

Optimization of Container Dwell Time at Tanjung Perak Port, Indonesia: Container Flow Approach

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Abstract: Dwell Time (DT) is the waiting period required for an imported container, measured from the time the container is unloaded from a ship until it leaves the port area. Tanjung Perak Port, Indonesia's second-largest logistics hub, recorded a DT of 3.36 days in July 2025, exceeding the national target of 2.87 days. In July 2025, Tanjung Perak Port handled 53,446 import containers, representing 20.98% of the total import containers entering Indonesia's five main ports. This study aims to determine the optimal DT point at Tanjung Perak Port using quantitative econometric methods, specifically quadratic models and optimization. The study uses secondary data from January to September 2025, comprising 397,485 containers, which were analyzed using Stata 19 and Excel Solver. The results indicate that the minimum optimal DT at Tanjung Perak Port is 2.48 days. The time components consist of 1.24 days from stacking to job order (X1), 0.96 days from job order to gate-in (X2), and 0.28 days from truck gate-in to gate-out (X3). These findings suggest that the DT at Tanjung Perak Port can be further optimized to reach its minimum level. This study uses container flow as a proxy for goods movement; therefore, future research may incorporate both goods and document flows to provide a more comprehensive analysis.

Keywords: Container, Dwell Time, Optimization, Tanjung Perak

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INTRODUCTION

Container Dwell Time (CDT) refers to the length of time a container remains in a port terminal yard (Lee, Park, Lee, Son, & Kim, 2024). A longer CDT indicates that a container remains in the yard for a longer period, thereby occupying yard space for a longer time. Specifically, in import activities, Dwell Time (DT) is defined as the time an imported container spends waiting from the moment it is unloaded from a ship until it leaves the port area (LNSW, 2025a). CDT is a crucial operational indicator because it is directly correlated with port terminal productivity and efficiency. Terminal efficiency depends on the synchronization of quayside and landside operations and on the implementation of a digital container booking system (Shiraishi, Zhang, Shibasaki, & Elhan-Kayalar, 2026). In Indonesia, the Indonesian National Single Window Agency (LNSW) defines Dwell Time as the time a container spends from stacking until gate-out.

Globally, logistics performance can be measured through indicators such as the Logistics Performance Index (LPI) published by the World Bank. The LPI includes a survey of six components, divided into input and outcome areas. The input areas consist of the efficiency of customs and border management clearance, infrastructure, and the

competence and quality of logistics services. The outcome areas include timeliness of delivery, ease of arranging international shipments, and the ability to track and trace goods. Indonesia's LPI score in 2023 was 3.0 on a scale of 5 (World Bank, 2026). Although CDT does not directly translate into the LPI, particularly regarding customs and border management clearance indicators, the LPI score and ranking can serve as benchmarks for assessing Indonesia's logistics performance globally. In 2023, Indonesia's customs and border management clearance score was 2.8 (World Bank, 2026), ranking 59th out of 139 countries. This ranking was below that of five other ASEAN countries, namely Singapore, Malaysia, Thailand, the Philippines, and Vietnam (Arvis, Ojala, Shepherd, Ulybina, & Wiederer, 2023).

At the national level, CDT is measured by the Indonesian National Single Window Agency (LNSW). Based on LNSW data in July 2025, the national import Dwell Time (DT) was 2.63 days, representing 108.99% of the national target of 2.87 days (LNSW, 2025b). However, the Dwell Time performance at Tanjung Perak Port, one of Indonesia's main ports, was 3.36 days, which remained above the national target (LNSW, 2025b).

