to the increased efficiency changes (1.004) and technological changes (1.411). Whereas in 2014, the productivity of marine services decreased compared to the previous year (0.886). This was due to a decrease in the efficiency changes where the port was not able to utilizing the input to get the maximum output.



	2010-2011	2011-2012	2012-2013	2013-2014
Balikpapan tfpch	1.04509	0.972441	1.12808	1.02685
Balikpapan effch	1.05436	0.941235	0.93871	1.08511
Balikpapan techch	0.9912	1.03315	1.20173	0.946315

source: MPI analysis result

Figure 22. MPI result of Balikpapan port

Figure 22 indicates a decrease in the rate of productivity in 2014 compared with the previous year. In 2014, the port of Makassar can utilize the existing input to generate a maximum output, so the value of efficiency changes was more than one

(1.085). Although the technological change was decline, the value of the productivity of marine services keeps increasing.

5.3. Forecasted Ship Calls and Marine Service Production in 2020

As already explained in Chapter 3 regarding the forecasting approach, this sub-chapter describes the sequence of forecasting method.

5.3.1. Finding the CAGR of GRDP in 2010 – 2014 period

Together with CAGR of marine service variables, CAGR of GRDP (in constant prices) will be used to determine the elasticity of the marine service variables. To find the elasticity, the period of observed data should be same. Therefore, both CAGR of marine service and GRDP should be in the same period, 2010 – 2014.

However, the data available at Indonesian Centre of Bureau Statistic (BPS) were only the GRDP at 2010 – 2013. Therefore, firstly, the GRDP in 2014 should be forecasted using extrapolation from GRDP in 2013 by considering the annual growth and the acceleration rate of the annual growth of previous GRDP. For example, the GRDP of North Sumatera in 2012 (134,461 billion Rupiahs) was growth by 6.22% compare to GRDP in 2011 (126,587 billion Rupiahs). Next year, the GRDP in 2013 (142,537 billion Rupiahs) was growth by 6.01% compare to GRDP in 2012 (134,461 billion Rupiahs). Therefore, the declining growth of GRDP from 6.22% to 6.01% indicates that despite the GDRP increasing, the growth rate becomes lower. Hence, it is important to know the acceleration of the GRDP growth rate. Taking again North Sumatera as an example, the growth rate of GRDP 2012, as stated before, is 6.22% then it became lower to 6.01% in 2013. Thus, the acceleration rate of these growth rates is -3.44%. Based on this acceleration rates, we can predict the growth rate in 2014 is 5.80%. It means that the growth rate in 2014 (5.80%) is -3.44% lower than the growth rate in 2013 (6.01%). Once the growth rate in 2014 is predicted, we can move a step further to predict the GRDP in 2014 using the predicted growth rate in 2014 and actual GRDP in 2013. The result of the calculation shows that the predicted GRDP of North Sumatera in 2014 is 150,802.94 billion Rupiahs. This technique also applied to the other provinces to predict the GRDP in 2014. Appendix B shows the GRDP, the annual growth, and the acceleration rate of the annual growth over 2010 – 2013.

The following Table 34 shows the GRDP of each province where the observed ports are located. The table consists of GRDP in 2010, 2013 and forecasted 2014. The table also shows the share of GRDP of each province to the total of Indonesian GRDP as well as the CAGR of GRDP in 2010-2014. The explanation of how to measure the annual growth by using CAGR method is already explained in Chapter 3.

Table 34. GRDP and CAGR of GRDP in 2010 – 2014

Port *(Province)*	**GRDP** ***(in thousand)***			**% Share of total GRDP 2013**	**CAGR of GRDP 2010-2014**
	2010	**2013**	**2014** ***(forecasted)***		
Belawan ***(North Sumatra)***	118.7	142.5	150.8	5.36%	6.16%
Dumai	97.7	109.0	111.1	4.10%	3.27%

(Riau)					
Tanjung Priok ***(DKI Jakarta)***	395.6	477.2	504.5	17.94%	6.27%
Palembang ***(South Sumatra)***	63.8	76.4	80.9	2.87%	6.11%
Tanjung Perak ***(East Java)***	342.2	419.4	444.1	15.76%	6.73%
Tanjung Emas ***(Central Java)***	186.9	223.0	234.9	8.38%	5.88%
Makassar ***(South Sulawesi)***	51.1	64.2	68.7	2.42%	7.65%
Balikpapan ***(East Kalimantan)***	110.9	121.9	122.7	4.58%	2.56%
Total GRDP	2,222.9	2,661.0	-		

Source: partly derived from BPS, 2014 and own calculation

5.3.2. Forecast the CAGR of GRDP in 2014 – 2020 period

The CAGR of GRDP in 2014 – 2020 (in constant prices) together with the elasticity of variables in 2014 – 2020 will be used to forecast the marine variables in 2020. To obtain the CAGR of GRDP in 2014 – 2020, we can use a forecasted GDP from a reliable source as the reference to predict the CAGR of GRDP in 2014 - 2020. In this case, a forecasted Indonesian GDP by IMF's World Economic Outlook (WEO) 2015 will be used. The following Table 35 shows the forecasted Indonesian GDP up to 2020 and its growth rate over the years.

