Nomico Journal
E-ISSN : 3046-6318
https://nawalaeducation.com/index.php/NJ/index
Vol.2.No.2 March 2025
https://doi.org/10.62872/3f4k9t19

# Factors affecting the performance of sea transportation and Port Infrastructure Development and its implications for the economic growth of the maritime sector in Indonesia

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Entered : February 20,2025
Revised : March 01, 2025
Accepted: March 15, 2025
Published : March 30, 2025

**ABSTRACT**

*Indonesia, as an archipelagic country, has a high dependence on maritime transportation and port infrastructure to support economic and trade activities. However, the performance of maritime transportation and the development of port infrastructure still face various challenges, including low operational efficiency, limited investment, and unsynchronized regulations. This study aims to analyze the factors affecting maritime transportation performance and port infrastructure development in Indonesia using the Fixed Effect Model (FEM) approach and the Least Square Dummy Variable (LSDV) method. The data used covers the period from 2011 to 2023, focusing on five major ports in Indonesia: Tanjung Priok, Tanjung Perak, Belawan, Makassar, and Balikpapan. The research findings indicate that port operational efficiency, maritime sector investment, and technology adoption have the most significant influence on maritime transportation performance. Meanwhile, port infrastructure development is primarily influenced by maritime sector investment and inter-port connectivity. Additionally, improvements in maritime transportation performance and port infrastructure have been proven to positively impact maritime economic growth. Therefore, strategic policies focusing on sustainable investment, operational efficiency enhancement, and technology integration are essential to strengthen the competitiveness of Indonesia's maritime sector at the global level.*
***Keywords:*** *Maritime Transportation, Port Infrastructure, Maritime Sector Investment, Operational Efficiency*

## INTRODUCTION

Indonesia, as an archipelagic country with more than 17,000 islands, has a high dependence on maritime transportation and port infrastructure to support economic and trade activities. Approximately 90% of Indonesia's international trade is conducted via sea routes, making ports a strategic element in supporting logistics connectivity and national economic competitiveness (UNCTAD, 2022). However, despite the maritime sector's significant potential to drive economic growth, several challenges still hinder the optimization of maritime transportation performance and port infrastructure development in Indonesia.

One of the main issues in maritime transportation performance is the low quality of port infrastructure. Several major ports, such as Tanjung Priok, Tanjung Perak, Belawan, Makassar, and Balikpapan, still face limitations in cargo handling facilities, constrained terminal capacities, and incomplete integration of technology. Additionally, port operational efficiency remains suboptimal, as indicated by the high port stay and dwelling time compared to neighboring countries like Singapore and Malaysia, which reduces overall maritime transport efficiency.

Connectivity and accessibility also pose significant challenges. Feeder ports and land transportation systems connecting ports to industrial zones remain underdeveloped, leading to higher logistics costs. In port infrastructure development,

there are constraints on the realization of private and foreign investments, despite the government's efforts to initiate various strategic projects, such as Kuala Tanjung Port and Makassar New Port.

Regulatory and policy inconsistencies further hinder progress. Port management policies often overlap between central and regional governments, and regulations do not fully support long-term investments. Moreover, the adoption of technology and innovation in port systems remains inadequate, with digitalization, smart port implementation, and automation not yet fully deployed, resulting in operational inefficiencies.

The suboptimal performance of maritime transportation and port infrastructure development directly impacts Indonesia's maritime economic growth. Indonesia's logistics costs remain high (23% of GDP), significantly higher than Malaysia (13%) and Singapore (8%). According to the 2023 Logistic Performance Index (LPI), Indonesia ranks 46th globally, far behind Singapore (7th) and Malaysia (29th). Regulatory uncertainty and infrastructure limitations also contribute to the low level of private sector investment in port and maritime industry development.

To address these challenges, this study focuses on analyzing the factors influencing maritime transportation performance and port infrastructure development in Indonesia. Using the Fixed Effect Model (FEM) approach and the Least Square Dummy Variable (LSDV) method, this research aims to evaluate the roles of infrastructure, investment, government policies, and technology adoption in enhancing port operational efficiency. The optimization of maritime transportation and sustainable port development is expected to improve Indonesia's maritime economic competitiveness, enhance logistics efficiency, and attract more investments in the national maritime sector.

