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Assessing the Technical Efficiency of Container Terminals in Indonesia A Pre and Post PELINDO Merger Analysis

by

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Abstract

In light of Indonesia's ambition to attain developed nation status by 2045, the efficiency of its maritime industry, especially container terminals, has gained paramount significance. This research delves deeply into the ramifications of the merger of PELINDO I, II, III, and IV into the consolidated Indonesia Port Corporation (IPC) concerning the technical efficiency of container terminals throughout the nation. A combined approach of Data Envelopment Analysis (DEA) and qualitative questionnaire distribution was employed to understand the pre and post-merger scenarios comprehensively.

The DEA methodology facilitated a nuanced comparative performance assessment of terminals, unveiling a spectrum of outcomes from the merger. While several terminals showcased enhanced efficiency in the post-merger phase, others encountered hurdles, signifying the merger's varied impact. Qualitative feedback was gathered through questionnaires distributed across various PELINDO divisions to augment the quantitative findings. The stakeholders' narratives painted a multifaceted picture. Many acknowledged the benefits of centralized decision-making and uniform policies, while others expressed reservations regarding potential monopolistic tendencies and challenges in cultural and system integrations.

Furthermore, regional variations emerged as a salient theme, with terminals in strategic and infrastructurally robust areas enjoying a more pronounced post-merger advantage. Conversely, smaller terminals occasionally grappled with the merger's ramifications. On a broader scale, the merger has bolstered Indonesia's positioning within the South East Asian maritime sector, with the IPC standing as a unified and stronger negotiator amidst global partners.

This study, amalgamating quantitative and qualitative insights, offers a holistic understanding of the PELINDO merger's impact, illuminating pathways for stakeholders and policymakers to harness the merger's potential while addressing its challenges in a targeted manner.

Keywords: PELINDO Merger, Indonesia, Container Terminals, Technical Efficiency, Data Envelopment Analysis, Qualitative Analysis, Regional Disparities, Stakeholder Feedback

Table of Contents

List of Tables

List of Figures

Chapter 1 Introduction

1.1 Background

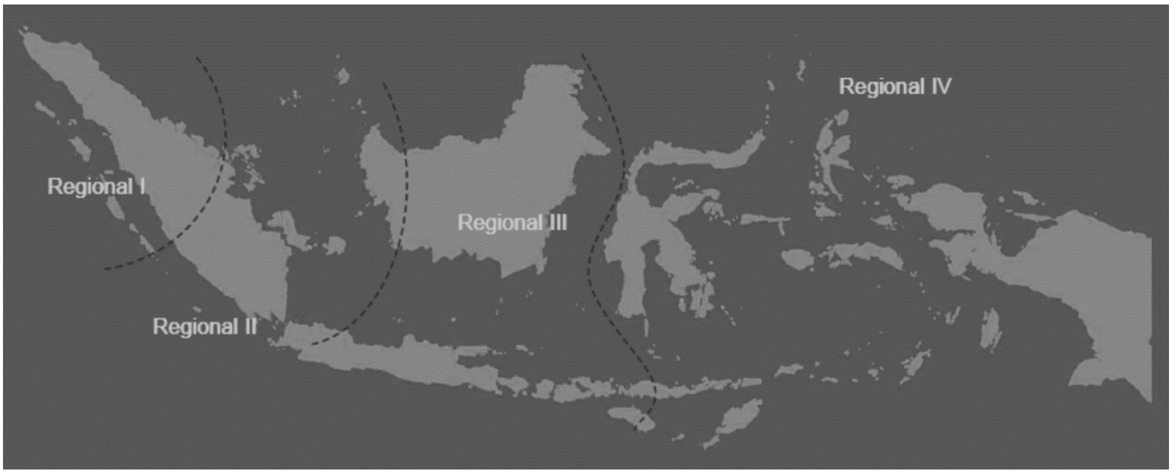
The maritime industry in Indonesia holds a crucial role in supporting the national economic growth that aims to be a developed country in 2045 as stated in long-term national vision. As the world's largest archipelago, Indonesia has vast potential for maritime transportation, especially for containerized cargo that transported a wide range of products and commodities. These are including the manufactured goods, electronics, machinery, textiles, consumer goods, and food products which could be vary depending the hinterland regional economics activities and geographical location. The role of container terminals in Indonesia are critical gateways for national development, connecting the economy of Indonesia to the whole worlds and minimize the disparity of regional development. The Indonesian government believed that container terminal is the key interface between seaborne and land-based transportation which facilitating the movement of goods which could develop the prosperity of the national living standard.

The container terminal has become an essential component of international trade, and its growth has been exponential in recent years. The year 2021 witnessed an 11% increase in containerized cargo growth compared to the previous year, which has drawn significant attention from economists and policymakers worldwide. According to the United Nations Conference on Trade and Development on the Review of Maritime Transport 2022, containerized trade is projected to continue its upward trajectory, with an average annual growth rate of 2.7% for the next following five years. The growth of containerized cargo has significant implications for the global economy, and policymakers need to address the challenges and opportunities associated with this trend. (UNCTAD, 2022). In the case of Indonesia, the port of container across the country was managed by the PELINDO as a state-owned enterprise where it means that the port was managed and controlled by the Indonesian government that hold 95% of container's market share. The company's primary objective is to develop and manage all ports in Indonesian to support the overall national economic growth and maintain the port high standard of competitiveness in the global market.

Therefore, The Indonesian government officially announced the merger of PELINDO I, II, III, and IV in September 2021, as part of a broader effort to streamline, modernize the country's port sector and to catch-up for the global containerized development. The merger is expected to create a more efficient and competitive port system, and to position Indonesia as a major player in the global shipping industry especially as a big nation in South East Asia. The merger strategic as huge step for the Indonesian Government was legally implemented through **Government Regulation No. 101 Year 2021**

Prior to the consolidation of PELINDO I, II, III, and IV, each of these were all separate state-owned port corporations, responsible for the management and operation of various ports and terminals across the country. While there are some similarities in terms of the types of services they provide, each corporation operates independently and has its own port management board and administrative structure. This means that each corporation has its own specific policies, procedures, and operating practices that may differ from the others. Additionally, each corporation may have different levels of efficiency and productivity, as well as varying degrees of operational and financial performance.

Figure 1 shows the Nationwide Operation of Pelindo



Source: Pelindo 2022 by Moody Reports

The merger involves the combination of the four differ into a single entity, known as **Indonesia Port Corporation (IPC)**. The new entity will be responsible for the management and operation of all major ports in Indonesia, including container terminals, bulk terminals, and passenger terminals. The merger is expected to lead to greater coordination and collaboration among the ports, as well as improvements in efficiency, productivity, and service quality.

The merger is part of a broader nation development and effort by the Indonesian government to modernize the port sector and position Indonesia as a major player in the global shipping industry. Indonesia as the biggest ASEAN country and one of the largest archipelagic countries in the world, with more than 17,000 islands and a vast coastline, making it a strategically important location for global trade and commerce. As part of the merger, the Indonesian government has also announced plans to invest in the development of new ports and terminals, as well as in the expansion and modernization of existing facilities. The government aims to increase the capacity and competitiveness of the country's port sector, and to attract more investment and trade to Indonesia

1.2 Problem Identification

The merger of PELINDO I, II, III, and IV into a single entity has raised important questions about the efficiency of container terminals in Indonesia. While the merger was intended to improve productivity by creating a more integrated and streamlined system, it is unclear whether this has been achieved. Moreover, there are concerns about the potential negative effects of the merger, such as increased bureaucracy and reduced competition, which could lead to lower levels of efficiency. Therefore, the main problem that this research seeks to address is whether the merger of PELINDO I, II, III, and IV into a single entity has had a positive impact on the efficiency of container port in Indonesia. In order to address this problem, it is necessary to conduct research by measuring the technical efficiency of container terminals both prior and post the period of merger, using a methodology such as Data Envelopment Analysis (DEA).

1.3 Research Question and Objectives

Based on the background regarding the projected containerized cargo and the merger of the PELINDOs into single entity, this research paper came with main research question:

What is the impact of PELINDO's I, II, III, and IV merger into Indonesia Port Corporation (PELINDO) as single entity on the technical efficiency of the container terminal?

In addition to uphold the primary question and provide a better and wider concept and understanding for this thesis research, we provide several sub research questions:

1. What is the geographical market and port administrative distribution between PELINDO I, II, III, IV?
2. What were the economic, political, and strategic reasons for the merger of PELINDO I, II, III, and IV into a single entity?
3. What are the changes in the organizational structure, governance, and management practices of the container terminals following the merger?
4. How have the PELINDO employees on various divisions related to the container terminal responded to the merger?
5. What were the expectations and predictions of the stakeholders and experts regarding the impact of the merger on the efficiency and competitiveness of the container terminals?

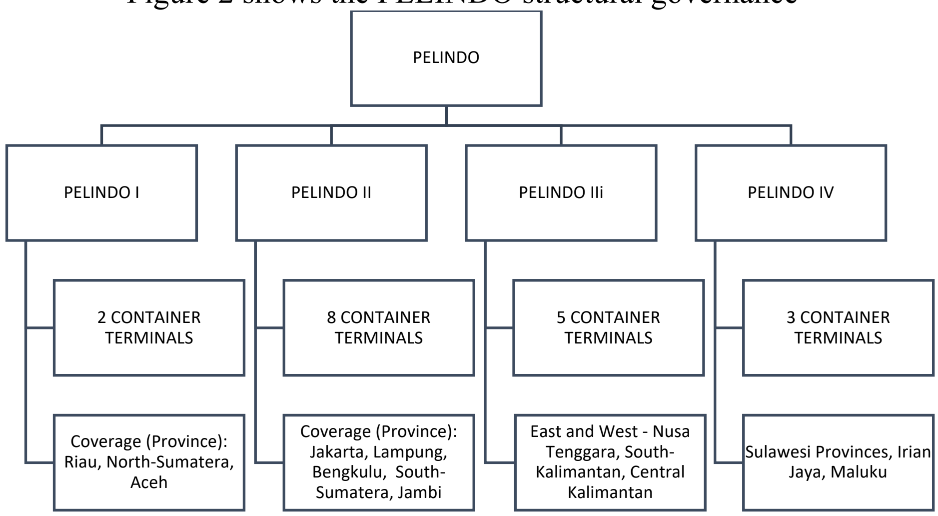
This study of PELINDO considers the complete list of Indonesian Container Terminal that divided into four-state enterprises. Hence, the objectives for this research are mentioned as follows:

- To measure/calculate the Indonesian container terminal relative efficiency of 17 container terminal in the period of year 2020 and 2022 using cross-sectional where data available and to determine total factor productivity through the examination of panel data
- Classify based on the analysed data of the container terminal into low or high-performance terminal and identify consistency the container terminal performance.
- To seek a valuable insight for the shareholders and decision-making board to be able concentrate on the low-performance port that possibly could follow the best implementation from the high-performance ports in terms of scale/ and technology.

1.4 Scope and Limitation of the Research

This thesis which concentrates to analyse the technical analysis related to the container terminal efficiency to the selected container terminals in Indonesian which classified into several level. Therefore, there will be only 17 container terminals that will be included in this research as the limitation of the scope.

Figure 2 shows the PELINDO structural governance



Source: author elaboration based on PELINDO Reports

The selected container has several classes namely Main Class, Subsidiary, Class I, Class II, and First A Class, and First B class. Every container detail will be reviewed later on the next chapter that will be followed by the class on each port, port administrative, and status. The year of 2020 and 2022 will be use as the based data period that going to be used for this research that will be relevant as the year before and after the merger of the PELINDO.

In order to evaluate and analyse the technical performance required input and output variables as the benchmarking indicator to seek the efficiency among the terminals. The scope for the input are namely: quantity of equipment in the yard, quantity of quay cranes, the length of quay (m), and the draft of the port (m). In the other hands, the annual throughput in TEUs will be used as output variable.

1.5 Research Methodology

To investigate the technical efficiency of container terminals in Indonesia by analyzing their historical performance data. The efficiency analysis will be conducted using the Data Envelopm\ent Analysis (DEA) model, which is a well-established and robust approach for measuring the relative efficiency of decision-making units (DMUs). Specifically, the study will employ the CCR and BCC models to determine the technical efficiency of each container terminal. The CCR model implies constant returns to scale, while the BCC model allows for variable returns to scale. Moreover, this study will also calculate the scale efficiency of each container terminal, which measures the degree to which a DMU is operating at an optimal scale.

To perform the DEA analysis, the study will use supporting software such as Python, Stata, R Studio or Excel, which have the capability to implement the DEA model. This approach allows for a systematic and objective evaluation of container terminal each performance. By analyzing the efficiency on each terminal, this study will identify the strengths and weaknesses of their operational performance and provide valuable insights for improving their efficiency.

As a quantitative research method, this study will analyze each value for each container terminal, providing a comprehensive evaluation of their technical efficiency. The results will allow for a comparison of the performance of different container terminals and identify the most efficient ones. Moreover, this study will provide a benchmark for future evaluations of the container terminal efficiency in Indonesia, which can help in tracking progress over time.

To enhance the research quality and achieve a comprehensive analysis, a qualitative analysis will be conducted on several related division that has a direct influence for the technical efficiency of the terminal. This part will involve secondary qualitative analysis from various literature review and distributing digital questionaries associate with terminal performance. The objective of conducting a qualitative analysis through the distribution of questionnaires to port shareholders is to gain an understanding of the subjective experiences, opinions, and perceptions of these individuals regarding the container terminal's performance. By collecting data on the views and perspectives of stakeholders, the research can gain a deeper insight into the strengths and weaknesses of the container terminal and identify potential areas for improvement.

By engaging with these stakeholders and soliciting their feedback, the research can identify critical factors that affect the performance of the container terminal, such as service quality, operational efficiency, infrastructure, and regulatory issues. Both combination results of the qualitative analysis with the quantitative analysis expected to develop richer understanding of the container terminal's performance and identify specific areas for improvement in Indonesia.

1.6 Thesis Structure

The research for the technical efficiency in the Indonesian container terminal under PELINDO will consist of six chapters. The brief description about each chapter will be explained in the following table:

Table 1 shows the research structure through all chapters

Chapter Number	Description of Content
Chapter 1 Introduction	This chapter provides an introduction to the study, including the background, problem identification, research question and objectives, scope, research limitations, research methodology, and thesis structure.
Chapter 2 The Literature Review	This chapter covers an overview of general understanding of container, port of container state In Indonesia, the merger of PELINDO I, II, III, and IV, container terminal facility, operational performance, efficiency of operational performance, indicators of efficiency performance measurement, sustainable development, Data Envelopment Analysis (DEA), DEA applications for benchmarking container terminal, DEA research on container terminal, and Malmquist Productivity Index (MPI)
Chapter 3 Research Methodology	This chapter describes the research framework and design, identification of input and output, sample size and duration for DEA, and data collection, including profiles, port specifications, and operational performance for each PELINDO terminal.
Chapter 4 Data Processing and Analysis	This chapter covers the data processing and analysis using DEA, including the initial analysis for 2020 and analysis after the merger in 2021/2022, efficiency and inefficiency status, CCR and BCC efficiency vs throughput, and Malmquist Productivity Index (MPI) calculation.
Chapter 5 Conclusion and Suggestions	This chapter provides a conclusion to the study, areas for further research, and recommendations for improving container terminal efficiency and productivity in Indonesia.

Source: author own elaboration

Chapter 2 – The Literature Review

The seconds chapter aims to provide a broad-ranging analysis of the core concepts, trends, and methodologies pertinent to the research study. The discourse begins with an exploration of the container's role as a cornerstone in global trade and logistics, followed by an in-depth examination of terminal container facilities, detailing these crucial infrastructures' major components and functionalities.

Subsequently, an overview of the Indonesian Port Corporation's (IPC) container terminals across Indonesia is provided. This perspective is particularly important as it sets the stage for the ensuing discussion on the merger of PELINDO I, II, III, and IV. The merger's implications for operational efficiency and the industry's broader landscape are analysed comprehensively.

This thesis delves into measuring operational efficiency within container terminals, a critical determinant of performance and profitability. Specific indicators used in gauging efficiency performance and benchmarking practices are evaluated in this regard. As the narrative progresses, the spotlight shifts towards the intersection of port efficiency and sustainable development. It highlights the increasing significance of integrating environmental considerations into operational practices.

Following this, Data Envelopment Analysis (DEA) is introduced as a powerful tool for efficiency analysis. The fundamentals of model orientation and linear programming within the DEA framework are thoroughly explained. The latter part of this chapter canvasses the wider field of DEA research on container terminals globally and specifically within Indonesia. It affords invaluable insights into the applications and outcomes of DEA in this context.

At the end of this comprehensive literature review, the Malmquist Productivity Index (MPI) is presented as tool for tracking productivity changes over time in selected period of time. This discourse provides a firm foundation for the subsequent empirical investigation, grounded on the intersection of theory and practice.

2.1 Container

A container, as defined, is a large, standard-sized, weather-resistant cuboid constructed from steel, primarily designed for transporting and storing goods. It facilitates long-distance transportation and the smooth transition of goods from one kind of mode of transport to another without the need for unloading its contents (Kramadibrata, S, 1977). Containers are standardized steel boxes shaped freight carriage used for the secure transport of goods globally which is described by the Custom Convention on Container (1972). They were introduced in the mid-20th century, revolutionizing the shipping industry by allowing the efficient and streamlined transfer of goods between the different modes/types of transportation, such as from ship to rail or truck, in a process known as intermodal transport. Container sizes are typically measured in twenty-foot equivalent units (TEUs), with standard lengths of 20 or 40 feet. Containers protect goods from weather and theft, and their uniform dimensions mean they can be stacked and handled efficiently, greatly reducing the time and cost of cargo handling.

2.2 Container Terminal Facility

Container terminals exhibit distinct features compared to traditional ports or terminals. Their primary purpose revolves solely around facilitating the loading and unloading of container ships. These terminals are furnished with tailored infrastructure and various equipment to accommodate the specific demands of container movement handling, particularly given the fast turnaround times associated with container vessels. Ensuring an efficient operational tempo necessitates the availability of adequate facilities and machineries to uphold the time required (speed) of loading and unloading operations. Therefore, improving the operational performance and overall efficiency of the container port is crucial. The specific port of container terminal facilities which are essential consist of:

2.2.1 Quay Wall

The quay wall at a container terminal fundamentally shares similarities with those found at other ports; typically, they are built from concrete and include a rail line on the quay surface to position quay cranes for container loading and unloading operations. Several designs are available for quay walls, such as deck on pile and caisson. These designs are contingent upon factors like the terminal's location, the quay's capacity, and the investment allocated for the terminal's construction.

The distinctions between a conventional port and a container terminal primarily reside in the dimensions of the quay. Container terminals require larger quay sizes to accommodate loading and unloading operations and enable equipment's manoeuvrability. The terminal's design includes a deeper draft and the capability to accommodate larger loads, considering that container ships are generally longer and heavier than other ships of cargo. Similarly, the design of dock floor needs to be sturdy. Bigger in size of container cranes are usually placed above the quay, necessitating for higher load-bearing capacities for the dock ground.

2.2.2 Container Yard

The container yard is a fundamental area within a container terminal, serving as a crucial hub for the transfer and storage of containers. Its primary function is to act as a temporary storage location for containers awaiting transfer between different modes of transport, such as from ship to truck or rail, and vice versa. The organization and management of the container yard can significantly impact the efficiency of a terminal's operations, affecting cargo dwell time, yard space utilization, and the productivity of handling equipment.

Container yards typically consist of several designated zones or stacks, each designed for a specific type or class of container, such as import, export, or transshipment containers. Efficient yard management includes optimizing container stacking strategies to minimize reshuffling and promote rapid turnaround. Advanced terminals may employ automated systems to improve efficiency further, such as ASC (Automated Stacking Cranes) or AGV (Automated Guided Vehicles) for container transport within the yard (Vis & De Koster, 2003). Additionally, modern terminal management systems utilize data-driven techniques, such as artificial intelligence and machine learning, to optimize yard planning and operations, contributing to increased terminal efficiency and competitiveness

2.2.3 Container Handling Equipment (Waterside)

The primary role of waterside equipment lies in facilitating the transfer of containers from the ship to the dock during the operation/processes of loading and unloading. The necessary equipment for waterside operations comprises the following:

1. Container Crane

   Also known as shore to ship (STS) cranes, they are integral components of a container terminal's operations on the waterside. These large, specialized cranes are utilized for the operation on loading and unloading of the containers between the dock and the container vessel (Notteboom and Rodrigue, 2009).

   Three main types of container cranes are classified according to the size of the ship they can handle: Super Post-Panamax, Panamax, Post-Panamax, and. The classification is based on the maximum ship size that can pass through the Panama Canal (UNCTAD, 2014).

2. Container Spreader

   A container spreader is an indispensable piece of equipment for container handling operations at terminals. This tool, specifically designed for the safe and efficient transport of containers, engages with the corner fittings found on top of each unit. Telescopic spreaders, a common variety, adjust their length to cater to different container sizes (20ft, 40ft, and 45ft), adding an element of flexibility vital to modern terminal operations that encounter a range of container sizes. The efficiency and reliability of a spreader are pivotal factors influencing terminal productivity. With the progression of technology, modern spreaders now incorporate advanced features such as automatic container size recognition, damage prevention systems, and remote monitoring capabilities. This advancement towards automation and 'intelligence' paves the way for enhanced safety and operational efficiency in container terminals.

2.2.4 Container Handling Equipment (Landside)

Landside operations of a container terminal are horizontal integration to maintain an efficient flow of containers, involving several specialized pieces of equipment tailored to handle containers safely and effectively (sea, rail, and road). Therefore, the types of equipment categorized on the landside are mentioned below:

1. Container Trucks:

   Container trucks, or haul trucks, play a critical role in transporting containers between the terminal and external destination that has high intramodality due to the ability to manoeuvre. These trucks usually come in various sizes, with the capacity to carry different sizes of containers, including 20, 40, or 45 feet.

2. Reach Stackers

   These are another key component of landside equipment as large vehicles that capable of lifting and moving containers with great precision. With the specification to stack containers up to high of six and reach into adjacent rows, they offer flexibility and are especially useful in terminals where space may be a limiting factor.

3. Automated Guided Vehicles (AGVs):

   AGVs are modern driverless vehicles within the port that are used to move/transport containers from one area to another area. Guided by a system of lasers, GPS, or a similar technology, they move containers between the quay and the yard or between different locations within the yard. The use of AGVs can significantly increase efficiency and reduce operational costs in the long run, making them an increasingly popular choice in modern, automated container terminals.

4. Straddler Carrier

   A straddle carrier is a specialized vehicle frequently deployed in terminals for the transport and stacking of containers from quay to landside or to the designated stacking zone. It functions as a gateway vehicle, capable of collecting, elevating, and positioning the container as needed. The process of operation securing, elevating, and moving the container by surrounding the load, with a container spreader providing a secure lock during the movement of container box. This equipment possesses the capacity to stack containers to a height of up to four tiers (Wikipedia, 2018). Its key advantage lies in its ability to perform loading and unloading tasks without the need for additional handling equipment like as forklifts or cranes. In some of the terminals, straddle carriers have been automated, eliminating the need for a human operator, hence termed Automated Straddle Carriers (ASCs)

2.2.5 Container Handling Equipment (Stacking Yard)

These particular equipment on this area forms the backbone of the stacking yard operations in a container terminal, facilitating efficient and safe container handling, storage, and retrieval.

1. **Side Loaders**

   Side loaders, also known as side lifters, are specialized trucks equipped with cranes on either side of the vehicle chassis, enabling them to lift and transport containers in a parallel orientation. Their design offers superior flexibility for loading and unloading containers directly from the ground or another vehicle, particularly in constrained spaces or during off-site operations. In the stacking yard, they are often used to move containers to and from the stacks or between different terminal sections.

2. **Container Forklifts**

   Container forklifts are versatile equipment capable of lifting and transporting containers around the stacking yard. They are equipped with a special attachment, known as a container handler or spreader, which can securely grasp the top corners of a container. Container forklifts are highly manoeuvrable and especially valuable for handling empty containers or actions in smaller terminals where the equipment may not be feasible.

3. **Rubber Tyred Gantry (RTG) Cranes**

   RTGs are mobile cranes that straddle multiple lanes of containers, allowing them to lift and move containers within the stacking yard. They can stack containers several units high and can traverse long distances within the terminal. RTGs bring high flexibility and efficiency to stacking yard operations and are widely used in large container terminals.

4. **Rail Mounted Gantry (RMG) Cranes**

   RMGs, on the other hand, are gantry cranes that move on rails rather than tires. They offer a greater lifting height and capacity than RTGs, making them suitable for terminals with high-density container stacking. Their operation is usually more energy-efficient and requires less maintenance than RTGs. However, their movement is restricted to their rail tracks, reducing their flexibility in terms of lateral movement.

2.3 Overview of IPC Container Terminal in Indonesia

In 2022, Indonesia Port Corporation, a prominent terminal operator company, reported a container throughput of 11.16 million TEUs, marking a 1.08% increase compared to the 11.04 million TEUs recorded in 2021. However, this figure falls short of the company's target of 11.65 million TEUs. According to Widyaswendra, various factors contributed to the unmet target, including the ongoing conflict between Russia and Ukraine, which affected foreign containers, and the closure of ports due to lockdown policies in some Chinese cities, which impacted Indonesia's export and import flow. (Corporate Secretary of IPC)

Additionally, domestic container traffic experienced a decline attributed to adverse weather conditions in several Indonesian regions. In 2022, foreign container flow reached 3.48 million TEUs, achieving 94.28% of the 3.66 million TEUs target, representing a 2.04% increase from 2021's 3.41 million TEUs. Simultaneously, domestic containers accounted for 7.67 million TEUs, or 96.1% of the 7.98 million TEUs target, with a 0.65% growth from 2021's 7.62 million TEUs. (IPC, 2023)

IPC anticipates further container flow growth in 2023, setting a target of approximately 11.53 million TEUs. The company will focus on the operational transformation of container terminals as its primary program for 2023, aiming to increase productivity and reduce port stay times. This initiative will involve the enhancement of terminals such as TPK Pantoloan, TPK Kendari, TPK Jayapura, TPK Bitung, TPK Kupang, and TPK Tarakan. Other endeavours include digitalization and systematization of terminal container operations, asset optimization, and port development through strategic partnerships.

Emphasizing the potential for cargo containerization to increase the volume handled and distributed to its hinterland, particularly in eastern Indonesia, requires improvements to several ports in the region that can ensure to facilitate container activities. Eastern Indonesia's potential for container loads, particularly in the marine and fisheries sectors, depends on regional ports' ability to handle container loading, unloading, and refrigeration facilities. Moreover, increasing overseas container flows entails the development of terminals that function as transhipment hubs. Comprehensive stakeholder involvement, including the government, is essential to establish a robust ecosystem encompassing bunker facilities, berthing locations, financial and payment systems, and ship pilotage and towing. Strengthening this ecosystem is crucial to compete with neighbouring countries dominating the market in the Malacca Straits. (Siswanto, 2023)

2.4 The merger of PELINDO I, II, II, IV

Trans-organizational transformations within PT Pelindo I, II, III, and IV have garnered concurrence from governmental bodies and significant stakeholders, primarily intending to diminish logistics costs. The basic background of the merger is the government's target to improve Indonesia's logistics costs which have ballooned by 23%, from an average benchmark of 12%. Far different from neighbouring countries like Malaysia with a logistics cost of 13%. Even though the detail cost of sea logistics is only 2%, it turns out to be one of the main issues causing less than optimal national logistics cost (Hendra Birawa, 2022)

Given PT Pelindo's pivotal role in maintaining the logistics distribution chain, these alterations are critical in boosting national economic progress. The unification of operations across various organizations sharing the same heritage and objectives expected to exploit greater opportunities and enhance efficiency in performance management. This process of trans-organizational change within Pelindo has been labeled the Mergers Strategy. This strategy denotes integrating two or more formerly independent organizations into a singular, corporate entity. Several general objectives have prompted the need for a merger of the Indonesian ports, which include diversification, horizontal integration, expansion of access to global markets, technology, and other resources, and the pursuit of operational efficiency, innovation, and resource sharing. The process of integration or merger might appear simple, but it is crucial for all parties involved to understand that the merger encapsulates differing cultures, regulations, and technologies. Each of the port corporation holds its unique identity, which must be blended seamlessly during the process. Therefore, it is emphasized that none of this port corporations, whether Pelindo I, II, III, or IV, should perceive itself as the "leading" entity. (Fendy Suhariadi,2021)

To fully exploit the potential benefits of the merger while mitigating potential challenges, PELINDO requires the backing of all stakeholders and employees. As such, extensive engagement activities have been carried out with key stakeholders, including the Indonesian Parliament, the Ministry of State Secretariat of the Republic of Indonesia, Bappenas (Ministry of National Development Planning of the Republic of Indonesia), the Coordinating Ministry for Economic Affairs of the Republic of Indonesia and other organizations. The proposed merger of Pelindo is perceived to yield opportunities not only for the government but also for the broader community and its employees. There are four main objectives of these corporate transformation mentioned below:

- A decrease in logistics cost by approximately 0.3% by the year 2024.
- An enhancement in the efficiency of marine logistics and inventory cost

- The establishment of approximately 1,500 job opportunities between the years 2021 to 2025, owing to port development in cooperation with potential partners.
- An annual increase in Gross Domestic Product (GDP) by 0.4% over the period of 2021-2025, also attributed to port development in collaboration with potential partners.

