Factors Affecting Port Facility Infrastructure Performance in Jakarta and Banten with Port Business Entities Intervening

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ABSTRACT

Ports play a crucial role in Indonesia's national logistics system, particularly because Indonesia is an archipelagic country. However, port management continues to face challenges related to institutional support, bureaucratic inefficiency, and governance, which can constrain infrastructure performance. This study examines the effects of concession implementation, technology utilization, and port services on the role of Port Business Entities (BUP) and on port facility infrastructure performance in DKI Jakarta and Banten. A quantitative survey of 310 port service users was analyzed using Partial Least Squares Structural Equation Modeling. The results show that concession implementation, technology utilization, and port services significantly influence both the role of BUP and port facility infrastructure performance, directly and indirectly through BUP. The findings indicate that BUP functions as an important mediating mechanism in improving infrastructure performance. The study therefore highlights the need to strengthen concession transparency, technology utilization, service quality, and coordination among government agencies, BUP, and port stakeholders to improve the competitiveness and performance of Indonesian ports.

Keywords: concessions, technology, services, business, performance

A. Introduction

Based on the 2022 United Nations Conference on Trade and Development (UNCTAD) report, Indonesia was listed among the 20 countries with strong port performance. The statistic was derived from the average movement of container ships with a gross tonnage (GT) of 1,000 or more during the first half of 2022 (UNCTAD, 2023). Indonesia was reported in 12th position, behind countries including Italy, France, Greece, Germany, the United States, Russia, Australia, and Canada. Indonesia exceeded the global average in container ship arrivals. The average port-call duration worldwide was 20.1 hours, while Indonesia recorded 24.9 hours. A Pelindo press release in 2023 also reported that the average time taken by container ships to complete a round trip increased by 13.7% compared with 2020 and 2021 (Pelindo Press Release, 2023).

As an example, Tanjung Priok Port in DKI Jakarta remains a major gateway for Indonesian exports. During 2017-2021, exports passing through the port reached approximately US$274.2 billion, equivalent to 28.9% of Indonesia's total exports (datanesia.id, 2023). Tanjung Priok has also handled

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more than 30% of Indonesia's non-oil and gas commodities and around 50% of the goods flowing into and out of the country. These figures underline the port's strategic role in the national economy. The port provides vessel, cargo, supporting, and passenger services (pelindo.co.id, 2023).

A key governance issue concerns the Ministry of Transportation's limited budget for carrying out port-operator responsibilities. In addition, the mechanism for using a portion of Non-Tax State Revenue (PNBP), as stipulated in Minister of Finance Decree Number 518/KMK.06/2022, requires clear procedures for calculating, verifying, and validating concession revenue. Weaknesses in source-data verification and supporting documentation can reduce the reliability of concession-revenue calculations. These conditions indicate the need for stronger monitoring, annual reconciliation, and the systematic incorporation of independent audit findings.

Therefore, an in-depth analysis of concession implementation, technology utilization, and port service quality is needed to explain variations in port facility infrastructure performance. This study examines how these factors influence infrastructure performance in DKI Jakarta and Banten and identifies the role of Port Business Entities in this relationship. The findings are expected to provide practical evidence for improving infrastructure management, technology adoption, service quality, and port competitiveness.

Recent Indonesian studies have examined port performance factors, service delivery, digitalization, and logistics effectiveness, but these strands are generally analyzed separately (Sunitiyoso et al., 2022; Robbany et al., 2022; Ricardianto et al., 2023). This study addresses that gap by integrating concession implementation, technology utilization, and port services in one structural model and by positioning the role of Port Business Entities (BUP) as a mediator of their effects on port facility infrastructure performance in DKI Jakarta and Banten.

Ports are core nodes in maritime logistics because they connect shipping networks, cargo-handling activities, hinterland transport, and regulatory processes. In Indonesia, port performance depends not only on physical infrastructure but also on service procedures, information and communication technology, institutional coordination, and the interaction among port operators, shipping firms, and government agencies (Sunitiyoso et al., 2022; Ricardianto et al., 2023).

Logistics management at ports concerns the coordinated flow of goods, information, and services from vessel arrival to cargo transfer and onward distribution. Recent Indonesian evidence shows that port performance is shaped by the interaction of infrastructure, service procedures, technology, human resources, and stakeholder coordination rather than by a single operational factor (Sunitiyoso et al., 2022; Robbany et al., 2022).

Port facility infrastructure includes the physical and digital assets required to support safe, reliable, and efficient port operations. Contemporary port-performance frameworks increasingly treat automation, connectivity, information sharing, security, sustainability, and operational integration as important dimensions of infrastructure capability (Molavi et al., 2020; Makkawan & Muangpan, 2021; Yen et al., 2023).

In the Indonesian port-governance framework, concessions enable Port Business Entities to provide and manage port services under agreements with the port authority. The effectiveness of a concession depends on clear contractual responsibilities, regulatory oversight, performance monitoring, and incentives for infrastructure investment. Indonesian research has emphasized the strategic role of port concessions and BUP in port management (Samawati, 2021; Tri Achmadi & Khaqiqi, 2021), while international evidence shows that weaknesses in regulatory design can reduce the operational benefits of concession arrangements (Iwuoha et al., 2022).

Technology utilization has become

a central component of modern port management. Smart-port studies show that digital platforms, automation, data integration, the Internet of Things, and real-time monitoring can improve operational visibility and decision making, although their benefits depend on organizational readiness and effective implementation (Molavi et al., 2020; Othman et al., 2022; Yen et al., 2023; Paraskevas et al., 2024).

In Indonesia, digital transformation is closely linked to port service efficiency and logistics performance. Studies have identified information and communication technology, service procedures, and stakeholder coordination as interacting drivers of port performance (Sunitiyoso et al., 2022; Ricardianto et al., 2023). Recent work on Inaportnet also shows that integrated digital systems can support vessel-clearance processes and improve the coordination of port services (Setiawan et al., 2024).

The concept of a smart port extends beyond technology adoption. It also requires integrated governance, service quality, security, and collaboration among port authorities, terminal operators, shipping companies, and other users. Accordingly, technology should be evaluated as part of an organizational and institutional system rather than as an isolated technical input (Makkawan & Muangpan, 2021; Min, 2022; Paraskevas et al., 2024).

Port service quality reflects the reliability, responsiveness, efficiency, and consistency of services received by port users. Empirical studies in Indonesia indicate that service delivery and logistics effectiveness are closely associated with port operational performance (Robbany et al., 2022; Ricardianto et al., 2023). Comparative port research also shows that infrastructure and operational efficiency should be assessed together when evaluating port performance (Yen et al., 2023). These findings support the use of concession implementation, technology utilization, port services, the role of BUP, and infrastructure performance as linked constructs in the present model. Thus it can be hypothesized as follows (figure 1).

