GROSTLOG 2024
Global Research on Sustainable Transport & Logistics

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

Determinants of effectiveness on container handling services: Empirical evidence from Tanjung Priok port of Indonesia

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Abstract: Terminal operating system (TOS) is an system used in port container terminal operation. TOS manage planning of containers in all port activities effectively and implementation of TOS can speed up dock services. Research purpose to analyze the determinants of effectiveness on container services and the role of equipment availability as mediating variable in relationship between implementation of TOS towards the effectiveness of container services. This research method uses quantitative method through questionnaires from 107 respondents of Tanjung Priok Port personnel as TOS operating staff, manager level and administrative. Quantitative data processing using Smart-PLS with SEMPLS analysis method, to determine how strong the role of mediating variable. Results of p-value indicate that container handling tools and facilities availability significantly affects container handling services effectiveness with p-value 0.000 and 0.017, as well as has relevant predictive value with 99.81% significance. This emphasize that using modern equipment in TOS important for handling effectiveness.
Keyword : *Container handling services, Terminal operating system, Port of Tanjung Priok of Indonesia, Structural equation modelling, Global development of port*

1. Introduction

The digital port concept enhances operational efficiency and effectiveness in the port industry by optimizing container terminal operations, improving safety, and reducing environmental impacts (Pramesti et al., 2020). However, technological challenges in container handling and transportation during trans-shipment remain unresolved (Jakovlev et al., 2023). Container terminal operations at ports face issues such as information gaps, congestion, extended truck waiting times, and slow terminal performance. Key factors like crane productivity (BCH), truck waiting times, and crane operator delays contribute to prolonged ship berthing. Data from 2016 to 2018 indicates that despite terminal operating system (TOS) implementation, some ships still experience berthing times below targets due to low BCH and high waiting times. Effective TOS implementation is crucial to address these challenges (Barata et al., 2022).

The terminal operating system (TOS) is essential for controlling operations, recording data, and enhancing container container handling services. It manages and monitors terminal processes, including planning, transportation, storage, and real-time coordination of ship and truck arrivals, queues, and resource allocation to ensure efficiency (Hervás-Peralta et al., 2019). The effectiveness of container handling directly impacts a ship's time at port and operational efficiency, with longer port stays increasing costs. Container terminals facilitate goods transport, but issues like TOS errors, human error, and equipment malfunctions can impede the container handling process (Vicrihadi et al., 2021). Optimal operation of container handling equipment requires competent human resources. At ports, achieving BCH targets is often hindered by outdated and poorly maintained container cranes. Improving equipment availability and readiness is essential for enhancing the efficiency of container handling process (Sahara & Aprilia, 2023).

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The adoption of TOS software is crucial for effective container handling operations. Tanjung Priok Port in Jakarta has implemented TOS and is integrating it with handling facilities and equipment. Ensuring the maintenance of TOS and port equipment is vital for the productive and sustainable operation of container handling activities. The results of previous research conducted by Hervás-Peralta et al. (2019) and Barata et al. (2022), primarily focuses on TOS implementation aspects like human resource readiness and resource efficiency, with limited exploration of container handling equipment and facility availability as mediators. This study, titled "Determinants of Container Handling Service Effectiveness: Empirical Evidence of Tanjung Priok Port Indonesia," addresses this gap.

2. Literature Review

2.1. Terminal operating system implementation

The Terminal Operating System (TOS) is a key core system in a container terminal that has the ability to automate numerous tasks that would otherwise require manual execution. Various definitions of TOS can be found in the literature. TOS has been defined by certain authors as according to Hervás-Peralta et al. (2019):

1. Software that provides management, storage, and control of the movement of various types of cargo at terminals, with basic functions to support logistics processes;
2. "A computer system designed to plan, track and manage the movement and storage of all cargo, the use of assets and the deployment of people in and around a port terminal or hinterland in real-time";
3. "The Terminal Operating System (TOS) offers a range of applications that gather, store, control, examine, and distribute data from different terminal operations. This enables a comprehensive overview of essential terminal processes and ensures optimal utilization of resources for cargo handling.".

