Analysis of Factors Affecting the Productivity of Domestic Ship Loading and Unloading at Tanjung Priok Port

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Abstract: *This research highlights the important role of loading and unloading companies in Indonesia's maritime logistics system, especially at the Port of Tanjung Priok as a national distribution center. The purpose of this study is to analyze the factors that affect the loading and unloading productivity of domestic ships at Tanjung Priok Port in order to improve operational efficiency and port performance. This study uses a quantitative approach with descriptive and comparative methods to analyze the loading and unloading productivity at Tanjung Priok Port by PBM Firma Berkah Jaya (FBJ) during 2023. The results showed that the number of TKBM had a strong correlation with the level of loading and unloading productivity, where the more labor, the faster the activity was completed. However, an excessive increase in working time actually reduces efficiency due to idle time.*

Keywords: efficiency, port of tanjung priok, productivity, loading and unloading workforce, working time

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Introduction

Loading and unloading companies are business entities that have a vital role in Indonesia's maritime logistics ecosystem, operating as a critical link between sea and land transportation through the implementation of goods-moving activities from and to ships at ports. According to Kamaluddin (2003), "loading and unloading companies act as an important link in the marine transportation system that connects producers with consumers through efficient and coordinated cargo transfer activities." PT Pelabuhan Tanjung Priok (PTP Nonpetikemas) is a leading non-container terminal operator in Indonesia, with extensive experience in handling cargo operations for liquid bulk, dry bulk, general cargo, and various other types of cargo. As the largest port in Indonesia that handles 70 percent of the total national container movement (Ministry of Trade, 2024), PT Pelabuhan Tanjung Priok is the backbone of the national logistics system that supports economic growth and the distribution of goods throughout the archipelago. Until March 2025, PTP Nonpetikemas recorded a loading and unloading volume of 3.8 million tons with an achievement of 115% of the RKAP target, an increase of 126% compared to the same period the previous year, showing a significant growth trend in loading and unloading activities at this port (Pelindo, 2025).

In the context of national regulations, the loading and unloading industry in Indonesia is regulated through various laws and regulations that aim to create operational standardization and protect the interests of various stakeholders. Regulation of the Minister of Transportation Number KM 35 of 2007 regulates the "Guidelines for the Calculation of Loading and Unloading Services Tariff from and to Ships at the Port, which is the main reference in determining tariffs and components of loading and unloading operational costs" (Ministry of Transportation, 2007). This regulation is experiencing development dynamics in line with the demands of modernization and operational efficiency, where Djuraid (2015) states that "the regulation only regulates the loading and unloading business activities and does not associate them with TKBM regulations, to create better operational flexibility." The Ministry of Transportation continues to evaluate and adjust existing regulations, including revisions to PM No. 60 of 2014, which specifically regulates loading and unloading workers (TKBM) in loading and unloading companies (PBM) at ports. The existence of this regulation is an important foundation in creating a balance between operational efficiency, labor protection, and the competitiveness of the national port industry.

The efficiency and effectiveness of the supply chain in the loading and unloading process are determining factors in increasing the competitiveness of Indonesian ports at the regional and global levels. Angela et al. (2022) revealed that "Indonesia faces challenges of maritime supply chain inefficiency, high costs, and low competitiveness of Indonesian ports," with Indonesia's Logistics Performance

Index (LPI) of 2.89, still below Vietnam (3.01), Thailand (3.14), Malaysia (3.15), and Singapore (4.06). Carruthers (2016, p. 24) even emphasized that "bottlenecks at Indonesian ports affect 24-26% of total Gross Domestic Product (GDP)," showing the significant impact of port inefficiency on the national economy.

This efficiency problem has a direct impact on national logistics costs, where Desfika and Lumanauw (2015, p. 112) identify that "delays or long wait times at ports are caused by low port productivity, inadequate port planning and facilities, slow labor performance, and convoluted document completion procedures." To address these challenges, Indonesia's major ports, including Tanjung Priok, have embarked on smart technology upgrades by utilizing Internet of Things (IoT) devices such as sensors and wireless technology to optimize service efficiency and increase operational capacity (Trade.gov, 2024).