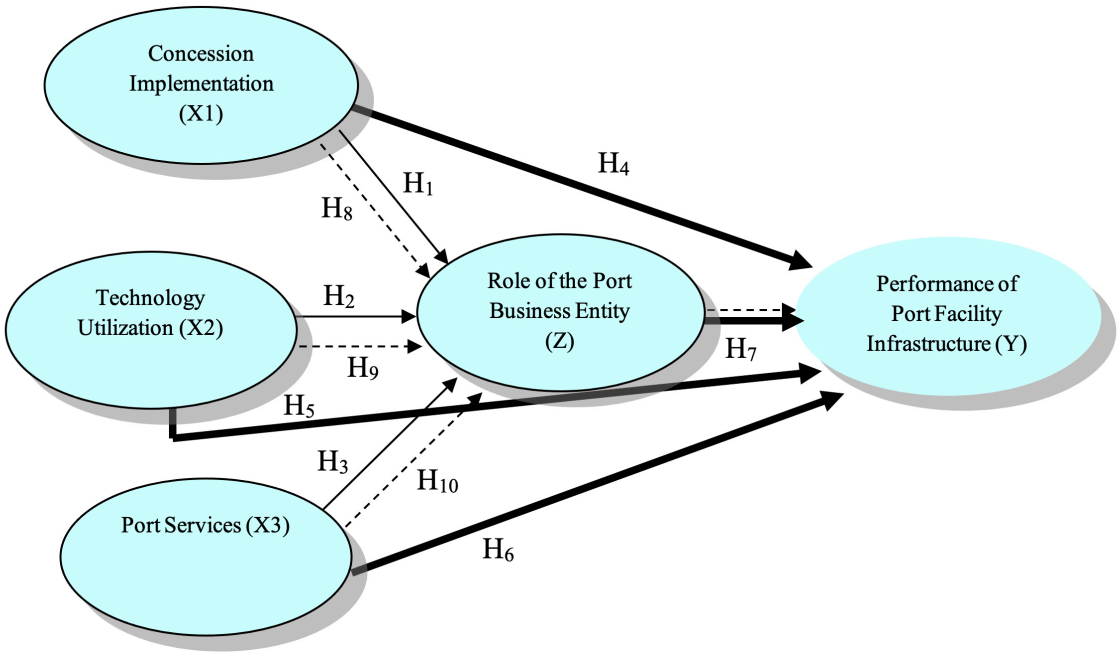

Figure 1. Conceptual Framework and Research Model

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H1: It is assumed that there is a significant influence of concession implementation on the role of the port business entity.
H2: It is assumed that there is a significant influence of technology utilization on the role of the port business entity.
H3: It is assumed that there is a significant influence of port services on the role of the port business entity.
H4: It is assumed that there is a significant influence of concession implementation on the performance of port facility infrastructure.
H5: It is assumed that there is a significant influence of technology utilization on the performance of port facility infrastructure.
H6: It is assumed that there is a significant influence of port services on the performance of port facility infrastructure.
H7: It is assumed that there is a significant influence of the role of the port business entity on the performance of port facility infrastructure.
H8: It is assumed that there is a significant influence of concession implementation on the performance of port facility infrastructure through the role of the Port Business Entity.
H9: It is assumed that there is a significant influence of technology utilization on the performance of port facility infrastructure through the role of the Port Business Entity.
H10: It is assumed that there is a significant influence of port services on the performance of port facility infrastructure through the role of the Port Business Entity.

The general objective of this research is to analyze and understand the influence of concession implementation, technology utilization, and port services on the role of port business entities and their impact on the performance of port facility infrastructure in Jakarta and Banten provinces.

B. Methods

The target population comprised users of services provided by Port Business Entities (BUP) in DKI Jakarta and Banten. Eligible units included shipping companies, ship agencies, stevedoring companies, transportation management service companies, cargo owners, and other businesses that interact directly with port operations. These service users were selected because they have direct experience with port services, BUP operations, and port facility infrastructure.

Because the exact population size was not available in a single consolidated register, the minimum sample size was determined using the indicator-based rule applied in PLS-SEM research. Using 10 observations per indicator produced a minimum target of 310 respondents ($31 \times 10 = 310$) (Hair et al., 2022).

The operational sampling frame was defined as eligible port-service users who met the study criteria and operated at ports managed by BUP in DKI Jakarta and Banten. Eligible units were grouped by administrative area or terminal cluster before sample selection so that differences in cluster size could be incorporated into the sampling procedure.

After proportional allocation, eligible service users were selected randomly within each cluster. The inclusion criteria were: (1) users of ports managed by BUP in DKI Jakarta or Banten; (2) service users registered with the relevant associations, including INSA, APBMI, and ISAA; and (3) shipping companies, ship agencies, transportation management service companies (JPT), stevedoring companies, cargo owners, or related port-service businesses. The achieved sample comprised 226 respondents from DKI Jakarta and 84 respondents from Banten, for a total of 310 respondents.

This study was a quantitative investigation utilizing specific statistical methods for data analysis. Data analysis in PLS-SEM for this study was conducted using SmartPLS version 4, which provides both basic and advanced options for in-depth

analysis (Ringle et al., 2023). The modeling process produces two primary outputs.

The first step in PLS-SEM analysis is evaluating the outer model (measurement model), which involves examining the correlation between indicators and latent variables (Hair et al., 2019). This evaluation is obtained through PLS algorithm calculations in SmartPLS and includes reliability and validity testing. For reliability, indicator reliability is assessed by measuring values from the model, while construct reliability is measured through Cronbach's alpha and composite reliability. For validity, construct validity is assessed using the average variance extracted (AVE) value, and discriminant validity is evaluated with the heterotrait-monotrait ratio (HT/MT). If all indicators meet reliability and validity criteria, structural model analysis can proceed (Hair et al., 2019).

The second step in PLS-SEM analysis is evaluating the inner model (structural model) to assess relationships among latent variables. This evaluation includes checking the Variance Inflation Factor (VIF) to identify any multicollinearity issues among independent variables. Multicollinearity can weaken the model's predictive capability.

The coefficient of determination (R^2) is then used to assess the model's predictive power, indicating how well the empirical data aligns with the proposed model. Higher R^2 values suggest greater predictive accuracy, with values categorized as substantial (0.75), moderate (0.5), or weak (0.25) (Hair et al., 2019).

The Q^2 or predictive relevance (Q^2_predict) assesses the model's predictive relevance. If Q^2_predict is above 0, it indicates relevant predictive power, while values below 0 imply no meaningful predictive capability. This analysis compares the error values from the PLS-SEM model with a linear model, ensuring the structural model's predictive relevance (Shmueli et al., 2019).