Tanjung Perak Port is the second-largest container port in Indonesia. In July 2025, Tanjung Perak Port handled 53,446 import containers, representing 20.98% of the total import containers entering Indonesia's five main ports (LNSW, 2025b). The volume of import containers handled at Tanjung Perak Port also influences the national Dwell Time level and the achievement of the national Dwell Time performance target. Several factors affect CDT. According to Lee, Park, Lee, Son, & Kim (2024), there are six key CDT factors: (1) temperature, (2) container weight, (3) container voyage number, (4) block, (5) shipping company, and (6) month of discharge. Meanwhile, the mode of transportation (rail versus truck) is the most critical predictor of CDT, with rail transport resulting in shorter dwell times (Chhetri, Nguyen, Gekara, & Sharma, 2025).

Reducing import Dwell Time improves the efficiency of container logistics services and helps lower trade costs (Rodrigues et al., 2024) (Arvis, Ojala, Shepherd, Ulybina, & Wiederer, 2023). However, other studies have identified a contradiction in importer behavior, whereby importers have little incentive to reduce Dwell Time, and their interests often conflict with Dwell Time objectives (Raballand, Refas, Beuran, & Isik, 2012) (Rachman, Rahayu, Sambarani, Sugianto, & Kwartama, 2022). The availability of tracking technology is strongly correlated with reduced container dwell time. Continuous tracking enables port managers to perform more accurate and efficient pre-planning for vessel offloading and loading operations (Saini & Lerher, 2024). In addition, using CDT predictions as an input for stacking optimization significantly reduces container rehandles (Maldonado, González-Ramírez, Quijada, & Ramírez-Nafarrate, 2019).

Empirical evidence from Dar es Salaam Port shows a drastic 42% reduction in average container dwell time, to 4.32 days. This achievement was driven by three key mechanisms: optical character recognition (OCR)-based gate automation, single-window system integration, and performance transparency (Majengo & Mwendapole, 2025). Operational challenges have emerged as vessel sizes continue to increase while port land availability remains constrained, making data-driven optimization strategies essential for enhancing terminal capacity without costly physical expansion (Saini & Lerher, 2024).

Long-term container storage in terminal yards increases container handling frequency and complicates container placement decisions, ultimately reducing container terminal productivity (Lee, Park, Lee, Son, & Kim, 2024). Therefore, it is not surprising that Terminal Operators (TOs) consistently prioritize reducing CDT as a primary objective (Lee, Park, Lee, Son, & Kim, 2024). The Smart Stacking (SS) strategy significantly reduces

total retrieval time, comprising Automated Stacking Crane (ASC) travel time and relocation time. Compared with random stacking, this strategy provides substantial efficiency gains, particularly when the volume of available customer information is high (Feng, Song, & Li, 2022).

Container Dwell Times are heavily influenced by terminal policies such as free time. Intra-regional containers tend to stay longer than long-haul ones because cargo owners often use the terminal as a "substitute warehouse". This occurs because demurrage fees are frequently lower than the costs of external warehousing and double handling (Shiraishi, Zhang, Shibasaki, & Elhan-Kayalar, 2026).

There are ten primary causes of prolonged container dwell time, which can be classified into three supply chain flow categories: (1) information flow, including delays in document dispatch by consignors, missing or inaccurate information in documents (such as HS codes or country of origin), and bureaucratic delays in the issuance of import licenses by government authorities; (2) cash flow, including corporate liquidity constraints; and (3) physical flow, including factors such as port congestion, public holidays, and COVID-19 lockdowns (Ewamer & Menyhárt, 2022).

The government's ongoing efforts to reduce Dwell Time are intended to improve the efficiency of container logistics. Therefore, research is needed to determine the optimal Dwell Time level (minimum point) based on container flow, which reflects importer behavior. In the context of producer behavior theory, importers (companies) act rationally to maximize profit. Profit maximization can be achieved by increasing revenue and/or minimizing costs. Importers tend to choose supply chain logistics strategies that offer the lowest opportunity costs; as a result, this behavior may contribute to a mismatch between efficiency policies and actual practices.