Table 35. Forecasted Indonesian GDP of 2014 – 2020

Year	**2014**	**2015**	**2016**	**2017**
GDP	888,648	895,677	951,943	1,036,556
% annual growth	-2.61%	0.79%	6.28%	8.89%
Year	**2018**	**2019**	**2020**	
GDP	1,116,967	1,207,434	1,306,622	
% annual growth	7.76%	8.10%	8.21%	

Source: IMF, WEO 2015

Afterwards, assuming the change in Indonesian GDP is linear to the change of GRDP, then the next year CAGR or annual growth can be predicted using extrapolation technique based on the previous percentage of GDP changes. The base year used to extrapolate the CAGR of GRDP is 2014. Taken North Sumatera as an example, the annual growth of GRDP in 2014 is 5.80%. The predicted annual growth of GRDP in 2015 can be extrapolated based on the percentage of change in predicted Indonesian GDP by IMF, which is 0.79%. Therefore the forecasted CAGR or annual growth of North Sumatera GRDP in 2015 is 5.84%.

This technique then also applied to calculate the annual growth in the upcoming years up to 2020. Since the growth rates are different from each year, then the CAGR or the growth rates should be averaged. The following Table 36Table 37 shows the forecasted CAGR of GRDP 2014 – 2020. For the complete spreadsheet, see Appendix D.

Table 36. Forecasted CAGR of GRDP 2014 – 2020

Port ***(Province)***	**Belawan** ***(North Sumatra)***	**Dumai** ***(Riau)***	**Tanjung Priok** ***(DKI Jakarta)***	**Palembang** ***(South Sumatra)***
CAGR	6.87%	2.99%	6.99%	6.94%
Port ***(Province)***	**Tanjung Perak** ***(East Java)***	**Tanjung Emas** ***(Central Java)***	**Makassar** ***(South Sulawesi)***	**Balikpapan** ***(East Kalimantan)***
CAGR	7.59%	6.74%	8.86%	1.84%

source: own calculation

5.3.3. CAGR of Marine Service Variables in 2010 – 2014 period

The CAGR of the marine services variables in a period of 2010 – 2014 should be calculated to obtain the elasticity of marine services in 2010 – 2014. Taken the ship calls in GT at the port of Belawan as the example, the CAGR of the variable is 4.47%. The figure was calculated using following formula:

$$CAGR\ of\ ship\ calls\ in\ GT\ 2010-2014=\left(\frac{ship\ calls\ in\ GT\ (2014)}{ship\ calls\ in\ GT\ (2010)}\right)^{1/(2014-2010)}-1$$

The figure of variables can be derived in Table 5

$$CAGR\ of\ ship\ calls\ in\ GT\ 2010-2014=\left(\frac{26{,}168{,}564}{21{,}966{,}981}\right)^{1/4}-1$$

$$CAGR\ of\ ship\ calls\ in\ GT\ 2010-2014=4.47\%$$

The following Table 37 shows the CAGR of marine service variables of each port.

Table 37. CAGR of marine service variables 2010 – 2014

Port (Variables)	**Belawan**	**Dumai**	**Tanjung Priok**	**Palembang**
(Ship Calls GT)	4.47%	2.64%	11.68%	12.37%
(Ship move GT)	1.48%	2.56%	5.07%	4.94%
(Ship hour GT)	1.69%	2.59%	7.06%	6.73%
Port	**Tanjung Perak**	**Tanjung Emas**	**Makassar**	**Balikapan**
(Ship Calls GT)	4.55%	3.00%	9.37%	9.30%
(Ship move GT)	9.31%	5.56%	8.83%	9.60%
(Ship hour GT)	13.03%	5.66%	11.27%	9.18%

source: own calculation

5.3.4. Elasticity of Marine Service Variables in period of 2014 – 2020

This step determines the elasticity of marine service with respect to the GRDP in constant prices of the period 2010 – 2014 and the forecasted period of 2014 – 2020. This method refers to research by (de Langen et al. 2012) which forecast the container throughput using the same method. The elasticity in 2010 – 2014 can be determined by dividing the CAGR of the variables to the CAGR of GRDP in the same period. In this step, the elasticity of marine service variables in 2014 – 2020 will use the elasticity in 2010 – 2014. However, it is still needed to be adjusted using the lower bound or upper bound of the average of elasticity. The reason behind this approach is because there are too many disturbances on the forecasting assumption and it is hard to predict the exact figures. Therefore, the elasticity will be put in the 25% boundary of the average. For example, GT ship hour in the port of Tanjung Perak which is initially 1.94 changed to the lower bound average of 1.22. The following table shows the elasticity of marine service in each port.

Table 38. Marine service variables elasticity 2014 - 2020

Port (Variables)	**Belawan**	**Dumai**	**Tanjung Priok**	**Palembang**
(Ship Calls GT)	1.07	1.07	1.79	1.79
(Ship move GT)	0.93	0.93	0.93	0.93
(Ship hour GT)	1.05	1.05	1.13	1.10
Port	**Tanjung Perak**	**Tanjung Emas**	**Makassar**	**Balikapan**
(Ship Calls GT)	1.07	1.07	1.22	1.79
(Ship move GT)	1.38	0.95	1.15	1.54
(Ship hour GT)	1.76	1.05	1.47	1.76
			Lower bound	**Upper bound**
Avg Ship calls GT		1.43	1.07	1.79
Avg Ship moves GT		1.23	0.93	1.54
Avg Ship hour GT		1.41	1.05	1.76

source: own calculation

5.3.5. Forecasted Marine Service Variables in 2020

To forecast marine service variables in 2020 we can use the data of variables in 2014 then multiply it by the factor of CAGR of GRDP 2014 – 2020 (in constant prices) and the variables elasticity and power to 6 as the number of CAGR GRDP period. The formula to calculate the forecasted variables in 2020 is as follow:

$$Forecasted\ variable\ 2020 = variable\ in\ 2014 \times (1 + Elasticity \times CAGR\ GRDP\ 2014 - 2020)^6$$

The following Table 39 shows the forecasted variables in 2020 derived by using the calculation above.