Following the model quality assessment, the analysis moves to hypothesis testing. Hypothesis testing in this study uses bootstrapping or re-sampling with SmartPLS. Hypotheses are assessed based on two criteria: (1) the significance of the correlation between variables, measured by comparing empirical t-statistics to critical t-values. A t-statistic above the critical t-value indicates a significant influence. This study uses $\alpha = 0.05$ with a one-sided t-value of 1.96. (2) the coefficient direction, where hypotheses are supported if the standardized coefficient is substantial and aligns with the expected hypothesis direction.

Finally, path analysis examines the influence of variables across mediation pathways. This step determines the mediating capability of the mediator variable in the research model by reviewing the specific indirect effect.

C. Results and Discussion

1. Hypothesis Testing Results

Outer Model Results

The concession implementation indicator shows the highest loading factor on statement KONS1 at 0.823, while the lowest is on KONS5 at 0.716. This means that KONS1 has the greatest contribution in measuring the concession implementation construct, whereas KONS5 has the lowest contribution. However, since all loading factor values are above the 0.7 threshold, all these indicators are considered valid in measuring the concession implementation construct. Thus, all indicators can be retained in the study. For the technology utilization indicator, statement TEK4 has the highest loading factor value at 0.937, while the lowest is TEK9 at 0.734. TEK4 is very strong in explaining the technology utilization variable, while TEK9, although the lowest, still makes a significant contribution. All indicators with values above 0.7 are considered valid, concluding that these indicators are overall robust and can be used to measure technology utilization in the study.

The port service indicator has the highest loading factor value at PEL4 with 0.822 and the lowest at PEL1 with 0.706. This indicates that

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PEL4 is more dominant in measuring the port service variable compared to PEL1. Although PEL1 has the lowest loading factor, its value is still above 0.7, meaning it remains valid in measuring the port service construct. For the Port Business Entity role indicator, the highest loading factor is on BUP7 at 0.844, and the lowest is on BUP4 at 0.705. BUP7 makes the largest contribution in explaining this variable, whereas BUP4, despite being the lowest, is still valid with a loading factor above 0.7. Overall, these indicators can be used in the study as their loading factor values meet validity requirements. The port facility infrastructure performance indicator shows the highest value on KIN16 with a loading factor of 0.923, while the lowest values are on KIN8 and KIN9 at 0.746. KIN16 is very strong in measuring this construct, while KIN8 and KIN9 contribute the least. However, these values are still valid as they exceed 0.7. Therefore, all indicators for port facility infrastructure performance are considered suitable for accurately measuring this variable.

Overall, all constructs measured through various indicators in this study are deemed valid, as the loading factor for each indicator exceeds the 0.7 threshold. Indicators with the highest loading factors represent the strongest statements in measuring each construct, while those with the lowest values are still valid, albeit with relatively smaller contributions. Based on the processed loading factor values in the diagram, it can be concluded that all values align with the rule of thumb, exceeding 0.7. Therefore, all variables from the sample of 310 respondents can be further analyzed.

The reliability test results from this study, based on data from 310 respondents were assessed through Cronbach's alpha (CA) and composite reliability (CR) values. According to the rule of thumb, CA and CR values of 0.6 and 0.7 or higher are considered sufficient to establish the reliability and trustworthiness of the variables.

The Performance of Port Facility Infrastructure variable achieved a Cronbach's alpha of 0.969 and a composite reliability of 0.972, while the Port Services variable scored 0.951 and 0.956, respectively. Similarly, Technology Utilization reached 0.977 and 0.979, Concession Implementation scored 0.962 and 0.965, and the Role of Port Business Entity achieved values of 0.961 and 0.965. These results indicate that each variable aligns well with the reliability criteria. Consequently, it can be concluded that all items and variables within the sample are valid and reliable, meeting the required standards. This reliability supports further analysis in evaluating the structural model.

Inner Results Model

The structural model (inner model) is a model that has the ability to provide the proof on causality that refers to latent variables. The following is a display of a path diagram using the PLS bootstrapping calculation.

R-Square (Coefficient of Determination)

The indigo coefficient of determination (R^2) is predicted to have the value of 0 to 1. R^2 values of 0.75, 0.50, and 0.25 indicate that the model is strong, moderate, and weak.

Table 1 shows that concession implementation, technology utilization, and port services jointly explain 49.2% of the variance in the Role of Port Business Entity (Z) ($R^2 = 0.492$; adjusted $R^2 = 0.487$). The remaining 50.8% is explained by factors outside the model. For Port Facility Infrastructure Performance (Y), concession implementation, technology utilization, port services, and the Role of Port Business Entity jointly explain 57.2% of the variance ($R^2 = 0.572$; adjusted $R^2 = 0.567$).

Effect Size (f^2) Results

Based on the results, Service Quality has a strong effect on the Role of Port Business Entity with a high f^2 value of 0.345, indicating that Service Quality is a significant factor influencing the role of port authorities. In contrast, its effect on Port Infrastructure Performance is weaker at 0.067. Technology Utilization has a moderate effect on Port

Infrastructure Performance (0.153) and a weaker effect on the Role of Port Business Entity (0.038). Concession Implementation exhibits weak effects on both Port Infrastructure Performance (0.051) and the Role of Port Business Entity (0.059). Lastly, the Role of Port Business Entity has a weak effect size of 0.073 on Port Infrastructure Performance. These findings underscore the importance of Service Quality in enhancing the role of the port authority, while Technology Utilization moderately impacts infrastructure performance

Q^2 Predictive Relevance Results

The predictive relevance values in assess the model's ability to predict relevant outcomes, categorized as small (<0.25), medium (0.25-0.5), or large (>0.5). The Q^2 value of Port Infrastructure Performance is 0.371, indicating medium predictive relevance, which means the model moderately predicts performance outcomes for this construct. Similarly, the Role of Port Business Entity has a value of 0.292, also showing medium predictive relevance.

Hypothesis Testing (Bootstrapping)

H1 of 3.065, which is higher than its significance level (3.065 > 1.96), and p-values of 0.002 which are lower than 0.05 (0.002 < 0.05), these results show that the implementation of concessions directly gives a significant effect on the role of port business entities in DKI Jakarta and Banten Provinces. Based on these results, the conclusion that can be drawn is H1 is accepted, which has a meaning that the application of concessions directly gives a significant positive impact to the role of port business entities in DKI Jakarta and Banten.

In accordance with the t-statistics H2 of 2.732 and higher than its significance level (2.732> 1.96), and p-values of 0.007 which are lower than 0.05 (0.007 <0.05), these results show that directly the use of technology gives a significant impact to the role of port business entities in the DKI Jakarta and Banten Provinces. Based on these results, the conclusion that can be drawn is H2 is accepted.