The terminal operating system (TOS) performs several key functions. Firstly, it effectively manages the movement of containers within the terminal, ensuring an efficient handling process. Secondly, it schedules loading, unloading, and yard transfer plans based on information provided by shipping companies, which includes the container positions on incoming ships. Thirdly, it processes container shipping information received from transportation companies. Tanjung Priok port has adopted technology in the form of using RFID and GPS to track the position and location of containers in real-time. The personel of IPC TPK already have ability to operate the technology. Lastly, it provides shipping and trucking companies with accurate information regarding the placement of containers (Liauw et al., 2018).

2.2. Container handling effectiveness

Container handling is an activity that includes services for goods entering and leaving the port, which involves loading/unloading, transferring from ships to the dock, from the dock to the warehouse or container yard (Dwi Priyohadi et al., 2023). With increasing complexity in human needs, the movement of goods, particularly through sea transportation in international trade, has grown. Container handling services play a crucial role in supporting these activities (Dwi Astuti et al., 2023).

The effectiveness of container handling depends on terminal capacity and the ability of port equipment to load and unload. Port services, including warehouse facilities, stacking yards, and docks, significantly impact the efficiency of handling goods at the port (Yani, 2018). Container handling effectiveness is crucial in the delivery and receipt of containers, whether internationally or domestically. Optimizing container handling needs adequate equipment and effective planning, ensuring efficient terminal operations from preparation to completion (Dwi

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Astuti et al., 2023). Effectiveness using TOS was assessed by reduction container registration queues. Containers are now central to these handling activities (Palguno & Supangat, 2016).

Containerized cargo handling consists of ship operation, quay transfer operation, storage operation and receive/delivery operation. Container operation activities that include these activities are as follows according to Suryantoro et al. (2023):

1. Ship operation involves container handling containers between the ship and the wharf. All incoming and outgoing containers go through ship operation, ship operation for that reason is also called the "dominate system";
2. The movement of moving containers between the dock and the stacking yard (container yard) is called quay transfer operation (QTO), which plays a role in regulating and balancing the speed of ship operations. QTO greatly affects the speed of container handling containers to and from the ship;
3. Containers are generally temporarily placed in the yard while waiting for the completion of documents, administration, and other formalities. Since the yard is considered an open warehouse, this activity is called storage operation which serves as a security stock between the delivery/receipt operation and the ship operation;
4. Receiving/delivery operation is the operation of receiving and delivering containers. This operation connects the container terminal with road transportation vehicles and rail transportation.

2.3. Container handling tools and facilities availability

The availability of container container handling tools and facilities refers to the presence and readiness of various equipment and infrastructure used to move containers from ships to docks or vice versa, as well as to stack and organize containers yard (CY). Commonly used tools and facilities include:

1. Cranes: Includes quay cranes (QC) and rubber-tyred gantries (RTG), which are used to move containers between ships and land;
2. Automated guided vehicles (AGVs): Automated vehicles used to transport containers within the terminal;
3. Stacking equipment: Tools for stacking containers in the stacking area;
4. Terminal Infrastructure: Includes docks, warehouses, and stacking areas that must be large enough and efficient in supporting container handling activities.

The container handling tools and facilities availability is crucial for the efficient operation of container handling, directly affecting its overall effectiveness (Sucahyowati et al., 2024). Accessibility positively and significantly affects operational performance (Ricardianto et al., 2023).

The availability of container container handling tools and facilities greatly affects the effectiveness of container handling activities. Here are some of the benefits according to Ginting & Ridany Damanik (2021):

1. Speed up the container handling process: With adequate tools and facilities, the container handling process can be carried out more quickly and efficiently, reducing waiting time and idle time;
2. Reduce the risk of errors: Proper tools help in the arrangement and separation of hazardous cargo containers from regular containers, thus reducing the risk of errors that can occur during the container handling process;
3. Improves security: Good facilities ensure that dangerous goods are handled in a safe manner, according to established procedures, thereby reducing the chances of accidents or dangerous incidents occurring;

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Adequate equipment and facilities are crucial for smooth and effective container handling, with good infrastructure and high connectivity becoming essential for competitiveness (Notteboom et al., 2022). As a consequence, there is an increased reliance on electronic communications and processes with few human interaction (Eichenhofer et al., 2020). The application of TOS needs technology adoption by personnel IPC TPK and the fact that they are able to use it. Technology always develop and container handling problems always occur and human resource skills must be improved. Therefore human resources readiness and training are important to make the personnel always ready for TOS implementation inline to the latest trends.