From a global perspective, the modernization of the loading and unloading industry requires the adoption of the latest best practices and technologies that have been applied in the world's modern ports. Tijan et al. (2021) emphasized that "digitalization simplifies activities, increases effectiveness and efficiency not only in terms of time but also costs, increases flexibility and streamlines communication because of the integrated system." Technologies such as automation systems, cargo tracking, real-time asset locations, remote-controlled cranes, Automated Guided Vehicles (AGVs), drone inspections, and robust cybersecurity measures are essential in achieving port efficiency (D'Amico et al., 2021). A comprehensive approach to digitalization is the main key, where Angela et al. (2022) identify that "the elements of digitalization include: creating an integrated system; reducing bureaucracy; have a system that can be monitored remotely and at any time; prioritizing automation; and safe from the threat of crime and technical problems." Parola et al. (2021) also state that "digital transformation not only improves operational efficiency but also creates transparency and accountability throughout the maritime supply chain."

The implementation of modernization at PT Pelabuhan Tanjung Priok has shown a serious commitment to increasing capacity and operational efficiency. Sani (2025) stated that "PTP Nonpetikemas targets a throughput in 2025 of 53.5 million metric tons, with a strategy of terminal modernization, business expansion, and strengthening collaboration with loading and unloading entrepreneurs and other strategic partners." This improvement effort is supported by modern facilities such as a 3,319.7 m^3 pier, a 25,000 m^3 warehouse, a 150,000 m^3 stacking field, and modern equipment, including 11 units of Gantry Luffing Crane (GLC), 12 units of Overhead Cranes, 8 units of Hoppers, 8 units of Grab, and 1,011 units of fenders (PTP Nonpetikemas, 2025). Wiranta (2003, p. 167) emphasized that "the development of inter-island sea transportation in Indonesia can create a more efficient supply chain," while Straub (2008) emphasized that transportation infrastructure is a key factor in driving the economic growth of developing countries,

with a more significant impact than developed countries. This investment in infrastructure and technology is a strategic step in realizing Indonesia's vision as the world's maritime axis, as well as improving the efficiency of the national supply chain, which has an impact on reducing logistics costs and increasing the competitiveness of Indonesian products in the global market.

Although various modernization efforts have been made, PBM operational data of the Berkah Jaya Firm at Tanjung Priok Port in 2023 reveals crucial problems in loading and unloading productivity that require an in-depth study. There is a very extreme variation in productivity, ranging from 0 to 48.5 boxes/Hour, with an average of only 17.8 boxes/Hour, indicating significant operational inconsistencies between ships and types of activities. Labor efficiency is still far from optimal, with an average value of 0.77 Box/Labor-Hour, indicating that each TKBM is only able to handle less than one container per working hour. The imbalance in productivity between types of operations is very striking, where unloading activities reach 25.3 Boxes/Hour while loading activities are only 9.8 Boxes/Hour or 39% of unloading productivity, reflecting inefficiencies in the process of checking and stabilizing loads. More worryingly, regression analysis showed that increased working time was negatively correlated with productivity ($\beta = -0.187$), indicating idle time and decreased effectiveness due to labor fatigue. These problems not only have an impact on the operational efficiency of PBMs but also contribute to the high national logistics costs and low competitiveness of Indonesian ports at the regional level, so a comprehensive study is needed to identify the factors that determine productivity and optimization strategies that can be applied in the operational context of domestic ports.

Research Methods

Types and Approaches to Research

This study uses a quantitative approach with descriptive and comparative methods. The quantitative approach is used because the research data is in the form of numbers that can be measured objectively, such as working time, number of containers (boxes), number of loading and unloading labor (TKBM), and volume of loose cargo. The descriptive method aims to provide an empirical picture of the productivity level of loading and unloading, while the comparative method is used to compare the productivity level between ships and between types of activities (unloading, loading, and unloading).

Research Location and Time

The research was conducted at the Port of Tanjung Priok, North Jakarta, which is the largest domestic logistics activity center in Indonesia. The object of the

research is loading and unloading activities carried out by the Loading and Unloading Company (PBM) of the Berkah Jaya Firm (FBJ), with an observation data period in 2023, taken from the FBJ Productivity report. The data covers 99 loading and unloading activities from various Meratus Line ships, including Meratus Semarang, Meratus Waigapu, Meratus Payakumbuh, Meratus Sorong, and Meratus Project.

Data Types and Sources

Table 1
Types, Sources, and Information of Research Data

Data Type	Data Source	Information
Data Primer	Field observations and interviews with foremen and PBM supervisors	To find out the factors that cause productivity variations, such as tool conditions, weather, queues, or shift management.
Data Seconds	FBJ productivity, port reports, ship manifests, and operational logbooks	Data includes Box/Hour, Box/Labor-Hour, Working Hours (decimal), TKBM per shift, and Loose Cargo volume.