In accordance with the t-statistics H3 of 7.452 which is higher than its significance level (7.452> 1.96), and p-values of 0.000 which are lower than 0.05 (0.000 <0.05), then these results show that port services directly give a significant impact to the role of port business entities in the DKI Jakarta and Banten Provinces. Based on these results, the conclusion that can be drawn is H3 is accepted.

In accordance with the t-statistics H4 of 3.087 which is higher than its significance level (3.087> 1.96), and p-values of 0.002 which are lower than 0.05 (0.002 <0.05), these results show that the implementation of concessions directly give a significant impact to the performance of port facility infrastructure in DKI Jakarta and Banten Provinces. According to these results, the conclusion that can be drawn is H4 is accepted.

In accordance with the t-statistics H5 of 5.504 which is higher than its significance level (5.504> 1.96), and p-values of 0.000 which are lower than 0.05 (0.000 <0.05), these results show that directly the use of technology gives a significant impact to the performance of port facility infrastructure in DKI Jakarta and Banten Provinces. According to these results, the conclusion that can be drawn is H5 is accepted.

In accordance with the t-statistics H6 of 3.319 which is higher than its significance level (3.319> 1.96), and p-values of 0.001 which are lower than 0.05 (0.001 <0.05), then these results show that port services directly give a significant impact to the performance of port facility infrastructure in DKI Jakarta and Banten. According to these results, the conclusion that can be drawn is H6 is accepted.

If the role of port business entities has increased by 1, then the performance of port facility infrastructure will increase by 0.249. In accordance with the t-statistics H7 of 3.357 which is higher than its significance level (3.357> 1.96), and p-values of 0.001 which is lower than 0.05 (0.001 <0.05), then these

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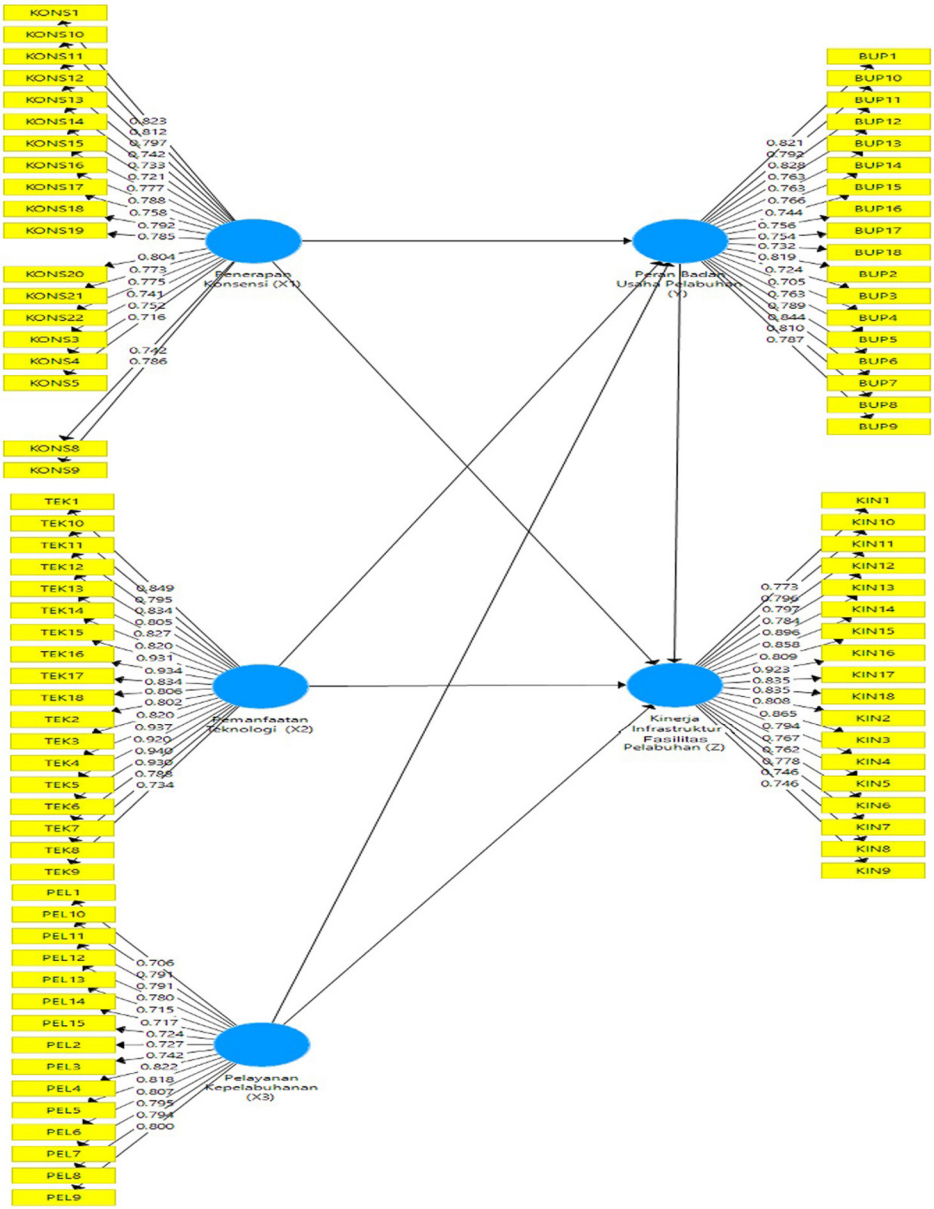

Figure 2 Outer Loading Stage 3

results show that directly the role of port business entities gives a significant impact to the performance of port facility infrastructure in DKI Jakarta and Banten Provinces. According to these results, the conclusion that can be drawn is H7 is accepted.

In accordance with the t-statistics H8 of 2.254 which is higher than its significance level (2.254> 1.96), and p-values of 0.025 which are lower than 0.05 (0.025 <0.05), these results show that indirectly the implementation of concessions gives a significant impact to the performance of port facility infrastructure through the role of port business entities. Based on these results, the conclusion that can be drawn is H8 is accepted.

In accordance with the t-statistics H9 of 2.085 which is higher than its significance level (2.085> 1.96), and p-values of 0.038 which are lower than 0.05 (0.038 <0.05), these results show that indirectly the use of technology gives a significant impact to the performance of port facility infrastructure through the role of port business entities.

Based on these results, the conclusion that can be drawn is H9 is accepted.

In accordance with the t-statistics H10 of 3.058 which is higher than its significance level (3.058> 1.96), and p-values of 0.002 which are lower than 0.05 (0.002 <0.05), these results show that indirectly port services give a significant impact to the performance of port facility infrastructure through the role of port business entities. Based on these results, the conclusion that can be drawn is H10 is accepted.