Table 39. Forecasted variables in 2020 (in thousand)

Port *(Variables)*	**Belawan**	**Dumai**	**Tanjung Priok**	**Palembang**
(Ship Calls GT)	38,387	39,211	54,198	29,776
(Ship move GT)	45,385	47,605	189,188	23,337
(Ship hour GT)	64,592	61,780	355,133	43,035
Port	**Tanjung Perak**	**Tanjung Emas**	**Makassar**	**Balikapan**
(Ship Calls GT)	114,676	30,999	52,292	72,305
(Ship move GT)	409,821	51,594	53,415	74,318
(Ship hour GT)	1,101,173	69,992	165,341	126,218

source: own calculation

5.3.6. Adjusting the Forecasted Marine Service Variables in 2020

Based on the assumption on economic growth in 2015 – 2019 stated in the Indonesian Master Plan of Indonesian Economics Development Acceleration (MP3EI), it is also necessary to make adjustment on the forecasted marine service variable in 2020 with moderate scenario. The following Table 40 shows the scenario and its assumption of Indonesian economic growth. Therefore, Table 41 shows the final result of forecasted variables by 7% adjustment based on moderate Indonesian economic growth as well as the % growth based variables in 2014. The table also shows the percentage of change compare to 2014.
`

Table 40. Scenario and assumption on Indonesian economic growth

Scenario	Assumptions Economic Growth 2015-2019
Pessimistic	5%
Moderate	7-8%
Optimistic	9%

Source: (KP3EI 2011)

Table 41. Final forecast of marine service variable in 2020 (in thousand)

Port (Variables)	**Belawan**	**Dumai**	**Tanjung Priok**	**Palembang**
(Ship Calls GT)	41,074	41,955	57,992	31,860
% growth	0.57	0.32	1.03	0.99
(Ship move GT)	48,562	50,937	202,431	24,971
% growth	0.49	0.28	0.50	0.49
(Ship hour GT)	69,114	66,105	379,993	46,047
% growth	0.56	0.31	0.61	0.58
Port	**Tanjung Perak**	**Tanjung Emas**	**Makassar**	**Balikapan**
(Ship Calls GT)	122,704	33,169	55,953	77,367
% growth	0.62	0.54	0.83	0.40
(Ship move GT)	438,508	55,206	57,154	79,521
% growth	0.83	0.48	0.78	0.35
(Ship hour GT)	1,178,255	74,891	176,915	135,053
% growth	1.09	0.53	1.03	0.39

source: own calculation

5.4. The Efficiency and Productivity of Planned Investment in 2020

In their long-term project, each Pelindo's management already has the plan to invest in marine service equipment in 2020 such as an addition to the number of pilot boat and harbour tug. They also already make a projection plan on the number of pilots required to perform the marine service.

Table 42. The planned investment and required number of pilot

Port	**Belawan**	**Dumai**	**Tanjung Priok**	**Palembang**
Number of pilot boats	2	-	1	2

Number of harbour tugs	3	3	4	2
Number of pilots	5	5	9	4

	Tanjung Perak	Tanjung Emas	Makassar	Balikapan
Number of pilot boats	1	1	2	-
Number of harbour tugs	3	2	2	2
Number of pilots	6	3	4	5

Source: Pelindo's long term plan projection

Table 42 presents the investment plan and the required number of the pilot. By using the DEA-based MPI method, the total factor productivity change (TFPCH) of marine service in 2020 compared to 2014 can be determined. It is assumed that between the periods 2014 – 2020 there is no additional equipment of marine services.

Table 43. MPI result on the investment plan

Port	TFPCH	EFFCH	TECHCH
Belawan	0.946179	0.605758	1.56197
Dumai	1.11238	0.665726	1.67092
Tanjung Priok	1.131545	0.840854	1.56442
Palembang	0.757188	0.510535	1.48313
Tanjung Perak	1.67323	1	1.67323
Tanjung Emas	1.11038	0.710879	1.56197
Makassar	1.35396	0.808074	1.67554
Balikpapan	1.01211	0.693166	1.46013
Average	1.01212	0.72937	1.58141

source: MPI analysis result

The Malmquist productivity index of marine services after the investment plan on 2020 is presented in Table 43. It shows that over the observed period, after the investments the majority of ports are expected to have a growth in TFPCH except the port of Belawan and the port of Palembang. The port of Tanjung Perak is predicted to have the most productive marine services which can indicated by the TFPCH (1.673). The impact of the investment plan in 2020 showed that the productivity of the services will increase due to the increasing TECHCH (1.673). Meanwhile, the port of Belawan is predicted to have 0.946 TFPCH, which means that the service in 2020 will be less productive and efficient due to the regressed EFFCH (0.605). The proposition that follows from regressed TECHCH is that these companies reflected a less benefit from enhanced technology and capital equipment because of the inadequate transfer of technology.