The merger generates high value for the government, society and employees. But of course, to achieve these values there are challenges along with opportunities, there are change strategies that need to be finalized, and there are employees who need to be convinced. The term merger is not just 1 port corporation + 3 others corporations equal to 4, mergers can have huge implications for the whole ecosystem of the corporations. Therefore, after the merger there needs to be a continuous evaluation regarding the change strategy and the operational performance trend accompanied by the business transformation process. In carrying out strategies in business, movers need to understand how their digital strategy is. This is because the digital strategy will affect the opportunities as well as challenges in operations in the current era. If depicted in the form of diagrams, organization and processes will shape flexibility, processes and digital technology will shape efficiency, organization and digital technology will shape effectiveness. Then if flexibility, efficiency, and effectiveness are combined, the company will achieve operational excellence (Author, 2023).

2.5 Technical Efficiency

The concept of technical efficiency, pivotal in operations and production management, refers to an enterprise's capacity to derive the maximum possible output from a specified set of inputs (Coelli et al., 2005). An enterprise is technically efficient when minimizing resource usage to generate a particular volume of goods or services. If an enterprise can either minimize any input while maintaining constant output or maximize output with constant inputs, it demonstrates signs of technical inefficiency.

The concept of technical efficiency is intrinsically linked with the production function, which maps the correlation between the physical output of a production process to its physical inputs (Farrell, 1957). The achievement of technical efficiency corresponds to an organization operating on its production function. Conversely, an operation below the production function is technically inefficient, as it indicates a potential for increased output with the same inputs or the ability to maintain the same output with decreased inputs.

Particularly in sectors with high costs and thin margins, technical efficiency gains paramount importance. Minimization of resources leads to cost reductions and augmented competitiveness

(Kumbhakar & Lovell, 2000). From an environmental standpoint, technical efficiency is crucial, resulting in decreased waste and diminished environmental impact, which are critical in the present sustainability-focused world.

2.6 Efficiency of Operational Performance in Container Terminal

Container terminals, serving as trade facilitators and vital links in the logistic chain, prioritize efficiency, especially regarding the allocation and utilization of finite economic resources (Wang, Song, & Cullinane, 2002). Efficiency augments the terminal's capability to draw in clients in the short run by offering competitive pricing. Concurrently, long-term terminal development is crucial for recovering costs associated with the investment (Wang & Cullinane, 2006). Therefore, terminals must enhance their productivity and continually assess and maintain efficiency to prevent undesirable situations.

Evaluating efficiency levels in port operations has gained significant importance, as efficiency catalyzes port competitiveness and regional development (Merk & Dang, 2012). Merk and Dang (2012) argue that due to the advent of technologies development in the shipping industry and trends like containerization and integrated logistics services, clients exert pressure on seaports to develop and implement technologies that can reduce logistic chain costs. Ports are urged to continuously seek efficiency to remain appealing and maintain the port utilization by offering their competitive advantages within the market. The whole operational activities must have to be improved for the port's attractiveness to safeguard their numbers of vessel call traffic and to vie with the proximate competition. These emerging challenges encompass swiftly handling container activities by availing sufficient, high-performing equipment and tackling infrastructure issues such as berth times, delays, yard capacity for container stacking, and securing hinterland connectivity influenced by inland multimodal transportation. The impact of port efficiency is not confined to goods traffic and port users; neighboring regions also reap its benefits. Both the direct and the indirect access to associated activities, including financial aspect, reduced pricing, maritime premium insurance, and others, results from port performance efficiency, adding value to the overall supply chain. Thus, the most obvious advantages for surrounding port area is the conception of employment opportunities for residents around and local community.

Modern customers demand flexibility, reliability, speed, and affordability (E.-S. Lee & Song, 2010). As E.-S. Lee & Song (2010) outlined, these aspects are intrinsically tied to an organization's effectiveness and efficiency. Consequently, the worth of logistics within the maritime sector could be engendered through operational effectiveness and efficiency, which invariably impacts the certain level of service and the feedback from the customer satisfaction. The efficiency level gauges the degree of resource utilization within an organization, while effectiveness is primarily concerned with future-oriented goals and targets set according to the organization's strategic vision. When measuring efficiency within the logistics sector, four components are considered: reliability, costs, responsiveness/flexibility, and assets. Both for the cost and assets elements evaluate efficiency, while reliability and responsiveness/flexibility assess effectiveness. E.-S. Lee & Song (2010) have developed a method for quantifying effectiveness and efficiency in the mode of transport logistics sector, as presented in table below. As for the transport logistics sector encompasses maritime logistics, this conceptual framework can be feasibly applied to assess the value of the logistic within the maritime.

Table 2 shows The Evaluation Effectiveness and Efficiency in the Transport Logistics Sector

Logistic Process Component	Evaluation Standards	Performance Markers
Efficiency Oriented (Internal Facing)	Cost	1. Comprehensive logistics management expense 2. Productivity metrics 3. Cost of processing returns
	Asset Management	1. Cash-to-cash cycle duration 2. Days of inventory supply 3. Asset turnover rate
Effectiveness Oriented (Customer Facing)	Reliability	1. Delivery success rates 2. Order fulfillment rates
	Flexibility & Responsiveness	1. Perfect order fulfillment rate 2. Response duration 3. Flexibility of production

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

2.7 Indicators for Measuring Efficiency Performance and Benchmarking

In the operational domain of organizations, particularly ports regarded as Decision-Making Units (DMUs), efficiency performance takes on an imperative role. The primary virtue of efficiency performance assessment is its capacity to analyze production enhancements as it evaluates the starting state and future performance. This form of evaluation furnishes valuable information that can guide recommended actions to improve or maintain performance based on the outcomes of these performance measurements. However, it is crucial to note that if performance measurements are improperly defined, they can unintentionally misguide the system (Cullinane et al., 2004).

Conventionally, performance of port was assessed by investigating the productiveness of cargo handling at the berth. This process typically involved a singular productivity factor and compared the actual throughput with the prospective business blueprint over the designated period of time range (Cullinane et al., 2004). As Talley (2006) expressed, "Historically, ports has appraised their performance indicator by juxtaposing the actual and ideal throughput value (gauged in tonnage/volume of container being managed)." Moreover, evaluating the actual throughput of a port with its ideal throughput effectively quantifies intra-port performance (Marlow & Paixão Casaca, 2003). Notably, throughput is a widely embraced metric to ascertain port performance. However, this measure does not encompass the economic implications of the port's existence on regional growth or its attractiveness as a site for port ecosystem-related industries (P. de Langen, Nijdam, & Horst, 2007). Bichou & Gray (2004) also contended that the port measures traditionally concentrate more to the sea-pivotal leg link than the land- pivotal leg, hence, advocating for an improved appraisal of land-side efficiency.

As proposed by UNCTAD in the 1976 and summary conducted by Marlow & Paixão Casaca (2003), conventional port performance metrics encapsulate productivity and efficacy as delineated in Table 3..

Table 3 shows the performance indicator on the port

Operational Indicator	Financial Indicator
1. Service time 2. Turn-around time 3. Arrival rate 4. Fraction of time berthed ships worked 5. Tonnage per ship 6. Waiting time 7. Number of gangs employed per ship per shift 8. Tons per ship-hour in port 9. Tons per ship-hour at berth 10.Tons per gang hours 11.Fraction of time gangs idle	1. Cargo handling revenue per ton of cargo 2. Capital equipment expenditure per ton of cargo 3. Berth occupancy revenue per ton of cargo 4. Tonnage works 5. Contribution per ton of cargo 6. Labor expenditure 7. Total contribution

Source: UNCTAD (1976)

Bichou & Gray's (2004) proposition divides port efficiency into three distinct segments: physical parameters, the factor of productivity parameters, and economics and finance parameters. The concrete physical parameters relate to measurements of ship time, including factors like the turnaround of ship in time, time the ship spends waiting, the berth occupancy rate, the duration of operation at berth, and measurements of time-related to coordination with land-side party, as of the time of dwelling. The parameters of factor productivity are concerned with the evaluation of labor and capital committed to the handling of goods. On the other hand, economic and financial parameters generally focus on the totality of income and expenses linked with the maritime segment.

Expanding the perspective, Chung (2005) views the performance of a port as a combination from operational metrics (Specifically as the speed of vessels, the rate of cargo, and the time taken for handling cargo), utilization of assets, and financial performance. The specifics of these indicators deployed in this analysis are illustrated in the subsequent table:

Table 4 shows the performance indicator on port by combination of involved operation

No.	Indicator
1.	Average ship turnaround time
2.	Average tonnage per vessel day (hour)
3.	Average vessel time at berth
4.	Average vessel time outside
5.	Average waiting (idle time)
6.	Average waiting rate
7.	Tons per gang hour
8.	TEUs per crane (hook) (hour)
9.	Dwell time
10.	Berth throughput
11.	Throughput per linear meter
12.	Berth occupancy rate
13.	Berth utilization rate
14.	Income per GRT of shipping
15.	Operating surplus per ton cargo handled
16.	Rate of return on turnover

Source: Chung (2005)

In addition, the indicator of productivity form the foundation for assessing the performance of container terminals. These are typically divided into categories such as gate, crane, yard/storage, berth, and gang/stevedore, as proposed by Kasypi & Shah (2007). For clarity, these performance indicators can be represented in the succeeding table below:

Table 5 Indicators for Port Analysis Considering Terminal Productivity

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

Source: Kasypi & Shah (2007)

In the performance view of port services, which extends to vessels, cargo, and inland transportation, performance cannot be gauged merely based on single-factor productivity

(Cullinane et al., 2004). Given the composite production attributes of ports, a comprehensive performance assessment should involve an array of indicators.

The Frontier statistical model presents a valuable framework for measuring the technical efficiency of a multi-port performance by scrutinizing both the throughput (as for the output) and resources (as for the input). Technical efficiency is realized when a maximum throughput value is achieved against a defined level of resources. In contrast, a scenario where the throughput is less than the maximum for a particular resource level signals technical inefficiency (Talley, 2006).

Among various methodologies, Data Envelopment Analysis (DEA) is frequently employed in port performance analysis due to its capacity to incorporate multi-inputs and multi-outputs. As Talley (2006, p. 512) defined, DEA is a "non-parametric mathematical programming technique which facilitates the formulation of the frontier model."

The current globalized world, ports are subject to vigorous competition, necessitating robust performance strategies to retain user satisfaction and increase market share. Sometimes, capacity enhancement via constructing new terminals becomes an unavoidable requirement. However, before executing such investment decisions, it is vital to analyze the maximal usage of the current facilities compared to the maximum output they can generate. This concept lends itself to the model of output-oriented as a benchmark in the term of the container terminal case (Cullinane et al., 2004).

Establishing port performance indicators facilitates performance assessment by comparing the actual and optimal metrics. From an economic viewpoint, port management has the ability to manipulate these performance indicators (or choice indicators) to optimize operational objectives. To maximize profit, port management should choose variable values that lead to the most significant profit. These variable values are referred to as benchmarks or indicator standards. As Talley (2006, p. 507) noted, "When the actual indicator values approach (or deviate from) their respective standards over time, it signifies an improvement (or deterioration) in the port's performance concerning the specified economic objective."

Seaports in Europe apply to benchmark their performance against rivals, a strategy adopted in response to the intensifying modal competition (Barros, 2006). Similarly, amidst transformations in port operations, Italian seaports are making concerted efforts to amplify input efficiency by benchmarking their operations against those of the leading ports (Barros, 2006). The DEA, as of a linear programming method/technique capable to use in handling multi-inputs and also multi-outputs, is useful for identifying benchmarking targets for seaports with room for efficiency improvements.

The intensified inter-port and intra port competition has urged port managing body to scrutinize their overall performance for optimal efficiency. Considering the significant expenses involved in infrastructural development and land utilization, this becomes even more crucial. One commonly used method for assessing terminal performance is benchmarking, i.e., comparing it with ports demonstrating superior performance. This process is affected by three determinants (Rankine, 2013):

1. Terminal size and trade: The Benchmarking have to ideally start with competitors of similar size.
2. Local attributes such as navigational factors, the configuration of the terminal, and connections to the hinterland.
3. Reference points for measurement may include labor productivity, service level, capital, and tariffs.

A multitude of factors can affect the productivity and efficiency of a terminal. In this context, benchmarks serve as standards since they are considered the most efficient Decision-Making Units (DMUs) — in this specific case of the port. Hence, performance of port could being assessed and evaluated longitudinally by referencing these performance benchmarks to uphold its current level or strive for improvements.

2.8 Port Efficiency and Sustainable Development

The connection between the efficiency of container terminals and sustainable development is substantial, as proficient operation of these terminals can considerably augment environmental sustainability. This premise originates primarily from the role of container terminals as key contributors to CO2 emissions, resulting in environmental contamination and global warming. Thus, it is imperative to curtail these emissions and energy consumption at the container terminal to alleviate their environmental consequences. This viewpoint has gained worldwide acceptance, leading to the construction of contemporary container terminals under the "green port" concept, advocating environmental sustainability, judicious resource use, minimal energy consumption, and reduced emissions.

Numerous container terminals have initiated plans focused on energy efficiency and emission reduction. These strategies often incorporate technological advancements such as electrifying container handling equipment, devising power conservation strategies for refrigerated containers, and employing alternative fuels or renewable energy sources. To estimate their carbon emissions, ports across the globe employ diverse methodologies, such as air emission inventory techniques and activity-driven emission models. Moreover, straightforward methods are also suggested, like estimating carbon emissions based on vessels' travel distance, considering all components in the port. Other methodologies concentrate on approximating vehicle pollution factors according to geometric and traffic conditions, factoring in the vehicle's primary activities and journey duration. Emission reduction is frequently gauged based on the energy consumption of various equipment like rubber-tired gantries, automatic stacking cranes, and yard trucks. Utilizing renewable energy sources for container handling equipment has demonstrated substantial emission reduction1.

Despite these efforts, the influence of terminal layouts on energy consumption and CO2 emissions remains relatively underexplored. Existing research on container terminal layout design predominantly centers around resource allocation, block length or width optimization, and choice of operating technologies, but not necessarily energy consumption and emissions. However, certain studies have indicated the significant influence of container terminal layouts on these factors. For instance, container terminals with parallel array layouts have demonstrated up to 12% improved performance in terms of container throughput time relative to terminals with upright stack configurations. This indicates that a container terminal's physical layout can impact its efficiency and environmental footprint. (M. Arif Budiyanto et al,, 2021)

The research context of their study aims to assess the energy consumption and CO2 emissions in diverse container terminal layouts. Two significant Indonesian container terminals were considered as case studies, revealing considerable variations in energy consumption and CO2 emissions based on the container terminal layout. The research also authenticated an estimation model of CO2 emissions in container terminals utilizing the movement-per-modal method and emissions derived from energy consumption.

2.9 Data Envelopment Analysis (DEA)

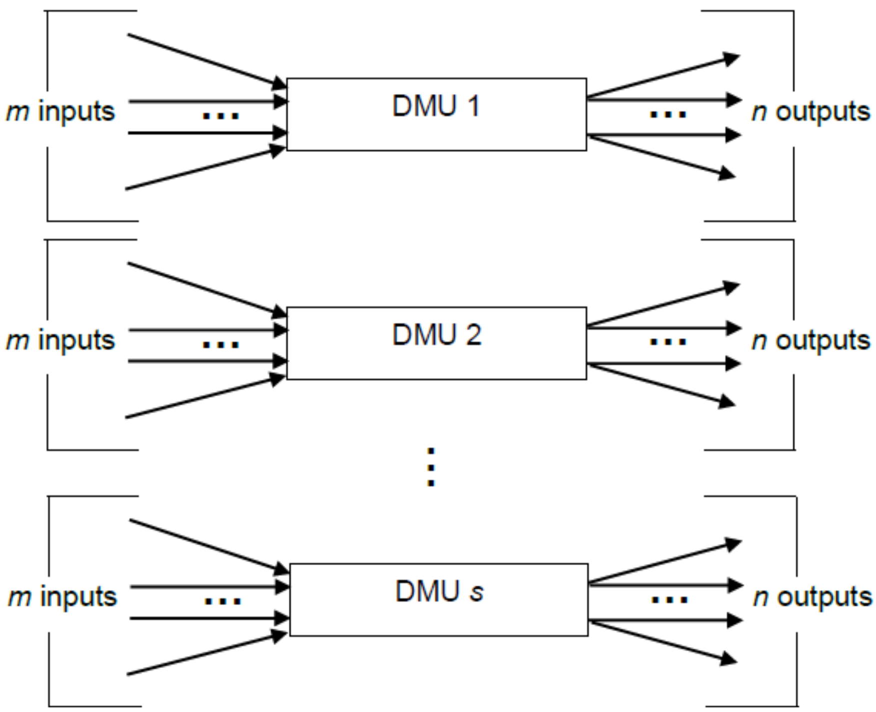
The DEA, as a non-parametric LP (Linear Programming) technique/method in operational research and economics, has been applied broadly to estimate production frontiers and measure relative efficiency among Decision-Making Units (DMUs) with multi-inputs and multi-outputs (Charnes, Cooper, & Rhodes, 1978). Firstly, the initial introduction by Charnes, Cooper, and Rhodes in the peiod of late 20th century marked a significant advancement in the field of efficiency evaluation.

The inception of DEA could be trace back to the work of Farrell in 1957, who first proposed a measure of efficiency that accounts for multiple of inputs and also outputs. The three gentlemen namely Charnes, Cooper, and Rhodes later refined and generalized Farrell's concept, leading to the development of the DEA methodology that we know today. DEA quickly gained popularity due to its capability to handle multiple input and output variables without necessitating a predefined functional form linking these variables. There are two seminal DEA models – the Constant Returns to Scale (CRS) model (CCR model) and the Variable Returns to Scale (VRS) model (BCC model). The CCR model posits that output scales proportionally with inputs, suitable for optimal resource utilization scenarios, whereas the BCC model allows for decreasing or increasing that returns to scale (Banker, Charnes, & Cooper, 1984).

Interestingly, the model of CCR is named in regards of its creators – Charnes, Cooper, and Rhodes – who developing it based on the assumption of constant returns to scale. A few years later, Banker joined Charnes and Cooper to extend the model into account that for variable returns to scale, leading the creation of BCC model. These two models, while bearing fundamental similarities, provide different and complementary perspectives on DMU efficiency. While the CCR model offers an overall efficiency measure, the BCC model helps identify sources of inefficiency. The application of these models has spanned diverse fields such as healthcare, education, banking, manufacturing, and logistics, underscoring their utility in facilitating efficiency measurement and benchmarking.

Wang and his colleagues (2002) articulate the concept of DEA as a process of gauging the comparative productivity of a Decision-Making Unit (DMU). This comparison is established against other similar units, all engaging in the transformation of an identical set of quantifiable, positive inputs into analogous categories of the measurable, output of positive.

Figure 3 shows DMU & unit in homogenous condition



Source: T.F. Wang (2002)

It's vital to consider that when choosing Decision-Making Units (DMUs), the driving factors should be homogeneous, implying that they undertake comparable tasks and objectives within a similar market environment and variables (both for the output and input) (Mokhtar, 2013). The flow-chart above illustrates the connection among the DMU, output, and inputs, and these inputs could be conveniently expressed through matrices X and Y, as portrayed in Equation 1 and Equation 2. Within this context, 'xij' represents the ith input data for the DMU of j, whereas 'yij' stands for the ith output for the j DMU (Wang et al., 2002).

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

Equation 1

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

Equation 2

As previously mentioned, the efficiency could be estimated by computing the proportion of a weighted sum of the outputs to a weighted sum of the inputs of the DMUs. This is considered an aspect of productivity, which is also a ratio but of the actual output to the projected standard output, as delineated in the equation number three and four (Kasypi & Shah, 2007). Moreover, it's noteworthy that superior performance is often associated with larger of DMUs, and count of DMUs that should ideally being no less than double the sum of inputs and outputs (Mokhtar, 2013).

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

Equation 3 →

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

Equation 4

Equation 3 and Equation 4 are generally applicable to simplistic data sets, usually in scenarios where efficiency assessment involves a singular input and output. However, in cases involving multiple inputs and outputs, the aforementioned equations require modification through a weighted cost approach, as suggested by Equation 5 (Kasypi & Shah, 2007).

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

(Equation 5)

All weights are uniform → Could be re-write into equation..

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

(Equation 6)

u_r = weight which attached to r output

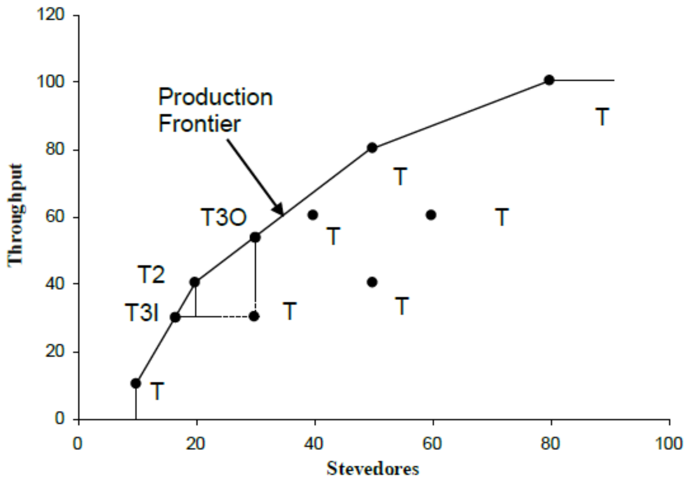
v_s = weight which attached to s input

x_s = the quantity of *s* input

y_r = the quantity of r input

The unit is regarded as efficient when the result equals 1, with efficiency being between 0 and 1. In addition to the commonly researched DEA CCR and BCC models, Wang et al. (2002) introduced the Additive model as another variant of DEA. The Additive model and the BCC model align in terms of their production frontiers. However, they differ in how they project towards the production frontier. To elaborate, as depicted in Figure 3, the BCC model would project an inefficient unit like T3 towards the production frontier to achieve efficiency, aligning with points T3I or T3O. In contrast, the Additive model would project towards T2. The discrepancies between the three models result in varying efficiency outcomes due to their distinct paths to the production frontier (Wang et al., 2002).

Figure 4 shows the difference between Additive Models and BBC



Source: T.F. Wang (2002)

2.10 The Model Orientation and Linear Programming in DEA

Fundamental understanding of Data Envelopment Analysis (DEA) involves the development of frontiers, capitalizing on the most proficient Decision Making Units (DMUs). These DMUs serve as pointers for the enhancement needed by each of the less efficient units, based on quantified and selected inputs and outputs. The Linear Programming, as mathematical conversion of equation, being discussed in an academic context, without applying the port data, given the non-parametric analysis nature of DEA. The DEA's primary utility lies in using application/software to ascertain the efficiencies level of DMUs.

Mokhtar in 2013 mentions that the measurement of efficiency under basic model, known as constant return to scale (CRS), are obtained by solving N linear programming problems, following the approach proposed by Charnes et al. 1978, as demonstrated below:

$$\left.\begin{array}{l} Min_{\psi,\lambda}\psi_{\lambda} \\ \sum_{i=1}^{N}\lambda_i y_{ri} \geq y_j; \quad r = 1,\ldots\ldots,R \\ \sum_{i=1}^{N}\lambda_i x_{si} \geq \psi_j x_j; \quad s = 1,\ldots\ldots,S \\ \lambda_i \geq 0; \quad \forall_i \end{array}\right] \text{Equation 7}$$

$y_i = (y_{1i}, y_{2i}, \cdots, y_{Ri})$ = the vector of output
$x_i = (x_{1i}, x_{2i}, \cdots, x_{si})$ = the vector of input

To address Equation 7, for each of the N container terminals, N weights are considered, resulting in N optimal solutions. Each optimal solution, symbolized as ψ^*j, acts as the efficiency score of the container terminal j, and is limited to $\psi^*j \leq 1$. It is straightforward to deduce that container terminals where $\psi^*j<1$ are classified as inefficient, whereas those with $\psi j=1$ are regarded as efficient. As discussed earlier, the CRS model was further elaborated by Banker et al. (1984) and eventually generalized into a VRS model by incorporating an additional of constraint $\sum_{i}^{N} = 1$ ëï= 1 . The model was subsequently modified into following detail:

$$\left.\begin{array}{l} Min_{\vartheta,\lambda}\vartheta_{\lambda} \\ \sum_{i=1}^{N}\lambda_i y_{ri} \geq y_j; \quad r = 1,\ldots\ldots,R \\ \sum_{i=1}^{N}\lambda_i x_{si} \geq \vartheta_j x_j; \quad s = 1,\ldots\ldots,S \\ \sum_{i=1}^{N}\lambda_i = 1; \ \lambda_i \geq 0; \quad \forall_i \end{array}\right] \text{Equation 8}$$

Mokhtar in 2013 delineates the highlight distinction between the DEA CCR version and DEA BCC version model. The CCR version or the CRS model, excels in identifying relative efficiency and also spotting inefficient resource utilization. In contrast, the DEA BCC version VRS model, has the capacity to discern both scale and technical inefficiency, allowing for the exploration of potential increases, decreases, or constancy in returns to scale for future progress. In summary, under the CCR model, DMUs are deemed efficient only if both technical and scale efficiencies are being met or satisfied. However, in the BCC version, DMUs can attain the status of efficiency by merely satisfying technical efficiency (Mokhtar & Shah, 2013).

The developed model by Charnes, Cooper, and Rhodes (CCR) allowing for the handling of multiple inputs and outputs for each Decision Making Unit (DMU). It operates by defining a ratio of the hypothetical input to the hypothetical output, resulting in an efficiency value. This value is conveniently comparable to other DMUs, in this scenario, ports (Sharma & Yu, 2009). In terms of linear programming, Sharma & Yu (2009) state that this ratio can be articulated as follows:

$$\max \quad h_o(u, v_i) = {\sum_r (u_r y_{ro})} \Big/ {\sum_i (v_i x_{io})} \qquad \text{Equation 9}$$

u_r = the output value.

v_i = the value of the input.

y_{ro} = the examined number 'y' of output 'r', produced by DMU_0 from the input x_{io}.

x_{io} = the examined number of output 'i' used to generate number 'y' by the output of 'r' for DMU_0

The introduction of a specific constraint stating that the proportion of abstracted input into abstracted output for all DMUs should not exceed one. Therefore, the linear programming to be expressed below:

$$\max \quad h_o(u, v_i) = {\sum_r (u_r y_{ro})} \Big/ {\sum_i (v_i x_{io})} \xrightarrow{\text{Subject to}} \begin{array}{ll} {\sum_r (u_r y_{rj})} \Big/ {\sum_i (v_i x_{ij})} \leq 1 & \text{for } j = 1, \ldots\ldots, n, \\ u_r v_i \geq 0 & \text{for all } i \text{ and } r \end{array} \qquad \text{(Equation 10)}$$

In order to conduct a detailed exploration, the constraint $u_r v_i \geq 0$ for all i and r can be substituted with a non-Archimedean element, denoted as Ɛ, thus transforming it into

$$\frac{u_r}{\sum_{i=1}^{m} v_i x_{io}}, \frac{v_i}{\sum_{i=1}^{m} v_i x_{io}} \geq \varepsilon > 0$$

It is imperative that Ɛ should remain smaller than any given positive real number (Sharma & Yu, 2009).