RESEARCH METHODS

This study employs a quantitative approach, consisting of descriptive analysis and econometric quadratic models to obtain the objective function, and Excel Solver to determine the minimum optimal point (Chiang & Wainwright, 2005). The analysis uses a container/goods flow approach. Due to data limitations, the Dwell Time objective function is modeled as a function of the time intervals from stacking to job order, from job order to gate-in truck, and from gate-in truck to gate-out truck, as follows:

$$DT = f(X_1^2, X_2^2, X_3^2) \dots\dots\dots (1)$$

Where:

DT	:	Container Dwell Time (days)
X1	:	Container time from stacking to job order (days)
X2	:	Container time from job order to gate-in truck (days)
X3	:	Container time from gate-in truck to gate-out truck (days)



Figure 1. Dwell Time in Indonesia

Source: processed by the authors

Where:

- Discharge : The time at which the container is unloaded from the means of transport
- Stacking : The time at which the container is stored in the yard (Temporary Storage Area)
- SPPB : Letter of Approval for the Release of Goods, indicating that the container is permitted to leave the yard (Temporary Storage Area)
- Job Order (SP2) : The time at which the importer or authorized representative orders a truck
- Gate-in-truck : The time at which the truck enters the yard (Temporary Storage Area) to transport the container
- Gate-out-truck : The time at which the truck leaves the yard (Temporary Storage Area)

This study uses secondary data on container flows obtained from Pelindo (PT Pelabuhan Indonesia (Persero)) and the Indonesian National Single Window Agency (LNSW). The data are cross-sectional, consisting of information collected from multiple objects at the same point in time (Triola, 2019). The study period covers January to September 2025. A total of 397,485 import containers at Tanjung Perak Port were included in the dataset.

Optimization is a mathematical process used to determine the best (optimal) value of an objective function representing an economic quantity to be maximized or minimized, such as profit, cost, or utility (Chiang & Wainwright, 2005). This process typically involves:

- Determining the objective function to be optimized, in which the independent variables are those that economic actors can control.
- Identifying extreme points (extreme values), namely the points at which the function reaches its relative maximum or minimum value (relative maximum/minimum) or its absolute value (global maximum/minimum).

Optimization is the process of searching for or determining the value of a variable that yields the best (optimal) value of an objective function, whether a maximum or minimum value, in accordance with the intended objective of the economic analysis (Chiang & Wainwright, 2005).

Predictive analytics in seaports is heavily dominated by Machine Learning (ML) techniques, including Artificial Neural Networks (ANNs), Random Forests (RFs), and Convolutional Neural Networks (CNNs). In contrast, prescriptive analytics (optimization) primarily utilizes Operations Research (OR) methods, particularly mathematical programming (mainly Mixed-Integer Programming/MIP) and evolutionary computation techniques such as Genetic Algorithms (Jahangard, Xie, & Feng, 2025).

A review of the evolution of optimization techniques for container terminal operation planning found that genetic algorithms, integer linear programming, and heuristics are among the most widely used operations research techniques in container terminal optimization (Weerasinghe, Perera, & Bai, 2024).