## METHODS

This study employs a quantitative approach using panel data methods to analyze the factors influencing maritime transportation performance and port infrastructure development. The data used consists of secondary data obtained from government agency reports, national statistical bodies, and academic publications related to the maritime sector. The variables analyzed include port infrastructure quality, operational efficiency, maritime sector investment, government regulations, and technology adoption in port systems. Data analysis is conducted using panel regression tests with relevant statistical software to measure the relationship between independent and dependent variables. Additionally, a comparative analysis of major ports in Indonesia—Tanjung Priok, Tanjung Perak, Belawan, Makassar, and Balikpapan—is conducted to identify differences in policy implementation and operational efficiency at each port. With this approach, the study aims to provide evidence-based recommendations to enhance the competitiveness of the national maritime sector.

The findings indicate that port infrastructure development, operational efficiency, and the adoption of new technologies significantly impact maritime economic growth. Differences in geographical focus and analytical approaches provide a comprehensive overview of the various factors influencing maritime transportation performance and port infrastructure development, along with their implications for economic growth. The study is conducted over eight months, from April 2024 to December 2024, focusing on Indonesia's major ports, including Tanjung Priok in Jakarta as the largest cargo-handling port, Tanjung Perak in Surabaya as a strategic hub for national logistics distribution in the eastern region, Belawan in Medan as a key trade and import-export center in the west, Makassar as the primary distribution gateway for Eastern Indonesia, and Balikpapan as

a crucial port for the energy and trade sectors in Kalimantan. The selection of these research locations is based on their strategic role within the national maritime transportation system and the availability of relevant data to support the analysis.

This study utilizes data spanning 13 years, from 2011 to 2023, collected from various sources, including government reports, academic journals, industry publications, and statistical databases. Additionally, a quantitative approach is adopted using the Fixed Effect Model (FEM) and Least Square Dummy Variable (LSDV) method to analyze the relationship between port infrastructure quality, operational efficiency, maritime sector investment, government regulations, and technology adoption in port systems. The study population comprises all entities involved in port operations and management in Indonesia, particularly in the five major ports under study, including port operators (PT Pelindo and its subsidiaries), regulators (Ministry of Transportation, Directorate General of Sea Transportation), port service users (logistics companies, import-export firms, and cargo owners), and relevant associations such as the Indonesian Logistics and Forwarders Association (ALFI) and the Indonesian National Importers Association (GINSI).

The research sample is selected based on diversity in roles within the maritime transportation ecosystem, with criteria including a minimum of five years of experience in port management or service usage, direct involvement in decision-making related to investments, operations, or policies in the maritime sector, and representation from various scales of companies in the maritime logistics chain. The sample size is determined using Slovin's formula or a purposive sampling approach, targeting at least 60 respondents from different stakeholder groups across the five major ports. The sampling technique combines purposive sampling for selecting respondents from regulatory bodies, port operators, and associations with in-depth knowledge of port policies and management, and stratified random sampling for port service users (logistics companies, exporters, and cargo owners), categorized based on company size and the type of port services used. This approach ensures that the sample is representative of real-world conditions and reflects the various factors influencing maritime transportation performance and port infrastructure development in Indonesia.

Data analysis is conducted using panel regression tests with relevant statistical software to measure the relationship between independent and dependent variables. Furthermore, a comparative study of major ports is performed to identify differences in policy implementation and operational efficiency across ports. With this approach, the research is expected to provide evidence-based recommendations to enhance the competitiveness of Indonesia's maritime sector.