Port of Tanjung Perak reported positive scores on EFFCH (1.131). The rest of the ports displayed a regressed EFFCH. This was due to the company's decline in managerial performance efficiency (shown in SECH index). Average EFFCH over the observed period reflected to be at 0.729. This indicates that in overall, the marine service in 2020 will be technically less efficient. An annual average on TECHCH has been observed to be at 1.581. During the observation period, the majority of ports reported having improved on TECHCH. The result of MPI analysis of the investments plan is displayed in Appendix E.

5.5. The Efficiency Level of Marine Service in 2020

To measure the future of the marine service efficiency in 2020, the input and the output data were taken from projected variables in Table 39 as well as the investment plan on the number of pilot boats, harbour tugs and the pilots as showed in Table 42. For the result of DEA analysis of marine service technical efficiency in 2020, see Appendix F

Table 44. Input variables (data of 2020)

DMU	Input		
	NOP	NOPB	NOHT
Belawan	32	8	7
Dumai	38	8	10
Tanjung Priok	90	8	19
Palembang	21	6	4
Tanjung Perak	71	7	15
Tanjung Emas	27	3	6
Makassar	46	5	6
Balikpapan	52	5	8

Source: Pelindo's long term plan projection

Table 45. Output variables (data of 2020) (in thousand)

DMU	Output	
	SMG	SHG
Belawan	48,562	69,114
Dumai	50,937	66,105
Tanjung Priok	202,431	379,993
Palembang	24,971	46,047
Tanjung Perak	438,508	1,178,255
Tanjung Emas	55,206	74,891
Makassar	57,154	176,915
Balikpapan	79,521	135,053

source: own calculation

Table 44 and Table 45 above shows the input and output data. These data then processed with the DEA method. The result of the analysis of DEDA can be seen in the following Table 46.

Table 46. Comparison of technical efficiency in 2014 and 2020

Rank	Port	Technical efficiency		Rank 2014
		2020	2014	
1	Tanjung Perak	1	1	-
2	Tanjung Priok	0.403931	0.480382	↑ (3)
3	Makassar	0.375375	0.464531	↑ (5)
4	Balikpapan	0.340021	0.490533	↓ (2)
5	Tanjung Emas	0.331057	0.465701	↓ (4)
6	Belawan	0.245713	0.405628	↑ (7)
7	Dumai	0.217035	0.326013	↑ (8)
8	Palembang	0.213545	0.418277	↓ (6)

source: DEA analysis result

In 2020, the port of Tanjung Perak is still the most efficient port in the marine service. Meanwhile, the other ports ranks are changes such as the Port of Balikpapan which in 2014 is in the second place, in 2020 will drop to the fourth place which is indicated by the decline in the efficiency score. Moreover, port of Palembang will become the least efficient in its marine service. It also can be concluded that the marine services in most of the ports still become inefficient because of the overcapacity equipment. See Appendix F for the complete results.

Table 47. Benchmarks of marine services variables per port (2020)

DMU	NOP/NOPB	SMG/NOPB (in thousand)	SHG/NOHT (in thousand)
Belawan	4.00	6,070	9,873
Dumai	4.75	6,367	6,610
Tanjung Priok	11.25	25,304	20,000
Palembang	3.50	4,162	11,512
Tanjung Perak	10.14	62,644	78,550
Tanjung Emas	9.00	18,402	12,482
Makassar	9.20	11,431	29,486
Balikpapan	10.40	15,904	16,882

source: own calculation

Table 47 shows the benchmarks of marine service variables per port in 2020. It can be seen that in general, the ratio between the number of pilots and a number of pilot boat is still in the same range as compared with the ratio in 2014 in Table 31. The most significant difference in the ratio found in the port of Tanjung Emas and port of Makassar were originally identical 9 pilots per pilot boat boat pilot, then in 2020 become 12 and 14 pilots per boat respectively. This may imply that the increase in the number of pilots in the ports more than the increase in the number of pilot boats.

The majority of the ratio between ship movement in GT and the number of pilot boat in 2020 also indicates a decrease in the amount of output per unit of the pilot boat. It is found in all of the ports except the port of Palembang and port of Tanjung Emas. Whereas, the other ports is slightly changes compared to 2014. This means that the addition of the number of pilot boat in 2020 at these ports more than the expected increase of its output.

Compared to the year 2014, some ports has different ratio between ship hours in GT and the number of harbour tugs shows. The port of Belawan, port of Dumai and port Palembang indicates an increase in the amount of output per unit of harbour tug. This means that the addition of the number of harbour tugs in 2020 is less than the expected increase of its input. Otherwise, in the port of Tanjung Perak and port of Tanjung Priok indicates the opposite situation where the amount of ship hours in GT per harbour tug is decreased.

6. Conclusion and Recommendation

In this thesis, some analysis on Indonesian ports marine services have been done. First, an analysis of the marine services' performance efficiency compared to the other ports studied. Second, an analysis of marine services' productivity over the period 2010 - 2014. Third, a projection of the marine services' output in 2020. Next, an analysis of the productivity after the investments in 2020. Lastly, the analysis of the marine services' performance efficiency of Indonesian ports in 2020. The whole efficiency and productivity analysis which mentioned above were done using Data Envelopment Analysis (DEA) and Malmquist Productivity Index (MPI) methods.