2. Research Results Summary

Based on the survey results on the implementation of concessions, technology, port services, the role of the Port Business Entity, and port infrastructure performance, there are several interesting and relevant findings for management to evaluate and follow up. The survey shows that the aspect "Data disclosed by the port in the context of the concession is transparent and accurate"

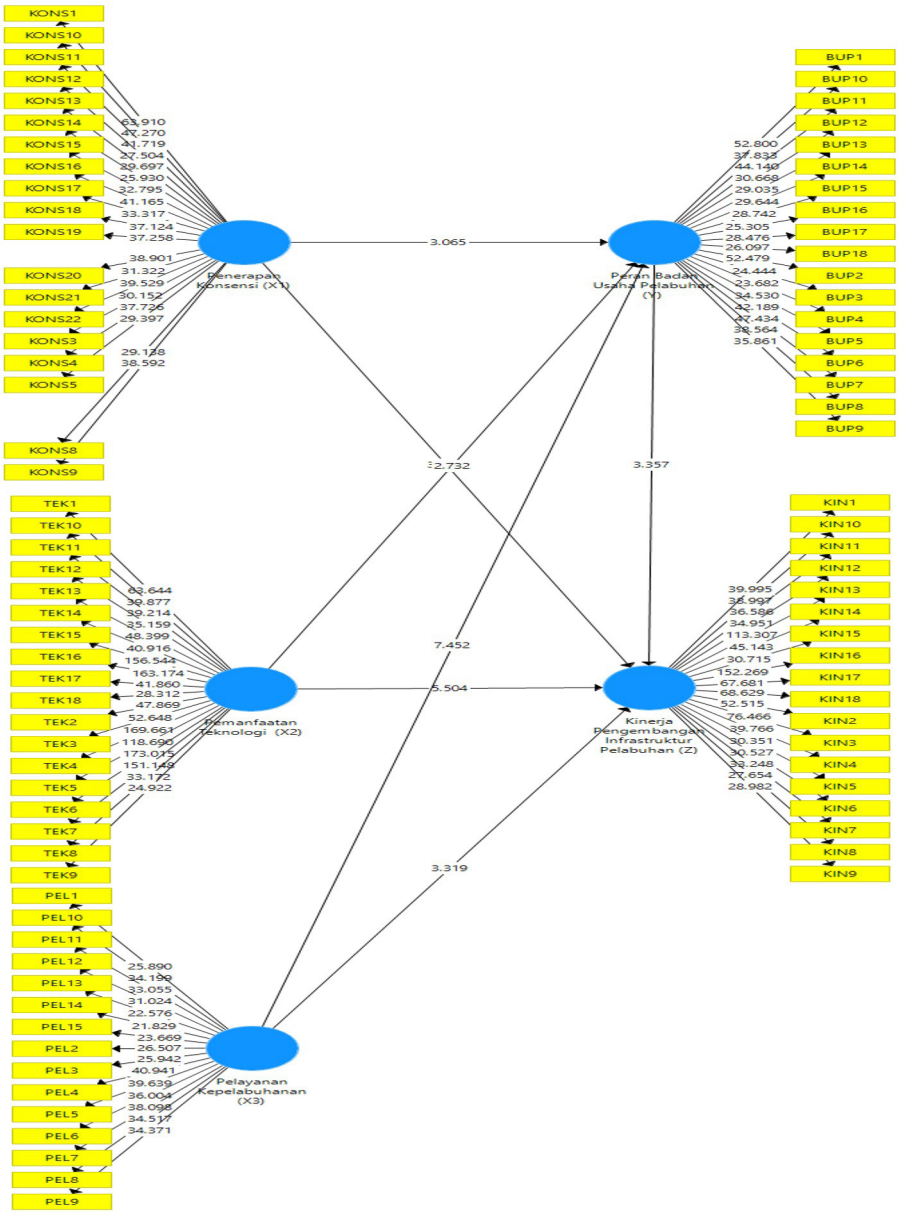

Figure 3.Bootstrapping

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received the highest score, which is 4.555. This reflects that data transparency and accuracy are highly appreciated by respondents, indicating a high level of trust in the port. However, the indicator "The provisions of the concession agreement are clearly and transparently formulated" has the lowest score, 3.348, indicating dissatisfaction regarding the clarity of the agreement. Overall, the average score for the implementation of the concession was 3.835, indicating that respondents generally agree that the implementation of the concession is going well, but it should be improved in terms of clarity and transparency of the agreement.

In terms of technology utilization at the port, "Port operations are in accordance with real conditions in the field" received the highest score of 4.652, indicating that the port is able to operate well according to the real situation in the field, so respondents are very satisfied with this. However, the indicator with the lowest score is "The digital business model has been successfully implemented at the port," with a score of 3.116. This indicates that the implementation of the digital business model at the port still needs to be improved, perhaps related to infrastructure or human resources. Overall, the average value of this variable is 3.966, indicating that although technology has been utilized well, there is room to improve the implementation of digital technology at the port.

Respondents highly appreciate the port's efforts in maintaining "operational and occupational safety," which has the highest score of 3.806. This indicates that the port has succeeded in providing safe and responsible services. However, "fast service" is still considered less than optimal, with a score of 2.816, indicating that management needs to find ways to improve service efficiency, for example, by speeding up operational processes. Overall, the average score for port services is 3.540, indicating that although the service is quite good, increasing the speed of service is a top priority.

The survey also highlighted that "Community participation mechanism in business development" received the highest score, 3.903, indicating that respondents were satisfied with the port's efforts in involving the community. However, the "checks and balances mechanism" was considered less than optimal with a score of 3.152, indicating that transparency and accountability in the management of the port business entity need to be strengthened. Overall, the average score for the role of the Port Business Entity was 3.654, indicating fairly good performance with some areas that need improvement.

In terms of port infrastructure, "Port network security" has the highest score of 4.497, indicating that the cybersecurity aspect is highly appreciated by respondents. However, "Office buildings that support administrative activities" received the lowest score of 3.271, indicating that office facilities still need to be improved to be more optimal in supporting administrative operations. Overall, the average for port infrastructure performance is 3.861, indicating a fairly positive assessment from respondents, especially in terms of security, although there are many options to improve in physical facilities.

From the overall survey results, transparency, data accuracy, and security of port infrastructure received high appreciation from respondents, indicating that the port is on the right track in several important areas. However, challenges such as clarity of concession agreements, implementation of

Table 1 R-Square Test Results (R2)

	R Square	R Square Adjusted
Port Facilities Infrastructure Performance	0.572	0.567
Role of Port Business Entity	0.492	0.487

Table 2 Effect Size (f^2) Results

Variables	Port Infrastructure Performance	Service Quality	Technology Utilization	Concession Implementation	Role of Port Business Entity
Port Infrastructure Performance					
Service Quality	0.067				0.345
Technology Utilization	0.153				0.038
Concession Implementation	0.051				0.059
Role of Port Business Entity	0.073				

digital business models, speed of service, and office administration facilities require more attention. Management needs to improve clarity of communication, accelerate services with technology, and ensure physical facilities support operations efficiently. With these evaluation and improvement steps, the port can continue to build a more transparent, responsive, and trustworthy working environment for all parties.