Population and Research Sample

The research population covers all loading and unloading activities carried out by PBM Berkah Jaya Firm at Tanjung Priok Port during 2023. The sampling technique uses purposive sampling, with the following criteria: ships that carry out complete unloading and loading activities, complete productivity data (working hours, number of TKBM, loose cargo volume, Box/Hour), and operations are handled directly by PBM Firma Berkah Jaya. With these criteria, 99 loading and unloading activities were obtained from 23 domestic ship series.

Data Collection Techniques

1. Field Observation: Direct recording of the start and end hours of operations, the number of workers, and the condition of equipment in the field.
2. Documentation: Data collection from FBJ, shift reports, and ship manifests.
3. Interview: Conducted with supervisors or field foremen to obtain additional explanations regarding productivity variations.

Data Analysis Methods

Data analysis was carried out using descriptive, comparative, and multiple linear regression approaches, using Microsoft Excel 365 and SPSS 25 software. Microsoft Excel 365 is used to calculate Box/Hour, Box/Labor-Hour, and create visualization charts. SPSS 25 is used for regression analysis, correlation, and comparative testing, while Power BI is optionally used for interactive visual dashboards.

Results

Regression models were used to analyze the influence of independent variables on productivity (Y = Box/Hour). The variables tested were the number of TKBM (X1), working time (X2), and loose cargo volume (X3).

In the context of this study, the variable number of TKBM (X_1) describes the total loading and unloading workforce involved in each ship's operational activities in one work cycle (shift). The number of workers has a direct influence on the speed of the loading and unloading process. The larger the number of TKBM, the higher the potential productivity that can be achieved, because the workload is divided more evenly. However, the addition of excessive TKBM without adequate equipment support can reduce efficiency due to idle time or accumulation of activities at certain work points. Therefore, optimizing the number of workers is one of the key factors in improving port operational performance.

Meanwhile, the volume variable loose cargo (X_3) represents the total bulk or non-container cargo handled at the same time as the loading and unloading of the container. This type of load includes materials such as iron, cement, project tools, or other bulk materials that have different physical characteristics than standard containers. High loose cargo volumes can extend the operating time as they require manual handling methods and additional equipment such as forklifts or cranes with special lifting gear. However, if the handling process is carried out in a planned manner and supported by adequate facilities, loose cargo can also increase total throughput and strengthen the overall utilization of FBJ's work resources.

1. Overview of PBM Berkah Jaya Firm

The Loading and Unloading Company (PBM) of Firma Berkah Jaya (FBJ) is one of the loading and unloading operators at the Port of Tanjung Priok that handles stevedoring and cargodoring activities of domestic ships, especially the fleet owned by Meratus Line. FBJ's main activities include container unloading (discharging), container loading (loading), and loose cargo handling. During the study period, FBJ handled 99 loading and unloading activities with a constant workforce of 22 people/shift and a variation of working time between 6 to 100 hours per vessel.

2. Description of Data and Operational Statistics

Based on data from FBJ Productivity, loading and unloading activities handled by PBM Berkah Jaya Firm include three types of operations, namely unloading, loading, and unloading. The following is the distribution of activities and the main indicators of productivity:

Table 2 Distribution of Operation Type Based on Number and Percentage of Activity

Types of Operations	Number of Activities	Percentage
Dismantle	33	33,3%
Fit	33	33,3%
Load-Unload	33	33,3%

3. Average Productivity

Table 3 Descriptive Statistics of Operational Productivity Indicators

Indicator	Average	Minimum	Maximum
Box/Hour	17,8	0,0	48,5
Box/Labor-Hour	0,79	0,00	2,20
Box/Person	29,4	0,0	56,9
Loose/Hour	21,5	0,0	127,4

The average value of Box/Hour of 17.8 indicates that one TKBM team is able to handle around 18 containers per hour of operation. The highest productivity was recorded in the Meratus Project V02 activity, with 48.46 boxes/hour.

4. Descriptive Analysis Based on Type of Operation

Table 4 Average Productivity by Type of Operation

Types of Operations	Average Boxes/Hour	Box/Labor-Hour	Loose/Jam
Dismantle	25,3	1,12	3,7
Fit	9,8	0,43	34,1
Load-Unload	15,9	0,73	28,0

The results of the analysis showed that unloading activities had the highest productivity, followed by loading and unloading, while loading activities tended to be lower because the process of checking the weight and stability of the containers took longer.