The categorization of the overall efficiency of Decision-Making Units (DMUs) can be strong, indicating absolute efficiency, or weak, signifying inefficiency, and this is contingent upon the presence of slack. Specifically, DMUs are classified as absolutely efficient if ɵ* equals 1 and all slacks approach zero. On the contrary, DMUs are labelled as less efficient if ɵ * is 1 but accompanied by some slacks. The kind of overall efficiency in the context of Linear Programming is determined by its constraints; the non-archimedean factor yields DMUs that are absolutely efficient, while other constraints indicate that DMUs exhibiting overall efficiency should be designated as minimally efficient. The Farrell model, visualized in figure 2 below, accommodates the presence of DMUs that less efficient.

As indicated by Sharma and Yu (2009), for any/each DMU identified as inefficient, the DEA undertakes an evaluation of efficient units which may serve as performance benchmarks to elevate the less efficient ones. These benchmarks can be sourced from the dual problem, that is, the Farrell model, which is showcased in figure 2, where ɵ denotes value of efficiency and λs are treated as the dual-variables. The dual-problem detects inefficiency of DMUs by analyzing an alternate set of the DMUs (referred to as composite-DMUs) that deploy fewer inputs but manage to produce an output level that is at least equivalent to that of the DMUs that being inefficient. Therefore, the unit being involved in the formation of the composite-DMU could be harnessed as the benchmarking value for the DMUs that was not being efficient.

Figure 5 shows The Types of DEA Model

DEA model types (Cooper et al., 2004)

Charnes–Cooper transformation	LP dual ('Farrell model')	LP dual solution (score)
Input-oriented DEA model		
max $z = \sum_{r=1}^{s} \mu_r u_{ro}$ subject to $\sum_{r=1}^{s} \mu_r y_{r0} - \sum_{i=1}^{m} v_i x_{ij} \leqslant 0$ $\sum_{i=1}^{m} v_i x_{ij} = 1$ $\mu_r, v_i \geqslant 0$	$\Theta^* = \min \quad \Theta$ subject to $\sum_{j=1}^{n} x_{ij} \lambda_j \leqslant \Theta x_{io}, \quad i = 1, 2, \ldots, m;$ $\sum_{j=1}^{n} y_{ij} \lambda_j \geqslant y_{ro}, \quad r = 1, 2, \ldots, s;$ $\lambda_j \geqslant 0, \quad j = 1, 2, \ldots, n;$	Solution: $\Theta^* \leqslant 1$ Score: If $\Theta^* < 1$, DMU is inefficient If $\Theta^* = 1$, DMU is efficient
Output-oriented DEA model		
min $q = \sum_{r=1}^{m} v_i x_{io}$ subject to $\sum_{r=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \geqslant 0$ $\sum_{r=1}^{s} \mu_r y_{ro} = 1$ $\mu_r, v_i \geqslant \varepsilon$	$\Theta^* = \max \quad \Theta$ subject to $\sum_{j=1}^{J} z_j x_{jn} \geqslant \Theta u_{jm}, \quad m = 1, 2, \ldots, M;$ $\sum_{j=1}^{J} z_j x_{jn} \leqslant x_{jn}, \quad n = 1, 2, \ldots, N;$ $z_g \leqslant 0, \quad j = 1, 2, \ldots, J;$	Solution: $\Theta^* \leqslant 1$ Score: If $\Theta^* < 1$, DMU is inefficient If $\Theta^* = 1$, DMU is efficient

Source: Yu and Sharma (2009)

2.11 Worldwide DEA Research on Container Terminal

The domain of efficiency assessment has experienced considerable progress throughout the years. The DEA-CCR model, introduced initially by Charnes in 1978, stands as an illustration of such progress. This model has seen substantial advancements in its theoretical framework, methodologies, and practical applications over the years. Its importance is reflected by the fact that, as pointed out by Cullinane and his associates in 2004, it has garnered more than 700 citations since 1999. Most of these studies have primarily focused on efficiency production at the terminal level as opposed to the port level, thus highlighting the terminal-oriented focus of this research area.

In 2000, Gray & Valentine carried out a pivotal study aimed at evaluating the efficiency for total of 31 container ports, chosen globally for top-100, specifically in the year 1998. Their study, anchored in the DEA-CCR model, employed a range of inputs like the total length of berth, container berth length, and outputs including the number of containers and total tons throughput. The results indicated a connection between the ports' efficiency and their ownership structure and organizational makeup. Ports under private ownership emerged as the most efficient, followed by publicly owned ports. Despite these findings, the authors emphasized the need to include additional input variables such as the port's primary operations, berth length, and size of port. They also recognized the limitations of employing assets as an input to attain more comparable outcomes.

Simultaneously, Tongzon's 2001 study used a DEA analysis to probe the factors impacting the efficiency of performance four 12 port of container and 4 Australian Ports in the year of 1996. This study adopted a dual-model approach consisting of the DEA-CCR model and an additive model. The chosen inputs incorporated six variables: the count of cranes, container berths, and tugs; terminal area; delay time; and labor units. These inputs were juxtaposed with two outputs, namely port total throughput and the working rate of ships. Contrary to traditional belief that port size or function singularly determines efficiency, the study's conclusions suggested that the efficiency of port did not strictly/limited hinge on the size or function of the port itself.

Table 6 shows research on container terminal using DEA model (2001-2023)

Year	Authors	Model	Inputs	Outputs	Sample Data / Geographic
2001	Tongzon	Additive DEP; DEA-CCR	Delay time of Labour(units); Expanse of the terminal; Quantity of container berths; Tally of tugs; Total cranes	Throughput & total quantity of shipcalls	12 int container ports and 4 Australian's
2006	Cullinane et al.	DEA-BCC; DEA-CCR	Expanse of the terminal; Count of quay cranes; Quantity of straddle carriers; Length of the terminal; Tally of yard gantry cranes.	Total of Throughput (TEU)	Port of Container (with total to 30)
2007	Cullinane and Wang	DEA-BCC; DEA-CCR	Count of yard cranes; Expanse of the terminal; Total quay cranes; Quantity of straddle carriers.	Total of Throughput (TEU)	Port of Container (with total to 57)
2007	Gonzales and Trujillo	Parametric & DEA	Quantity of employees; Berths' Length(m) ; Area of the port.	Passenger, Container, Others Cargo, Liquid Bulk Cargo	Port of Container (with total to 30 - Spanish)
2009	Hai-ho and He-zhong	SFA	Net value of permanent assets; Total number of employees.	Main business revenue	Port of Container (with total to 13 - China)
2009	Jiang and Li	DEA-BCC; DEA-CCR.	Count of cranes; Length of the berth; GDP by region; Total exports and imports by customs.	Total of Throughput (TEU)	Port of Container (with total to 12 - Asia)
2009	Wu & Goh	DEA-Windows Analvsis;DEA-BCC; DEA-CCR;	Count of equipment pieces; Length of the total quay; Area of the terminal.	Total of Throughput (TEU)	Port of Container (with total to 21, major CT)
2010	S.W. Hung	Bootstrap Technique DEA, DEA-BCC; DEA-CCR;	Count of berths; Count of Ship-to-Ship container cranes; Length of the quay wall total; Area of the terminal.	Total of Throughput (TEU)	Port of Container (with total to 31- AsiaPasific)

2010	Lozano, Villa & Canca	Centralized Data Envelopment Analysis utilizing a non-radial Russell indicator for gauging technical proficiency.	Count of total cranes; Length of the total quay; Area of land and stacking; Total quantity of tug boat	Container Throughput (TEU), Traffic of port, Number of Ship calls	Port of Container (with total to 50 - Spanish)
2010	Sharma & Yu	DTBased context- DE of Dependent	Quantity of transfer cranes; Total quay length; Count of straddle carriers; Quantity of reach stackers; Terminal area; Total quay cranes.	Total of Throughput (TEU)	Port of Container (with total to 70)
2011	Lim, Leem Bae	DEA-RAM, additive non oriented	Quantity of gantry cranes; Length of the quay; Total area.	Total of Throughput (TEU)	Port of Container (with total to 26 Asian)
2012	Bichou	DEA-CCR ; DEA-BCC; Panel data	Index of quay crane; Maximal draft; Count of gates; Index of yard stacking; Length of the quay; Area of the terminal.	Total of Throughput (TEU)	Port of Container (with total to 420)
2012	Sanchez & Millan	Malmquist index	Quantity of intermediate consumption; Count of employees; Total capital.	Non-containerized general cargo, Containerized general cargo, Solid bulk, Liquid bulk	Port of Container (with total to 46 - Spanish)
2013	Li et al.	DEA; SFA	Count of equpment for handling (beam cranes, mobile, bridge); Length of the terminal; Total number of employees.	Total of Throughput (TEU)	42 Coastal ports on China
2013	Wanke	Network-DEi centralized efficiency	Frequency of container (shipments); Area of warehousing; Count of berths; Area of the yard.	Total of Throughput (TEU)	Port of Container (with total to 27 - Brazilian)
2013	Wilmsmeie rand al.	Malmquist index	Equivalent ship-to-shore crane capacity; Area of the terminal; Count of employees.	Total of Throughput (TEU)	Port of Container (with total to 30 - Central & South Africa)
2014	Bray et al.	Fuzzy DEA	Quantity of container berths; Delay time; Count of tugs; Area of the terminal; Total number of port authority employees; Count of cranes.	Total of Throughput (TEU) ; Shiprate; Shipcalls; productivity; Crane's quantity	Port of Container (with total to 16)
2014	Guimaraes et al.	DEA-BCC; DEA-CCR.	Total energy consumption; Water consumption per worker; Total emissions; Consumption of office supplies; Emission of sewage; Non-renewable energy consumption.	Total of Throughput (TEU)	Port of Container (with total to 15 - Brazilian)
2015	Almawshe ki & Shah (2015)	DEA-CCR	Quantity of quay cranes; Draft maximum; Length of the quay; Quantity of yard equipment; Area of the terminal.	Total of Throughput (TEU)	Port of Container (with total to 19 - Middle East)
2015	Garmend ia & Schwartz	DEA-CCR DEA-BCC	Quantity of mobilize cranes with > than 14t capacity; Quantity of Ship to ship gantry cranes; Length of the quay; Terminal area.	Total of Throughput (TEU)	Port of Container (with total to 63 - Latin America & Caribbean)
2020	K. C. Iyer & V.P.S.N. Nanyam	DEA-BCC, DEA CCR, MPI	Quay length, Terminal area, Turn around time per TEUs, Draft, Total yard equipment, Handling trucks, Frequency of calls, Total quayside cranes, Size of container yard, and Number of berths	Total of Throughput (TEU)	Container Terminal (With total 26 ports on India)
2023	Wen-Kai K. Hsu et al.	DEA-CCR and DEA-BCC	Total cargo hadling in ship-to-shore gantry crane, quntity of yard gantry cranes, total berth length, total container yard area, the Fixed costs, and Variable costs	Total of Throughput (TEU)	Port in Taiwan. The port has 30 container terminals.

Source: Authors elaboration via multiple sources

2.12 DEA Research on Indonesia Container Terminal

Table 7 shows Port Researches in Indonesia

Publication Year	Authors	Model	Inputs	Outputs	Sample Data / Geographic
2004	Purwantoro	Output oriented, DEA-BCC Model	Haulage; Equipment; Infrastructure; Auxiliary vessel	Total of Throughput (TEU)	Pelindo II & Pelindo IV (with total of 24 ports)
2010	Andenoworih	Input Oriented, DEA-BCC; DEA-CCR	Employee count; yard area (m2); quantity of gantry cranes; length of berth	Total of Throughput (TEU)	All Pelindo (with 12 of total container terminal
2012	Aye, Seo and Ryoo	Output oriented, DEA-CCR Mode;	Quantity of cranes; the length of the berths; the area dedicated to the container yard; the total count of berths.	Total of Throughput (TEU)	4 Port in Indonesia and 30 Ports on ASEAN country
2014	Sari	Input Oriented, DEA-CCR	Area designated for containers; quay crane quantity; duration of service; yard equipment count; length of berth	ship visit frequency; Hourly container movement rate; Total container processed	Pelindo II (with 5 of total container terminal)
2017	N. Kutin, T.T. Nguyen, T. Vallee	Output oriented, DEA-BCC Model	The berth max depth, quantitty of equipment (trucks, forklift, RMG, SC, RTG), quay cranes quantitiy, size of container yard area	Total of Throughput (TEU)	Poirts in ASEAN country (with 25 of total ports

Source: Authors elaboration via multiple sources

This table presents a summary of research conducted in terms of the efficiency in the world-wide container terminal operation, focusing on Data Envelopment Analysis (DEA) models. The studies span from 2004 to 2017 and primarily use container throughput, measured in Twenty-foot Equivalent Units (TEUs), as the output measure of terminal efficiency.

Purwantoro (2004) used an output-oriented DEA-BCC model with haulage, equipment, infrastructure, and auxiliary vessel as input parameters to examine the efficiency of 24 ports under Pelindo II & Pelindo IV. Similarly, a study by N. Kutin, T.T. Nguyen, T. Vallee in 2017, using an output-oriented DEA-BCC model, assessed the efficiency of 25 ports in ASEAN countries using inputs such as the maximum depth of the berth, quantity of various types of equipment (water-land side), and the size of container yard area(m^2). The output-oriented DEA explained that the research concentrates on the how to increase their throughput rather have to reduce their inputs variable.

Studies by Merk & Dang (2012), and Seo and colleagues (2012) have notably applied Data Envelopment Analysis (DEA) in the assessment of Indonesian ports. Seo et al. (2012) utilized the DEA-CCR model with an output-oriented approach to analyze the performance of 30 ASEAN ports, inclusive of Belawan, Tanjung Priok, Tanjung Perak, and Makassar from Indonesia. Key performance variables they used included berth numbers, length of quay wall, the size area of container yard, quantity of cranes, and total of container throughput. Conversely, Merk & Dang (2012) carried out a detailed analysis of 42 container and 35 bulk terminals, including Indonesia's Tanjung Priok, Balikpapan and Tanjung Bara Ports. Variables such as quantity of cranes, designated refrigeration points, the size of yard area, and length of berth and yard cranes were used to determine container throughput, while berth length, storage area, and load/unload capacity were used to measure cargo throughput for the bulk terminals.

Further to these, several other investigations such as those by Andenoworih (2010), Purwantoro (2004), and Sari (2014) have been conducted to measure the performance of Indonesian ports via DEA analysis. For instance, Purwantoro (2004) employed the DEA-BCC model to evaluate with total of 24 ports under the management of Pelindo II and IV. Despite the breadth of this analysis, which included ship, bulk, and container outputs, its broad categorization of input variables resulted in a lack of specificity in the findings.

Andenoworih (2010), on the other hand, utilized both DEA-CRS (DEA-CCR) and DEA-VRS (DEA-BCC) models to analyze 12 container terminals managed by Pelindo in Indonesia. The study classified four out of twelve terminals as efficient under the first model, while five out of twelve were classified as technically efficient under DEA-VRS. Although this study aimed to identify efficient terminals and benchmark peers, it did not provide specific recommendations for stakeholder investment to improve efficiency.

Sari (2014) employed an input-oriented DEA-CRS model to evaluate five container terminals managed by Pelindo II, comparing their performance before and after a significant investment. Interestingly, despite the additional equipment resulting from investment, productivity dropped, suggesting that more input does not necessarily yield more output. This study thus highlighted the complexity of improving efficiency in container terminals.

2.13 Malmquist Productivity Index (MPI)

The productivity alteration within a decision-making unit (DMU) over a specific timeframe is quantified by the Malmquist productivity index, a measurement tool named after the Swedish economist Sten Malmquist. This index plays a vital role in studies related to efficiency and productivity, particularly when applying data envelopment analysis (DEA). The productivity fluctuation is evaluated by the Malmquist productivity index through the comparison of the output distance ratios between two distinct periods or data points.

The Malmquist productivity index is constituted by two essential components: the transformation in efficiency and the shift in technology. The former assesses the effectiveness of a DMU in transmutating inputs into corresponding outputs, while the latter gauges the evolution in production technology. The amalgamation of these two components provides a holistic perspective of the modifications in productivity over time.

Efficiency change can further be decomposed into the scale and pure efficiency changes. Scale efficiency change relates to changes in the size of operations, while pure efficiency change concerns improvements in the management of resources. If a company can produce more output with the same level of inputs, it is considered to have improved its efficiency.

On the other hand, technical change is about innovation and technological progress, often driven by research and development activities. Given the current resources and technology, it is about pushing the frontier of what is possible. If a company can produce more with the same resources because of new technology, it is considered to have undergone a technical change.

The Malmquist productivity index is calculated using linear programming techniques and requires data on inputs and outputs for the DMUs under consideration. The index value equals 1 when there is no productivity change, greater than 1 for productivity improvement, and less than 1 for productivity decline.

The Malmquist productivity index is used in various fields, including health care, banking, agriculture, logistics and manufacturing. It is a valuable tool for benchmarking and identifying areas for improvement. It also offers insights into the effects of policy changes or managerial decisions on productivity. Therefore, the MPI could be calculated through equation as follow:

$$\text{Catch-up} = \frac{\text{Efficiency of } (X,Y)^{2022} \text{ with respect to frontier of 2022}}{\text{Efficiency of } (X,Y)^{2020} \text{ with respect to frontier of 2020}}$$

(Equation 11)

$$\text{Frontier Shift} = \sqrt{\frac{\text{Efficiency of } (X,Y)^{2020} \text{ with respect to frontier of 2020}}{\text{Efficiency of } (X,Y)^{2020} \text{ with respect to frontier of 2022}} \, x \, \frac{\text{Efficiency of } (X,Y)^{2022} \text{ with respect to frontier of 2020}}{\text{Efficiency of } (X,Y)^{2022} \text{ with respect to frontier of 2022}}}$$

(Equation 12)

MPI = Catch-up X Frontier Shift

(Equation 12)

Notes: DMU represented by X and Y

At the end of Chapter 2, we conclude by drawing upon an extensive literature review, the application of robust models, and insights gleaned from various research studies. This research sets out to conduct an in-depth analysis of 17 comparable container terminals under PELINDO I, II, III, and IV governance. The period for this examination includes the periods before the merger in 2020, the year of the merger in 2021, and the post-merger period in 2022.

R. Studio is the primary software tool for this empirical investigation, utilizing both DEA-CCR and DEA-BCC models. These models will utilize five input variables: maximum draft, length of berth, the quantity of quay crane, quantity of yard equipment, and the total area of the yard. Thus, we also need the output variable, so we considered the total throughput in a single year for these models.

The data processing through these models is expected to measure relative efficiency across the selected container terminals. Furthermore, the output derived from R. Studio will be instrumental in computing the Malmquist Productivity Index. This structured approach builds on the existing literature and incorporates operational realities to yield more accurate and comprehensive insights. The details of the methodological approach and the subsequent results will be extensively discussed in the forthcoming chapter.

Chapter 3 - Methodology

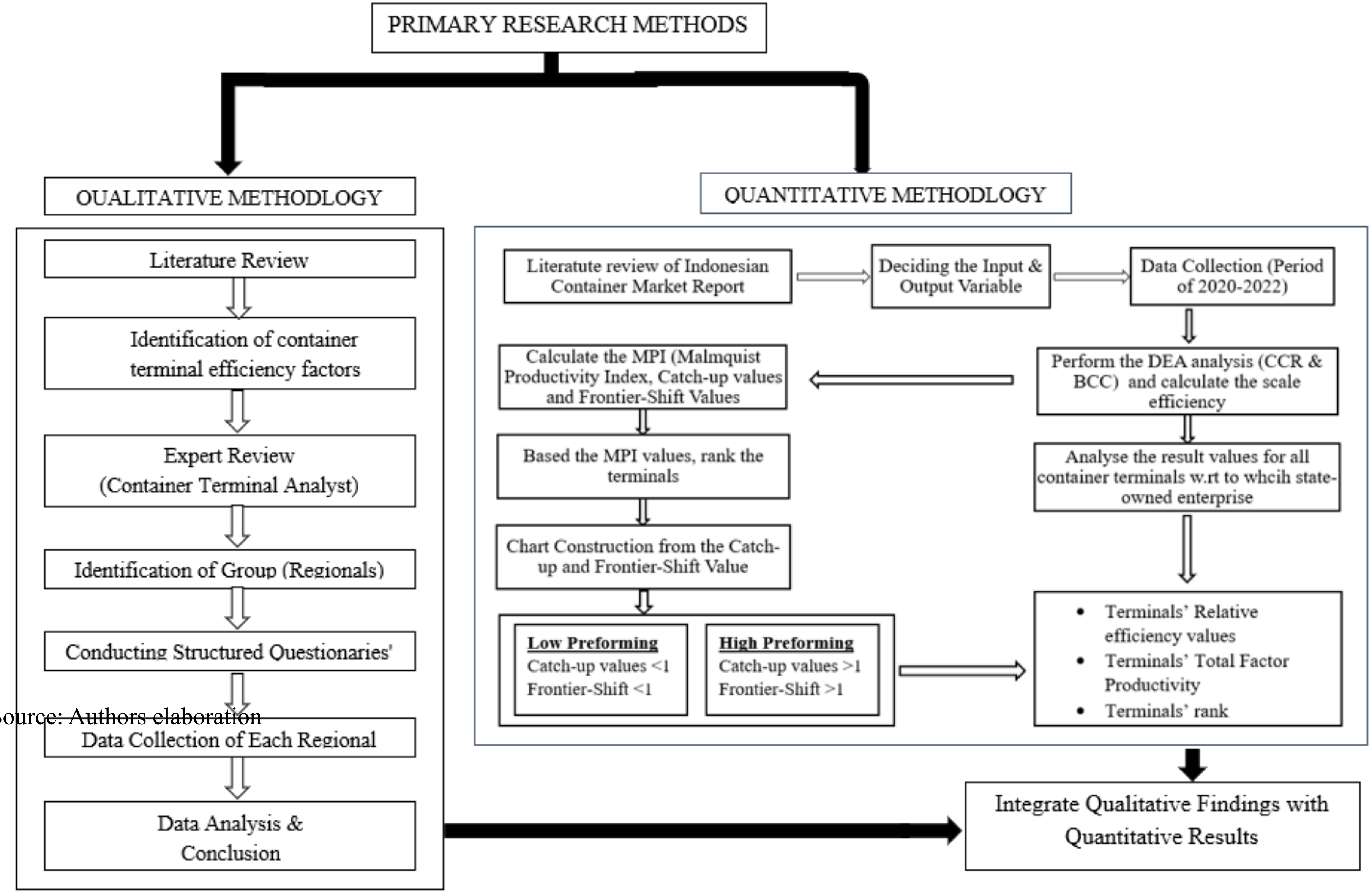
3.1 Research Framework and Design

In order to conduct comprehensive research of the technical efficiency of container terminals in Indonesia, this study will be designed utilizing a holistic framework, and it will use both quantitative and qualitative research strategies. Combining in-depth data analysis with incisive observations, the two-pronged strategy ensures a comprehensive comprehension of the operational performance within the sector.

The first part of this study uses a quantitative research design, which has been painstakingly organized to quantify the efficiency of certain state-owned container terminals between 2020 and 2022. A thorough analysis of the existing research on the Indonesian container market will serve as the foundation of this stage. This step lays the groundwork for selecting the input and output variables best suited for the Data Envelopment Analysis (DEA) model. After that, data collection takes place for these variables, followed by an exhaustive analysis in R studio that uses both the CCR and BCC models of DEA. This method will result in the discovery of essential pieces of data such as the scale efficiency, the relative efficiency values of the terminals, and their total factor productivity.

After that, we will use these quantitative results to compute the Malmquist Productivity Index (MPI), catch-up, and frontier-shift values. This essential data will be used to determine the ranking of the terminals and the construction of charts, which will enable differentiation between the terminals that demonstrate high performance and those that demonstrate low performance.

After the quantitative phase is complete, a qualitative research design will be implemented to complement the results of the quantitative phase. This phase begins with a comprehensive review of the relevant literature, which enables the identification of key factors that impact the efficiency of container terminals. After these factors have been selected, expert reviews are carried out, which assist in the design of structured questionnaires for data collection across regional groups. When all of the data has been compiled, a thorough analysis will be carried out, ultimately resulting in conclusive findings regarding the operational effectiveness of container terminals in Indonesia. In the final step of the investigation, the quantitative and qualitative findings will be combined. This method underlines the validity of the research by ensuring that qualitative insights are used to support and enhance the quantitative data. As a result, the validity of the research is strengthened. Combining these two approaches to research results in a more complete and in-depth understanding of the operational performance of container terminals, which sheds light on potential methods for improvement.



Source: Authors elaboration

3.2 Identification for The Input and Output

Identifying inputs and outputs is a crucial stage in applying the Data Envelopment Analysis (DEA) approach in this study. As such, a review of previous literature was undertaken to assist in determining the essential inputs and outputs for the efficiency analysis of container terminals. Our understanding of these factors in the context of container terminals is guided by the established premise that output variables are a function of input variables (Almawsheki & Shah, 2015).

In our study, the production measure is the throughput, quantified as the number of containers handled. On the other hand, inputs, also known as resources, are classified into three categories: land, labour, and capital. Land refers to natural resources like the quay length, yard area, and draft, while labour pertains to the human effort involved in the terminal operation. However, obtaining concrete labour data takes much work. Capital, as the third category, represents intermediate products like equipment used at the berth and yard.

For our analysis, the input variables encapsulate the terminal's physical characteristics, such as terminal area and yard infrastructure. The selection of these variables was largely guided by data availability specific to the terminal rather than the entire port. In line with most researchers, we considered the yard area, berth draft, number of quay cranes, length of berth, number of yard equipment, truck and vehicles, and gate lanes as inputs. Outputs, in this case, are determined by the total throughput of the terminal. The specific variables employed in our analysis are outlined in Table 8 and have been selected based on their recurrent usage in literature, data availability, and distribution across the three input resource categories.

Data collection regarding the input and output variables for the chosen container terminals was performed through various official online sources, including the PELINDO official website and Indonesia container market reports. The selected data set, encompassing 2020-2022, offers panel and cross-sectional data for multiple container terminals under PELINDO I, II, III, and IV. This comprehensive data collection will assist in delivering a robust DEA analysis and contribute to a broader understanding of the efficiency of Indonesian container terminals.

Table 8 outlines the selected input and output to perform DEA

Number of Decions Making Unit (DMU)	Year	Input			Output		
		Variable	Abbre.	Total	Variable	Abbre.	Total
17 Container Teerminals	2020-2022	Yard Area (Ha)	YA	7	Throughput (TEUs)	T	1
		Berth Draft (m)	BD				
		Quay Crane (No.)	QC				
		Length of Berth (m)	BL				
		Yard Equipment (No.)	YE				
		Trucks &Vehicle (No.)	TV				
		Gate Lanes (No.)	GL				

3.3 Sample Size and Duration of Research

In our investigation of container terminal efficiency, the research design incorporated a strategic selection of sample size and defined the duration of the study. For this study, we leveraged a robust sample size comprising 17 container terminals across Indonesia. These terminals fall under the administrative purview of four distinct regional management entities: PELINDO I, II, III, and IV. The diverse geographical representation ensured a comprehensive understanding of terminal efficiency under varying regional management strategies and contexts.