6.1. Key Findings

DEA and MPI are useful methods to measure and compare the technical efficiency and productivity index of various firms. By using these methods, it can be known that in 2014, the port of Tanjung Priok has the highest technical efficiency compared to the other observed ports. This result also means that the port is able to utilize their resources optimally such as the number of marine pilots, the number of pilot boats and harbour tugs to produce the marine services product such as the ship movements and ship hours. Meanwhile most of the other observed ports indicate an overcapacity on their resource.

By looking from the marine services' productivity aspect, however, some ports indicate an improvement in the total factor productivity over 2010 – 2014. These ports consist of the port of Belawan, port of Dumai, port of Tanjung Perak, port of Tanjung Emas and port of Balikpapan. This is due to the ability of the port's management to organize their marine services equipment to produce the output. Meanwhile, the productivity of the port of Tanjung Priok, port of Palembang and port of Makassar are drop in the past five years. This could be an impact of declining efficiency which means that the ports' marine services equipment is overcapacity compared to the other ports.

In 2020, the ship calls in GT is predicted to increase 66% on average. The highest growth is the port of Tanjung Priok (103%) while the lowest growth is the port of Dumai (32%). Meanwhile, the pilotage production in the number of ship movement is projected to increase by 53% on average. The port of Dumai has the lowest growth factor (28%) while the port of Tanjung Perak has the highest growth factor (83%). The towage service production in ship hours is forecasted to growth by 64% on average. Port of Tanjung Perak predicted to growth by 109%, while, the port of Dumai only growth by 31%.

To anticipate the growth of the ship traffic, Pelindo management already planned some investments in marine services equipment. Using MPI method, the impact of the investments in 2020 indicates an improvement in the term of total factor productivity (TFP) compared to 2014. While the other ports present productivity improvement, the port of Belawan and port of Palembang's productivity is decline.

In 2020 some ports showed an increase marine services' efficiency among the other ports compares to 2014. This port includes port of Tanjung Priok and port of Tanjung Emas. Meanwhile the port of Palembang showed decrease efficiency compared to 2014. It also can be concluded that the marine services in several ports still will have overcapacity on their marine services equipment.

From the analyses which carried on in this thesis, it can be suggested that the DEA method is useful technique to analyse and benchmarks the port's marine services efficiency among the other Indonesian ports. Meanwhile, the MPI is a practical method to show the productivity change of the marine services of the Indonesian ports over the periods. It also can be used to show the productivity of marine services after the investment in 2020.

6.2. Limitations of the Research

Even though the analysis results can measure and compare the efficiency and productivity level of the marine services, the DEA and MPI methods only measure the efficiency and productivity value relatively to the other port. The result of the methods does not reflect the real efficiency and productivity based on the real condition on each port. The ability to investigate further on the DEA and MPI results also limited due to lack of information from each port.

6.3. Suggestions for Further Research

At present, there is no study conducted on the technical efficiency and productivity index on port marine services. Hence, there is no reference about the indicator performance which can be used as a standard to measuring the marine services' performance. Started by this reason, this thesis only measure the marine services' performance based only on the physical aspects which relatively easy to collect the data. Therefore, in the further research, it is suggested that the financial indicators might be used to measure the marine services' performance.

Moreover, the further research can also be carried on to measures the marine services' performance regarding the ship waiting time for pilotage service. The distance and the time spent to travel from the pilot station to ship might be considered as the input variables.

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Appendixes

A. Report of DEA analysis of efficiency over 2010 – 2014

CRS-INPUT Oriented DEA Efficiency Results:

	rank	theta	ref: Belawan	ref: Dumai
dmu:Belawan	7	.405628	0	0
dmu:Dumai	8	.326013	0	0
dmu:Tanjung_Priok	3	.480382	0	0
dmu:Palembang	6	.418277	0	0
dmu:Tanjung_Perak	1	1	0	0
dmu:Tanjung_Emas	4	.465701	0	0
dmu:Makassar	5	.464531	0	0
dmu:Balikpapan	2	.490533	0	0

	ref: Tanjung_Priok	ref: Palembang	ref: Tanjung_Perak	ref: Tanjung_Emas
dmu:Belawan	0	0	.135209	0
dmu:Dumai	0	0	.165514	0
dmu:Tanjung_Priok	0	0	.560446	0
dmu:Palembang	0	0	.0697128	0
dmu:Tanjung_Perak	0	0	1	0
dmu:Tanjung_Emas	0	0	.155234	0
dmu:Makassar	0	0	.154844	0
dmu:Balikpapan	0	0	.245267	0

	ref: Makassar	ref: Balikpapan	islack: NOP	islack: NOPB
dmu:Belawan	0	0	2.16335	1.62251
dmu:Dumai	0	0	0	1.61502
dmu:Tanjung_Priok	0	0	2.48197	0
dmu:Palembang	0	0	2.57938	1.25483
dmu:Tanjung_Perak	0	0	0	0
dmu:Tanjung_Emas	0	0	1.08664	0
dmu:Makassar	0	0	9.44545	.464531
dmu:Balikpapan	0	0	7.11273	.981066

	islack: NOHT	oslack: SMG	oslack: SHG
dmu:Belawan	0	0	31724.5
dmu:Dumai	.29592	0	42670.1
dmu:Tanjung_Priok	.480382	0	79410.8
dmu:Palembang	0	0	10097.2
dmu:Tanjung_Perak	0	0	0
dmu:Tanjung_Emas	0	0	38459.6
dmu:Makassar	0	5054.24	0
dmu:Balikpapan	0	0	41094.1