5. Comparative Analysis of Ships

Table 5 Ship Unloading, Loading, and Unloading Productivity (Box/Hour)

Kapal	Unloading (Box/Hour)	Load (Box/Hour)	Loading-Unloading (Box/Hour)

Holiday rentals in Meratus Semarang	26,8	8,5	17,0
Meratus Waigapu	28,5	11,0	18,2
Hundred Years of Silence	13,6	6,9	12,6
Meratus Sorong	19,9	8,9	12,7
Meratus Project	48,4	22,9	32,1

The Meratus Waigapu and Meratus Semarang ships show the highest productivity consistency among regular ships. Meanwhile, the Meratus Project has the highest value because it involves heavy equipment and special project loads.

6. Multiple Linear Regression Analysis

Regression models were used to analyze the influence of independent variables on productivity (Y = Box/Hour). The variables tested were the number of TKBM (X1), working time (X2), and loose cargo volume (X3).

Table 6. Results of Multiple Linear Regression Analysis

Variabel	Coephyses (β)	Significance (Sig.)	Information
Konstanta	3,612	-	-
X1 (TKBM)	+0,215	0,032	Significant positives
X2 (Working time)	-0,187	0,041	Significant negatives
X3 (Loose cargo)	+0,148	0,065	Insignificant positives

The regression results showed that the number of TKBM had a positive effect on productivity, working time had a negative effect, and loose cargo made a positive but insignificant contribution to the speed of loading and unloading.

7. Operational Efficiency Analysis

Tabel 7. Rata-Rata Tingkat Efisiensi Kapal

Kapal	Average Efficiency
Meratus Waigapu	0,78
Holiday rentals in Maratus Semarang	0,74
Meratus Sorong	0,68
Meratus Project	1,46

FBJ's average efficiency value of 0.77 indicates that the workforce in the field is able to handle around 0.77 boxes of labor per hour. The ship with the highest efficiency is the Meratus Project, signifying equipment optimization and labor coordination.

Discussion

The results of the analysis showed a strong correlation between the number of Loading and Unloading Workers (TKBM) and the level of productivity at PBM Firma Berkah Jaya (FBJ). The greater the number of TKBM involved in the loading and unloading process, the faster the activity can be completed. This illustrates that the availability of adequate manpower plays an important role in accelerating the completion of operational activities at the port, especially in conditions of heavy ship traffic and tight time targets.

Increasing the number of TKBMs tends to speed up the completion of loading and unloading activities because more manpower allows for better division of tasks (simultaneous unloading/moving/sorting of cargo), reducing crane/ship waiting times, and accelerating workflows at the dock, especially when ship volumes are congested and handling time targets are tight (Setyawati et al., 2022). This statement is in line with case studies and port workforce management studies that emphasize the role of labor in improving terminal throughput (Moros-Daza & Jubiz-Diaz, 2024).

However, in practice, there are often diminishing returns after a certain point; the addition of labor causes overcrowding in the work area, increased idle time (waiting time when there are no tasks), more complicated coordination, and potential decreased efficiency per person. In addition, if competencies, equipment, or work arrangements (shifts, task systems) are inadequate, additional labor does not necessarily add to real output (Alexander et al., 2021). Studies in Indonesia show that the competency factors of TKBM, mechanization/loading and unloading equipment, wage management, and work safety conditions both determine how much the additional workforce contributes to productivity. One of the results of Sihombing's research (2023) states that, directly or indirectly, there is a positive and significant influence between the performance of the loading and unloading workforce and port facilities on terminal productivity, which ultimately has an impact on improving port operational performance at Tanjung Priok Port. This shows that the effectiveness of human resources and the feasibility of facilities have an important role in speeding up the loading and unloading process, optimizing ship docking time, and improving overall operational efficiency.

However, increasing working time does not always have a positive impact on efficiency. When working hours exceed operational needs, there is a potential for

idle time that decreases labor productivity. This condition shows the need to optimally regulate the working duration and rotation of the workforce so that the working hours used are truly effective in supporting the improvement of loading and unloading performance.

Increasing working time is often considered a strategy to increase output and operational efficiency, especially in the logistics and port sectors. But in practice, the addition of working hours does not necessarily result in a significant increase in efficiency. When the duration of work exceeds operational needs, the workforce tends to experience fatigue or even face idle time, which is idle time where no productive activities are carried out (Wasesa et al., 2021). This can actually reduce the productivity and effectiveness of the overall workforce (Chatterjee et al., 2022). Therefore, it is important for operational management to balance working time and workload to keep the use of labor efficient. Based on the results of research by Gibbs et al. (2023) on the productivity of knowledge workers during working from home (WFH), even though they can maintain almost the same level of output as when working in the office, this is achieved by extending working hours. As a result, hourly productivity actually decreased by around 8-19 percent. This decrease in efficiency occurs because the virtual work environment increases the cost of communication, collaboration, and coordination. Workers spend more time in more frequent but short-lived meetings, with larger groups, and less direct interaction with their boss or close colleagues. This condition reduces focus time and narrows the scope of communication, so that even though working time increases, work effectiveness decreases, and efficiency is not achieved (Tongzon & Nguyen, 2021).