3. Research Method

This research was conducted over two months (July-August 2024) at the Indonesian Port Container Terminal (IPC TPK) Tanjung Priok, Jakarta. As Indonesia's largest and one of Southeast Asia's busiest ports, Tanjung Priok plays a crucial role in international trade and the economy. It features various facilities, including docks, warehouses, and terminals, to support container handling and passenger activities. The port serves as a key logistics hub, handling bulk, conventional, and container goods. Ongoing development and modernization, including the use of TOS applications, aim to enhance its capacity and efficiency in the globalized era.

Source: IPC TPK (2024)

Fig. 1. Research location at the Container Terminal of Tanjung Priok Port Jakarta (IPC TPK)

This study employs a quantitative methodology, which is a research strategy grounded in the positivist philosophy. It aims to investigate specific populations or samples by random sampling and collects data using tools for statistical analysis. (Sugiyono, 2018). Quantitative research methods refer to philosophical research methods employed to examine specific populations or samples, involving the collecting of data using research instruments, and subsequent analysis of quantitative or statistical data (Sugiyono, 2022). The research was carried out at IPC TPK Tanjung Priok Jakarta. The Slovin formula, as described by Sugiyono (2017), is a mathematical equation used to determine the sample size required to accurately reflect the whole population.

ISSN: 2622-5778 (online)
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$$n = \frac{N}{1 + Ne^2}$$

Description:
n= Sample number
N= Population number
e^2= Precision 5%

This research was conducted at IPC TPK Tanjung Priok Jakarta. The sampling technique used the Slovin formula with 107 respondents as a sample of 146 population with a precision of 5%. The respondents came from employees of the container terminal at Tanjung Priok Port Jakarta. The data was gathered by a survey methodology, in which participants were requested to fill out a questionnaire employing a 5-point Likert scale. The data analysis in this study utilized Structural Equation Modelling Partial Least Squares (SEM-PLS) with the assistance of SmartPLS version 4 software. The variables in this study were measured using operational definitions, which can be found in Table 1. The variables used in this study consist of the independent variable “container handling services effectiveness” and the dependent variable “terminal operating system implementation” as well as the mediating variable “container handling tools and facilities availability”.

Tabel 1
Measurement Variables

Variable	Operational Definition	Source
Terminal Operating System Implementation (X)	The TOS is a software system that oversees the operations of a Container Terminal, offering up-to-date and accessible data through internet means. It effectively manages the coordination of commodities, equipment, and facilities at the port, frequently including technology such as the internet, Electronic Data Interchange (EDI), mobile devices, RFID, and DGPS. The TOS (Terminal Operating System) comprises crucial components for managing cargo operations and coordination, including berthing, vessel and yard planning, and communication. The system is specifically created to strategically coordinate, monitor, and oversee the transportation and storage of goods, resources, and individuals within and in the vicinity of the terminal, with immediate updates.	(Rangga Hidayat et al., 2023) (Gekara & Nguyen, 2020)