B. Report of MPI analysis on investment plan in 2020

Cross CRS-DEA Result:

	from	thru	t	t1
dmu:Belawan	2010	2011	.699772	.918009
dmu:Dumai	2010	2011	.431052	.538705
dmu:Tanjung_Priok	2010	2011	.636366	.662267
dmu:Palembang	2010	2011	.470043	.413909
dmu:Tanjung_Perak	2010	2011	1.02722	1.2611
dmu:Tanjung_Emas	2010	2011	.517522	.550254
dmu:Makassar	2010	2011	.442078	.40125
dmu:Balikpapan	2010	2011	.507139	.489569
dmu:Belawan	2011	2012	.509436	.633532
dmu:Dumai	2011	2012	.416383	.325207
dmu:Tanjung_Priok	2011	2012	.660019	.680879
dmu:Palembang	2011	2012	.495018	.425549
dmu:Tanjung_Perak	2011	2012	1.33724	1.23058
dmu:Tanjung_Emas	2011	2012	.543178	.425939
dmu:Makassar	2011	2012	.489172	.5296
dmu:Balikpapan	2011	2012	.510795	.508414
dmu:Belawan	2012	2013	.483339	.401659
dmu:Dumai	2012	2013	.339988	.298448
dmu:Tanjung_Priok	2012	2013	.512333	.520385
dmu:Palembang	2012	2013	.448278	.390292
dmu:Tanjung_Perak	2012	2013	1.41194	.958481
dmu:Tanjung_Emas	2012	2013	.418152	.408796
dmu:Makassar	2012	2013	.853707	.426339
dmu:Balikpapan	2012	2013	.54596	.40273
dmu:Belawan	2013	2014	.383852	.448757
dmu:Dumai	2013	2014	.28478	.362692
dmu:Tanjung_Priok	2013	2014	.454593	.480962
dmu:Palembang	2013	2014	.395822	.416204
dmu:Tanjung_Perak	2013	2014	1.15409	1.14479
dmu:Tanjung_Emas	2013	2014	.4407	.400559
dmu:Makassar	2013	2014	.536109	.523905
dmu:Balikpapan	2013	2014	.464199	.477705

Malmquist efficiency INPUT Oriented DEA Results:

	year	dmu	CRS_eff	VRS_eff
1.	2010	Belawan	.909931	1
2.	2010	Dumai	.533965	.752054
3.	2010	Tanjung Priok	.555448	.632715
4.	2010	Palembang	.410267	1
5.	2010	Tanjung Perak	1	1
6.	2010	Tanjung Emas	.545411	1
7.	2010	Makassar	.412172	.884245
8.	2010	Balikpapan	.485261	.826558
9.	2011	Belawan	.705984	1
10.	2011	Dumai	.434879	.749739
11.	2011	Tanjung Priok	.758746	.821324
12.	2011	Palembang	.474216	1
13.	2011	Tanjung Perak	1	1
14.	2011	Tanjung Emas	.522116	1
15.	2011	Makassar	.430365	.90424
16.	2011	Balikpapan	.511642	.751565
17.	2012	Belawan	.465175	.824342
18.	2012	Dumai	.339683	.637954
19.	2012	Tanjung Priok	.592284	.679885
20.	2012	Palembang	.444216	1
21.	2012	Tanjung Perak	1	1
22.	2012	Tanjung Emas	.465277	1
23.	2012	Makassar	.601967	1
24.	2012	Balikpapan	.481575	.714823
25.	2013	Belawan	.424665	.788213
26.	2013	Dumai	.31682	.666613
27.	2013	Tanjung Priok	.45014	.547941
28.	2013	Palembang	.39386	1
29.	2013	Tanjung Perak	1	1
30.	2013	Tanjung Emas	.367392	1
31.	2013	Makassar	.604632	1
32.	2013	Balikpapan	.452059	.70752
33.	2014	Belawan	.405628	.754793
34.	2014	Dumai	.326013	.664942
35.	2014	Tanjung Priok	.480382	.559813
36.	2014	Palembang	.418277	1
37.	2014	Tanjung Perak	1	1
38.	2014	Tanjung Emas	.465701	1
39.	2014	Makassar	.46453	1
40.	2014	Balikpapan	.490533	.714313