In this study, an analysis was conducted on 10 hypotheses that examine the influence of concession implementation, technology utilization, and port services to the role of Port Business Entities (BUP) and the performance of port facility infrastructure in DKI Jakarta and Banten. The outcomes show that the implementation of concessions, technology utilization, and port services significantly affect port performance, both directly and through the role of BUP. This study is also in line with a number of theoretical and empirical studies from previous studies that support the findings.

Influence: Implementation of concessions to the role of Port Business Entities

Based on the research outputs, the implementation of concessions has a positive impact to the role of Port Business Entities (BUP) and possesses a parameter coefficient of 0.204. This indicates that every 1 unit increase in the implementation of concessions will increase the role of BUP by 0.204 units. With a t-statistic of 3.065 and a p-value of 0.002, it can be concluded that this influence is statistically significant.

Table 3 Q^2 Predictive Relevance Results

Variables	SSO	SSE	Q^2 (=1 - SSE/SSO)
Port Infrastructure Performance	5580.0	3510.653	0.371
Role of Port Business Entity	5580.0	3948.165	0.292

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Concessions, as an important instrument used by the government to involve the private sector in port management, play a central role in improving operational efficiency and the role of BUP. Private sector participation through concessions not only improves efficiency in port management but also strengthens the capacity of BUP in managing and utilizing existing port infrastructure. From a transport management perspective, these concessions help achieve higher efficiency in the movement of goods and passengers at the port, as expressed by (Tamin, 2018). Logistics management also supports that concessions are able to strengthen the efficiency of logistics distribution at the port, especially in the management of goods flow and logistics facilities. (Ghiani et al., 2014).

Adam & Dwiastuti, (2015), said the decline in the quality and quantity of ports

Table 4 Indirect Influence and Direct Influence

	Indirect Influence and Direct Influence	Coeffi-cient Parameter	*T-Statistics*	*P-Values*	Results
H1	Implementation of Concessions -> Role of Port Business Entities	0.204	3,065	0.002	H1 accepted
H2	Utilization of Technology -> Role of Port Business Entities	0.161	2,732	0.007	H2 accepted
H3	Port Services -> Role of Port Business Entities	0.489	7,452	0,000	H3 accepted
H4	Implementation of Concessions -> Port Facility Infrastructure Performance	0.179	3,087	0.002	H4 accepted
H5	Technology Utilization -> Port Facility Infrastructure Performance	0.305	5,504	0,000	H5 accepted
H6	Port Services -> Port Facilities Infrastructure Performance	0.229	3,319	0.001	H6 accepted
H7	Role of Business Entities Port -> Port Facilities Infrastructure Performance	0.249	3,357	0.001	H7 accepted
H8	Implementation of Concessions -> Role of Port Business Entities -> Port Facility Infrastructure Performance	0.051	2,254	0.025	H8 accepted
H9	Utilization of Technology -> Role of Port Business Entities -> Port Facility Infrastructure Performance	0.040	2,085	0.038	H9 accepted
H10	Port Services -> Role of Port Business Entities -> Port Facility Infrastructure Performance	0.121	3,058	0.002	H10 accepted

was caused by the state's declining financial capacity due to fiscal pressures related to high debt costs, subsidies, and increasing regional fund transfers. In addition, the closed participation of the private sector also had a negative impact on the performance of port facility infrastructure.

Tri Achmadi & Khaqiqi, (2021), in the results of his research analyzed the implementation of concessions in Indonesia using a calculation model using the BCR (Benefit Cost Ratio) method and sensitivity analysis. This study aims to provide an effective and mutually beneficial concession model between the parties involved. The results of his research state that the most influential components are concession fees and port tariffs.

The Impact of Technology Utilization to the role of the Port Business Entity

With a t-statistic of 2.732 and a p-value of 0.007, this effect is stated to be significant. The use of technology such as the Inaportnet system, which directly automates many processes at the port, has a significant impact of reducing ship waiting times, increasing distribution efficiency, and facilitating better communication between stakeholders. Tamin (2018) supports that "technology plays an important role in ensuring the smooth flow of goods and passengers at the port. Technology is able to optimize the arrangement of logistics flows and distribution of goods more efficiently."

The ship agency service has changed the completion of ship documents from a manual system to an online system. The online system is expected to improve fast, reliable, transparent, and standardized ship services so that it can minimize ship handling costs at the port and improve the performance of handling trade and goods traffic activities, especially encouraging the acceleration of the port clearance process so that ships do not experience delays (Setiawan et al., 2024).

Support from Robbany et al., (2022), Paraskevas et al., (2024), and Ricardianto et al., (2023) underlined that technology plays a crucial role to improve the operational efficiency of the port, which is managed by BUP. (Ubjaan et al., 2024), And (Sunitiyoso et al., 2022)stated that the implementation of technology such as Inaportnet strengthens BUP in managing ship traffic and loading and unloading activities.(Suryandi et al., 2022) as well as (Nurjanah et al., 2023) supports this by emphasizing technology as a strengthening factor in the performance of ports managed by BUP

Impact of Port Services to the role of the Port Business Entity

With a t-statistics value of 7.452 and a p-value of 0.000, this influence is very significant. Fast and efficient services, such as in terms of loading and unloading and cargo management, have a direct impact on increasing port productivity and competitiveness, which ultimately strengthens the role of BUP in port operations. Nasution (2014), good service at the port supports the smooth transportation of goods and passengers, ensuring that the port functions as an efficient node in the marine transportation system. Efficient port services accelerate the distribution of goods and strengthen the logistics supply chain (Ghiani et al., 2014).

Pallis & de Langen, (2010) in the results of his research mentioned that the ability and strategy needed to obtain a concession to operate a terminal at the port. To what extent the concession procedure creates barriers to entry and reduces market stability. The importance of reducing economic, institutional and location barriers to entry at the port, because the concession procedure greatly influences market entry. It is proven that tenders can reduce barriers to entry by ensuring transparency, limiting discrimination and exclusivity and limiting concessions to certain periods.

Influence Implementation of concessions to port facility infrastructure performance with a t-statistic of 3.087 and a p-value of 0.002, indicating a significant effect.

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Concessions provide opportunities for the private sector to invest in the development of port infrastructure, which ultimately increases the efficiency and capacity of the port in handling increasing demand. Nasution (2014), good port infrastructure plays an important role in supporting smooth sea transportation. Good infrastructure performance increases the efficiency of logistics distribution and port competitiveness (Ghiani et al., 2014).