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
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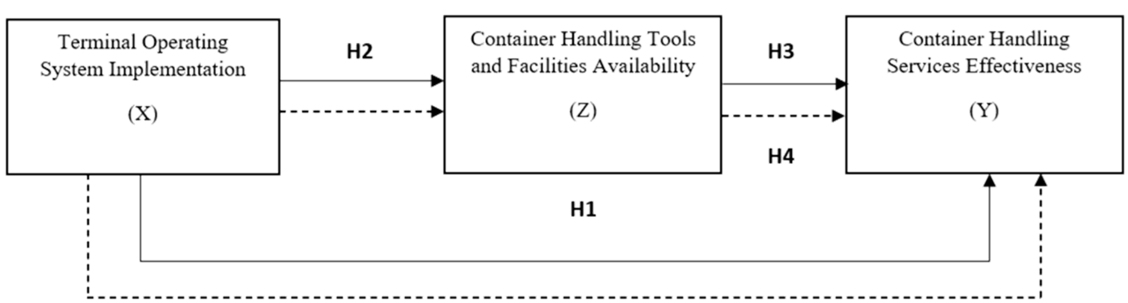
Container Handling Services Effectiveness (Y)	The container handling effectiveness operations is contingent upon both the terminal's capacity and the capability of port equipment to facilitate loading and unloading. Port goods service refers to the supply of warehousing facilities, stacking areas, and docks at a port. The port's capacity to handle the volume of products entering it is a key indicator of the degree of port service. Based on the given description, the facility has a substantial impact on the efficiency of container handling operations at the port.	(Yani, 2018)
Container Handling Tools and Facilities Availability (Z)	The Container Handling Tools and Facilities Availability can be defined as a condition where all equipment, machinery, and infrastructure required to perform the container container handling process are available, functioning properly, and ready to be used when needed.	(Dahri et al., 2024)

Source: Research Analysis Results (2024)

Based on the description of variable measurements previously described in Table 1, the hypothesis model of this study is to test the mediating role of the container handling tools and facilities availability on the relationship between terminal operating system implementation and container handling services effectiveness with the hypothesis in Figure 2 as a research model.



Source: Research Analysis Results (2024)

Fig. 2. Research Model

The hypothesis serves as a provisional solution to the formulation of research questions, which are expressed as declarative statements. The ephemeral nature of the replies is attributed to their reliance on appropriate theories rather than empirical facts derived from data collection. The hypothesis of this investigation is as follows:

H1: There is a relationship between terminal operating system implementation and handling services effectiveness

H2: There is a relationship between terminal operating system implementation and container handling tools and facilities availability

H3: There is a relationship between container handling tools and facilities availability on container handling services effectiveness

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
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H4: Terminal operating system implementation and container handling tools and facilities availability simultaneously affect the container handling services effectiveness.

Based on the above background, the problem formulations in this study are:

1. How is the relationship between terminal operating system implementation and container handling services effectiveness?
2. What is the relationship between terminal operating system implementation and container handling tools and facilities availability?
3. What is the relationship between the container handling tools and facilities availability on container handling services effectiveness?
4. How does terminal operating system implementation and the container handling tools and facilities availability simultaneously affect the container handling services effectiveness?.

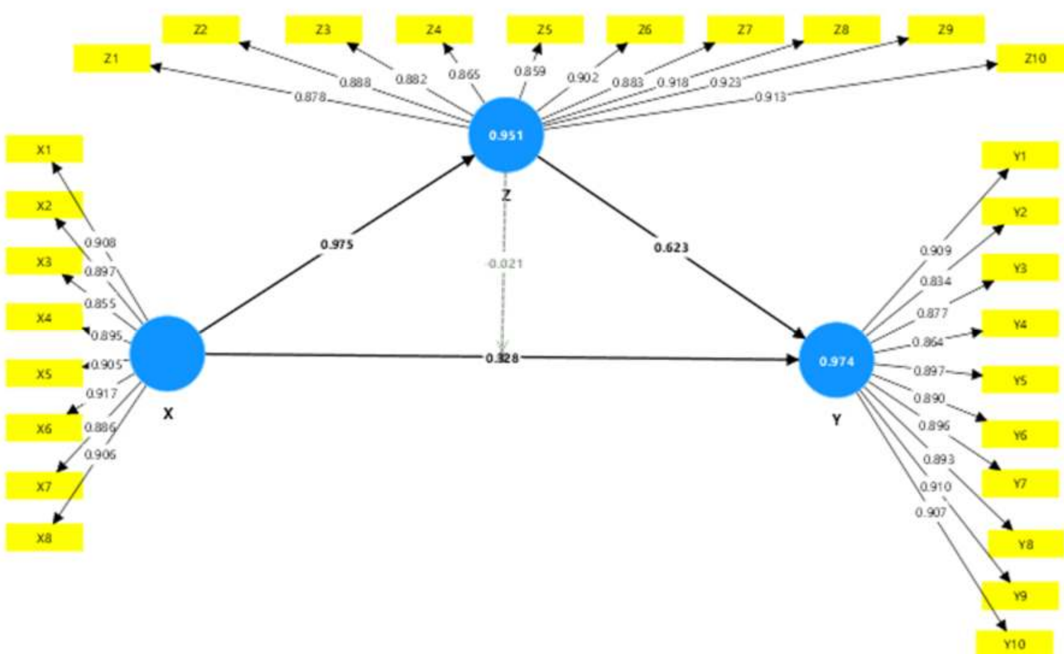
Based on the background and problem formulation above, the objectives of this study are:

1. Knowing the relationship between terminal operating system implementation and container handling services effectiveness
2. Knowing the relationship between terminal operating system implementation and container handling tools and facilities availability
3. Knowing the relationship between the container handling tools and facilities availability on container handling services effectiveness
4. Knowing terminal operating system implementation and the container handling tools and facilities availability simultaneously affect the container handling services effectiveness.

4. Results and Discussion

a. Outer model

The outer loading value or loading factor is utilized to assess convergent validity. An indicator is considered to have convergent validity in the excellent category if its outer loading value exceeds 0.7.



Source: Research Analysis Results (2024)

Fig. 3. Outer Model

ISSN: 2622-5778 (online)
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b. *Convergent validity*

Convergence in the measurement model with reflective indicators can be assessed through the relationship between the value of each indicator and the construct it measures, which can be observed through the output value of external loading. This external loading is obtained through the estimation process using the partial least squares (PLS) algorithm through SmartPLS 4 software.

Tabel 2
Output Outer Loading Construct

No	Variable	Indicator	Outer Loading
1	Terminal Operating System Implementation	X1	0.908
		X2	0.897
		X3	0.855
		X4	0.895
		X5	0.905
		X6	0.917
		X7	0.886
		X8	0.906
2	Container Handling Services Effectiveness	Y1	0.909
		Y10	0.907
		Y2	0.834
		Y3	0.877
		Y4	0.864
		Y5	0.897
		Y6	0.890
		Y7	0.896
		Y8	0.893
		Y9	0.910
3	Container Handling Tools and Facilities Availability	Z1	0.878
		Z10	0.913
		Z2	0.888
		Z3	0.882
		Z4	0.865
		Z5	0.859
		Z6	0.902
		Z7	0.883
		Z8	0.918
		Z9	0.923

Source: Research Analysis Results (2024)

Table 2 indicates that this study comprises three variables: "terminal operating system implementation" (X), "cargo handling services effectiveness" (Y), and "container handling tools and facilities availability" (Z). The three variables demonstrate. Significant results were obtained when the loading factor value exceeded 0.7. The loading factor value signifies the correlation between the indicator and the construct. Indicators that have low loading values imply indicating the indication is ineffective in the measurement methodology. The anticipated loading value should be more than 0.7. Within in outer model, we identify the phenomenon of cross loading. This value represents an additional indicator of the extent to which different constructs are distinct from one another. The expected result is that each indication will demonstrate a higher level of loading for the measured construct. When comparing the loading

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
http://proceedings.itltrisakti.ac.id/index.php/altr

value to other constructions. In the outer model, we identify composite elements. Composite elements dependability. Rating indicates a strong internal consistency, specifically a high composite reliability value. Consistency value of each indication is indicated in measuring its construct. Composite realibility value is indeterminate. Projected value is anticipated to be greater than 0.7, as stated by (Ghozali, 2016). To clarify, the three variables hold considerable importance and legitimate.