Malmquist productvity index INPUT Oriented DEA Results:

	period	dmu	tfpch	effch	techch	pech	sech
1.	2010~2011	Belawan	.769038	.775866	.9912	1	.775866
2.	2010~2011	Dumai	.807266	.814433	.9912	.996922	.816948
3.	2010~2011	Tanjung Priok	1.14568	1.36601	.838708	1.29809	1.05232
4.	2010~2011	Palembang	1.1457	1.15587	.9912	1	1.15587
5.	2010~2011	Tanjung Perak	.90252	1	.90252	1	1
6.	2010~2011	Tanjung Emas	.948865	.957289	.9912	1	.957289
7.	2010~2011	Makassar	1.07256	1.04414	1.02722	1.02261	1.02105
8.	2010~2011	Balikpapan	1.04509	1.05436	.9912	.909271	1.15957
9.	2011~2012	Belawan	.727899	.658902	1.10471	.824342	.799307
10.	2011~2012	Dumai	1.00004	.781098	1.28031	.850901	.917966
11.	2011~2012	Tanjung Priok	.869882	.780609	1.11436	.827792	.943001
12.	2011~2012	Palembang	1.04387	.936737	1.11436	1	.936737
13.	2011~2012	Tanjung Perak	1.04243	1	1.04243	1	1
14.	2011~2012	Tanjung Emas	1.06603	.891137	1.19626	1	.891137
15.	2011~2012	Makassar	1.13665	1.39874	.812622	1.1059	1.26479
16.	2011~2012	Balikpapan	.972441	.941235	1.03315	.951112	.989615
17.	2012~2013	Belawan	1.04812	.912916	1.14811	.956173	.95476
18.	2012~2013	Dumai	1.03078	.932693	1.10517	1.04492	.892595
19.	2012~2013	Tanjung Priok	.865012	.760006	1.13816	.805932	.943016
20.	2012~2013	Palembang	1.00914	.886641	1.13816	1	.886641
21.	2012~2013	Tanjung Perak	1.21372	1	1.21372	1	1
22.	2012~2013	Tanjung Emas	.898717	.789619	1.13816	1	.789619
23.	2012~2013	Makassar	1.41819	1.00443	1.41194	1	1.00443
24.	2012~2013	Balikpapan	1.12808	.93871	1.20173	.989784	.948399
25.	2013~2014	Belawan	.903893	.955171	.946315	.957601	.997463
26.	2013~2014	Dumai	.89887	1.02902	.873521	.997493	1.0316
27.	2013~2014	Tanjung Priok	1.00433	1.06718	.941101	1.02167	1.04455
28.	2013~2014	Palembang	1.00498	1.06199	.946315	1	1.06199
29.	2013~2014	Tanjung Perak	1.00405	1	1.00405	1	1
30.	2013~2014	Tanjung Emas	1.18094	1.26759	.931642	1	1.26759
31.	2013~2014	Makassar	.88667	.768287	1.15409	1	.768287
32.	2013~2014	Balikpapan	1.02685	1.08511	.946315	1.0096	1.07479

C. GRDP, annual growth, and its acceleration rate (2010 – 2014)

PORT	GRDP 2010	GRDP 2011	GRDP 2012	GRDP 2013	Predicted GRDP 2014
BELAWAN (North Sumatra)	18,718	126,587	134,461	142,537	150,802
%Annual growth		6.63%	6.22%	6.01%	5.80%
%Acceleration rate			-6.15%	-3.44%	
DUMAI (Riau)	97,735	102,665	106,29	109,073	111,173
%Annual growth		5.04%	3.54%	2.61%	1.93%
%Acceleration rate			-29.86%	-26.24%	
TANJUNG PRIOK (DKI Jakarta)	95,622	22,242	49,805	477,285	504,574
%Annual growth		6.73%	6.53%	6.11%	5.72%
%Acceleration rate			-2.98%	-6.41%	
PALEMBANG (South Sumatra)	63,859	68,008	72,095	76,409	80,961
%Annual growth		6.50%	6.01%	5.98%	5.96%
%Acceleration rate			-7.50%	-0.44%	
TANJUNG PERAK (East Java)	42,280	66,983	93,662	419,428	444,143
%Annual growth		7.22%	7.27%	6.55%	5.89%
%Acceleration rate			0.73%	-9.97%	
TANJUNG EMAS (Central Java)	86,992	98,270	10,848	23,099	234,972
%Annual growth		6.03%	6.34%	5.81%	5.32%
%Acceleration rate			5.19%	-8.41%	
MAKASSAR (South Sulawesi)	51,199	55,093	59,718	64,284	68,761
%Annual growth		7.61%	8.39%	7.65%	6.96%
%Acceleration rate			10.38%	-8.92%	
BALIKPAPAN (East Kalimantan)	10,953	15,489	20,085	21,990	122,761
%Annual growth		4.09%	3.98%	1.59%	0.63%
%Acceleration rate			-2.67%	-60.14%	

D. Forecasted CAGR of GRDP 2014 - 2020

PORT	Predicted GRDP 2014	Forecasted CAGR 2015	Forecasted CAGR 2016	Forecasted CAGR 2017	Forecasted CAGR 2018	Forecasted CAGR 2019	Forecasted CAGR 2020	Average CAGR 2014-2020
BELAWAN (North Sumatra)	5.80%	5.84%	6.16%	6.31%	6.25%	6.27%	6.28%	6.19%
DUMAI (Riau)	1.93%	1.94%	2.05%	2.10%	2.07%	2.08%	2.08%	2.05%
TANJUNG PRIOK (DKI Jakarta)	5.72%	5.76%	6.08%	6.23%	6.16%	6.18%	6.19%	6.10%
PALEMBANG (South Sumatra)	5.96%	6.00%	6.33%	6.49%	6.42%	6.44%	6.45%	6.35%
TANJUNG PERAK (East Java)	5.89%	5.94%	6.26%	6.42%	6.35%	6.37%	6.38%	6.29%
TANJUNG EMAS (Central Java)	5.32%	5.36%	5.66%	5.79%	5.73%	5.75%	5.76%	5.68%
MAKASSAR (South Sulawesi)	6.96%	7.02%	7.40%	7.58%	7.50%	7.53%	7.54%	7.43%
BALIKPAPAN (East Kalimantan)	0.63%	0.64%	0.67%	0.69%	0.68%	0.68%	0.68%	0.67%
Forecasted GDP (IMF Database)	888,648	895,677	951,943	1,036,556	1,116,967	1,207,434	1,306,622	
% annual growth	-2.61%	0.79%	6.28%	8.89%	7.76%	8.10%	8.21%	