Moreover, the temporal range of the study was thoughtfully selected to capture the crucial transition period marked by the merger of these four PELINDO entities. Specifically, the data spans three years from 2020 to 2022, comparing terminal efficiency pre- and post-merger. This duration provides a unique opportunity to examine the merger's direct implications on the terminals' operational efficiency. Consequently, by considering this strategic sample size and duration, our study can offer insightful conclusions on the efficiency and performance of container terminals within the dynamic landscape of Indonesia's maritime industry.

3.4 Data Collection

Delineates the process of gathering essential information necessary for this study. The primary data source for this research is secondary data, specifically cross-sectional and panel data drawn from the annual operational reports of the 17 container terminals under PELINDO's jurisdiction. Cross-sectional data, which refers to data collected at a specific time, was obtained for the year 2020 and encompassed various facility data pertinent to the operation of the container terminals. This data provides a snapshot of the terminal facilities, capturing the state of the resources and infrastructure.

In contrast, the panel data, also known as longitudinal data, captures the container throughput from 2020 to 2022. Panel data combines cross-sectional and time-series dimensions and is instrumental in tracking the dynamics of the terminals over these three years, thereby enabling an in-depth analysis of their performance before and after the PELINDO merger.

It is essential to emphasize that the data used in this research is legitimate and reliable. It was directly sourced from PELINDO's internal records, which ensures its accuracy and reliability. Moreover, this data is considered confidential and is used in compliance with PELINDO's data privacy regulations. Consequently, the data's authenticity and the respect for confidentiality underline the rigorous methodological approach adopted in this study. Therefore, the data collected data and source could be see as follow:

Table 9 shows detail data source

No.	Variable of Input	Data	Sources	Year
1	Yard Area (Ha)	Total land space for storage	Pelindo Yearly Report	2020
2	Berth Draft (m)	Depth of water at berth	Pelindo Yearly Report	2020
3	Quay Crane Index	Lift. Capacity & Index	Pelindo Yearly Report	2020
4	Length of Berth (m)	Distance covered by berth	Pelindo Yearly Report	2020
5	Yard Equipment (No.)	Number of yard machinery	Internal Report	2020
6	Gate Lanes (No.)	Number of access gate lanes	Internal Report	2020
No.	Variable of Output	Data	Sources	Year
7	Throughput	Volume of containers handled	Internal Report	2020-2022

3.5 Pelindo I Profile

Figure 6 shows the operational area of Pelindo I

Source: Annual Report of Pelindo I 2020

Pelabuhan Indonesia (Pelindo) I as a port corporate entity is a state-owned enterprise in which the Republic of Indonesia wholly owns the shares. It was formally incorporated on December 1, 1992, under the instrument of incorporation No. 1, dated December 1, 1992, certified by

Notary Imas Fatimah, S.H., based in the capital city of Indonesia (Jakarta). The Minister of Justice of the Republic of Indonesia approved Decree No. C2-8519.HT.01.01 of 1992, dated June 1, 1992. Therefore, it was published in the State Gazette of the Republic of Indonesia No. 8612 on November 1, 1994, addendum No. 87.

The operational territory of Pelindo 1 spans four provinces: Aceh, North Sumatera, Riau, and Riau Islands. The organization oversees 15 ports, eight port locations, one business unit, and five subsidiary entities across these four Sumateran provinces, many of which lie on the Strait of Malacca, the world's most active strait. The primary economic activities in Pelindo 1's hinterland consist of agriculture, plantation, and mining.

3.5.1 Profile of Belawan Port

The Port of Belawan, one of the prominent facilities under the authority of PT Pelabuhan Indonesia I, stands as a significant cog in the logistics and maritime transport system of Indonesia, significantly as the largest port in Sumatra Island. The port's strategic location coupled with its comprehensive range of services makes it an essential gateway for both national and international shipping lines. It serves as a crucial node in the regional and global supply chain, facilitating the efficient exchange of goods and contributing significantly to the economic vibrancy of the region.

The Port of Belawan is replete with state-of-the-art infrastructure designed to cater to diverse shipping needs. One of its key elements is the dedicated container terminal, equipped to handle high volumes of containerized cargo. The terminal comprises extensive yard space and modern handling equipment, such as quay cranes and gantries, which ensure the smooth and swift loading and unloading of containers. Furthermore, the terminal maintains an impressive depth at the berth, allowing it to accommodate large container ships. The detail of Belawan Port shows in the table below.

Table 10 shows The Facility and Equipment of Belawan's Port

Port of Belawan	
Infrastructre (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	3500
Area of Container Yard (m2)	80288
Depth (m)	(- 5 to -7)
Length (m)	675
Stacking Height	4
Number of Equipment	
Harbour Mobile Crane	1
Mobile Crane	4
Forklift Diesel	11

3.5.2 Profile of Belawan International Container Terminal

Belawan International Container Terminal (BICT), strategically nestled in the Port of Belawan in North Sumatra, Indonesia, serves as a pivotal junction in the intricate web of global maritime trade. BICT's geographic coordinates, 3.78 latitudes and 98.68 longitudes place it strategically on the Malacca Strait, one of the world's busiest shipping lanes. This location and its world-class infrastructure and management make it a key player in the region's container handling sector.

This container terminal showcases a harmonious blend of modernity, efficiency, and sustainability, providing comprehensive solutions to the dynamic demands of containerized cargo movements. Its extensive yard area, designed for high-volume container storage and a deep-draft berth capable of accommodating large vessels, underscores BICT's capability to facilitate large-scale maritime trade.

Recently, BICT has embarked on an ambitious trajectory of growth and innovation. As part of its expansion blueprint, the terminal will enhance its capacity and operational efficiency through infrastructural upgrades and the adoption of intelligent technologies. Furthermore, in keeping with global trends, BICT has begun incorporating sustainable practices into its operations, aspiring to become a leading green port.

BICT's strategic location, world-class facilities, and dedication to continuous improvement play an instrumental role in bolstering Indonesia's maritime sector. As BICT continues to evolve, embracing innovative technologies and sustainable practices, it is well-poised to solidify its position as a top-tier international container terminal. The detail of BICT shows in the table below.

Table 11 shows The Facility and Equipment of BICT

BICT	
Infrastructre (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	16900
Area of Container Yard (m2)	257871
Depth (m)	(- 7 to -10)
Length (m)	950
Stacking Height	4 to 6
Number of Equipment	
Harbour Mobile Crane	1
Container Crane	12
Transtainer MC (Rubber-Tired Gantry Cranes)	30
Forklift Diesel	5
Side-Loader	3
Reachstacker	7

3.6 Pelindo II Profile

PT Pelabuhan Indonesia II (Persero), widely recognized as Pelindo II or Indonesia Port Corporation (IPC), is an integral entity in the Indonesian maritime landscape. With a primary mandate to manage and operate port services across the country, Pelindo II holds a prominent position in the vast archipelago's shipping and logistics sector.

Strategically headquartered in Jakarta, Pelindo II oversees an extensive network of 12 branch ports and several subsidiaries from Sumatra to Papua. This expansive reach underscores its pivotal role in bolstering Indonesia's connectivity and promoting maritime trade.

A commitment to exceptional service and state-of-the-art infrastructure marks Pelindo II's operations. Its facilities, such as the Tanjung Priok Port in Jakarta, showcase advanced technology and globally competitive facilities, solidifying its status as a leading player in the shipping industry. With well-equipped terminals, comprehensive logistics services, and cutting-edge technology, Pelindo II plays a pivotal role in handling the country's burgeoning container traffic, promoting efficient cargo movement, and mitigating congestion issues.

Guided by a dynamic and forward-thinking leadership team, Pelindo II has anchored its strategies on technological advancement and operational excellence. It is an industry pioneer in adopting automation and digitalization, implementing innovative systems to streamline operations, enhance efficiency, and foster transparency. These efforts align with its vision to transform Indonesia's ports into world-class entities that drive national economic growth.

Figure 7shows the operational area of Pelindo II

Source: Annual Report of Pelindo II 2020

On the sustainability front, Pelindo II is dedicated to environmental stewardship and social responsibility. The corporation has initiated measures to promote greener port operations, including energy efficiency and waste management programs. It also plays an instrumental role in uplifting local communities by creating job opportunities and fostering economic development in its operating regions.

3.6.1 Profile of Tanjung Priok Port

Tanjung Priok Port, administratively overseen by PT Pelabuhan Indonesia II (Persero), or Pelindo II, is the largest and busiest seaport in Indonesia, serving as the primary maritime gateway to the country. Strategically located in North Jakarta, Tanjung Priok is commanding on the northern coast of Java, Indonesia's most populous island. The port's geographical coordinates are approximately 6°06′S latitude and 106°54′E longitude, offering significant navigational advantages and facilitating efficient maritime connections to national and international ports.

Spanning over an area of approximately 661 hectares, Tanjung Priok Port has an impressive infrastructure designed to handle the diverse requirements of modern maritime trade. It features many multi-purpose and dedicated container terminals, accommodating the high container throughput with state-of-the-art facilities. The port's capabilities include various services, from container handling to bulk and general cargo operations. These facilities are supported by advanced cargo handling equipment, such as modern quay cranes and yard gantry cranes, enhancing the port's operational efficiency and productivity. The detail of Tanjung Priok Port shows listed in the table below.

Table 12 shows The Facility and Equipment of Tanjung Priok Port

Port of Tanjung Priok	
Infrastructre (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	30476
Area of Container Yard (m2)	796121
Depth (m)	(-10 to -12)
Length (m)	1030
Stacking Height	5
Number of Equipment	
Harbour Mobile Crane	29
Crane	10
Quay Container Crane	17
GLC	13
Shore Crane	1
Rubber-Tyred Gantry Crane	52
RMCG	9
Top-Loader	3
Reach-Stacker	19
Side-Loader	1
Forklift	22

3.6.2 Profile of Teluk Bayur Port

The Port of Teluk Bayur, historically known as Emma Haven, is one of the vital maritime gateways on the western coast of Indonesia. Situated in the city of Padang, within the province of West Sumatra, this port is strategically located at approximate coordinates of 0°56′S latitude and 100°21′E longitude. This pivotal geographical location allows the port to facilitate critical sea trade routes, connecting Sumatra to various national and international destinations. With its rich historical legacy dating back to the Dutch colonial era, Teluk Bayur has witnessed a considerable transformation over the years, evolving from a natural harbor into a modern, multifunctional port complex.

As a crucial asset under PT Pelabuhan Indonesia II (Persero) management, the Port of Teluk Bayur manifests an impressive capacity to handle diverse cargo types. The port is renowned for its robust container handling facilities, underpinning its importance within the Indonesian port ecosystem. Comprising state-of-the-art cranes, warehousing amenities, and other essential operational equipment, Teluk Bayur caters to the complex logistical needs of the maritime industry. The port's technical competencies and strategic geographical positioning significantly contribute to its operational efficiency. The detail of Teluk Bayur Port shows listed in the table below.

Table 13 shows The Facility and Equipment of Teluk Bayur Port

Port of Teluk Bayur	
Infrastructre (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	4825
Area of Container Yard (m2)	62250
Depth (m)	(- 10 to -11)
Length (m)	222
Stacking Height	5
Number of Equipment	
Mobile Crane	1
GLC	4
Truck	10
Head truck	10
Top-Loader	1
Reach-Stacker	3
Side-Loader	1
Forklift	4

3.6.3 Profile of Palembang Port

The port is Positioned at the coordinates 2°59′S latitude and 104°45′E longitude, and this port is strategically nestled on the Musi River in South Sumatra. Historically recognized as an important river port, Palembang has experienced extensive modernization, enhancing its capability to accommodate ocean-going vessels. This transformation has augmented its geographical advantage, allowing it to serve as a critical logistical node connecting the rich natural resources of South Sumatra to domestic and international markets.

Regarding container handling facilities, the Port of Palembang exhibits commendable competence. With its highly equipped container terminals, robust warehousing facilities, and efficient operational equipment, Palembang can handle diverse cargo types, including bulk, liquid, and containerized goods. To increase operational efficiency and reduce ship turnaround times, the port has invested in various infrastructural advancements, such as acquiring modern quay cranes and implementing an integrated container yard system. The detail of Palembang Port in the table below.

Table 14 shows The Facility and Equipment of Palembang Port

Port of Palembang	
Infrastructre (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	4376
Area of Container Yard (m2)	57357
Depth (m)	(- 6 to -9)
Length (m)	266
Stacking Height	5
Number of Equipment	
CC	3
Gantry Jib Crane	4
RMGC	4
Head truck	14
Forklift	16
Reach-Stacker	1
Side-Loader	2

3.6.4 Profile of Panjang Port

Strategically situated on the southwest coast of Sumatra, the Port of Panjang stands as a significant maritime entity under PT Pelabuhan Indonesia II (Persero) or the Indonesia Port Corporation (IPC). Its advantageous location, marked by the coordinates 5°47′S latitude and 105°17′E longitude, is situated on the Sunda Strait, which links the Indian Ocean to the Java Sea. This geographic positioning permits the port to serve as a vital logistics nexus for the western region of Sumatra, underlining its importance in regional trade and commerce.

Blessed with a comprehensive suite of modern facilities, the Port of Panjang is proficient in managing various cargo types. It comprises well-organized terminals that efficiently process bulk, liquid, and containerized commodities. The port boasts extensive warehousing capabilities and is fortified by a lineup of handling equipment. The port's infrastructural strength lies in its sufficient berth length that caters to many maritime vessels. The detail of Panjang Port listed in the table below.

Table 15 shows The Facility and Equipment of Panjang Port

Port of Panjang	
Infrastructure (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	6848
Area of Container Yard (m2)	75000
Depth (m)	(- 7 to -16)
Length (m)	401
Stacking Height	4
Number of Equipment	
CC	3
Gantry Jib Crane	4
Top-Loader	1
Head truck	13
Forklift	7
Transtainer	5
Side-Loader	1

3.6.5 Profile of Pontianak Port

Located on the equator, the Port of Pontianak, managed by PT Pelabuhan Indonesia II (Persero) plays an integral role in the maritime infrastructure of Western Kalimantan. The port, stationed at the confluence of the Kapuas and Landak Rivers, leverages its geographic positioning, delineated by 0°1′26″N latitude and 109°20′27″E longitude. Its placement offers easy access to the South China Sea, making it an indispensable logistics hub for Kalimantan and its neighboring regions. The Port of Pontianak, equipped with modern facilities and a skilled workforce, efficiently handles various cargoes. Its well-structured terminal layout supports smooth containerized, liquid, and bulk goods operations. With a range of contemporary warehousing options and cargo-handling equipment, the port efficiently caters to the needs of various maritime vessels. The detail of Pontianak Port listed in the table below.

Table 16 shows The Facility and Equipment of Pontianak Port

Port of Pontianak	
Infrastructure (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	3753
Area of Container Yard (m2)	47794
Depth (m)	-6
Length (m)	295
Stacking Height	5
Number of Equipment	
CC	2
GJB	2

RMGC	4
Reachstaker	4
Forklift	10
Side Loader	4
Truck	10
Head Truck	6
Term. Tractor	4
Road Truck	4

3.6.6 Profile of Jakarta International Container Terminal

Jakarta International Container Terminal (JICT), positioned as a principal component of the Port of Tanjung Priok, is the epitome of modern port operations within the Indo-Pacific region. As Indonesia's most extensive and technologically advanced container terminal, JICT acts as a pivotal node in the global trade network, facilitating seamless import and export activities that bolster the country's economic growth. Commanding a strategic location within the bustling cityscape of North Jakarta, JICT is conveniently nestled at the geographical coordinates of approximately 6°06′S latitude and 106°54′E longitude. This prime location permits efficient maritime connections with national and international ports, offering logistic advantages to various clientele, ranging from shipping lines to freight forwarders.

The terminal spans a considerable area, accommodating significant container throughput. It houses advanced facilities explicitly tailored for container operations, including cutting-edge quay cranes and yard gantry cranes that expedite the loading and unloading processes, thereby augmenting operational efficiency. The layout of JICT and dedicated infrastructure signify a clear commitment to promoting efficient container handling, significantly reducing vessel waiting times, and enhancing service reliability. The terminal's capacity is constantly nurtured through ongoing development projects, substantiating its readiness to meet future demands and host larger vessels. The detail of JICT in listed the table below.

Table 17 The Facility and Equipment of JICT

Port of JICT	
Infrastructure (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	44365
Area of Container Yard (m2)	547400
Depth (m)	(- 11 to -14)
Length (m)	2150
Stacking Height	4
Number of Equipment	
QCC	19
Forklift	21
Side-Loader	6
Reachstacker	5
Rubber-Tired Gantry Cranes	74
Head Trcuk	140

3.6.7 Profile of Koja Port

KOJA Container Terminal, managed by PT Jakarta International Container Terminal (JICT), is a renowned container handling facility nestled in the bustling area of North Jakarta. It is strategically located within the precincts of Indonesia's busiest maritime gateway, the Port of Tanjung Priok, offering it an ideal setting to cater to the intense trade activities in the region. Its geographic coordinates are approximately 6°07'30.1"S latitude and 106°51'44.2"E longitude, positioning it as a critical connection point between domestic and international maritime routes. KOJA Container Terminal is distinguished by its sophisticated infrastructure and advanced operational capabilities. Its well-equipped terminal facilitates the seamless handling of various types of containers, including refrigerated, dry cargo, and dangerous goods containers. Its expansive yard, designed for optimal storage and manoeuvrability. KOJA Terminal has adopted a cutting-edge Terminal Operating System (TOS) that aids in streamlining its operations and enhancing the overall productivity of the port. Its extensive berth length and suitable draft depth enable the terminal to serve various vessel sizes, from feeder ships to large mainline vessels. The detail of Koja listed in the table below.

Table 18 shows The Facility and Equipment of KOJA

Port of KOJA	
Infrastructure (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	18900
Area of Container Yard (m2)	218000
Depth (m)	-13
Length (m)	650
Stacking Height	4
Number of Equipment	
CC	7
Reachstacker	3
Rubber-Tired Gantry Cranes	25
Head Trcuk	48

3.7 Pelindo III Profile

PT Pelabuhan Indonesia III, colloquially known as Pelindo III, is a state-owned corporation tasked with administering and managing port services in the central part of Indonesia. As a critical player in the nation's maritime sector, it oversees a vast network of ports serving as crucial trade hubs for local and international commerce. Established in 1992, Pelindo III holds jurisdiction over 43 public ports and terminals spread across seven provinces, including East Java, Central Java, Bali, South Kalimantan, Central Kalimantan, West Nusa Tenggara, and East Nusa Tenggara. Its impressive portfolio demonstrates diverse ports, from bustling commercial hubs to essential ferry ports and small multipurpose terminals.

Pelindo III's mission is to deliver high-quality, efficient, and reliable port services, optimizing the utilization of its port assets to benefit stakeholders. To this end, it deploys state-of-the-art port technologies and infrastructure, investing in advanced handling equipment, IT systems, and capacity-building initiatives. A prime example of its commitment to technology-driven efficiency is implementing its integrated Port Enterprise Resource Planning system, which significantly enhances operational coordination and transparency. Furthermore, Pelindo III continuously focuses on sustainability and eco-conscious practices, driving projects such as developing green ports. It aspires to balance economic growth with environmental preservation, ensuring its operations leave a minimal ecological footprint.

Figure 8 shows the operational area of Pelindo III

Source: Annual Report of Pelindo III 2020

3.7.1 Profile of Banjarmasin Port

Situated in the heart of South Kalimantan at coordinates 3.3185° S, 114.5941° E, the Trisakti Port, colloquially known as the Port of Banjarmasin, is an indispensable hub for regional trade and commerce. Governed by PT Pelabuhan Indonesia III (Pelindo III), the port administration has been steadfast in enhancing operational proficiency and infrastructural capacities, aligning its growth trajectory with the broader economic vision of Indonesia.

Encompassing an extensive geographical footprint, the Port of Banjarmasin has been designed to accommodate many maritime services. It boasts a dedicated container terminal to cater to the escalating demand for containerized cargo in the region and general cargo handling facilities. The port can manage various vessel types thanks to the expansive docking amenities and state-of-the-art operational equipment, solidifying its position as a fundamental pillar of regional and national economies. Moreover, acquiring cutting-edge cranes and machinery has significantly developed the port's cargo handling capabilities, resulting in expedited cargo processing times. The detail of Banjarmasin Port listed in the table below.

Table 19 shows The Facility and Equipment of Banjarmasin

Port of of Banjarmasin	
Infrastructure (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	6460
Area of Container Yard (m2)	81133
Depth (m)	-7
Length (m)	505
Stacking Height	5
Number of Equipment	
CC	4
Mobile Crane	2
Rubber-Tired Gantry Cranes	11
Side-Loader	2
Forklift	1
Head Truck	25

3.7.2 Profile of Tanjung Perak Port

Strategically located at 7.1957° S, 112.7333° E in Surabaya, East Java, the Port of Tanjung Perak is pivotal in Indonesia's maritime logistics network. It is under the management of PT Pelabuhan Indonesia III (Pelindo III), which diligently oversees its expansive operations. Tanjung Perak is one of the busiest ports in the country, processing millions of tons of cargo annually, underscoring its critical role in Indonesia's burgeoning economy.

The port's facilities are impressively diverse and comprehensive, encompassing container terminals, general cargo handling facilities, and specialized terminals for various bulk commodities. The container terminal is equipped with robust container handling equipment, including gantry cranes and reach stackers, to ensure swift, efficient container movements. The availability of extensive warehousing and storage facilities further amplifies its capabilities, ensuring smooth handling and storage of cargo. It is also well-connected with the hinterland through robust road and rail networks, which aids in facilitating seamless cargo movements. The detail of Banjarmasin Port listed in the table below.

Table 20 shows The Facility of Tanjung Perak Port

Port of Tanjung Perak	
Infrastructure (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	3895
Area of Container Yard (m2)	34880
Depth (m)	-8
Length (m)	320
Stacking Height	4
Number of Equipment	
Gantry Crane	3
Harbour Mobile Crane	6
Rubber-Tired Gantry Cranes	7
Forklift	1
Truck	17

3.7.3 Profile of Berlian Jasa Terminal Indonesia

Berlian Jasa Terminal Indonesia (BJTI), located at 6.9569° S, 112.6134° E, is a highly significant terminal in Gresik, East Java, Indonesia. This terminal is managed by PT Pelabuhan Indonesia III (Pelindo III) and plays an essential role in contributing to the region's logistics infrastructure. Notably, BJTI boasts substantial experience handling bulk and breakbulk cargoes, offering extensive services catering to domestic and international trade.

BJTI has an array of sophisticated facilities to cater to a wide range of cargo types. Its state-of-the-art facilities and strategic geographic location make it a desirable choice for shippers and consignees in East Java. The terminal's hinterland connectivity through well-structured road and rail networks promotes seamless cargo movement, thereby enhancing the terminal's competitiveness. The detail of BJTI listed in the table below.

Table 21shows The Facility of BJTI

Port of BJTI	
Infrastructure (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	7426
Area of Container Yard (m2)	43301
Depth (m)	(- 6.5 to -9.6)
Length (m)	1420
Stacking Height	6

Number of Equipment	
Harbour Mobile Crane	23
Rubber-Tired Gantry Cranes	15
Forklift	11
Reachstacker	4
Headtruck+trailer	115
Yard truck + chasis	12

3.7.4 Profile of Terminal Petikemas Semarang

Terminal Petikemas Semarang (TPKS), located at coordinates 6.9677° S, 110.4281° E, is a crucial container terminal in Semarang, Central Java, Indonesia. The terminal is managed under PT Pelabuhan Indonesia III (Pelindo III), which oversees its smooth and efficient operation. This port plays a crucial role in national and international trade movements, significantly focusing on containerized cargo. It services the Central Java and Yogyakarta region, providing a vital link to these bustling economic centers.

TPKS boasts well-developed facilities and services, including advanced container handling and storage equipment. The terminal offers comprehensive container handling solutions, including loading, unloading, stacking, and moving containers. Its infrastructure also includes a vast container yard for temporary storage. TPKS leverages its strategic location and superior connectivity to facilitate smooth transportation and logistics operations. The port is well-connected to a broad network of roadways and rail, expediently enhancing its capacity to transport cargo to and from its hinterland. The detail of TPKS listed in the table below

Table 22 shows The Facility of TPKS

Port of TPKS	
Infrastructure (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	10816
Area of Container Yard (m2)	187168
Depth (m)	-10
Length (m)	495
Stacking Height	5
Number of Equipment	
CC	5
Rubber-Tired Gantry Cranes	19
Forklift	8
Reachstacker	3
Top Loader	1
Side-Loader	2
Head Truck & Term. Tractor	44

3.7.5 Profile of Terminal Petikemas Surabaya

Terminal Petikemas Surabaya (TPS), located at coordinates 7.0223° S, 112.7271° E, is a significant container terminal in Surabaya, East Java, Indonesia. The terminal falls under the management of PT Pelabuhan Indonesia III (Pelindo III), a key player in the country's maritime sector. The strategic placement of TPS at the crossroads of numerous global trade routes amplifies its importance in the containerized cargo handling network in Indonesia and beyond. TPS is equipped with state-of-the-art infrastructure and provides an extensive suite of services for containerized cargo operations. The terminal's capabilities include efficient handling of containers, such as loading, unloading, stacking, and moving, bolstered by a well-maintained fleet of container handling equipment. The detail of TPS listed in the table below

Table 23 shows The Facility of TPS

Port of TP Surabaya	
Infrastructure (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	34252
Area of Container Yard (m2)	397000
Depth (m)	(- 7.5 to -10.5)
Length (m)	1450
Stacking Height	5
Number of Equipment	
CC	11
Rubber-Tired Gantry Cranes	28
Forklift	18
Reachstacker	6
Skystacker	3
Translifter	7
Head Truck	80

3.8 Pelindo IV Profile

PT Pelabuhan Indonesia IV (Persero), also known as Pelindo IV, is a prominent state-owned enterprise in Indonesia that plays a pivotal role in the country's maritime industry. Headquartered in Makassar, Pelindo IV is responsible for managing port operations across eastern Indonesia, with jurisdiction covering the regions of Sulawesi, Maluku, and Papua. The enterprise plays a strategic role in facilitating trade, contributing significantly to the growth and prosperity of the Indonesian economy.

Established in 1983, Pelindo IV has continued to demonstrate commitment to providing high-quality port services, constantly adapting to the evolving needs of the maritime industry and positioning itself at the forefront of port innovation. The company oversees 23 ports in its jurisdiction, each equipped with modern infrastructure and advanced facilities for efficient handling of various types of cargo, including containers, bulk, and general cargo. Pelindo IV is also committed to integrating technology into its operations, evident in its use of state-of-the-art equipment and adoption of digital solutions for enhancing operational efficiency and service quality. This commitment to service excellence and continual improvement forms the cornerstone of Pelindo IV's vision to become a world-class port operator.

Figure 9 shows the operational area of Pelindo IV

Source: Annual Report of Pelindo IV 2020

3.8.1 Profile of Makassar Port

Situated in the bustling city of Makassar, South Sulawesi, the Port of Makassar, known as Soekarno-Hatta Port, is a critical commercial conduit and an economic lifeline for the eastern regions of Indonesia. The port is governed by PT Pelabuhan Indonesia (Pelindo) III, one of the country's primary state-owned operators responsible for port management.

Given its geographical location and well-developed infrastructure, the port is strategically positioned to function as an interisland shipping hub. The port's features include extensive docking facilities, a deep harbor basin suitable for larger vessels, and comprehensive cargo handling amenities. Containerized, bulk and general cargo are processed efficiently due to the port's comprehensive equipment base and streamlined operations. The port's annual capacity for handling TEUs underlines its pivotal role in fostering regional trade. The detail of Makassar Port listed in the table below

Table 24 shows The Facility and Equipment of Makassar Port

Port of Makassar	
Infrastructure (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	2925
Area of Container Yard (m2)	60038
Depth (m)	(-11 to -13)
Length (m)	1200
Stacking Height	3
Number of Equipment	
Mobile Crane	3
Reachstacler	2
Loader	1
Forklift	5
Head Truck	3

3.8.2 Profile of Unit Terminal Petikemas Makssar

Unit Terminal Petikemas Makassar (UTPM), managed by Pelindo IV, is a crucial hub for container handling and logistics in Eastern Indonesia. Situated at coordinates 5.1395° S, 119.4126° E in the bustling city of Makassar, South Sulawesi, the terminal is strategically positioned to facilitate domestic and international trade. As one of the primary terminals within the Soekarno-Hatta Port, UTPM serves as a critical connector within Indonesia's expansive maritime network, ensuring the smooth transit of goods to and from the eastern part of the archipelago.