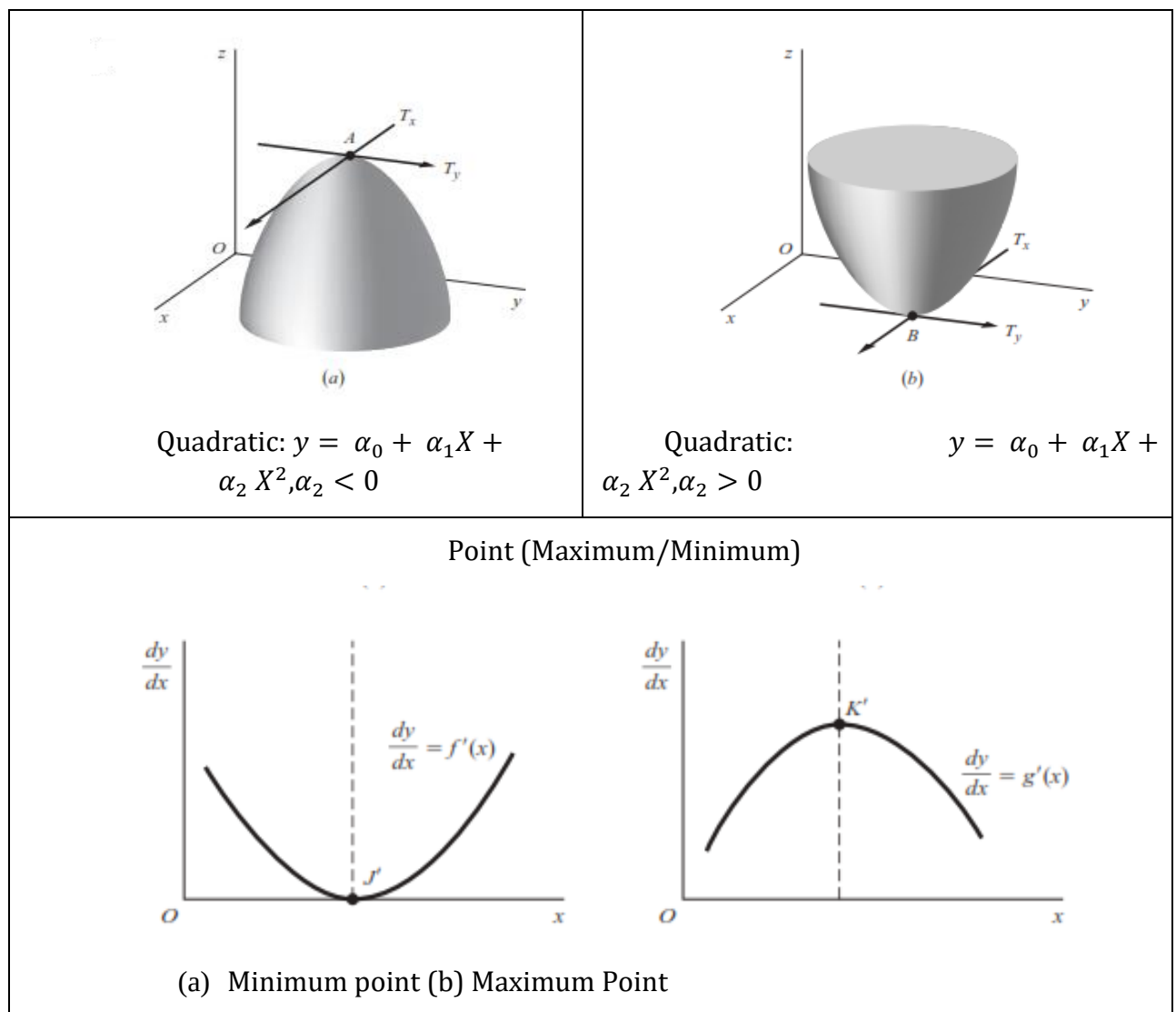


Figure 2. Optimization Function

Source: (Chiang & Wainwright, 2005)

RESULTS AND DISCUSSION

The number of import containers entering through Indonesia's five major ports is presented in Table 1. In July 2025, Tanjung Perak Port was the second-largest port in terms of import container volume, after Tanjung Priok Port (LNSW, 2025b).

Table 1 Number of Import Containers at Indonesia's Five Major Ports, July 2025

No.	Port	Number of Import Containers Received by LNSW	Percentage (%)
1	Belawan	19,588	7.69
2	Makassar	234	0.09
3	Tanjung Emas	23,109	9.07
4	Tanjung Perak	53,446	20.98
5	Tanjung Priok	158,408	62.17
	Total	254,789	100

Source: (LNSW, 2025b)

Table 2 presents the descriptive statistics for the Tanjung Perak DT dataset. These statistics indicate considerable variability in DT (StDev = 3.28) and in the stacking-to-job-order variable (X1) (StDev = 3.13). In contrast, the variability of the job-order-to-gate-in variable (X2) is relatively small, whereas that of the gate-in-to-gate-out variable (X3) is very small. Specifically, the average values of DT, stacking-to-job-order (X1), job-order-to-gate-in (X2), and gate-in-to-gate-out (X3) are 3.27, 2.50, 0.73, and 0.04 days, respectively.