In the short term, the impact of port facility infrastructure performance will affect the jobs in the construction sector, while in the medium and long term it will make the logistics in the Role of Port Business Entities more efficient and productive. The involvement of the private sector can support faster facility infrastructure performance, more efficient and accountable infrastructure management and innovation in infrastructure technology, thereby increasing better economic competitiveness,(Meersman & Nazemzadeh, 2017).

The Impact of Technology Utilization to the performance of port facility infrastructure

With a t-statistic of 5.504 and a p-value of 0.000, this effect is very significant. The use of technology in ports, such as in the use of automation of loading and unloading systems, speeds up the process, increases transparency of management, and reduces ship waiting times. Technology applied in ports can increase the efficiency of the movement of goods and passengers, accelerate sea transportation services (Nasution, 2014). Technology helps better logistics management by reducing process time and increasing accuracy in the distribution of goods (Ghiani et al., 2014).

Technology has a vital role in improving port efficiency. The utilization of advanced technologies, such as automation and IoT, has the potential to improve port infrastructure performance by speeding up loading and unloading processes and reducing human error. Paraskevas et al. (2024) and Ricardianto et al. (2023) found that the use of technology such as IT-based port management systems improves the efficiency and performance of port infrastructure. Ubjaan et al. (2024) and Sunitiyoso et al. (2022) also indicate that technology can support shorter ship waiting times and improved logistics services, which in turn supports infrastructure performance.

Impact of Port Services on the performance of port facility infrastructure

With a t-statistics value of 3.319 and a p-value of 0.001, this influence is proven to be significant. Efficient services, such as in terms of handling loading and unloading, enable better port infrastructure management, speed up operational processes, and increase port capacity. Tamin (2018), emphasized that good service at the port supports the smooth transportation of goods and passengers. Good service improves logistics efficiency, which contributes to improving port infrastructure performance (Ghiani et al., 2014).

In the research by (Amril & Logahan, 2016), it is stated that "the results of the study showed a positive and significant influence on the relationship between ship services, loading and unloading equipment and loading and unloading operators simultaneously on JICT Terminal Performance" .Study (Malisan, 2014) sayIdle hours at the port are very large when compared to effective hours, and have an impact on ship productivity that is not linear with relatively large ship visits. It can be explained that operational performance can be influenced by several factors such asservices and equipment facilities and loading and unloading productivity. In addition, based on the criteria data related to the Flow of Goods and Flow of Ship PT. JICT Tanjung Priok shows the existing limitations and inconsistencies.

The influence of the role of the Port Business Entity to the performance of port facility infrastructure.

The t-statistics value of 3.357 and the p-value of 0.001 indicate that this influence is very statistically significant. This means that BUPs that play an active and efficient role in the management and maintenance of port

facilities contribute to improving the quality of infrastructure. The role of BUPs that include responsibility for planning, implementing, and maintaining infrastructure not only improves the condition of facilities but also increases the overall operational efficiency of the port. Tamin (2018), good service from BUP supports the smooth transportation of goods and passengers by ensuring that port infrastructure functions optimally. Ghiani et al. (2014) emphasized that effective logistics management by BUPs can improve operational efficiency and infrastructure performance.

The performance of port facility infrastructure plays a role in changing GDP output by 0.7% (developing countries) to 44% (developed countries) for every 10% increase in port infrastructure budget. The performance of port facility infrastructure can also be seen through the role of facility infrastructure performance in increasing productivity by 0.7% to 1%, especially through capital-intensive or labor-intensive infrastructure,(Calderón et al., 2015).

The role of BUP as a port operator is very influential in ensuring that port infrastructure is managed and developed properly. BUP plays an important role in maintaining infrastructure performance through concession management and port operations. Study by (Samawati, 2021) and (Danladi et al., 2024)emphasized that BUP has a big responsibility in managing and developing port infrastructure.(Tri Achmadi & Khaqiqi, 2021) and (Ambarini et al., 2019)also supports that the role of BUP is very important in increasing the capacity and quality of port infrastructure

The indirect impact of concession implementation to the performance of port facility infrastructure through the role of the Port Business Entity

The t-statistics value of 2.254 and the p-value of 0.025 indicate that this effect is significant. This shows that with the existence of concessions, BUP can carry out its role more effectively in managing and developing port infrastructure. The implementation of concessions, which involve the private sector in port management, allows BUP to access additional resources, technology, and innovation which in turn improves infrastructure performance. Tamin (2018), concessions have the potential to increase the efficiency of the transportation system by involving third parties who can inject funds and expertise. The involvement of the private sector through concessions can improve the quality and capacity of port infrastructure (Ghiani et al., 2014).

Port development projects are categorized as high risk, like the return on investment of port development (rate of return on investment) is relatively low, has a very long duration and has a relatively high level of externalities. Therefore, it is only natural that the government provides incentives to the private sector to minimize the emergence of investment cost reimbursement guarantees from the government if the port development project is stalled in the middle of the road, for example because land acquisition is hampered or the project is rejected by the local community so that it cannot continue.

This finding is in line with the previous research by Nwanosike et al., (2016) which stated that “concessionaires have not brought in the expected investment in modernization to boost port efficiency in Nigeria. Calabar and Apapa ports experienced the highest productivity growth, while the lowest was Onne Port”. While the research by (Monios & Bergqvist, 2015) stated that “some uncertainties in intermodal concession contracts, particularly related to the lack of clear provisions on performance monitoring and measurement, open access for users, infrastructure maintenance, service marketing and handover procedures. This study identifies how the existing port concession framework can be adapted for intermodal terminals, as a first step towards developing a global standard as used in the port sector”.

The indirect influence of technology utilization on the performance of port facility infrastructure through the role of the Port Business Entity

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The H9 results show that technology utilization has a significant indirect effect on Port Facility Infrastructure Performance through the Role of Port Business Entity. The indirect-effect coefficient is 0.040, with a t-statistic of 2.085 and a p-value of 0.038. Because the p-value is below 0.05, H9 is supported. This result indicates that technology utilization contributes to infrastructure performance partly through BUP's role in coordinating, implementing, and managing technology-enabled port operations. The variable label, coefficient, t-statistic, and p-value are consistent with the H9 values reported in Table 4.

Technology can be used to improve interactions with customers and other stakeholders. Utilizing digital platforms to report cargo status, make reservations, and obtain other important information can improve customer satisfaction. Analytical and predictive technology can help BUP make better decisions based on data and trends. This can help in planning investments, forecasting capacity needs, and optimizing development strategies.

This is supported by research Suryandi et al., (2022) which stated that "the presence of Inaportnet can be an easy-to-use solution between shipping agents and port organizers. In order to improve services at the port office and port authority class 1 Tanjung Balai Karimun". While the research by Sitorus et al., (2016) shows that the application of technology-based information systems, it is hoped that port management performance can improve and it is hoped that the Government will provide guidance, supervision and enforce the law against stakeholders at the port who makes violation to the rules.