With a quay length of 100 meters, a depth of 12 meters, UTPM boasts a capacity to handle substantial container volumes. The terminal continues to invest in infrastructural upgrades and technological advancements, demonstrating its commitment to contributing significantly to Indonesia's maritime growth and development. The detail of UTPM listed in the table below.

Table 25 shows The Facility and Equipment UTPM

Port of UTPM	
Infrastructure (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	9480
Area of Container Yard (m2)	114446
Depth (m)	(-9 to -12)
Length (m)	1000
Stacking Height	5
Number of Equipment	
CC	5
Side-Loader	1
Rubber-Tired Gantry Cranes	11
Forklift	7
Reachstacker	2
Head Truck	30

3.8.3 Profile of Bitung Container Terminal

Bitung Container Terminal, managed under the authority of Pelindo IV, is a primary maritime gateway serving the trade needs of North Sulawesi, Indonesia. Located at coordinates 1.4451° N, 125.1824° E, the port resides in the city of Bitung, positioned strategically along the international shipping lanes on the Pacific Ocean. Bitung Container Terminal is crucial in the country's maritime logistics infrastructure, bridging the gap between domestic and international markets, particularly within the Pacific region.

The terminal offers impressive operational capabilities, boasting a quay length of 365 meter and a draft of up to 11 meters. This allows it to accommodate a substantial throughput of containers annually. It employs a robust technology-driven operational management system to streamline workflows, contributing to its reputation for operational efficiency and reliability. The detail of Bitung Container Terminal listed in the table below.

Table 26 shows The Facility and Equipment BCT

Port of BCT	
Infrastructure (Berthing of Container Vessel)	
Capacity of Yard (TEUs)	12875
Area of Container Yard (m2)	33000
Depth (m)	-11
Length (m)	365
Stacking Height	4

Chapter 4 – Data Processing and Analysis

4.1 Data Processing and Analysis

Table 27 shows the statistics summary of the variables

Variables	YA (m2)	BD (m)	QC (Idx)	BL (m)	YE (No)	GL (No)	TP (TEU)
Mean	149.813,47	10,54	15,41	787,88	32,12	4,53	750.531,94
Min	33.000,00	6,00	3,00	222,00	8,00	2,00	8.245,00
Max	796.121,00	16,00	88,00	2.150,00	106,00	13,00	2.787.017,00
Std. Dev.	191.943,13	2,68	20,84	534,65	30,77	3,62	836.424,16

Source: Author

In this study, Data Envelopment Analysis (DEA) is employed as the primary tool for assessing the technical efficiency of the container terminals under the PELINDO authority. Both CCR (Charnes et al.) and BCC (Banker et al.) models, which are output-oriented, are utilized to conduct this efficiency analysis. This analysis was conducted using the R Studio software, specifically leveraging the 'b enchmarking' package, known for its robust and comprehensive approach to DEA modelling.

The DEA CCR model is instrumental in calculating the Overall Technical Efficiency (OTE) for each container terminal. The OTE reflects how effectively a terminal utilizes its inputs to generate the corresponding outputs. This measurement allows us to compare the relative performance of different terminals, providing a score that signifies how close each terminal is to the best-performing, or 'frontier', terminal. An OTE score of one indicates optimal efficiency, as a terminal performs on the 'efficiency frontier', utilizing its resources in the best possible way to maximize output.

In contrast, the DEA BCC model allows us to calculate the Pure Technical Efficiency (PTE), which predominantly captures the managerial performance in converting inputs to outputs. This model helps identify managerial inefficiencies instead of scale inefficiencies, allowing a deeper understanding of the potential areas for operational improvement.

Scale efficiency (SE) refers to the optimal size or scale at which a terminal can most efficiently produce its output. First, a constant returns to scale are indicated by a SE score 1, suggesting that the terminal is operating at its most efficient scale. In this scenario, a proportional increase in all inputs results in a proportional output increase. In such a case, the terminal is said to be operating on the production frontier, denoting maximal efficiency. Second, a decreasing returns to scale is characterized by a SE score of less than 1. This suggests that the input variation exceeds the output variation, implying that the terminal may be operating beyond its optimal scale. Such a terminal may observe an improvement in efficiency by scaling down its operations. On the contrary, increasing returns to scale is denoted by a SE score greater than 1, where output variation is larger than input variation. This situation signifies that the terminal is operating below its optimal scale, suggesting that increased operations could improve efficiency.

$$Scale\ Efficiency = \frac{OTE}{PTE}$$

Scale efficiency on the respective terminal is calculated by above equation (Tsekeris & Niavis 2012).

4.2 DEA Analysis Before Merger (2020)

In this section, the analysis of data collected from 17 PELINDO-operated container terminals for 2020, we employed R Studio and the 'Benchmarking' package to implement an input-oriented **Banker, Charnes, and Cooper (BCC**) DEA model. This approach, emphasizing efficiency optimization at the input level and accounting for variable returns to scale, produced a data frame of efficiency scores for each terminal. We subsequently exported this data frame into an Excel file to facilitate a clear and accessible representation of our findings, laying the groundwork for future efficiency optimization strategies and policymaking efforts.

Table 28 shows processed values of DEA BCC in 2020

No.	DMU Name	Input-Oriented (VRS) Efficiency	*SLACK*	*Input Slacks*						Output Slacks
				YA	*BD*	*QC*	*BL*	*YE*	*GL*	TP
1	Belawan Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	BICT	0,96	TRUE	155426,70	0,00	0,00	201,45	18,58	4,08	0,00
3	Tanjung Priok	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	Teluk Bayur	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
5	Palembang Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
6	Panjang Port	1,00	TRUE	32540,40	6,80	0,00	0,00	3,88	0,00	416589,98
7	Pontianak Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
8	JICT	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
9	Koja	0,85	TRUE	146326,32	2,25	0,00	0,00	4,53	1,92	0,00
10	Banjarmasin Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
11	Tanjung Perak Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	BJTI	0,94	TRUE	0,00	0,00	7,04	664,81	0,00	0,47	0,00
13	TP Semarang	0,73	TRUE	94335,80	0,00	0,00	25,83	9,11	0,00	0,00
14	Tp Surabaya	0,97	TRUE	314079,26	0,00	0,00	229,26	0,00	5,13	0,00
15	Makassar Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
16	UTPT	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
17	BCT	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00

In a comprehensive exploration of operational efficiency across the four divisions of PELINDO's container terminals (PELINDO I, II, III, and IV), we employed the sophisticated Data Envelopment Analysis (DEA) method. Specifically, an input-oriented model under Variable Returns to Scale (VRS) conditions was utilized. It meticulously evaluates how these diverse terminals transform their inputs into outputs with the highest efficiency level.

Efficiency scores derived from this analysis spanned from 0.73 to 1.00, where a score of 1.00 epitomizes peak efficiency. Among the seventeen terminals analyzed, twelve demonstrated optimal efficiency, signifying exemplary conversion and utilization of their inputs. The terminals achieving this optimal score are spread across all four divisions of PELINDO, testifying to the widespread, efficient practices within the organization.

Conversely, five terminals (specifically, BICT, Koja, BJTI, Terminal Petikemas Semarang, and Terminal Petikemas Surabaya) produced efficiency scores below 1.00, indicating potential areas for improvement. Interestingly, these terminals are situated across all four regional divisions, suggesting that the need for operational enhancement is not confined to one specific region.

Furthermore, these less-than-optimal terminals displayed slack in certain inputs and outputs. In the context of DEA, the concept of slack reflects the excess of inputs or deficiency of outputs for a decision-making unit (DMU) to reach the efficient frontier. To illustrate, let us take the BICT terminal as an example. The terminal has displayed slack in several input dimensions, such as Yard Area (155426.70 m² slack), Berth Length (201.45 m slack), Yard Equipment (18,58 units slack) and Gate Lanes (4.08 lanes slack). These values suggest that BICT has surplus Yard Area, Yard Equipment, and Gate Lanes, which are not effectively utilised to generate optimal output.

Table 29 shows processed values of DEA CCR in 2020

No.	DMU Name	Input-Oriented (CRS) Efficiency	*SLACK*	*Input Slacks*						Output Slacks
				YA	*BD*	*QC*	*BL*	*YE*	*GL*	TP
1	Belawan Port	0,11	TRUE	2934,77	0,00	0,00	20,74	0,00	0,06	0,00
2	BICT	0,95	TRUE	144471,05	0,00	0,00	0,00	10,62	3,59	0,00
3	Tanjung Priok	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	Teluk Bayur	0,18	TRUE	6839,48	1,11	0,00	0,00	0,66	0,15	0,00
5	Palembang Port	0,23	TRUE	6622,11	0,61	0,00	0,00	3,85	0,10	0,00
6	Panjang Port	0,23	TRUE	6825,56	1,89	0,00	0,00	1,06	0,06	0,00
7	Pontianak Port	0,61	TRUE	8938,92	0,64	0,00	0,00	10,61	1,80	0,00
8	JICT	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
9	Koja	0,81	TRUE	123396,82	0,00	0,00	0,00	8,71	2,12	0,00
10	Banjarmasin Port	0,88	TRUE	27666,41	0,00	0,00	0,00	0,61	1,95	0,00
11	Tanjung Perak Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	BJTI	0,91	TRUE	0,00	0,00	6,32	631,27	0,00	0,50	0,00
13	TP Semarang	0,65	TRUE	87017,79	0,00	0,00	0,00	13,65	1,05	0,00
14	Tp Surabaya	0,92	TRUE	328881,58	0,00	0,00	223,02	0,00	5,44	0,00
15	Makassar Port	0,03	TRUE	491,53	0,22	0,00	22,90	0,00	0,03	0,00
16	UTPT	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
17	BCT	0,55	TRUE	0,00	3,66	0,00	40,58	2,55	0,63	0,00

To augment our understanding of the performance dynamics within PELINDO's container terminals, we further deployed the **Charnes, Cooper, and Rhodes (CCR)** model, a foundational variant of Data Envelopment Analysis (DEA) that operates under Constant Returns to Scale (CRS) showed in Table 26. This variant offers an unadulterated perspective of efficiency, assuming that output changes proportionally with inputs, thereby shedding light on the technical efficiency of each Decision Making Unit (DMU) independently of their scale of operations. The efficiency scores resulting shown in table above from this model exhibit a broad spectrum, ranging from a low of 0.03 to the optimum score of 1.00. This wide dispersion underscores the diversity in efficiency levels across the terminals and introduces a more nuanced understanding of their operational performance. Notably, a subset of terminals—namely Tanjung Priok, JICT, Tanjung Perak Port, and UTPT—have achieved an efficiency score of 1.00, reflecting their excellent technical efficiency under the CRS assumption.

Nevertheless, several terminals, such as Belawan Port, Teluk Bayur, Palembang Port, Panjang Port, and Makassar Port, exhibit significantly lower scores. For instance, Makassar Port recorded the lowest efficiency score of 0.03. These results suggest that these terminals are not converting their inputs into outputs as efficiently as their counterparts, thus presenting substantial opportunities for process enhancements and capacity building.

Moreover, some terminals, including BICT, Koja, Banjarmasin Port, BJTI, TP Semarang, and TP Surabaya, recorded scores between 0.81 and 0.95. These scores reflect a moderate level of technical efficiency, indicating some potential for input reduction or output augmentation.

4.3 DEA Analysis in The Transition Year (2021)

Table 30 shows processed values of DEA BCC in 2021

No.	DMU Name	Input-Oriented (VRS) Efficiency	*SLACK*	*Input Slacks*						Output Slacks
				YA	*BD*	*QC*	*BL*	*YE*	*GL*	TP
1	Belawan Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	BICT	0,97	TRUE	155910,31	0,00	0,00	194,40	18,36	4,09	0,00
3	Tanjung Priok	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	Teluk Bayur	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
5	Palembang Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
6	Panjang Port	1,00	TRUE	32540,40	6,80	0,00	0,00	3,88	0,00	437771,85
7	Pontianak Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
8	JICT	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
9	Koja	0,86	TRUE	147891,52	2,33	0,00	0,00	4,45	1,93	0,00
10	Banjarmasin Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
11	Tanjung Perak Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	BJTI	0,94	TRUE	0,00	0,00	7,10	664,48	0,00	0,46	0,00
13	TP Semarang	0,73	TRUE	97701,42	0,00	0,00	48,59	10,54	0,23	0,00
14	Tp Surabaya	0,97	TRUE	331783,75	0,00	0,00	318,09	0,00	5,61	0,00
15	Makassar Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
16	UTPT	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
17	BCT	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00

In the PELINDO transition year, the company witnessed a slight improvement in operational efficiency across most of its container terminals, as measured by the Input-Oriented (BCC) efficiency scores. This efficiency enhancement manifests in the container terminals under PELINDO I, II, and IV achieving an efficiency score of 1.00, demonstrating their optimal use of inputs to generate outputs, or in other words, their high-level operational effectiveness. The Belawan Port, Tanjung Priok, Teluk Bayur, Palembang Port, Panjang Port, Pontianak Port, JICT, Makassar Port, UTPT, and BCT have achieved maximum efficiency.

Among PELINDO III's terminals, Banjarmasin Port and Tanjung Perak Port, too, achieved perfect scores. However, the Terminal Petikemas Semarang (TP Semarang), with a score of 0.73, and Berlian Jasa Terminal Indonesia (BJTI), with a score of 0.94, signalled room for further optimization. Meanwhile, within PELINDO II, the Koja terminal, scoring 0.86, also identified a similar opportunity for improvement. These exceptions, notwithstanding, the robust efficiency scores reflect a trend towards increasingly effective operational practices within the PELINDO organization. This substantial progress emphasizes the success of PELINDO's strategic interventions during the transition period and denotes a promising trajectory towards achieving the company's long-term objectives.

Table 31 shows processed values of DEA CCR in 2021

No.	DMU Name	Input-Oriented (CRS) Efficiency	*SLACK*	*Input Slacks*						Output Slacks
				YA	*BD*	*QC*	*BL*	*YE*	*GL*	TP
1	Belawan Port	0,08	TRUE	2263,77	0,00	0,00	16,00	0,00	0,04	0,00
2	BICT	0,97	TRUE	146226,77	0,00	0,00	0,00	10,74	3,63	0,00
3	Tanjung Priok	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
4	Teluk Bayur	0,21	TRUE	7966,23	1,30	0,00	0,00	0,77	0,18	0,00
5	Palembang Port	0,22	TRUE	6230,83	0,58	0,00	0,00	3,62	0,09	0,00
6	Panjang Port	0,24	TRUE	7251,55	2,01	0,00	0,00	1,13	0,07	0,00
7	Pontianak Port	0,59	TRUE	8611,31	0,61	0,00	0,00	10,23	1,73	0,00
8	JICT	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
9	Koja	0,81	TRUE	123907,26	0,00	0,00	0,00	8,75	2,12	0,00
10	Banjarmasin Port	0,87	TRUE	27229,47	0,00	0,00	0,00	0,60	1,92	0,00
11	Tanjung Perak Port	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
12	BJTI	0,91	TRUE	0,00	0,00	6,26	625,53	0,00	0,50	0,00
13	TP Semarang	0,66	TRUE	88335,74	0,00	0,00	0,00	13,86	1,06	0,00
14	Tp Surabaya	0,92	TRUE	327904,72	0,00	0,00	222,35	0,00	5,42	0,00
15	Makassar Port	0,06	TRUE	1031,45	0,46	0,00	48,05	0,00	0,06	0,00
16	UTPT	1,00		0,00	0,00	0,00	0,00	0,00	0,00	0,00
17	BCT	0,60	TRUE	0,00	3,95	0,00	43,76	2,75	0,67	0,00

The year 2021 marked a significant transition for PELINDO's container terminals. Analyzing using DEA CCR, the efficiency scores during this period unveils a diverse range of operational effectiveness across different terminals. For instance, Tanjung Priok, JICT, Tanjung Perak Port, and UTPT showcased remarkable proficiency, boasting a perfect efficiency score 1.00. This performance implies optimal resource allocation and utilization, ensuring no surplus inputs or underproduced outputs.

However, not all terminals mirrored this exemplary efficiency. Notably, Makassar Port, with an efficiency score of 0.06, is an area of particular concern. Such a low score indicates significant room for improvement. The significant slack in Makassar Port's operations signifies that substantial resources are not being employed to their full potential. Understanding and addressing these inefficiencies can offer an important trajectory for increasing its operational efficiency.

Meanwhile, the transition year saw a surge in efficiency at some terminals, such as BICT, with its efficiency score rising to 0.97, TP Surabaya to 0.92, and BJTI to 0.91. Although these scores are commendable, there is still scope to attain complete efficiency, possibly by reducing input slack or increasing output.

It is crucial to address these discrepancies, and it is equally important to understand their root causes, which could be diverse and terminal-specific. Possible explanations include geographical constraints, infrastructure, equipment availability, or management strategies. Future steps should involve an in-depth investigation of these slacks, allowing for strategic decisions to boost overall efficiency in PELINDO's terminal operations

4.4 DEA Analysis After The Merger (2022)

Table 32 shows efficiency scores for all 17 container ports

No.	DMU Name	2020				2021				2022			
		CCR(CRS) OTE	BCC (VRS) PTE	SE	Reason	CCR(CRS) OTE	BCC (VRS) PTE	SE	Reason	CCR(CRS) OTE	BCC (VRS) PTE	SE	Reason
1	Belawan Port	0,11	1,00	0,11	SIE	0,08	1,00	0,08	SIE	0,09	1,00	0,09	SIE
2	BICT	0,95	0,96	0,99	PTIE	0,97	0,97	1,00	PTIE	0,96	0,97	1,00	PTIE
3	Tanjung Priok	1,00	1,00	1,00		1,00	1,00	1,00		1,00	1,00	1,00	
4	Teluk Bayur	0,18	1,00	0,18	SIE	0,21	1,00	0,21	SIE	0,20	1,00	0,20	SIE
5	Palembang Port	0,23	1,00	0,23	SIE	0,22	1,00	0,22	SIE	0,22	1,00	0,22	SIE
6	Panjang Port	0,23	1,00	0,23	SIE	0,24	1,00	0,24	SIE	0,23	1,00	0,23	SIE
7	Pontianak Port	0,61	1,00	0,61	SIE	0,59	1,00	0,59	SIE	0,59	1,00	0,59	SIE
8	JICT	1,00	1,00	1,00		1,00	1,00	1,00		1,00	1,00	1,00	
9	Koja	0,81	0,85	0,95	PTIE	0,81	0,86	0,94	PTIE	0,81	0,86	0,95	PTIE
10	Banjarmasin Port	0,88	1,00	0,88	SIE	0,87	1,00	0,87	SIE	0,86	1,00	0,86	SIE
11	Tanjung Perak Port	1,00	1,00	1,00		1,00	1,00	1,00		1,00	1,00	1,00	
12	BJTI	0,91	0,94	0,97	PTIE	0,91	0,94	0,96	PTIE	0,91	0,94	0,96	PTIE
13	TP Semarang	0,65	0,73	0,90	PTIE	0,66	0,73	0,90	PTIE	0,66	0,73	0,90	PTIE
14	Tp Surabaya	0,92	0,97	0,95	SIE	0,92	0,97	0,95	SIE	0,92	0,97	0,95	SIE
15	Makassar Port	0,03	1,00	0,03	SIE	0,06	1,00	0,06	SIE	0,06	1,00	0,06	SIE
16	UTPT	1,00	1,00	1,00		1,00	1,00	1,00		1,00	1,00	1,00	
17	BCT	0,55	1,00	0,55	SIE	0,60	1,00	0,60	SIE	0,59	1,00	0,59	SIE

: PELINDO I | : PELINDO II | : PELINDO III | PELINDO IV

Table 33shows Port's Efficiency and Inefficiency Summary

Terminal Efficiency Status	2020	2021	2020
Efficienct	4 (23%)	4 (23%)	4 (23%)
Inefficient	13 (77%)	13 (77%)	13 (77%)
Pure Technical Inefficient	4 (31%)	4 (31%)	4 (31%)
Scale Inefficiency	9 (69%)	9 (69%)	9 (69%)

The unification of PELINDO I, II, III, and IV into a single entity in 2021 marked a significant transition for the container terminals under its purview. The impact on the efficiency of these terminals varied, with some experiencing an increase, decrease, or no change at all. Based on the provided processed output until year of 2022, the merge's effect on technical efficiency - expressed through DEA CCR (OTE), DEA-BCC (PTE), and Scale Efficiency - was quite apparent.

For instance, Tanjung Priok, JICT, Tanjung Perak and UTPT maintained peak performance (an efficiency score of 1) throughout the transition years, indicating that these terminals remained fully efficient, regardless of any changes associated with the merger. In contrast, terminals such as Belawan Port and Makassar Port had consistently low scale efficiency (SE) throughout the transition period, reflecting scale inefficiencies (SIE). Despite the merger, these ports could not improve their scale of operation to an optimal level.

Interestingly, there were 9 terminals showed a consistent, Scale Inefficiency from 2020 to 2022. While these terminals were relatively efficient in managing their available resources (reflected in the efficiency score 0,73 – 0,96 on BCC model).

In performing a deeper analysis of the impact of the PELINDO merger on various container terminals, a few distinct categories emerge. **The first category** includes terminals that exhibited no change in efficiency after the merger, maintaining a constant efficiency score of 1. This group, which includes Tanjung Priok, JICT, and UTPT, showcases stability and high performance regardless of organizational changes, reflecting robust and efficient operational structures.

The second category includes terminals that demonstrated noticeable improvements in efficiency post-merger. For instance, BICT improved from a OTE score of 0.95 in 2020 to 0.97 in 2021, while BCT showed an uplift from 0.55 to 0.60 in the same period. These improvements suggest that the integration brought about positive changes in these terminals, perhaps due to enhanced resource allocation, shared best practices, or streamlined operations.

The third category includes terminals that experienced a slight decrease in efficiency scores, such as Banjarmasin Port, where the OTE score slightly declined from 0.88 in 2020 to 0.86 in 2022. This minor downturn might be due to transitional challenges, such as adapting to new operational frameworks or restructuring.

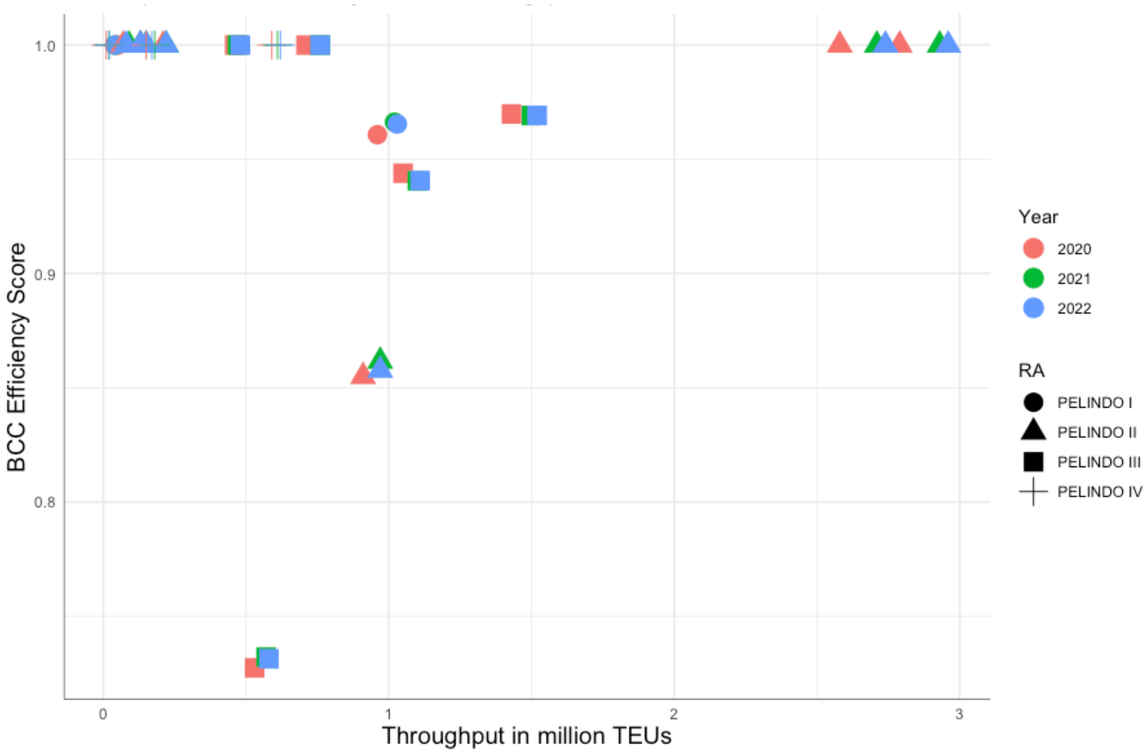
The last category comprises terminals like Belawan Port and Makassar Port, which consistently demonstrate low-scale efficiency. These ports have been the least impacted by the merger in terms of efficiency gains. Their persistent scale inefficiencies may signal underlying issues that need to be addressed at the root level, such as infrastructural upgrades or utilization of resources. While some terminals remained consistently efficient or showed improvement post-merger, others experienced a slight dip or no significant change. These variations underline the complexity of organizational transitions, particularly in the context of port operations. While the merger facilitated knowledge sharing and potentially improved resource utilization in some terminals, it also brought new challenges that may have affected operational efficiency in others. This underlines the importance of bespoke strategies and targeted interventions to maximize the benefits of such large-scale mergers.

A notable continuity of efficiency scores on table 30 above has been observed across the 17 container terminals scrutinized in the study. A minority subset of these terminals, approximately 23%, demonstrated efficient operations consistently throughout the period. This group, comprising Tanjung Priok Port, JICT, Tanjung Perak Port, and UTPT, signifies the benchmark of operational excellence within the industry.

Conversely, a considerable percentage of terminals, amounting to 77%, fell within the inefficiency bracket. This larger group is subdivided into two distinct categories based on their primary areas of improvement. Nine inefficient terminals, representing 69% of the subset, exhibited a need for enhancements predominantly within managerial performance and operational aspects. The operational aspects could encompass process optimization, technology utilization, workforce productivity, and resource allocation. Managerial improvements, on the other hand, might pertain to strategic decision-making, leadership, coordination, and control mechanisms. The remaining four terminals, constituting 31% of the inefficient group, showcased a requirement for improving their production scale. These terminals might benefit from strategies aimed at increasing the volume of their output or expanding their capacity, potentially through infrastructural investments, process enhancements, or strategic partnerships.

This analysis underscores the need for differentiated, terminal-specific strategies to boost efficiency levels across Indonesia's container port sector. The disparity in the areas of improvement for the terminals elucidates that a one-size-fits-all approach might yield a different uptick in efficiency. Instead, terminal-specific interventions, directed towards the identified improvement areas, could be the key to unlocking enhanced operational performance across the sector.