Table 2 Descriptive Statistics of DT at Tanjung Perak Port, January–September 2025

Statistic	DT (days)	stacking to job-order (days)	job order to gate-in-truck (days)	gate- in to gate- out - truck (days)
Mean	3.27	2.5	0.73	0.04
p50 (Median)	2.36	1.49	0.4	0.02
StDev	3.28	3.13	1.01	0.04
Min	0.01	0	0	0
Max	29.96	29.87	26.63	1.8
N	397,485 Import Containers			

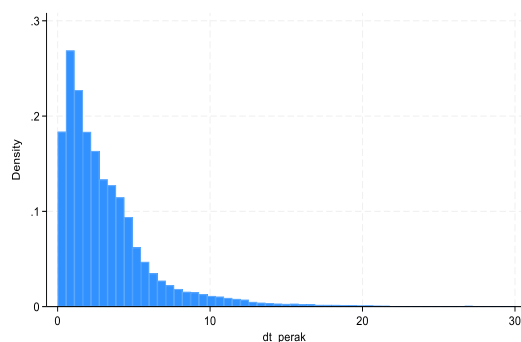
Source: (Pelindo, 2025), processed by the authors

The skewness statistic, which measures the degree of asymmetry in a data distribution around its mean, indicates that all four data series are positively skewed to the right, as evidenced by the mean values exceeding the median values. As a result, the average DT is pulled toward the right tail of the distribution, where larger DT values are concentrated. The standard deviation results further indicate that the four series exhibit varying volatility across observations.

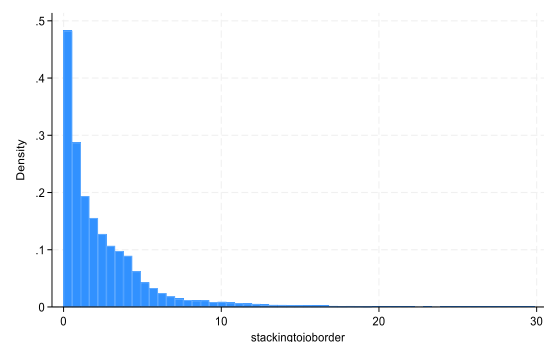
The minimum values of DT, stacking-to-job-order (X1), job-order-to-gate-in (X2), and gate-in-to-gate-out (X3) can reach 0.00 days. However, the distributions of DT, X1, X2, and X3 are skewed to the right, indicating the presence of relatively large values in their right tails.

The DT histogram for Tanjung Perak Port shown in Figure 3(a) is skewed to the right, indicating that most observations are concentrated at lower dwell times, while a small number of observations have relatively large values in the right tail. Similarly, the histogram of X1 (stacking-to-job-order) in Figure 3(b) is skewed to the right, indicating that most observations are concentrated at lower time values, with some relatively large values appearing in the right tail.

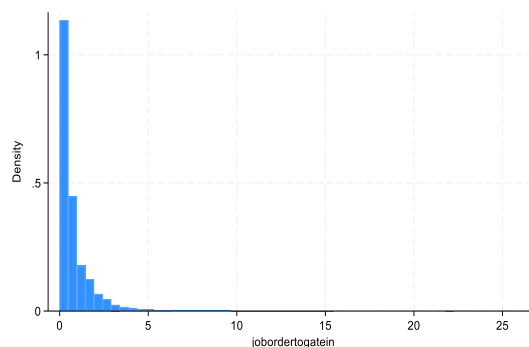
The histograms of X2 (job-order-to-gate-in) and X3 (gate-in-to-gate-out), shown in Figures 3(c) and 3(d), are also skewed to the right, indicating that most observations are concentrated at lower time values, while a small number of observations have relatively large values in the right tail.