c. *Test construct realibility and validity*

Reliability testing is a method used to assess the consistency and dependability of a questionnaire that contains indications of variables or constructs (Ghozali, 2018). The reliability test and construct validity are used to assess the degree to which a research instrument is dependable or has a high level of dependability, specifically in terms of its capacity to consistently collect accurate data. The range of cronbach's alpha values is as follows: alpha < 0.50 indicates low reliability, 0.50 < alpha < 0.70 indicates moderate reliability, alpha > 0.70 indicates sufficient dependability, alpha > 0.80 indicates good reliability, and alpha > 0.90 indicates excellent reliability. A lower alpha value suggests a higher degree of unreliability in the items. A research instrument is considered credible if the cronbach's alpha value exceeds 0.60 (Ghozali, 2016). Hence, the criteria used for decision-making in the dependability test are as follows: Question items in the questionnaire are considered reliable if the Cronbach's alpha value is more than 0.60. Question items in the questionnaire are considered unreliable if the cronbach's alpha value is less than 0.60.

Table 3 demonstrates that the cronbach's alpha and composite reliability values for each variable satisfy the criterion, with a value greater than 0.60. These findings suggest that the research data's dependability is satisfactory. The composite dependability value exceeds the cronbach's alpha value. This demonstrates that all variables in the study satisfy the necessary criteria for the desired level of reliability, which serves as the foundation for conducting structural equation model (SEM) analysis using SmartPLS 4 software. The test outcomes reveal that the variable "terminal operating system implementation" possesses a cronbach's alpha value of 96.5% and Composite Reliability of 96.5%, with a composite reliability of 97%. These figures indicate that this construct exhibits a high level of reliability. The variable in question has an Average Variance Extracted (AVE) value of 80.3%, indicating that it satisfies the requirements for convergent validity.

Thus, the indicators used to measure the "terminal operating system implementation" are adequate and reliable while the variable "container handling services effectiveness" has a cronbach's alpha value of 97% and composite reliability of 97.1% and composite reliability of 97.4%, which indicates that this construct has high reliability. The average variance extracted (AVE) value for this variable is 78.9%, which confirms that this construct is consistent in the "container handling services effectiveness" for the variable "container handling tools and facilities availability" has a cronbach's alpha value of 97.1% and composite reliability of 97.1% and composite reliability of 97.5%, which indicates that this construct has high reliability. The average variance extracted (AVE) value for this variable is 79.5%, based on the test results, "container handling tools and facilities availability" can be considered a valid and reliable construct, and the indicators have described this construct well. The results of the validity and reliability measurements in the measurement model below show that the data collection tools used in this study are valid and reliable.

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Tabel 3
Processing value composite reliability

No.	Variable	Cronbach's Alpha	Composite Reliability (rho_a)	Composite reliability (rho_c)	Average Variance Extracted (AVE)
1	Terminal Operating System Implementation	0.965	0.965	0.970	0.803
2	Container Handling Services Effectiveness	0.970	0.971	0.974	0.789
3	Container Handling Tools and Facilities Availability	0.971	0.971	0.975	0.795

Source: Research Analysis Results (2024)

d. *Test determination*

The R-Square value can be utilized to evaluate the impact of specific independent latent variables on the dependent latent variable, determining whether it has a significant influence. The R-Square values of > 0.75, 0.50, and 0.20 indicate that the model is strong, moderate, and weak, respectively. The PLS R-Square values indicate the extent to which the model explains the variance of the constructs. The R-square value was calculated using SmartPLS 4 and the result is presented in Table 4.