Figure 10 shows Throughput of Container VS BCC Efficiency Score

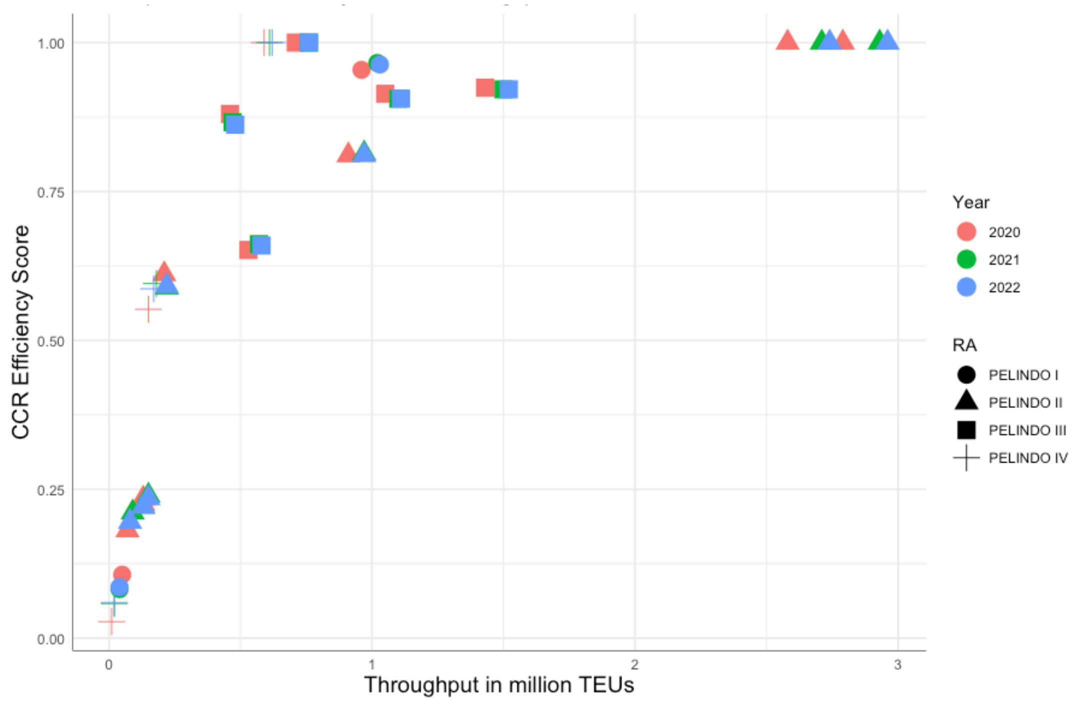


In the year 2020, prior to the merger of PELINDOs, the BCC efficiency scores were fairly consistent across most ports, with an average score of about 1.00. However, the throughput varied greatly across the different ports. For example, the Tanjung Priok and JICT ports under PELINDO II exhibited high throughput values, suggesting they were operating at higher capacities than other ports. Some ports, like Makassar Port under PELINDO IV, had an exceptionally low throughput value despite a high BCC score, suggesting the underutilization of resources.

In 2021, during the transition year of the merger, the BCC scores remained relatively stable, with an average of 1.00, similar to the previous year. There were slight increases in throughput for some ports, for instance, Tanjung Priok under PELINDO II and Tp Surabaya under PELINDO III. However, some ports, like Belawan Port under PELINDO I and Makassar Port under PELINDO IV, reduced throughput despite maintaining the same BCC score. This could indicate a decrease in demand or operational efficiencies in these ports during the transition period.

Following the merger in 2022, the BCC scores remained consistent at around 1.00, indicating that the merger did not significantly impact port efficiency. Throughput for several ports increased slightly, including the Tanjung Priok port under PELINDO II and the Tp Surabaya port under PELINDO III. This suggests that these ports benefited from the merger in terms of increased operational capacity or demand.

Figure 11 shows Throughput of Container VS CCR Efficiency Score



In the period preceding the merger of PELINDO I, II, III, and IV in 2020, the CCR (Constant Returns to Scale) efficiency scores varied notably across the ports. Some ports like Tanjung Priok, JICT under PELINDO II, Tanjung Perak Port under PELINDO III, and UTPT under PELINDO IV showed optimal efficiency with CCR scores of 1.00, coinciding with high throughput values. In contrast, ports like Belawan Port under PELINDO I and Makassar Port under PELINDO IV demonstrated significantly lower CCR scores, implying potential inefficiencies or underutilization, given their correspondingly low throughput figures.

During the transition year in 2021, most ports either maintained or slightly improved their CCR efficiency scores compared to 2020. This improvement aligns with marginal enhancements in throughput for some ports, such as BICT under PELINDO I and JICT under PELINDO II, suggesting a possible positive effect of the transition period on operational efficiency and capacity utilization. Conversely, some ports like Belawan Port and Makassar Port under PELINDO I and IV respectively experienced a decrease in their CCR efficiency scores and throughput, potentially due to challenges arising during the transition process.

Following the merger in 2022, there was an overall stability in the CCR efficiency scores, with some ports even exhibiting minor improvements. The throughput of many ports also remained stable or slightly increased, suggesting that the merger may have led to consistent operational efficiency across the unified entity. Notably, Tanjung Priok and JICT under PELINDO II, Tanjung Perak Port under PELINDO III, and UTPT under PELINDO IV consistently maintained their high efficiency and throughput throughout these periods, indicating sustained operational excellence.

4.5 Malmquist Productivity Index (MPI) Analysis

The Malmquist productivity index (MPI), with its core components of catch-up and frontier shift, has proved to be a critical tool in assessing the productivity and efficiency of various business operations. In the context of the recent merger of PELINDO I, II, III, and IV, the use of MPI has become increasingly crucial. The catch-up component of the MPI signifies the degree of progression or regression in a company's efficiency relative to the most efficient company or operation. In the PELINDO merger scenario, understanding catch-up will help gauge how each entity has evolved in terms of efficiency and what steps need to be taken to bring them at par with each other or the industry's best.

Table 34 shows the MPI for each container port

DMU Name	Regional	Catch-up	Frontier Shift	MPI	Rank
Makassar Port	PELINDO IV	2,16	0,68	1,47	1
Teluk Bayur	PELINDO II	1,08	0,96	1,04	2
BCT	PELINDO IV	1,06	0,97	1,03	3
Panjang Port	PELINDO II	1,04	0,98	1,02	4
TP Semarang	PELINDO III	1,01	0,99	1,01	5
BICT	PELINDO I	1,01	1,00	1,00	6
Koja	PELINDO II	1,00	1,00	1,00	7
Tanjung Priok	PELINDO II	1,00	1,00	1,00	8
JICT	PELINDO II	1,00	1,00	1,00	9
Tanjung Perak Port	PELINDO III	1,00	1,00	1,00	10
UTPT	PELINDO IV	1,00	1,00	1,00	11
Tp Surabaya	PELINDO III	1,00	1,00	1,00	12
BJTI	PELINDO III	0,99	1,00	1,00	13
Banjarmasin Port	PELINDO III	0,98	1,01	0,99	14
Pontianak Port	PELINDO II	0,97	1,02	0,98	15
Palembang Port	PELINDO II	0,94	1,03	0,97	16
Belawan Port	PELINDO I	0,80	1,11	0,90	17

The Malmquist productivity index (MPI), with its core components of catch-up and frontier shift, has proved to be a critical tool in assessing the productivity and efficiency of various business operations. In the context of the recent merger of PELINDO I, II, III, and IV, the use of MPI has become increasingly crucial. The catch-up component of the MPI signifies the degree of progression or regression in a company's efficiency relative to the most efficient company or operation. In the PELINDO merger scenario, understanding catch-up will help gauge how each entity has evolved in terms of efficiency and what steps need to be taken to bring them at par with each other or the industry's best.

The catch-up value, in the context of port administration, it quantifies the degree of progression or regression in a port's efficiency.If the catch-up value is greater than 1, it demonstrates relative efficiency increases between the observed periods. For instance, Makassar Port under PELINDO IV, with a catch-up value of 2.16, indicates a significant increease in relative efficiency. This suggests that Makassar Port has successfully improved its operational and logistical efficiencies to close the gap with the industry's best-performing ports.

When the catch-up value is equal to 1, as in the case of Koja, Tanjung Priok, JICT, Tanjung Perak Port, UTPT, and TP Surabaya under PELINDO II and III, it suggests a consistent efficiency level. These ports have maintained their operational efficiency without any notable improvement or deterioration. In the context of strategic planning, these ports need to identify innovative strategies and practices to enhance their performance and not just maintain their current efficiency levels.

A catch-up value of less than 1, as seen with Banjarmasin Port, Pontianak Port, Palembang Port, and Belawan Port under PELINDO II, III, and I, indicates a decline in relative efficiency over the given periods. This suggests these ports need to perform optimally and have seen a decrease in efficiency compared to industry leaders. For these ports, it is imperative to identify the areas contributing to this lower efficiency and develop strategies for improvement.

The frontier shift reflects the shifts in the technology or best practices that dictate the maximum attainable output from a set of inputs.The frontier shift values greater than 1, as evidenced by Banjarmasin Port, Pontianak Port, Palembang Port, and Belawan Port under PELINDO II, III, and I, suggest that there has been a technological advancement or the adoption of better practices. These ports have successfully integrated new technologies or management practices, improving output potential. Belawan Port, with a frontier shift of 1.11, particularly stands out, suggesting significant technological progress or operational innovations during the observed periods.

Frontier shift values equal to 1, observed in BICT, Koja, Tanjung Priok, JICT, Tanjung Perak Port, UTPT, TP Surabaya, and BJTI under PELINDO I, II, and III, suggest a stable technological or best practices frontier. These ports have not experienced any significant shifts in their output potential from technological advancements or adopting new best practices. Despite this seeming stability, it is crucial that these ports continuously seek advancements to ensure they stay caught up in an ever-evolving industry.

A frontier shift value less than 1, as seen with Makassar Port, Teluk Bayur, BCT, and Panjang Port under PELINDO II and IV, suggests a technology or best practices regression. This shows that the maximum attainable output from a given set of inputs has decreased due to technological or best practices degradation. In this context, Makassar Port, with a frontier shift of 0.68, has experienced a significant decrease in output potential, necessitating urgent strategic interventions to revert this negative trend

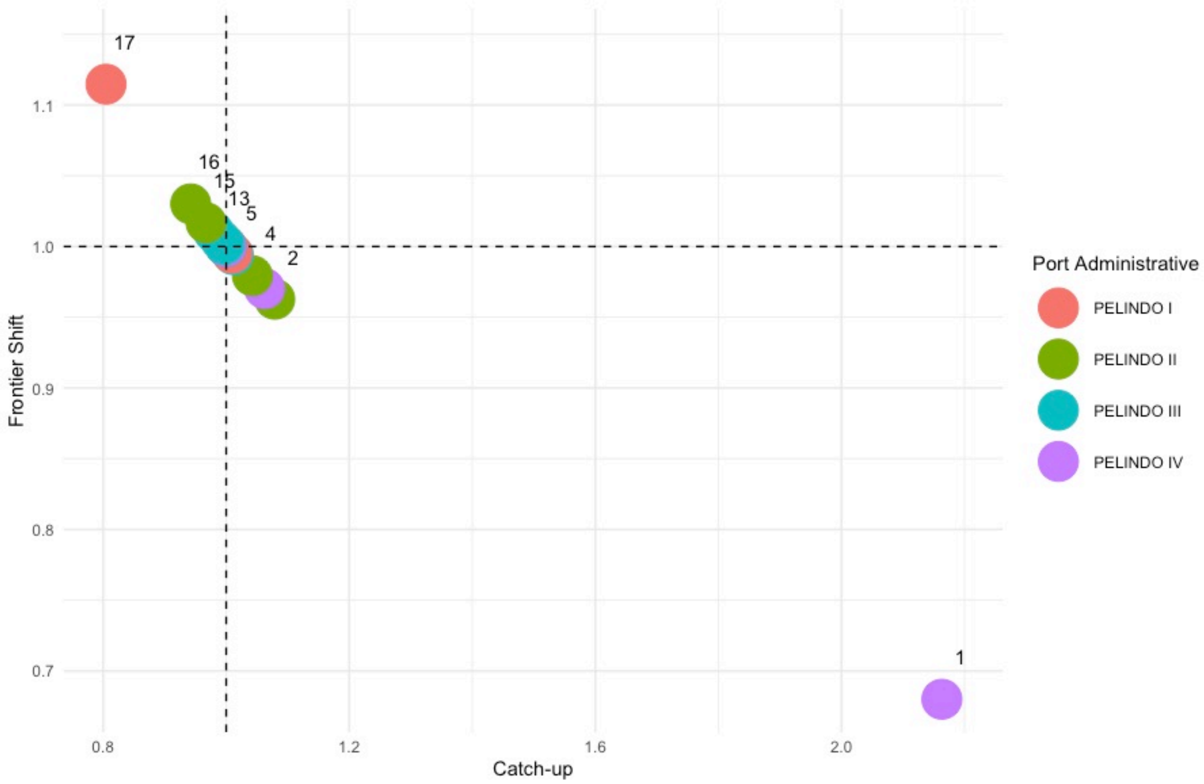
MPI values greater than 1 signify an improvement in total factor productivity. For instance, Makassar Port, under PELINDO IV, which leads the ranking with an MPI of 1.47, has experienced substantial productivity gains. This port's performance could be a benchmark for others in adopting productivity-enhancing strategies. Teluk Bayur, BCT, Panjang Port, and TP Semarang under PELINDO II, IV, and III, respectively, have also shown a slight improvement in productivity with MPI values marginally above 1, indicating a positive trend in their operational efficiencies.

MPI value of exactly 1 suggests that productivity has remained steady. This includes BICT under PELINDO I and ports such as Koja, Tanjung Priok, JICT, Tanjung Perak Port, UTPT, TP Surabaya, and BJTI under PELINDO II and III. Although maintaining productivity is commendable, these ports must strive for continuous improvement to remain competitive in an evolving industry landscape.

Finally, an MPI value of less than 1 indicates a decline in productivity. Banjarmasin Port, Pontianak Port, Palembang Port, and notably, Belawan Port, with an MPI of 0.90 under PELINDO III, II, and I, respectively, fall under this category. This regression signals a need for strategic intervention and reassessment of their operational and management practices to reverse the downward productivity trend

4.6 Performance Analysis

Figure 12 shows the performance of container terminal (Rank 1-17)



The dataset offers a multifaceted perspective on the performance dynamics of 17 container ports. We can deduce intricate nuances of port performance, growth strategies, and challenges by investigating the Catch-up, Frontier Shift, and the MPI.

1. Operational Excellence and its Anomalies:

   Makassar Port: It is an intriguing case. The disproportionately high Catch-up of 2.16 suggests a rapid adaptation to industry benchmarks. Nevertheless, its Frontier Shift of 0.68 is paradoxical. It indicates that while they are catching up remarkably, they might be doing so in an environment where the efficiency frontier is regressing. Their overall MPI, while impressive, could be driven primarily by their Catch-up efficiency, rendering it paramount for them to address the decreasing Frontier Shift.

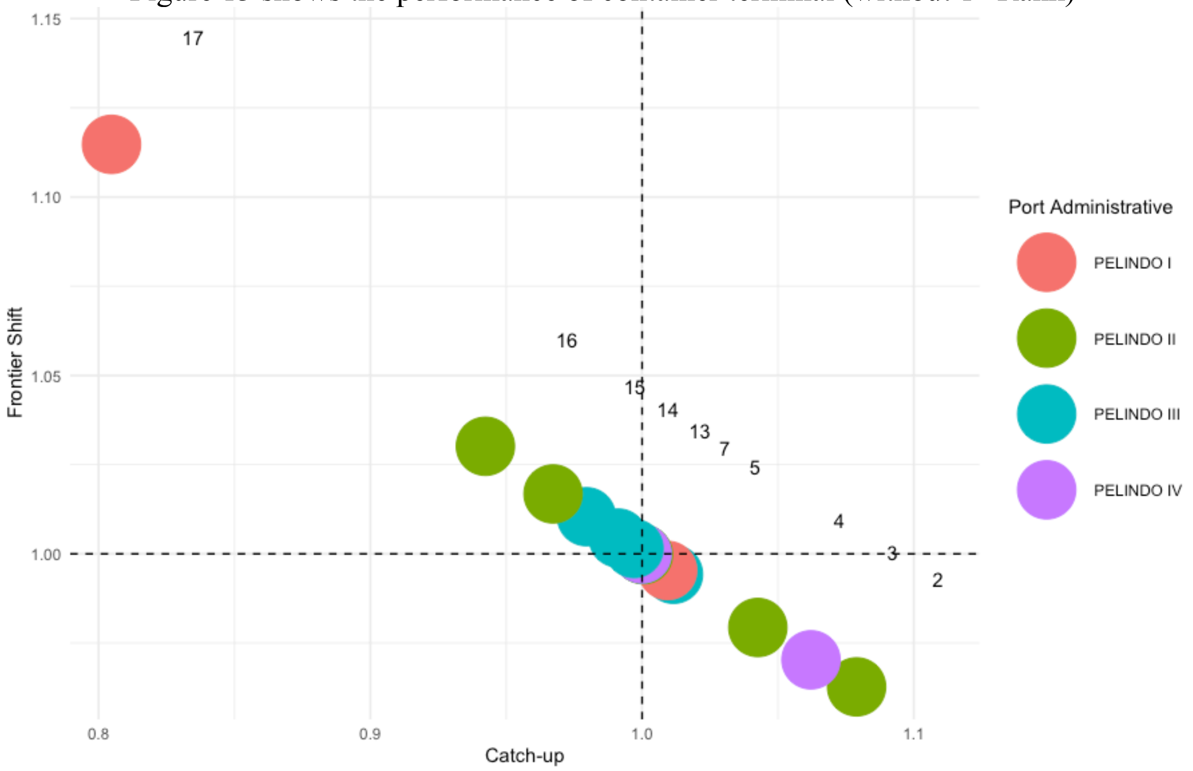
2. Dissecting PELINDO's Portfolios:

   PELINDO II: Ports under this administrative umbrella, such as Teluk Bayur and Panjang Port, thread the path of consistency. Their metrics gravitating around 1 for both Catch-up and Frontier Shift denote an equilibrium— they are progressing at par with the industry's best practices and setting commendable benchmarks.

   PELINDO IV: Beyond Makassar Port, other ports in this administration, particularly BCT, have a Catch-up value slightly above 1. This indicates a recent push to align with best practices. Their Frontier Shift, edging close to 1, denotes an evolving benchmark that's more or less stable.

3. The Dualities of PELINDO I & III:
   DESPITE BEING UNDER THE SAME ADMINISTRATION, PELINDO I: BICT and Belawan Port present dichotomous pictures. While BICT holds its ground with metrics clustering around 1, Belawan Port is a call for introspection. Its Catch-up of 0.80 signals a lag, coupled with a Frontier Shift of 1.11, which implies that they are falling behind even as the efficiency benchmarks advance.

Figure 13 shows the performance of container terminal (without 1st Rank)



Based on the processed data and the performance indicators (Catch-up, Frontier Shift, and MPI), the terminals can be broadly characterized into three categories:

1. **Outperforming**: This would be represented by values greater than 1 in MPI. From the data, **Makassar Port** is an evident outlier with an MPI of 1.47, driven by a very high Catch-up value of 2.16. This suggests it's rapidly improving its efficiency relative to its past performance. However, the Frontier Shift value below 1 indicates that while it's making great strides in catching up, the industry's frontier efficiency might be regressing.
2. **Moderate Performance**: Most of the terminals fall within this category. These are terminals with values close to 1 for both Catch-up and Frontier Shift. Container Terminals such as **TP Semarang**, **BICT**, **Koja**, **Tanjung Priok**, **JICT**, **Tanjung** 1,

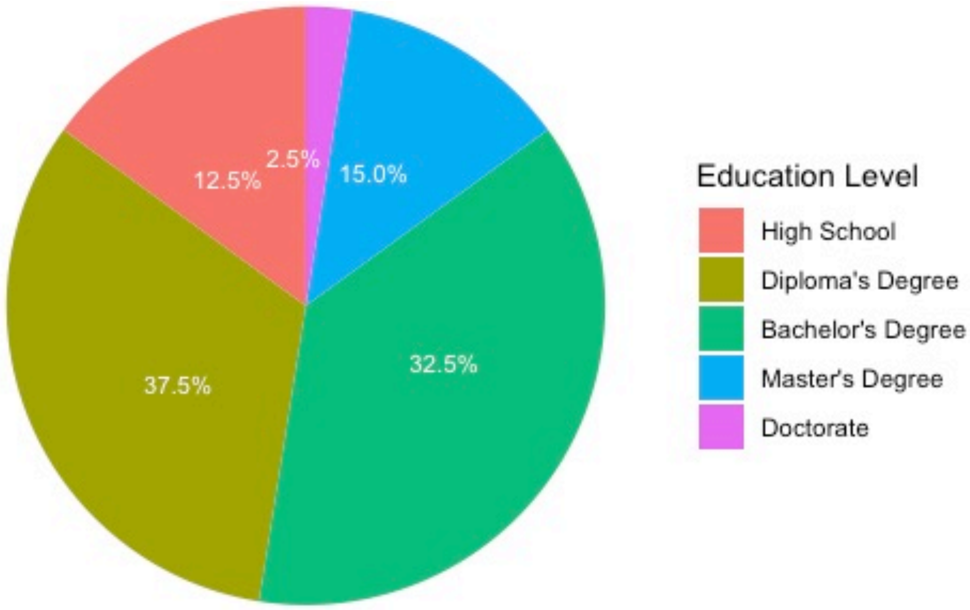
Perak Port, **UTPT**, and **Tp Surabaya** all showcase this trait. Their MPI hovers around indicating that they are moving in tandem with the industry benchmarks. They need to catch up and lead significantly.

3. **Slight Underperformance**: Terminals that fall slightly below the industry benchmarks in terms of Catch-up but are still close to 1 can be considered mildly underperforming. This includes **BJTI**, **Banjarmasin Port**, **Pontianak Port**, and **Palembang Port**. **Belawan Port** stands out as the most underperforming based on its Catch-up value of 0.80. However, its Frontier Shift is above 1, indicating that the efficiency frontier in the industry is progressing.

4.7 Qualitative Method Data Processing

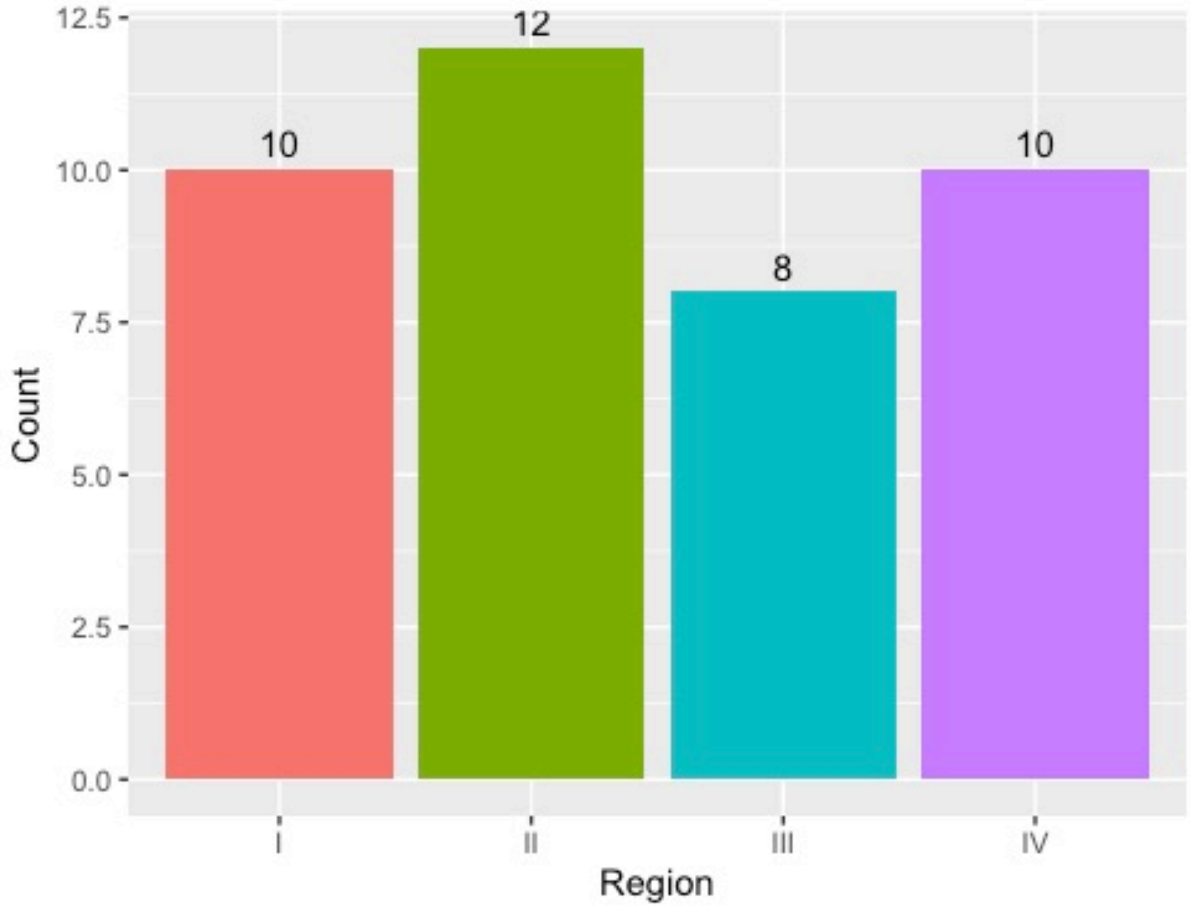
On the side of qualitative methods for this research, we distribute questionnaires to all region management of PELINDO I,II, III, and IV with total of 40 targeted respondents. The specific questionaries are attached in the Appendix(divided into Section A,B,C) later in this paper. Therefore, the detailed respondent will be explained in statistics infographics as follows:

Figure 14 shows the education level of 40 respondents



On the collected survey, the educational backgrounds of the 40 respondents reveal a diversity of academic accomplishments. The largest group, accounting for 37.5% of respondents, has achieved a Bachelor's degree. The next most frequent level of education is a Diploma degree, reported by 32.5% of participants. Those with a High School diploma represent 15% of the total, while individuals with a Master's degree constitute 12.5%. Notably, only one respondent, or 2.5% of the total sample, has reached the highest academic achievement of a Doctorate. These results demonstrate the range of educational qualifications present within the surveyed population, with the majority possessing a Bachelor's or Diploma degree.

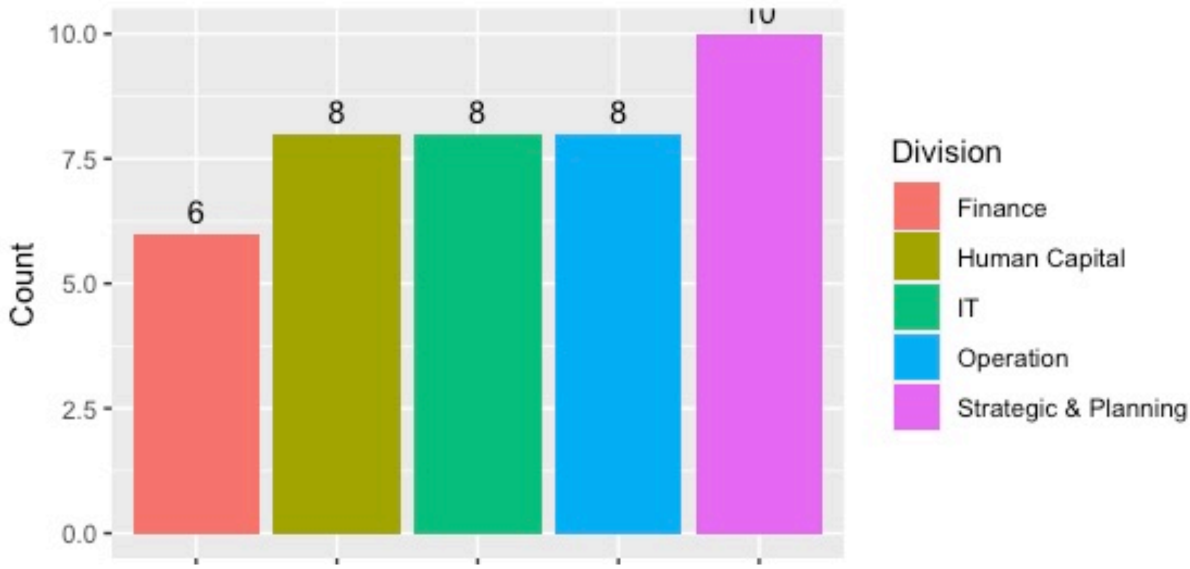
Figure 15 shows the regional area for the respondents



The geographical distribution of the 40 respondents in the survey represents all four regions of the PELINDO organization, thereby providing a balanced perspective across different operational areas. The highest representation comes from Region II, with 12 participants, which accounts for 30% of the total respondents. Regions I and IV share equal representation, each contributing 10 participants, collectively accounting for 50% of the total responses. Meanwhile, Region III is less represented, with 8 participants, comprising 20% of the overall respondent pool. This distribution ensures that the survey's findings capture the views, experiences, and insights from personnel working across the varied contexts and settings within PELINDO's expansive operational landscape.