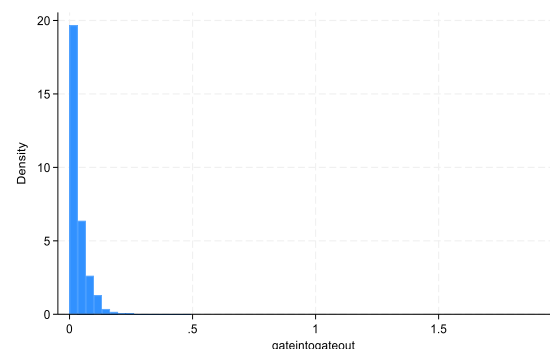
(a) Histogram, Y, DT Tanjung Perak



(b) Histogram, X1, stacking to job-order



(c) Histogram X2, job-order to gate-in



(d) X3 histogram, gate-in to gate-out

Figure 3. Histogram of Tanjung Perak DT based on container flow

Source: (Pelindo, 2025), processed by the authors

The DT at Tanjung Perak Port in Surabaya generally exceeded the national DT. Only in March 2025 was the DT at Tanjung Perak below or equal to the national DT. This condition can be observed from the distributions of DT, stacking-to-job-order (X1), job-order-to-gate-in (X2), and gate-in-to-gate-out (X3), all of which are skewed to the right.

Table 3 Comparison between the DT at Tanjung Perak Port and the National DT

Month	National DT (days)	DT at Tanjung Perak (days)	Comparison
Jan-2025	3.43	3.89	DT Tanjung Perak > DT National
Feb-2025	3.29	3.64	DT Tanjung Perak > DT National
Mar-2025	2.60	2.60	DT Tanjung Perak <= DT National
Apr-2025	4.02	4.13	DT Tanjung Perak > DT National
May-2025	2.99	3.28	DT Tanjung Perak > DT National
Jun-2025	3.07	3.27	DT Tanjung Perak > DT National
Jul-2025	2.63	2.81	DT Tanjung Perak > DT National
Aug-2025	2.47	2.72	DT Tanjung Perak > DT National
Sep-2025	2.60	3.00	DT Tanjung Perak > DT National

Source: (Pelindo, 2025)

According to Chiang & Wainwright (2005), the optimal solution to an objective function can be determined by constructing an objective function in which the independent variables are those that economic actors can control. Based on the econometrics model (with robust std. error), the estimated quadratic function is as follows:

$$\widehat{DT} = 2.23 + 0.05 \text{ stackingtojoborder}^2 + 0.11 \text{ jobbordertogatein}^2 + 4.67 \text{ gateintogateout}^2 \dots \dots (2)$$

Table 4. Objective Function Model for Minimizing DT at Tanjung Perak Port

DT Tanjung Perak	Coefficient	Robust std. error	t	Prob.
stacking to job-order (X1)_quad	0.053	0.00026	201	0.000***
job-order to gate-in (X2)_quad	0.114	0.00444	25.87	0.000***
gate-in to gate-out (X3)_quad	4.673	1.32241	3.53	0.000***
_cons	2.228	0.00819	272.1	0.000***
Number of obs	397,485			
F (3, 397481)	13696.24			
Prob > F	0			
R-squared	0.7548			
Root MSE	1.6239			

***significant at 1%, **significant at 5%, *significant at 10%

Source: Pelindo (2025), processed by the authors with Stata 19.

Based on the results of the objective function model, the constraint functions are subsequently determined. The constraints are established based on the characteristics of each variable, namely DT, stacking-to-job-order (X1), job-order-to-gate-in (X2), and gate-in-to-gate-out (X3) at Tanjung Perak Port.