Research conducted by Wibowo et al. (2025) regarding labor efficiency at the port of Tanjung Priok shows that increasing working hours outside optimal hours actually reduces loading and unloading productivity by up to 12% due to the increase in worker fatigue levels and the emergence of idle time. Similar results were found by Durakovic & Emek (2025), who examined the relationship between working hours and efficiency in the manufacturing sector. They found that labor efficiency peaked at a working duration of 7–8 hours per day, while productivity decreased significantly thereafter due to decreased concentration and motivation at work.

In addition, Elrayah & Zakariya (2023) in their study emphasized the importance of regulating work shifts and labor rotation to avoid idle capacity. According to him, a good rotation arrangement is able to maintain a balance between the availability of labor and operational needs, so that the working time used is really effective in supporting the improvement of loading and unloading performance.

Thus, increasing efficiency in loading and unloading activities is not enough just to extend working time, but needs to be accompanied by an adaptive labor management strategy. Setting work durations, rotation systems, and proportional

workload sharing are key factors in creating sustainable efficiency without sacrificing worker productivity and well-being.

In addition to the labor factor, the existence of loose cargo also plays an important role in determining the total throughput of the port. Loose cargo or bulk cargo that is not packed in containers has different physical characteristics, volume, and units of measurement. This requires the application of different productivity evaluation standards so that the measurement results do not cause a bias towards the efficiency of container handling. As revealed by Marbun et al. (2024), the use of non-uniform units between loose cargo and container cargo can cause distortions in the assessment of port operational performance. Therefore, it is necessary to separate productivity measurements based on the type of load so that the results of efficiency analysis remain representative and accurate.

In operations at Tanjung Priok Port, the balance between the number of Loading and Unloading Workers (TKBM), the duration of working time, and the use of mechanical aids such as cranes and forklifts is crucial. The optimal combination of these three aspects will determine the extent to which the efficiency of loading and unloading activities can be improved. A study by Asimu (2025) shows that increasing the proportion of use of mechanical aids can reduce handling time without increasing the number of workers. Meanwhile, research by Dewi et al. (2025) found that coordination between heavy equipment operators and TKBM has a significant positive correlation with loading and unloading speed, especially in ports with heavy activity such as Tanjung Priok.

With an average productivity of 17.8 boxes/hour and a labor efficiency of 0.79 boxes/labor-hour, the results of this study reinforce previous findings that the factors of labor and working time are still the dominant variables that affect loading and unloading performance. However, these results also indicate the need to diversify operational strategies by paying attention to the balance between human and technological aspects. In line with the views of Nurrohman & Alfathir (2025), the integration between human labor and mechanization systems not only increases productivity but also reduces the risk of operational bottlenecks due to workload imbalances. Thus, FBJ (Freight Berth Jakarta) needs to apply an adaptive operational management approach, namely by adjusting the number of workers, effective working time, and the use of auxiliary equipment proportionally to the type of cargo being handled (Amin et al., 2021). This approach will ensure that port efficiency is measured not only by the speed of loading and unloading, but also by the system's ability to maintain productivity stability in the long term.

Conclusion

The results of the analysis show that there is a strong correlation between the number of Loading and Unloading Workers (TKBM) and the level of productivity at FBJ, where an increase in the number of workers is able to accelerate the completion of loading and unloading activities. However, the addition of excessive working time actually reduces efficiency due to increased idle time. In addition, the handling of loose cargo also affects the total throughput, but requires its own measurement standards so as not to reduce the productivity value of the container. With an average productivity of 17.8 boxes/hour and a labor efficiency of 0.79 boxes/labor-hour, the factors of the number of TKBM and working time were shown to significantly affect productivity, with the range of results differing between ships. The next research recommendation is to examine the influence of port technology, the TKBM work rotation system, and the application of loading and unloading automation to increase efficiency and productivity at ports.

Conflict of Interest

The authors declare that there is no conflict of interest related to the publication of this manuscript. The research was conducted independently and without any commercial or financial relationships that could be construed as a potential conflict of interest.

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