E. Report of MPI analysis on investment plan in 2020

Cross CRS-DEA Result:

	from	thru	t	t1
dmu:Belawan	2014	2020	.410567	.277803
dmu:Dumai	2014	2020	.362649	.19511
dmu:Tanjung_Priok	2014	2020	.63192	.307066
dmu:Palembang	2014	2020	.321702	.286466
dmu:Tanjung_Perak	2014	2020	1.91743	.684871
dmu:Tanjung_Emas	2014	2020	.553172	.318945
dmu:Makassar	2014	2020	.628955	.277243
dmu:Balikpapan	2014	2020	.496475	.335952

Malmquist efficiency INPUT Oriented DEA Results:

	year	dmu	CRS_eff	VRS_eff
1.	2014	Belawan	.405628	.754793
2.	2014	Dumai	.326013	.664942
3.	2014	Tanjung Priok	.480382	.559813
4.	2014	Palembang	.418277	1
5.	2014	Tanjung Perak	1	1
6.	2014	Tanjung Emas	.465701	1
7.	2014	Makassar	.46453	1
8.	2014	Balikpapan	.490533	.714313
9.	2020	Belawan	.245713	.747267
10.	2020	Dumai	.217035	.652215
11.	2020	Tanjung Priok	.403931	.567048
12.	2020	Palembang	.213545	1
13.	2020	Tanjung Perak	1	1
14.	2020	Tanjung Emas	.331057	1
15.	2020	Makassar	.375375	.989322
16.	2020	Balikpapan	.340021	.78799

Malmquist productvity index INPUT Oriented DEA Results:

	period	dmu	tfpch	effch	techch	pech	sech
1.	2014~2020	Belawan	.946179	.605758	1.56197	.990028	.611859
2.	2014~2020	Dumai	1.11238	.665726	1.67092	.980861	.678716
3.	2014~2020	Tanjung Priok	1.31545	.840854	1.56442	1.01292	.830126
4.	2014~2020	Palembang	.757188	.510535	1.48313	1	.510535
5.	2014~2020	Tanjung Perak	1.67323	1	1.67323	1	1
6.	2014~2020	Tanjung Emas	1.11038	.710879	1.56197	1	.710879
7.	2014~2020	Makassar	1.35396	.808074	1.67554	.989322	.816796
8.	2014~2020	Balikpapan	1.01211	.693166	1.46013	1.10314	.628355

F. Report of DEA analysis of efficiency in 2020 (Step 4)

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options: RTS(CRS) ORT(IN) STAGE(2)
CRS-INPUT Oriented DEA Efficiency Results:
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	rank	theta	ref: Belawan	ref: Dumai
dmu:Belawan	6	.245713	0	0
dmu:Dumai	7	.217035	0	0
dmu:Tanjung_Priok	2	.403931	0	0
dmu:Palembang	8	.213545	0	0
dmu:Tanjung_Perak	1	1	0	0
dmu:Tanjung_Emas	5	.331057	0	0
dmu:Makassar	3	.375375	0	0
dmu:Balikpapan	4	.340021	0	0

	ref: Tanjung_Priok	ref: Palembang	ref: Tanjung_Perak	ref: Tanjung_Emas
dmu:Belawan	0	0	.110744	0
dmu:Dumai	0	0	.11616	0
dmu:Tanjung_Priok	0	0	.461636	0
dmu:Palembang	0	0	.0569454	0
dmu:Tanjung_Perak	0	0	1	0
dmu:Tanjung_Emas	0	0	.125895	0
dmu:Makassar	0	0	.15015	0
dmu:Balikpapan	0	0	.181344	0

	ref: Makassar	ref: Balikpapan	islack: NOP	islack: NOPB
dmu:Belawan	0	0	0	1.19049
dmu:Dumai	0	0	0	.923165
dmu:Tanjung_Priok	0	0	3.57768	0
dmu:Palembang	0	0	.441327	.882653
dmu:Tanjung_Perak	0	0	0	0
dmu:Tanjung_Emas	0	0	0	.111907
dmu:Makassar	0	0	6.6066	.825825
dmu:Balikpapan	0	0	4.80563	.430693

	islack: NOHT	oslack: SMG	oslack: SHG
dmu:Belawan	.0588326	0	61370.3
dmu:Dumai	.427957	0	70760.9
dmu:Tanjung_Priok	.750158	0	163932
dmu:Palembang	0	0	21049.2
dmu:Tanjung_Perak	0	0	0
dmu:Tanjung_Emas	.0979184	0	73445.5
dmu:Makassar	0	8687.98	0
dmu:Balikpapan	0	0	78617