Table 5 Constraint Function Model by Minimizing DT at Tanjung Perak Port

Variable	Constraint		Skewness
	Min (days)	Max (days)	
DT at Tanjung Perak (Y)	2.36	29.9	Right-skewed
stacking to job-order (X1)	1.49	29.9	Right-skewed
job order to gate - in (X2)	0.4	29.9	Right-skewed
gate - in to gate - out (X3)	0.02	29.9	Right-skewed

Because the data are positively skewed (right-skewed), the median was used as the measure of central tendency when determining the constraint values.

Source: (Pelindo, 2025), processed by the authors using Stata 19 and Excel solver

After the objective function and constraints have been established, the next step is to determine the optimal DT point at Tanjung Perak Port. The analysis uses the Excel Solver add-in to identify the values of stacking-to-job-order (X1), job-order-to-gate-in (X2), and gate-in-to-gate-out (X3) that minimize DT at Tanjung Perak Port, as follows:

Table 6 Optimization: Analysis of DT at Tanjung Perak

Variable	Optimum minimum (days)	Average Present Condition (days)
stacking to job-order (X1)	1.24	2.5
job order to gate-in (X2)	0.96	0.73
gate-in to gate-out (X3)	0.28	0.04
DT Tanjung Perak (Y)	2.48	3.27

Source: (Pelindo, 2025), processed by the authors using Excel solver

Based on these results, the optimal DT at Tanjung Perak Port is 2.48 days. However, given current conditions, the optimal DT can still be reduced further, particularly for the job-order-to-gate-in (X2) and gate-in-to-gate-out (X3) variables. The job-order, gate-in, and gate-out truck processes are closely related to port transportation systems and the availability of truck operators. In addition to trucks, transportation at the port can also be carried out by rail, which has been shown to result in shorter CDT (Chhetri, Nguyen, Gekara, & Sharma, 2025).

The reduction in CDT at Tanjung Perak Port is consistent with previous research, which reduced DT to 3 days using a discrete-time Queue Model of Container Processes approach (Sidik, Ramdani, Sopandita, Fadilah, & Efendi, 2020). Evidence from Dar es Salaam Port, Tanzania, demonstrates that privatization and capital investment can effectively address port congestion problems (Majengo & Mwendapole, 2025). Reducing CDT not only enhances port productivity and competitiveness but also provides environmental benefits by reducing emissions from idling vessels and trucks. Furthermore, an integrated multimodal hinterland strategy and cloud-based digital transformation can improve port performance (Chhetri, Nguyen, Gekara, & Sharma, 2025). Research using discrete-event simulation indicates that container handling equipment has only a limited impact on CDT. Based on the problem tree framework, the study found that CDT is primarily driven by prolonged container stays in the container yard (Hassan, Gurning, & Handani, 2020).

CONCLUSION AND RECOMMENDATIONS

Tanjung Perak Port is the second-largest container port in Indonesia. In July 2025, Tanjung Perak Port handled 53,446 import containers, representing 20.98% of the total import containers entering Indonesia's five main ports. The DT performance at Tanjung Perak Port, as one of Indonesia's main ports, was 3.36 days, which remained above the national target of 2.87 days. Based on quantitative secondary data covering the period from January to September 2025, the optimal minimum DT at Tanjung Perak Port was found to be 2.48 days. This value consists of a stacking-to-job-order time (X1) of 1.24 days, a job-order-to-gate-in time (X2) of 0.96 days, and a truck gate-in-to-gate-out time (X3) of 0.28 days. The DT at Tanjung Perak Port can still be further reduced.

This study uses container/goods flow as a proxy, represented by the waiting time of containers from stacking to gate-out. Future research could integrate both goods flow and document flow into the analysis. Document flow data are maintained by the Directorate General of Customs and Excise (DGCE) and include processes such as import permit applications, PIB (Import Declaration) submissions, customs validation, billing, SPPB (Import Release Permit) issuance, and other related procedures.

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