The findings are consistent with studies showing that digital systems can improve port service processes and operational coordination. Inaportnet-based services can support vessel scheduling, clearance processes, and information exchange among port stakeholders (Nurjanah et al., 2023; Setiawan et al., 2024). These results support the interpretation that technology utilization contributes to infrastructure performance when it is effectively implemented and managed by BUP.

Technology can influence port infrastructure performance both directly and through BUP management. Effective technology utilization requires organizational coordination, system integration, and operational implementation by the port business entity. Recent studies show that digitalization and smart-port practices can improve operational efficiency when technology is embedded in port governance and management processes (Sunitiyoso et al., 2022; Ricardianto et al., 2023; Paraskevas et al., 2024; Yen et al., 2023).

Indirect influence of port services on the performance of port facility infrastructure through the role of the Port Business Entity

The H10 results show that port services have a significant indirect effect on Port Facility Infrastructure Performance through the Role of Port Business Entity. The indirect-effect coefficient is 0.121, with a t-statistic of 3.058 and a p-value of 0.002. Because the p-value is below 0.05, H10 is supported. This result indicates that better port services strengthen infrastructure performance through BUP's role in coordinating service delivery, facility use, operational efficiency, and stakeholder relationships. The variable label, coefficient, t-statistic, and p-value are consistent with the H10 values reported in Table 4.

Good port services can strengthen the partnership relationship of the Port Business Entity Role with shipping companies, entrepreneurs, and related government agencies. This strong relationship can result in more effective collaboration in the development of port infrastructure and facilitate better access to resources and technology needed for better infrastructure development. Thus, the influence of port services on the Performance of facility infrastructure through the role of the Port Business Entity includes aspects of revenue, investment capacity, reputation,

operational efficiency, and better partnership relationships.

This has the similar outcome with the research by Amril & Logahan, (2016) which stated that "the results of the study showed a positive and significant influence on the relationship between ship services, loading and unloading equipment and loading and unloading operators simultaneously on JICT Terminal Performance". Study The Devil, (2014) say Idle hours at the port are very large when compared to effective hours, and have an impact on ship productivity that is not linear with relatively large ship visits. It can be explained that operational performance can be influenced by several factors such asservices and equipment facilities and loading and unloading productivity. In addition, based on the criteria data related to the Flow of Goods and Flow of Ship PT. JICT Tanjung Priok shows the existing limitations and inconsistencies.

Services managed by BUP will affect the overall performance of port infrastructure. Good service quality is supported by efficient infrastructure, which depends on the role of BUP in managing facilities. Research by Robbany et al. (2022) and Iswandi et al. (2024) shows that efficient services contribute to infrastructure development through the role of BUP. Amril & Logahan (2016) also support that good service, with management support by BUP, can improve the quality and capacity of port infrastructure

The structural model explains 49.2% of the variance in the Role of Port Business Entity ($R^2 = 0.492$). It also explains 57.2% of the variance in Port Facility Infrastructure Performance ($R^2 = 0.572$).

Based on the description above, it can be said that the Role of Port Business Entities strengthens the influence of concession implementation, technology utilization and port services on the performance of port facility infrastructure in DKI Jakarta and Banten Provinces. This finding shows that the role of Port Business Entities is not only as policy implementers but also as entities that give a significant impact in improving the Performance of port facility infrastructure

Furthermore, the findings highlight that the technology application give a significant impact to the performance of port facility infrastructure. Thus, investment and development in Information And Communication Technology (ICT) and other related technologies are essential to improve efficiency, productivity, and innovation in port infrastructure development. The use of technologies such as port information systems, automated monitoring and control, and digital applications can help accelerate the process of port infrastructure development.

In addition, the research findings also show that port services have a dominant impact on the role of the Port Business Entity. This indicates that services quality provided by the Port Business Entity Role, such as operational efficiency, responsiveness to customer needs, and overall user experience, give a significant impact on the Port Business Entity Role performance. Therefore, the endeavors of improving port service quality can be an effective strategy to improve the role and the Port Business Entity Role performance in developing port infrastructure.

Overall, these research results provide valuable insights for stakeholders, including the government, Port Business Entity Roles, and industry players, to have a deeper understanding of the dynamics and key factors that influence the performance of port facility infrastructure in the region. By understanding the role of Port Business Entities and the importance of port services, relevant parties can design more effective policies and strategies to achieve the goal of sustainable and efficient port infrastructure development.

D. Conclusion

First, there is a significant impact of the implementation of concessions on the role of BUP, which confirms that the concessions implemented effectively strengthen the capacity and responsibility of BUP in port

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management. Second, the utilization of technology gives a significant impact to the role of BUP in both provinces as well, indicating that advanced technology can make the efficiency and effectiveness of BUP operations in carrying out their duties will be improved. Third, port services show a significant direct effect on the role of BUP, highlighting that high-quality services strengthen BUP's position in providing optimal and efficient services. In addition, the implementation of concessions gives a significant direct impact to the performance of port infrastructure, it means that good concessions improve the quality and efficiency of infrastructure use.

The use of technology also shows a significant effect to the infrastructure performance, where the technology applied is able to improve and modernize port infrastructure. Port services also have a significant impact on infrastructure performance, confirming that high-quality services can improve infrastructure management and performance. Furthermore, the role of BUP gives a significant impact on infrastructure performance, indicating that the active role of BUP is very important in improving port infrastructure performance. There is also an indirect influence of the implementation of concessions, utilization of technology, and port services on infrastructure performance through the role of BUP, which means that the role of BUP strengthens the positive impact of the three variables on infrastructure performance.

Overall, this research has shown that the direct impact of concession implementation and technology utilization on infrastructure performance is very significant. Although the role of BUP as a mediator is also important, the direct impact of concession and technology is more dominant, indicating that good concession policies and the application of advanced technology play a crucial role in improving port infrastructure performance.

The novelty of this study lies in the integrated structure of the model, rather than in the research location or period alone. Previous Indonesian studies have examined port-performance factors and stakeholder interactions (Sunitiyoso et al., 2022), service-based determinants of port performance (Robbany et al., 2022), and logistics effectiveness and operational performance (Ricardianto et al., 2023). Smart-port studies have also emphasized technology-enabled performance and digital transformation (Yen et al., 2023; Paraskevas et al., 2024). A related PLS-SEM study by Yuwono et al. (2024) tested port technology and other operational factors through service performance as a mediator of service-user satisfaction, but it did not examine concession implementation, port services, and the role of BUP as a mediating governance mechanism for infrastructure performance. The present study therefore contributes an integrated mediation model in which concession implementation, technology utilization, and port services affect port facility infrastructure performance both directly and indirectly through the Role of Port Business Entity (BUP), using evidence from DKI Jakarta and Banten.

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