Table 4
Value R Square

	R-square	*R-square adjusted*
Container Handling Services Effectiveness	0.974	0.974
Container Handling Tools and Facility Availability	0.951	0.951

Source: Research Analysis Results (2024)

From Table 4, it can be concluded that the R-Square value for the variable "container handling services effectiveness" (Y) is 0.974, which means that 97.4% of the variation in the variable "container handling services effectiveness" can be explained by the independent variables in this research model. The remaining 2.6% of the variation is influenced by other factors outside the model. and the R-square value for the variable "container handling tools and facilities availability" (Z) is 0.951 which indicates that 95.1% of the variation in "container handling tools and facilities availability" can be explained by the factors in the model. Although this contribution is very significant, there is still 4.9% of the variation explained by other factors outside the model.

e. *Test predictive relevance /q-square*

Predictive relevance is an assessment that evaluates the accuracy of observation values obtained through the blindfolding technique by examining the Q square value. If the Q square value is greater than 0, it indicates a favorable observation value. Conversely, if the Q square value is less than 0, it signifies an unfavorable observation value. A Q-square number greater than 0 shows that the model has predictive significance. Conversely, if the Q-square value is

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Advances in Transportation and Logistics Research
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less than or equal to 0, it indicates that the model lacks predictive relevance. The amplitude of Q2 ranges from 0 to 1, with values closer to 1 indicating a higher model quality. The size of Q2 is equal to the coefficient of determination in path analysis. The Stone-Geisser Q-square test, as described by Chin in 1998, is being referred to. Q-Square is a metric that may assess the accuracy of both the observed values generated by the model and the estimated parameters (Ghozali, 2016). A Q-Square value above 0 shows that the model has predictive relevance. Conversely, if the Q-Square value is below 0, it indicates that the model has little to no predictive relevance (Chin, 1998).

Q^2 = 99,87%

The Q-Square calculation in this study yielded a value of 0.9987 or 99.87%. This indicates that the model employed in this study has a significant predictive value, as it can explain 99.87% of the information in the research data.

f. Test goodness of fit

Goodness of fit evaluates the extent to which a model or equation can accurately explain variations in the data. The higher the model fit, the better the model fits the data, and the results are considered more reliable.

Table 5
Output model fit

	Saturated model	Estimated model
SRMR	0.027	0.029
d_ULS	0.287	0.339
d_G	1.078	1.138
Chi-square	799.170	803.598
NFI	0.883	0.882

Source: Research Analysis Results (2024)

From Table 5, it can be seen that the structural equation model can be said to be fit if the SRMR value is < 0.10 and the model is declared unfit if the SRMR value is > 0.15, has a ChiSquare with a value range > 0.05 and has an NFI with a value range < 0.90 (Ghozali, 2016). From Table 5 it can be seen that: 1.) the SRMR value is 0.029, which is below the 0.08 threshold. This means that the model has a good fit, indicating that the difference between the observed covariance matrix and that predicted by the model is small with an SRMR of 2.9%, this model can be considered to have a good fit; 2.) The d_ULS value obtained is 0.339. This value, while not having a universal threshold, indicates that the model is within an acceptable range. The use of d_ULS helps in assessing model fit especially in the context of models that have non-normality of data; 3.) The d_G value obtained was 1.138. This value indicates that the model has adequate fit. Like d_ULS, d_G is a useful metric in measuring the model's fit to the data, and this result indicates that the model is within the bounds of a good fit; 4.) The Chi-Square test result shows a value of 803.598, indicating that the model has no significant difference between the observed and expected covariance matrix, which means that the model fits the data well; 5.) The NFI value obtained is 0.882, or 88.2%, which is above the threshold of 0.70. This indicates that this model has a good fit and that 88.2% of the initial mismatch in the base model has been corrected by this model.

g. *Hypothesis testing*

Structural model testing is a technique employed to elucidate the correlation between variables in a research investigation. In order to verify the accuracy of the suggested hypothesis, we can assess the statistical significance of the t-statistic and p-value. A smaller p-value indicates stronger support for the hypothesis. If the p-value is smaller than the predetermined significance level (0.05), the hypothesis can be rejected. On the other hand, if the p-value exceeds the significance level (0.05), the hypothesis can be deemed acceptable.