The distribution of survey respondents across different divisions within the PELINDO organization is reasonably even, allowing for diverse insights into the organization's operations. The Strategic & Planning division leads with ten respondents, representing 25% of the overall response pool. Operation and Human Capital divisions had the exact count of 8 respondents, each constituting 20% of the total responses. The Information Technology (IT) division also had 8 participants, providing an equal percentage (20%) as Operation and Human Capital. The Finance division had the most miniature representation, with six respondents, constituting 15%. Despite the minor difference in the respondent count, the survey captured perspectives from all

Figure 16 shows the division where the respondents assigned

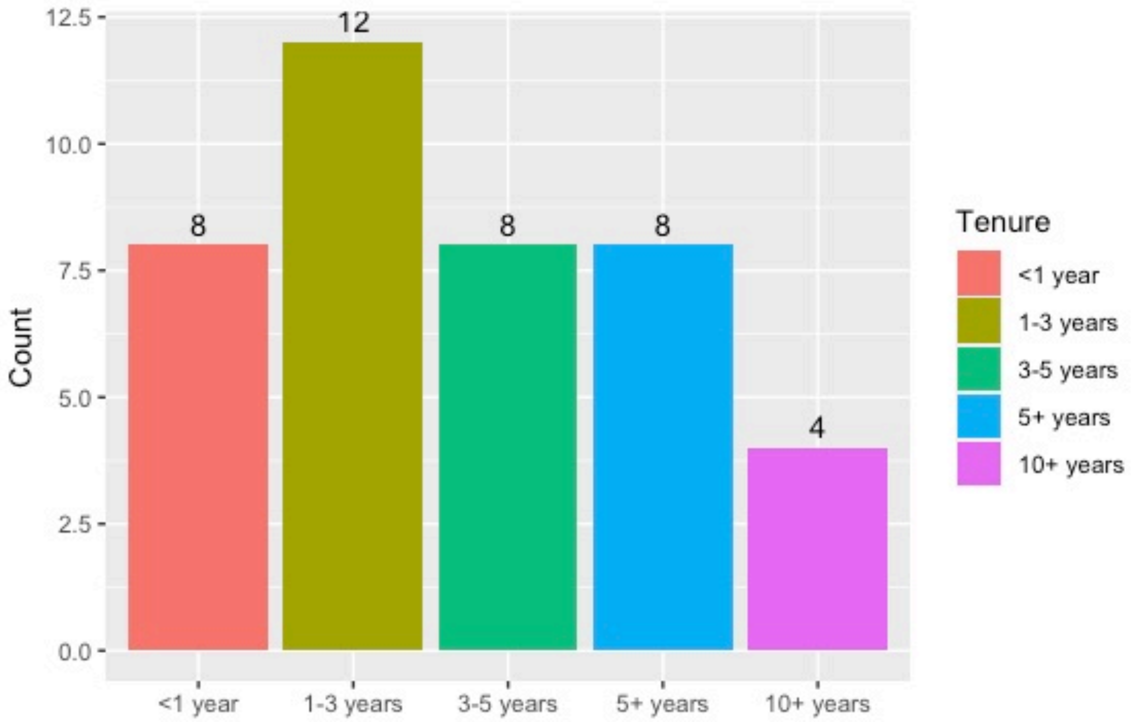


critical functional divisions within PELINDO, ensuring a comprehensive and balanced understanding of the organization's functions and operations.

Taking at the respondents' roles, we find a beautifully distributed set of voices. At the front lines, the Operators and Staff, each with a count of 10, encompass 25% of the total respondents respectively, bringing in firsthand experiences and insights from the ground up. Not far behind, Assistant Managers chime in with their perspectives, with eight respondents marking 20% of the overall voices. Similarly, the survey successfully garnered insights from 12 respondents, with 6 Managers and 6 General Managers at the managerial level. This equates to 15% of the total responses each, adding a strategic lens to the overall picture. This well-distributed participation across different roles within PELINDO ensures a rich, multi-dimensional, and comprehensive understanding of the organization's operations and strategies from all levels of management.

Peering into the tenure of our respondents, we uncover a striking span of experience within PELINDO. An impressive eight individuals, forming 20% of respondents, have served the organization for less than a year, bringing fresh perspectives and novel ideas from newer team members. With the largest share of 30%, 12 respondents belong to the 1–3-year tenure group, representing the dynamism and energy of early-career professionals. Equally compelling is the representation from the mid-career group, with eight respondents in the 3-5 years and 5+ years categories, each contributing 20% to the respondent pool. These groups carry a balanced blend of freshness and familiarity, being seasoned enough to understand the intricacies of the organization yet dynamic enough to adapt to its ongoing changes. Lastly, the long-serving veterans with 10+ years of tenure, while smaller in number with four respondents, still contribute an invaluable 10% of the voices in the survey.

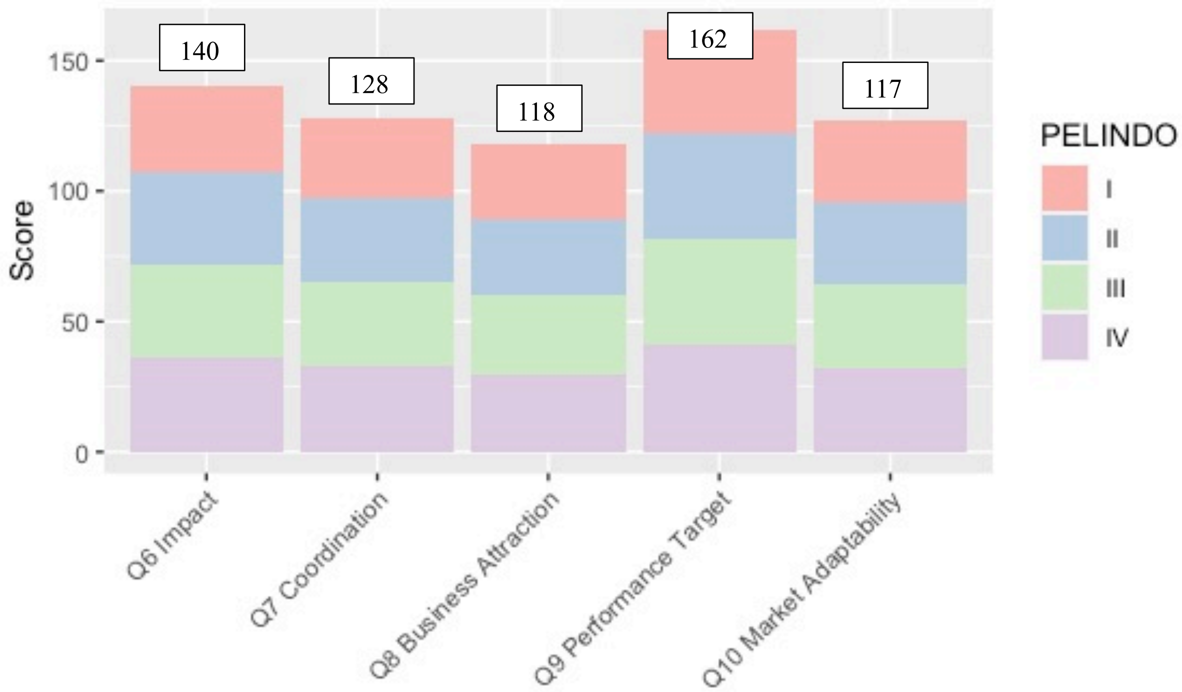
Figure 17 shows the tenure period of the respondents



These individuals provide a deep understanding that only comes with time, offering insights steeped in a deep-rooted understanding of the organization's history, culture, and evolution. The breadth of tenure amongst our respondents thus ensures a richly varied and nuanced view of PELINDO's operations.

4.8 Qualitative Method Analysis

Figure 18 shows the result of section B questionaries



*Notes: Score <120 (slight to impact, between), 120-160 (Moderate / Neutral), >160 Strong/Positive

The section B survey conducted among the various regions of PELINDO (PELINDO I, II, III, IV) provides insightful data regarding the perceived impact of the merger. Each aspect of the merger was evaluated and scored by the participants, thus revealing a range of impacts, from slight to positive. (See the detailed questionaries in Appendix)

The impact of the merger, as referred to in Q6, received a score of 140, which indicates a moderate impact on container terminal operations and port governance. The participants view this score as suggestive of substantial change. Yet, it's not perceived as overwhelmingly disruptive, instead presenting an acceptable level of disruption coupled with potential opportunities for growth and improvement.

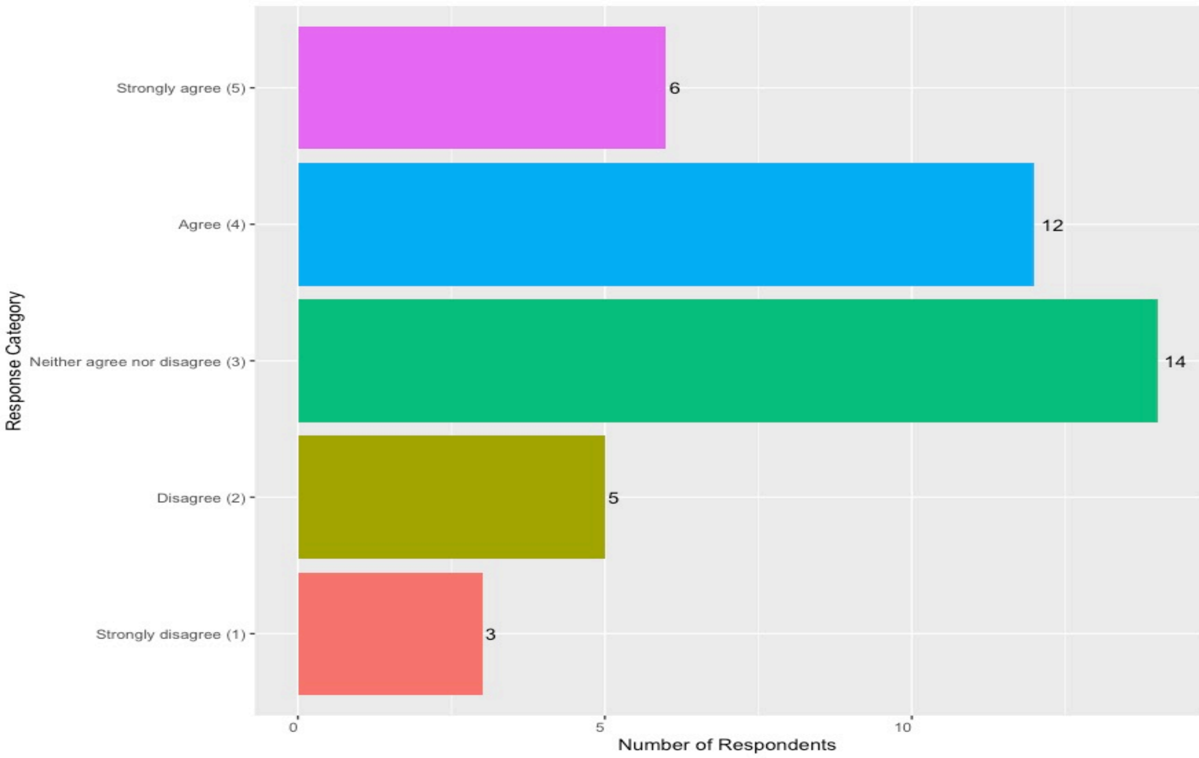
Similarly, the coordination aspect (Q7) and market adaptability (Q10) are perceived to have a moderate impact, with scores of 128 and 127, respectively. These scores denote a belief among the respondents that the merger has contributed to a reasonable improvement in coordination and information sharing among the terminals. Moreover, it's evident from these responses that the merged entity is perceived as relatively adaptable to shifting market conditions and evolving customer demands.

Contrastingly, the survey suggests a different narrative for attracting new business. The score for this aspect (Q8) is 118, which falls into the slight or no impact category. This suggests that the respondents need to perceive a considerable enhancement in the terminal's ability to attract new business or expand its international market share as a direct result of the merger.

In the following section, we delve into analyzing the technical efficiency of container terminal performance. This critical aspect of terminal operations is evaluated through five key indicators, including the effectiveness of container terminal operations, resource utilization relative to container throughput, the performance of Quay Cranes in loading and unloading container operations, yard capacity for stacking containers, and the reliability and sufficiency of yard machinery for loading and unloading operations. The evaluation is based on responses from diverse participants representing various stakeholders in the container terminal industry. Utilizing a qualitative approach, the survey was designed to collect nuanced opinions, perspectives, and insights that could provide an in-depth understanding of how these factors affect container terminal performance's overall technical efficiency.

Q11: Several indicators can be used to measure the effectiveness of container terminal operations, including increased container throughput levels, optimal resource utilization (Quays Cranes, Yards Equipment, Yard Area, etc.), Berth Crane Hours, and Berth Ship Hours.

Figure 19 shows the response for question eleven of Section C



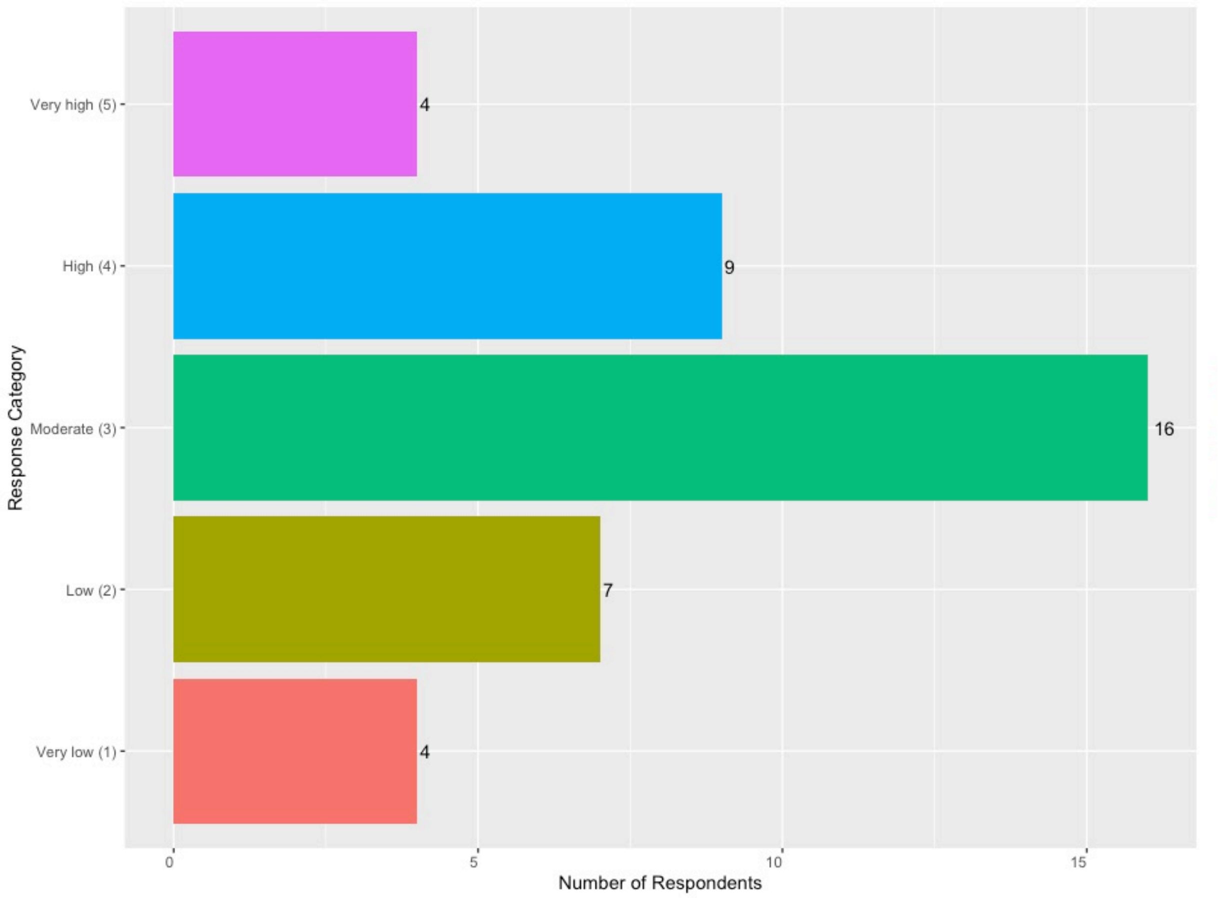
The highest number of respondents, 14 out of 40, expressed a neutral stance, implying considerable uncertainty or a lack of sufficient knowledge to form a strong opinion. This score also reflects the complexity of measuring container terminal efficiency, which the provided indicators may need to capture adequately.

On the positive side, a significant proportion of respondents (12) agreed with the statement, and another six strongly agreed. Therefore, 18 respondents, or 45% of the sample, believed in the effectiveness of these indicators in measuring the efficiency of the container terminal operations. This perspective aligns with widely accepted industry standards often using such performance metrics.

However, it is also notable that a combined total of 8 respondents either disagreed or strongly disagreed with the statement. This indicates that a small but significant portion of the respondents might have alternative views on what constitutes an effective measurement of container terminal efficiency. Such perspectives might advocate for including other metrics not covered in the statement, such as customer satisfaction, financial indicators, or environmental sustainability factors.

Q12: How do you assess the resource utilization, such as the quay, cranes, yards, and equipment, in relation to the current container throughput at your container terminal?

Figure 20 shows the response for question twelve of Section C



Q12 sought to gather respondents' opinions on resource utilization in their container terminal, explicitly focusing on the quay, cranes, yards, and equipment. This question is crucial as it highlights the efficiency aspect of container terminal operations, wherein optimal utilization of resources is a crucial indicator of performance.

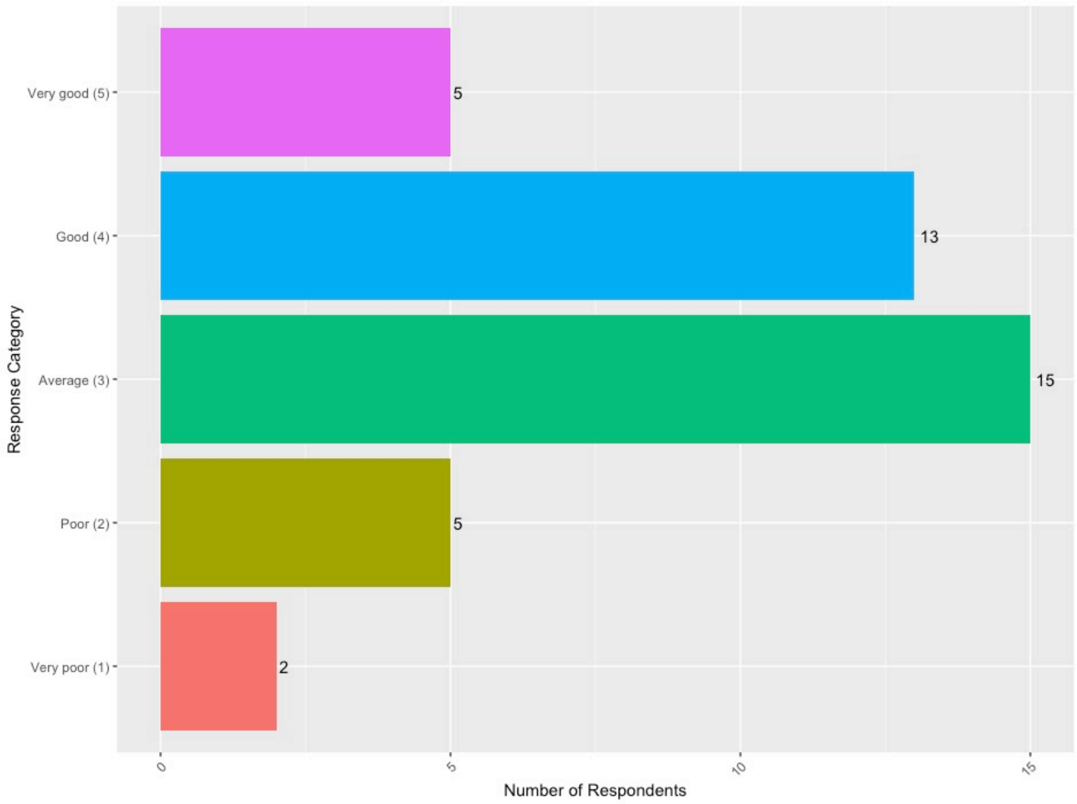
In response to this question, the majority of the respondents, 16 out of 40, rated resource utilization as moderate. This finding suggests that most respondents perceive their container terminals as reasonably effective at utilizing available resources. However, this "moderate" rating may also imply a potential for improvement, highlighting the need for strategic initiatives to boost resource efficiency.

Further, nine respondents assessed the resource utilization as high, while four considered it very high. Together, these responses account for 32.5% of the total, indicating that nearly a third of the respondents view their container terminal's resource utilization as above average. This positive evaluation signifies perceived effectiveness in using resources to achieve high container throughput, reflecting well on operational management.

On the other hand, a cumulative total of 11 respondents, representing 27.5% of the sample, rated resource utilization as low or very low. This suggests that a significant subset of respondents perceive their terminal operations as needing more resource efficient. These responses underscore the existence of potential inefficiencies and opportunities for improvement within specific container terminals.

Q13: How do you evaluate the performance of Quay Cranes in loading and unloading container operations for ships or trucks at your terminal?

Figure 21 shows the response for question thirteen of Section C



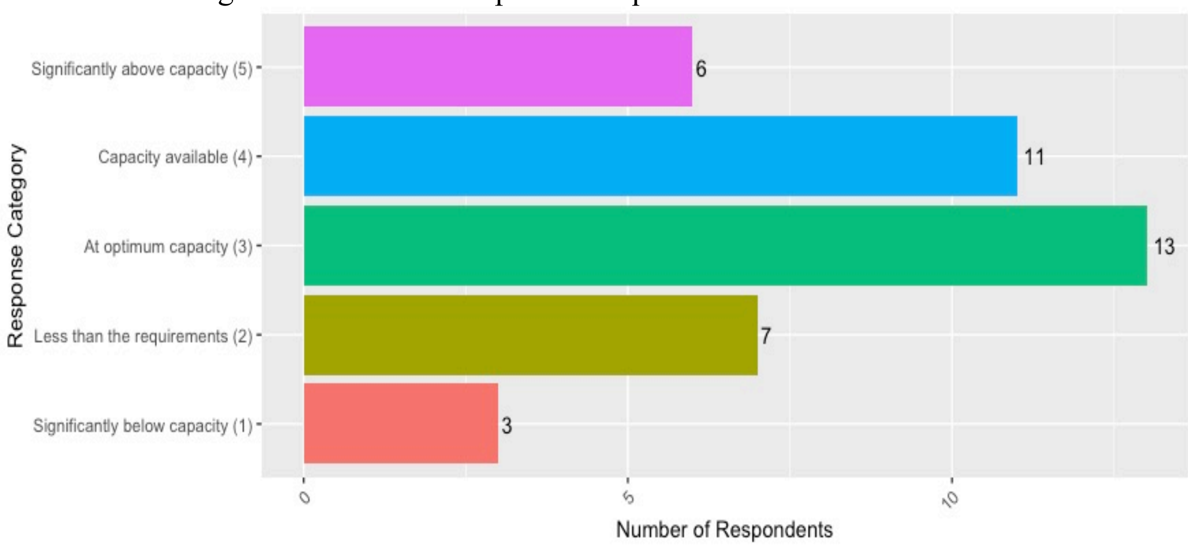
The analysis of Q13, which centered on evaluating Quay Cranes' performance in loading and unloading operations, provides pivotal insights into the operational efficiency of container terminals. The performance of these cranes is of critical importance as it directly affects container throughput, impacting the terminal's overall productivity and operational excellence. When asked to rate the performance of the Quay Cranes in their respective terminals, a significant portion of the respondents (15 out of 40) rated it as 'Average.' This result suggests that while these respondents did not find the performance notably deficient, they did not consider it outstanding. It indicates that for a considerable number of terminals, the performance of Quay Cranes is deemed satisfactory but may need to leverage their full potential for optimal productivity.

Moreover, 18 respondents, representing 45%, rated the performance as 'Good' or 'Very Good.' This reflects a positive evaluation from nearly half the sample, indicating that these terminals have successfully maintained efficient crane operations, contributing significantly to their loading and unloading process efficiency. This high level of performance may result from effective management strategies, advanced technological implementation, or a skilled workforce.

Contrarily, seven respondents (17.5% of the sample) indicated that the performance of their Quay Cranes was either 'Poor' or 'Very Poor.' This rating suggests that in some terminals, significant challenges may impact the effective functioning of Quay Cranes, which could hamper the terminal's overall productivity and effectiveness. These perceived inefficiencies indicate potential areas for improvement that could be addressed through targeted interventions.

Q14: How would you assess the capacity of the yard for stacking containers within the terminal?

Figure 22 shows the response for question fourteen of Section C



Upon scrutinizing the feedback obtained from Q14, which probes the yard's capacity for stacking containers within the terminal, the responses emerge as a captivating blend of opinions that collectively sketch a nuanced portrait of the current container terminal operations. A plurality of respondents, namely 13 out of 40, have rated the yard's capacity as 'Optimum Capacity.' This endorsement is a testament to these terminals' prevailing efficiency in spatial utilization and container stacking procedures. It is also an affirmation of proficient terminal management practices that balance maximizing yard space and preserving operational effectiveness.

Conversely, a significant cohort of participants, 11 out of 40, reported 'Capacity Available.' This perception signals an apparent underutilization of yard space, a scenario that leaves room for enhancing container handling efficiency and operational throughput. However, the narrative takes an intriguing twist, with a subset of respondents discerning their yard's capacity as either 'Significantly Below Capacity' or 'Less than the Requirements.' This view starkly contrasts and underscores potential challenges in managing container volumes due to limited yard capacity.

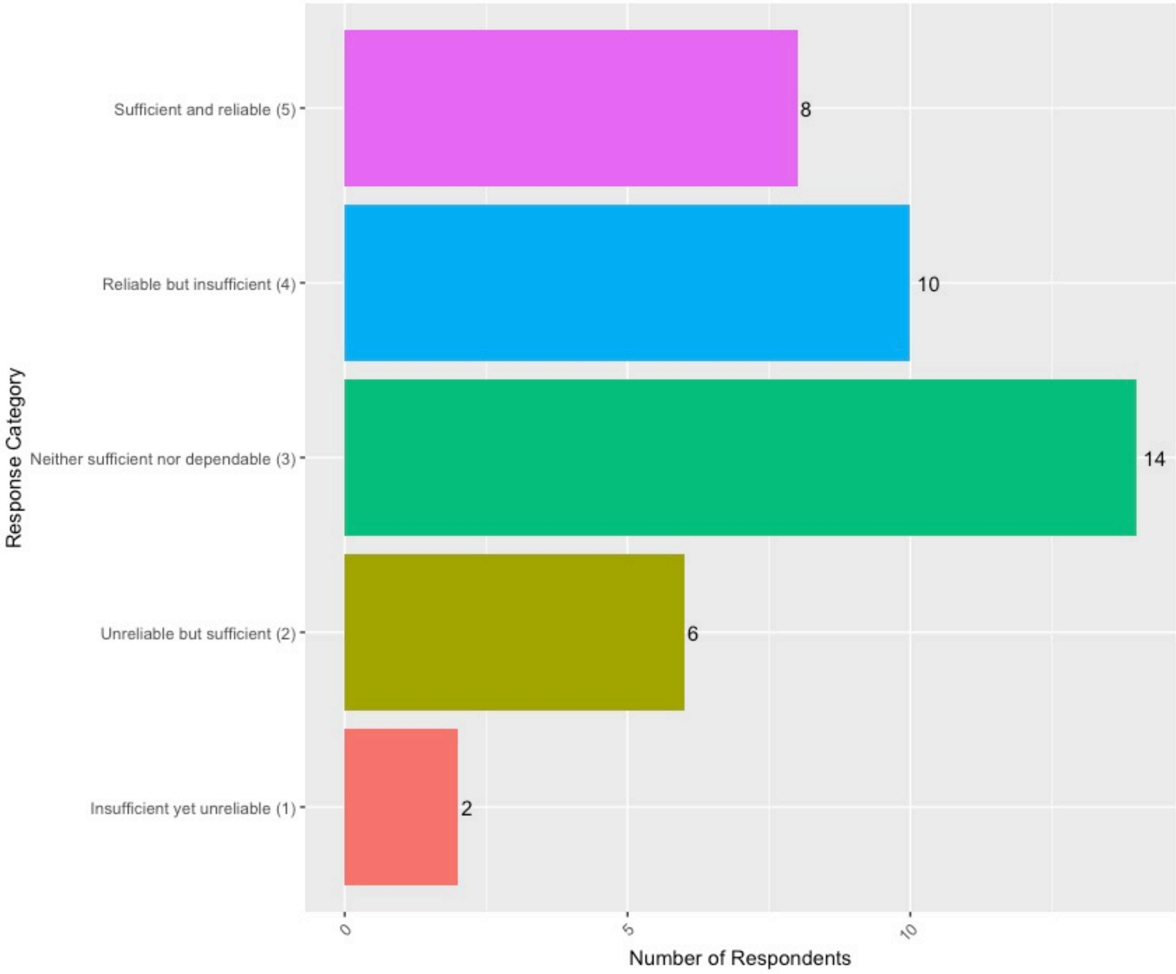
To add another layer of complexity, a handful of respondents, six in total, perceived their yard's capacity as 'Significantly Above Capacity.' This perception indicates a potential surplus of yard space, a circumstance that might be viewed as an under-exploitation of available resources. Collectively, these varied insights underscore the need for more personalized strategies for optimizing yard space utilization, bearing in mind the distinct operational contexts of different terminals. The orchestration of these strategies could illuminate pathways to drive higher terminal performance and operational excellence.

Q15: Does your container terminal equipped with adequate and reliable yard machinery to enhance the efficiency and speed of loading and unloading operations?

In addressing whether the container terminal is equipped with adequate and reliable yard machinery to enhance the efficiency and speed of loading and unloading operations (Q15), the responses gathered paint a variegated picture of the current situation, echoing the complexities of real-world operational contexts.

Approximately 14 out of 40 respondents characterized their machinery as insufficient and dependable. This finding hints at an urgent need for infrastructural enhancements and potential equipment upgrades. It implies a critical condition where the inadequacy and unreliability of yard machinery could compromise operational efficiency, impede cargo throughput, and affect the overall performance of the terminal. Adding to the intricate narrative, ten respondents perceived their machinery as reliable yet insufficient. This perspective indicates a situation where, although the existing machinery is reliable, the quantity or variety of the equipment fails

Figure 23 shows the response for question fifteen of Section C



to meet the terminal's operational demands. It calls attention to a different kind of challenge, where the operational reliability of equipment may not compensate for its inadequacy in quantity.

Interestingly, a slightly lesser number of respondents, eight in total, deemed their machinery to be both sufficient and reliable. This positive appraisal underscores the presence of terminals where the adequacy and reliability of machinery are well-aligned with the operational requirements, paving the way for optimized container handling operations.

Chapter 5 – Conclusion and Suggestion

5.1 Conclusion

The maritime industry, particularly container terminals, plays a pivotal role in Indonesia's economic growth. As the nation aims to become a developed country by 2045, the efficiency and effectiveness of these terminals are paramount. The merger of PELINDO I, II, III, and IV into a single entity, the Indonesia Port Corporation (IPC), was a strategic move by the Indonesian government to streamline operations and enhance the country's position in the global shipping industry. Therefore, we summary the key findings from this research as follows:

- **Efficiency of Merger on Operational Efficiency**: The amalgamation aimed to engender a consistent and streamlined modus operandi across terminals. Preliminary assessments indicate that while certain terminals witnessed pronounced enhancements in operational efficiency post-merger, others grappled with the intricacies of the transitioning process. It was evident that the merger has had varying impacts on the technical efficiency of container terminals across Indonesia. While some terminals demonstrated optimal efficiency, others signaled room for further optimization. The use of Data Envelopment Analysis (DEA) provided a robust framework to assess the relative performance of these terminals, both pre and post-merger.

- **Diversity in division perceptions**: The merger elicited a spectrum of responses from integral stakeholders comprising various division that has an influence on the container terminal operation. Notably, a faction lauded the shift towards a centralized decision-making paradigm and standardized regulations. However, a contrary sentiment underscored apprehensions related to potential monopolistic tendencies and the subsequent stifling of competition, which could curtail innovative strides.

- **Technical Progressions and Accompanying Hurdles**: The post-merger phase was characterized by discernible technological advancements, predominantly within terminals that were hitherto inadequately equipped. Nevertheless, the merger of disparate systems, cultural ethos, and operational frameworks stemming from the four distinct regional posed formidable challenges in specific terminals.

- **Geographical Inequities in Merger Benefits**: The dividends of the merger exhibited a marked non-uniformity across the geographical expanse of the nation. Strategically positioned or bolstered by expansive infrastructural edifices, terminals appeared to derive augmented benefits. In contrast, smaller terminals confronted predicaments in assimilating into the revised framework

5.2 Areas for Further Research

While this study offers a comprehensive analysis of the immediate impacts of the PELINDO merger on the technical efficiency of container terminals in Indonesia, the dynamic nature of the maritime industry and the evolving global trade landscape necessitate continuous exploration. The merger of such magnitude, encompassing multiple state-owned port corporations, undoubtedly has multifaceted implications that extend beyond the scope of this research. As the Indonesian maritime sector continues to adapt and evolve, several avenues that warrant deeper investigation offer opportunities to enrich our understanding further and optimize the nation's maritime potential. Therefore, there were four areas could be considered for further research as follows:

- Long-term Impact of the Merger: While this study focused on the immediate years surrounding the merger, a longitudinal study spanning a more extended period could provide insights into the long-term effects of the consolidation.
- Stakeholder Perspectives: A qualitative study capturing the views of employees, management, and other stakeholders could offer a more holistic understanding of the merger's impact.
- Comparative Analysis: Comparing the efficiency of Indonesia's container terminals with those in other ASEAN countries could provide a regional perspective and highlight areas where Indonesia excels or lags.
- Environmental and Social Impacts: Future research could delve into the environmental sustainability and social implications of the merger, assessing its broader effects beyond technical efficiency

5.3 Recommendation

Considering the findings and insights garnered from this research, it becomes imperative to chart a forward-looking course that addresses the current challenges and harnesses the opportunities presented by the PELINDO merger. Recommendations are not just about rectifying inefficiencies; they serve as a beacon, guiding strategic decisions and operational nuances to ensure that Indonesia's container terminals are poised for excellence in the global maritime landscape. The following recommendations are crafted to bolster technical efficiency, enhance stakeholder value, and ensure the nation's maritime aspirations align seamlessly with on-ground realities:

- Targeted Interventions: For terminals that displayed suboptimal efficiency, targeted interventions, possibly drawing from best practices of the high-performing terminals, could be implemented.

- Continuous Monitoring: Implement a system for continuous monitoring and assessment of terminal efficiency to ensure that improvements are sustained over time.
- Stakeholder Engagement: Regularly engage with stakeholders, including employees and management, to gather feedback and ensure that the merger's objectives align with ground realities.
- Investment in Technology: Embrace technological advancements to further enhance the efficiency of operations. This could include automation, advanced data analytics, and other Industry 4.0 technologies.
- Training and Development: Invest in the training and development of employees, ensuring they are equipped with the skills and knowledge to navigate the changes brought about by the merger and drive efficiency.

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Appendix 1 shows The DEA model on R Studio in the year of 2020

Final 2020.r

```r
library(Benchmarking) #LOAD THE PACKAGE FOR DEA
library(psych) #Load package for statistics
library(readxl) #load the package for reading the excel file into R
library(ggplot2)


PLD2020=PELINDO2020[,-1] #rename the file in the environment
rownames(PLD2020)=PELINDO2020[,1] #sort the Port's name to be out of the processed data

class(PLD2020) #check the dataset classfied as Data Frame
str(PLD2020) #check all the columns as numerical categories

#describe the statistics informatiom

describe(PLD2020$YA)
describe(PLD2020$BD)
describe(PLD2020$QC)
describe(PLD2020$BL)
describe(PLD2020$YE)
describe(PLD2020$GL)
describe(PLD2020$TP)

#make Data Frame for excel

stats <- data.frame(
  Variables = c("Mean", "Min", "Max", "Std. Dev."),
  YA = c(mean(PLD2020$YA, na.rm = TRUE), min(PLD2020$YA, na.rm = TRUE), max(PLD2020$YA, na.rm = TRUE), sd(PLD2020$YA, na.rm = TRUE)),
  BD = c(mean(PLD2020$BD, na.rm = TRUE), min(PLD2020$BD, na.rm = TRUE), max(PLD2020$BD, na.rm = TRUE), sd(PLD2020$BD, na.rm = TRUE)),
  QC = c(mean(PLD2020$QC, na.rm = TRUE), min(PLD2020$QC, na.rm = TRUE), max(PLD2020$QC, na.rm = TRUE), sd(PLD2020$QC, na.rm = TRUE)),
  BL = c(mean(PLD2020$BL, na.rm = TRUE), min(PLD2020$BL, na.rm = TRUE), max(PLD2020$BL, na.rm = TRUE), sd(PLD2020$BL, na.rm = TRUE)),
  YE = c(mean(PLD2020$YE, na.rm = TRUE), min(PLD2020$YE, na.rm = TRUE), max(PLD2020$YE, na.rm = TRUE), sd(PLD2020$YE, na.rm = TRUE)),
  GL = c(mean(PLD2020$GL, na.rm = TRUE), min(PLD2020$GL, na.rm = TRUE), max(PLD2020$GL, na.rm = TRUE), sd(PLD2020$GL, na.rm = TRUE)),
  TP = c(mean(PLD2020$TP, na.rm = TRUE), min(PLD2020$TP, na.rm = TRUE), max(PLD2020$TP, na.rm = TRUE), sd(PLD2020$TP, na.rm = TRUE)))


#input and output selection
x<- with(PLD2020, cbind(YA,BD,QC,BL,YE,GL))
y<- matrix(PLD2020$TP)

#calculatting the efficiency

#variable returns to scale

#dea(x,y, RTS="vrs", ORIENTATION= "in")


#VARIABLE Return to Scale
bcc <-dea(x,y, RTS="vrs", ORIENTATION = "in") #INPUT ORIENTED

shapiro.test(bcc$eff)

eff(bcc) #generate efficientcy of bcc input-oriented

data.frame(bcc$eff) #change the genereated output into data frame

summary(bcc) #generate the efficiency summary

sl<-slack(x,y,bcc) #to find the slack

data.frame(eff(bcc), eff(sl),sl$slack,sl$sx, sl$sy, lambda(sl))

PLD20_DEA <- data.frame(eff(bcc), eff(sl),sl$slack,sl$sx, sl$sy, lambda(sl))

dea.plot(x,y, RTS ="vrs", ORIENTATION = "in-out")

eff_scores <- data.frame(DMUs = rownames(PLD2020), Efficiency = eff(bcc)) # assuming the variable names and values from your previous code


#Install.packages("writexl")  # Uncomment this line if the package is not installed
library(writexl)

write_xlsx(stats, "your_dataframe.xlsx")

#CONSTANT RETURN TO SCALE
#dea(x,y, RTS="crs", ORIENTATION= "in")

ccr <- dea(x,y, RTS = "crs", ORIENTATION = "in")

shapiro.test(ccr$eff)

eff(ccr)

dea.plot(x,y, RTS="crs", ORIENTATION = "in-out", add = TRUE, lty="dashed")

excess(ccr,x)
```

Appendix III shows The DEA model on R Studio in the year of 2021

Final 2020.r × Final 2021.R ×

Source on Save Run Source

PELINDO2020 Next Prev All PELINDO2021 Replace All

In selection Match case Whole word Regex Wrap

```
library(Benchmarking) #LOAD THE PACKAGE FOR DEA
library(psych) #Load package for statistics
library(readxl) #load the package for reading the excel file into R
library(ggplot2)


PLD2021=PELINDO2021[,-1] #rename the file in the fenvironment
rownames(PLD2021)=PELINDO2021[,1] #sort the Port's name to be out of the processed data

class(PLD2021) #check the dataset classfied as Data Frame
str(PLD2021) #check all the columns as numerical categories

#describe the statistics informatiom

describe(PLD2021$YA)
describe(PLD2021$BD)
describe(PLD2021$QC)
describe(PLD2021$BL)
describe(PLD2021$YE)
describe(PLD2021$GL)
describe(PLD2021$TP)

#make Data Frame for excel

stats <- data.frame(
  Variables = c("Mean", "Min", "Max", "Std. Dev."),
  YA = c(mean(PLD2021$YA, na.rm = TRUE), min(PLD2021$YA, na.rm = TRUE), max(PLD2021$YA, na.rm = TRUE), sd(PLD2021$YA, na.rm = TRUE)),
  BD = c(mean(PLD2021$BD, na.rm = TRUE), min(PLD2021$BD, na.rm = TRUE), max(PLD2021$BD, na.rm = TRUE), sd(PLD2021$BD, na.rm = TRUE)),
  QC = c(mean(PLD2021$QC, na.rm = TRUE), min(PLD2021$QC, na.rm = TRUE), max(PLD2021$QC, na.rm = TRUE), sd(PLD2021$QC, na.rm = TRUE)),
  BL = c(mean(PLD2021$BL, na.rm = TRUE), min(PLD2021$BL, na.rm = TRUE), max(PLD2021$BL, na.rm = TRUE), sd(PLD2021$BL, na.rm = TRUE)),
  YE = c(mean(PLD2021$YE, na.rm = TRUE), min(PLD2021$YE, na.rm = TRUE), max(PLD2021$YE, na.rm = TRUE), sd(PLD2021$YE, na.rm = TRUE)),
  GL = c(mean(PLD2021$GL, na.rm = TRUE), min(PLD2021$GL, na.rm = TRUE), max(PLD2021$GL, na.rm = TRUE), sd(PLD2021$GL, na.rm = TRUE)),
  TP = c(mean(PLD2021$TP, na.rm = TRUE), min(PLD2021$TP, na.rm = TRUE), max(PLD2021$TP, na.rm = TRUE), sd(PLD2021$TP, na.rm = TRUE)))


#input and output selection
x<- with(PLD2021, cbind(YA,BD,QC,BL,YE,GL))
y<- matrix(PLD2021$TP)

#calculatting the efficiency

#variable returns to scale

#dea(x,y, RTS="vrs", ORIENTATION= "in")


#VARIABLE Return to Scale
bcc <-dea(x,y, RTS="vrs", ORIENTATION = "in") #INPUT ORIENTED

shapiro.test(bcc$eff)

eff(bcc) #generate efficientcy of bcc input-oriented

data.frame(bcc$eff) #change the genereated output into data frame

summary(bcc) #generate the efficiency summary

sl<-slack(x,y,bcc) #to find the slack

data.frame(eff(bcc), eff(sl),sl$slack,sl$sx, sl$sy, lambda(sl))

PLD20_DEA <- data.frame(eff(bcc), eff(sl),sl$slack,sl$sx, sl$sy, lambda(sl))

dea.plot(x,y, RTS ="vrs", ORIENTATION = "in-out")

eff_scores <- data.frame(DMUs = rownames(PLD2021), Efficiency = eff(bcc)) # assuming the variable names and values from your previous code


#Install.packages("writexl")  # Uncomment this line if the package is not installed
library(writexl)

write_xlsx(stats, "your_dataframe.xlsx")

#CONSTANT RETURN TO SCALE
#dea(x,y, RTS="crs", ORIENTATION= "in")

ccr <- dea(x,y, RTS = "crs", ORIENTATION = "in")

shapiro.test(ccr$eff)

eff(ccr)

dea.plot(x,y, RTS="crs", ORIENTATION = "in-out", add = TRUE, lty="dashed")

excess(ccr,x)
```

Appendix III shows The DEA model on R Studio in the year of 2022

```
Final 2020.r    Final 2021.R    Final 2022.R*
Source on Save                                  Run    Source
2021  Next  Prev  All   2022  Replace  All
In selection  Match case  Whole word  Regex  Wrap

library(Benchmarking) #LOAD THE PACKAGE FOR DEA
library(psych) #Load package for statistics
library(readxl) #load the package for reading the excel file into R
library(ggplot2)


PLD2021=PELINDO2021[,-1] #rename the file in the fenvironment
rownames(PLD2021)=PELINDO2021[,1] #sort the Port's name to be out of the processed data

class(PLD2021) #check the dataset classfied as Data Frame
str(PLD2021) #check all the columns as numerical categories

#describe the statistics informatiom

describe(PLD2021$YA)
describe(PLD2021$BD)
describe(PLD2021$QC)
describe(PLD2021$BL)
describe(PLD2021$YE)
describe(PLD2021$GL)
describe(PLD2021$TP)

#make Data Frame for excel

stats <- data.frame(
  Variables = c("Mean", "Min", "Max", "Std. Dev."),
  YA = c(mean(PLD2021$YA, na.rm = TRUE), min(PLD2021$YA, na.rm = TRUE), max(PLD2021$YA, na.rm = TRUE), sd(PLD2021$YA, na.rm = TRUE)),
  BD = c(mean(PLD2021$BD, na.rm = TRUE), min(PLD2021$BD, na.rm = TRUE), max(PLD2021$BD, na.rm = TRUE), sd(PLD2021$BD, na.rm = TRUE)),
  QC = c(mean(PLD2021$QC, na.rm = TRUE), min(PLD2021$QC, na.rm = TRUE), max(PLD2021$QC, na.rm = TRUE), sd(PLD2021$QC, na.rm = TRUE)),
  BL = c(mean(PLD2021$BL, na.rm = TRUE), min(PLD2021$BL, na.rm = TRUE), max(PLD2021$BL, na.rm = TRUE), sd(PLD2021$BL, na.rm = TRUE)),
  YE = c(mean(PLD2021$YE, na.rm = TRUE), min(PLD2021$YE, na.rm = TRUE), max(PLD2021$YE, na.rm = TRUE), sd(PLD2021$YE, na.rm = TRUE)),
  GL = c(mean(PLD2021$GL, na.rm = TRUE), min(PLD2021$GL, na.rm = TRUE), max(PLD2021$GL, na.rm = TRUE), sd(PLD2021$GL, na.rm = TRUE)),
  TP = c(mean(PLD2021$TP, na.rm = TRUE), min(PLD2021$TP, na.rm = TRUE), max(PLD2021$TP, na.rm = TRUE), sd(PLD2021$TP, na.rm = TRUE)))


#input and output selection
x<- with(PLD2021, cbind(YA,BD,QC,BL,YE,GL))
y<- matrix(PLD2021$TP)

#calculatting the efficiency

#variable returns to scale

#dea(x,y, RTS="vrs", ORIENTATION= "in")


#VARIABLE Return to Scale
bcc <-dea(x,y, RTS="vrs", ORIENTATION = "in") #INPUT ORIENTED

shapiro.test(bcc$eff)

eff(bcc) #generate efficientcy of bcc input-oriented

data.frame(bcc$eff) #change the genereated output into data frame

summary(bcc) #generate the efficiency summary

sl<-slack(x,y,bcc) #to find the slack

data.frame(eff(bcc), eff(sl),sl$slack,sl$sx, sl$sy, lambda(sl))

PLD20_DEA <- data.frame(eff(bcc), eff(sl),sl$slack,sl$sx, sl$sy, lambda(sl))

dea.plot(x,y, RTS ="vrs", ORIENTATION = "in-out")

eff_scores <- data.frame(DMUs = rownames(PLD2021), Efficiency = eff(bcc)) # assuming the variable names and values from your previous code


#Install.packages("writexl")  # Uncomment this line if the package is not installed
library(writexl)

write_xlsx(stats, "your_dataframe.xlsx")

#CONSTANT RETURN TO SCALE
#dea(x,y, RTS="crs", ORIENTATION= "in")

ccr <- dea(x,y, RTS = "crs", ORIENTATION = "in")

shapiro.test(ccr$eff)

eff(ccr)

dea.plot(x,y, RTS="crs", ORIENTATION = "in-out", add = TRUE, lty="dashed")

excess(ccr,x)
```

Appendix IV shows the BCC vs Throughput

```r
# Assuming your dataframe is named df

library(ggplot2)
library(tidyverse)

library(ggplot2)

# Change BCC and TP to numeric values if they are factors or characters.
BCCTP$BCC <- as.numeric(gsub(",", ".", BCCTP$BCC))
BCCTP$TP <- as.numeric(gsub(",", ".", BCCTP$TP))


ggplot(BCCTP, aes(x=TP, y=BCC, color=factor(YEAR), shape=RA)) +
  geom_point(size=5) +
  labs(x="Throughput in million TEUs", y="BCC Efficiency Score", color="Year", shape="RA") +
  theme_minimal() +
  theme(axis.title.x = element_text(size = 14),  # Increase x-axis title size
        axis.title.y = element_text(size = 14),  # Increase y-axis title size
        axis.line.x = element_line(size = 0.2, color = "black"),  # Bold x-axis line
        axis.line.y = element_line(size = 0.2, color = "black")) +  # Bold y-axis line
  ggtitle("Scatter plot of BCC Efficiency Score vs Throughput over time")
```

Appendix V shows the CCR vs Throughput

```r
# Assuming your dataframe is named df

library(ggplot2)
library(tidyverse)

library(ggplot2)

ggplot(CCRTP, aes(x=TP, y=BCC, color=factor(YEAR), shape=RA)) +
  geom_point(size=5) +
  labs(x="Throughput in million TEUs", y="CCR Efficiency Score", color="Year", shape="RA") +
  theme_minimal() +
  theme(axis.title.x = element_text(size = 14),  # Increase x-axis title size
        axis.title.y = element_text(size = 14),  # Increase y-axis title size
        axis.line.x = element_line(size = 0.2, color = "black"),  # Normal x-axis line
        axis.line.y = element_line(size = 0.2, color = "black")) +  # Normal y-axis line
  ggtitle("Scatter plot of CCR Efficiency Score vs Throughput over time")
```

Appendix VI shows the performance plotting

CBC × | Untitled2* × | Untitled1* × | CBC2 ×

Source on Save | Run | Source

```
# Define performance category based on Catch-up and Frontier Shift
CBC$Performance <- ifelse(CBC$`Catch-up` > 1 & CBC$`Frontier Shift` > 1, "High",
                          ifelse(CBC$`Catch-up` < 1 & CBC$`Frontier Shift` < 1, "Low", "Moderate"))

# Load library
library(ggplot2)

# Plot scatter plot
ggplot(CBC, aes(x = `Catch-up`, y = `Frontier Shift`)) +
  geom_point(aes(color = `Port Administrative`)) +
  geom_text(aes(label = `Rank.`), nudge_x = 0.03, nudge_y = 0.03, check_overlap = TRUE) +
  geom_hline(yintercept = 1, linetype="dashed", color = "black") +
  geom_vline(xintercept = 1, linetype="dashed", color = "black") +
  theme_minimal() +
  labs(title = "Performance Scatter Plot", x = "Catch-up", y = "Frontier Shift", color = "Port Admini


# Plot scatter plot
# Plot scatter plot
ggplot(CBC2, aes(x = `Catch-up`, y = `Frontier Shift`)) +
  geom_point(aes(color = `Port Administrative`)) +
  geom_text(aes(label = `Rank.`), nudge_x = 0.03, nudge_y = 0.03, check_overlap = TRUE) +
  geom_hline(yintercept = 1, linetype="dashed", color = "black") +
  geom_vline(xintercept = 1, linetype="dashed", color = "black") +
  annotate("text", x = 1, y = max(CBC2$`Frontier Shift`), label = "Catch-up ", hjust = 1.05, vjust =-
  annotate("text", x = max(CBC2$`Catch-up`), y = 1, label = "Frontier Shift ", vjust = -1.2, hjust =
  theme_minimal() +
  labs(title = "Performance Scatter Plot", x = "Catch-up", y = "Frontier Shift", color = "Port Admini

ggplot(CBC2, aes(x = `Catch-up`, y = `Frontier Shift`)) +
  geom_point(aes(color = `Port Administrative`), size = 15) +  # Increase the size of the dots here
  geom_text(aes(label = `Rank.`), nudge_x = 0.03, nudge_y = 0.03, check_overlap = TRUE) +
  geom_hline(yintercept = 1, linetype="dashed", color = "black") +
  geom_vline(xintercept = 1, linetype="dashed", color = "black") +
  theme_minimal() +
  labs(title = "Performance Scatter Plot", x = "Catch-up", y = "Frontier Shift", color = "Port Admini
```

Appendix VII Shows The Distributed Questionaries

Section A - General Information

1. What is your highest level of education completed?
   ☐ High School
   ☐ Diploma's Degree
   ☐ Bachelor's Degree
   ☐ Master's Degree
   ☐ Doctorate

2. In which PELINDO region do you work?
   ☐ Regional I
   ☐ Regional II
   ☐ Regional III
   ☐ Regional IV

3. In which specific division are you assigned within the PELINDO organization?
   ☐ Strategic & Planning Division
   ☐ Operation
   ☐ Finance and Risk Management
   ☐ Human Capital and General Affairs
   ☐ Information Technology

4. What is your current role or position within PELINDO?
   ☐ Operator
   ☐ Staff
   ☐ Assistant Manager
   ☐ Manager
   ☐ General Manager

5. How long have you been employed at PELINDO?
   ☐ Less than 1 year
   ☐ 1-3 years

☐ Neutral

☐ Positive

☐ Strongly Positive

6. How well do you think the merged container terminal has adapted to changing market conditions and customer demands?

☐ Very Poorly

☐ Poorly

☐ Fairly

☐ Well

☐ Very Well

Section C- Technical Efficiency of Container Terminal Performance

7. Several indicators can be used to measure the effectiveness of container terminal operations, including increased container throughput levels, optimal resource utilization (Quays Cranes, Yards Equipment, Yard Area, etc.), Berth Crane Hours, and Berth Ship Hours.

☐ Strongly disagree (1)

☐ Disagree (2)

☐ Neither agree nor disagree (3)

☐ Agree (4)

☐ Strongly agree (5)

8. How do you assess the resource utilization, such as the quay, cranes, yards, and equipment, in relation to the current container throughput at your container terminal?

☐ Very low (1)

☐ Low (2)

☐ Moderate (3)

☐ High (4)

☐ Very high (5)

9. How do you evaluate the performance of Quay Cranes in loading and unloading container operations for ships or trucks at your terminal?

☐ Very poor (1)

☐ Poor (2)

☐ Average (3)

☐ Good (4)

☐ Very good (5)

10. How would you assess the capacity of the yard for stacking containers within the terminal?

☐ Significantly below capacity (1)

☐ Less than the requirements (2)

☐ At optimum capacity (3)

☐ Capacity available (4)

☐ Significantly above capacity (5)

11. Does your container terminal equipped with adequate and reliable yard machinery to enhance the efficiency and speed of loading and unloading operations?

☐ Insufficient yet unreliable (1)

☐ Unreliable but sufficient (2)

☐ Neither sufficient nor dependable (3)

☐ Reliable but insufficient (4)

☐ Sufficient and reliable (5)