Table 6
Path Coefficients (Mean, STDEV, T-Statistic)

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
X -> Y	0.328	0.337	0.104	3.139	0.002
X -> Z	0.975	0.975	0.007	133.233	0.000
Z -> Y	0.623	0.616	0.095	6.533	0.000
Z x X -> Y	-0.021	-0.020	0.009	2.379	0.017

Source: Research Analysis Results (2024)

1. H1 Accepted: The results showed a significant relationship between terminal operating system implementation (X) and container handling services effectiveness (Y). The direction of the relationship can be seen from the resulting research p value, which is 0.002 also does not exceed the predetermined standard (<0.05). The interpretation of this finding is that the higher the application of TOS at the Container Terminal of Tanjung Priok Port Jakarta, the higher container handling services effectiveness at the port.
2. H2 Accepted: The results showed a significant relationship between terminal operating system implementation (X) and the container handling tools and facilities availability (Z). The direction of the relationship can be seen from the resulting research p value, which is 0.000 also does not exceed the predetermined standard (<0.05). The interpretation of this finding is that the higher the application of the TOS at the Container Terminal of Tanjung Priok Port Jakarta, the higher the container handling tools and facilities availability.
3. H3 Accepted: The results showed a significant relationship between the container handling tools and facilities availability (Z) and container handling services effectiveness (Y). The direction of the relationship can be seen from the resulting research p value, which is 0.000 also does not exceed the predetermined standard (<0.05). The interpretation of this finding is that the higher the application of TOS at the Container Terminal of Tanjung Priok Port Jakarta, the higher container handling services effectiveness at the port.
4. H4 Accepted: The results showed a significant relationship between the container handling tools and facilities availability (Z) and terminal operating system implementation (X) with container handling services effectiveness (Y). The direction of the relationship can be seen from the p value value generated by the study, which is 0.017 not exceeding the predetermined standard (<0.05). The interpretation of this finding is that the higher and more complete the availability of container container handling tools and facilities as well as the use of the TOS application at the Container Terminal of Tanjung Priok Port Jakarta, it will be followed by an increase in the container handling services effectiveness.

ISSN: 2622-5778 (online)
Advances in Transportation and Logistics Research
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5. Conclusion

Based on the problems that have been formulated, the results show that the variable "terminal operating system implementation" has a positive and significant effect on the "container handling services effectiveness". This means that if the higher the application of TOS at the Container Terminal of Tanjung Priok Port, it will have an impact on increasing the "container handling services effectiveness", and the variable "container handling tools and facilities availability for container handling containers" has a positive and significant effect on "terminal operating system implementation" and "the container handling services effectiveness", which means that if "the container handling tools and facilities availability for container handling containers" at the Container Terminal of Tanjung Priok Port Jakarta is higher, this will have a positive effect on "terminal operating system implementation" and "the container handling services effectiveness".

Judging from the results of p values, this study concludes that "the container handling tools and facilities availability" significantly affects "terminal operating system implementation" to achieve "the container handling services effectiveness" with a significance level of 99.81%.

6. Implications

Based on the above conclusions, there are several implications that need to be considered for future improvements. One of the main implications is the importance of the container handling tools and facility availability as a key factor that can strengthen the relationship between the TOS implementation and the container handling services effectiveness. Adequate tools and facilities allow the use of terminal operating systems to run more optimally, so as to speed up the container handling process and reduce the berthing time of ships. This mediation role opens up opportunities to improve port management efficiency, make port operations more sustainable and optimize container handling performance. Therefore, the successful combination of the terminal operating system and container handling tools with facility availability is anticipated to enhance the efficiency of the Tanjung Priok Port container terminal and facilitate the transition towards digitalization at Tanjung Priok Port.

7. Research Limitations

Based on this study, the mediation of "container handling tools and facilities availability" on the relationship between "terminal operating system implementation" and "container handling services effectiveness" has been identified as an important factor that has a positive effect. Nevertheless, like other research endeavors, it is essential to acknowledge certain limitations that should be taken into account for future enhancements. A primary constraint is that the mediation solely concentrates on "container handling tools and facilities availability". While this mediation provides significant insights, it may not capture all the factors that influence terminal performance. "container handling tools and facilities availability" is one important aspect, but it is possible that other factors, such as the quality of operational management, labor skills, or information technology integration also play a significant mediating role but were not explored in this study.

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