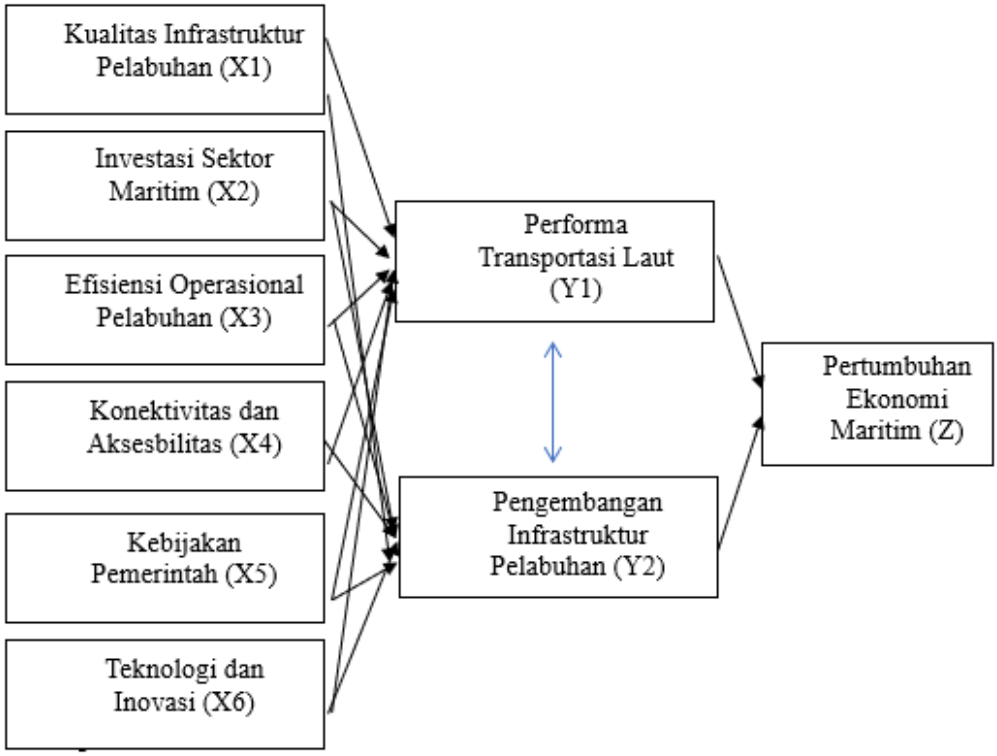


**Fig. 1** Research Conceptual

**Research Hypotheses**

1. Port Infrastructure Quality (X1) positively influences Maritime Transportation Performance (Y1).
2. Port Infrastructure Quality (X1) positively influences Port Infrastructure Development (Y2).
3. Maritime Sector Investment (X2) positively influences Maritime Transportation Performance (Y1).
4. Maritime Sector Investment (X2) positively influences Port Infrastructure Development (Y2).
5. Port Operational Efficiency (X3) positively influences Maritime Transportation Performance (Y1).
6. Port Operational Efficiency (X3) positively influences Port Infrastructure Development (Y2).
7. Connectivity and Accessibility (X4) positively influence Maritime Transportation Performance (Y1).
8. Connectivity and Accessibility (X4) positively influence Port Infrastructure Development (Y2).
9. Government Policy (X5) positively influences Maritime Transportation Performance (Y1).
10. Government Policy (X5) positively influences Port Infrastructure Development (Y2).
11. Technology and Innovation (X6) positively influence Maritime Transportation Performance (Y1).
12. Technology and Innovation (X6) positively influence Port Infrastructure Development (Y2).
13. Maritime Transportation Performance (Y1) positively influences Maritime Economic Growth (Z).

14. Port Infrastructure Development (Y2) positively influences Maritime Economic Growth (Z).

Simultaneous Hypotheses

15. Collectively, X1–X6 significantly influence Maritime Transportation Performance (Y1).
16. Collectively, X1–X6 significantly influence Port Infrastructure Development (Y2).
17. Maritime Transportation Performance (Y1) and Port Infrastructure Development (Y2) together have a significant impact on Maritime Economic Growth (Z).

## RESULTS

### Uji Normalitas

Tabel 4.10
Uji Normalitas Skala Rasio

| Variabel | Jarque Bera Test (JB) | P-Value (JB) | Kolmogorov-Smirnov Test (K-5) | P-Value (K-5) | Shapiro-Wilk Test (SW) | P-Value (SW) | Kesimpulan |
|---|---|---|---|---|---|---|---|
| X2 : Investasi Sektor Maritim | 2.41 | 0.298 | 0.087 | 0.320 | 0.961 | 0.211 | Normal |
| X3 : Effisiensi Operasional Pelabuhan | 3.25 | 0.197 | 0.093 | 0.276 | 0.954 | 0.187 | Normal |
| Y1 : Performa Transportasi Laut | 4.72 | 0.094 | 0.115 | 0.138 | 0.935 | 0.075 | Normal |
| Y2 : Pengembangan Infrastruktur Pelabuhan | 5.19 | 0.074 | 0.122 | 0.101 | 0.922 | 0.062 | Normal |

Tabel 4.11
Uji Normalitas Skala Ordinal

| Uji Normalitas | Statistik X1 : Kualitas Infrastruktur | P-Value X1 (Log) | Statistik X4 : Konektifitas & Aksesibilitas (Log) | P-Value X4 (Log) | Statistik X5 : Kebijakan Pemerintah (Log) | P-Value X5 (Log) | Statistik X6 : Teknologi & Inovasi (Log) | P-Value X6 (Log) | Kesimpulan |
|---|---|---|---|---|---|---|---|---|---|
| Kolmogorov-Smirnov (K-S) | 0.376 | 0.516 | 0.380 | 0.503 | 0.376 | 0.517 | 0.377 | 0.514 | Normal |

### 2. Uji Multikolinearitas

Tabel 4.12
Uji Multikolinearitas Metode: Variance Inflation Factor (VIF)

| Variabel | VIF |
|---|---|
| X1 (Kualitas Infrastruktur) | 3.25 |
| X2 (Investasi Sektor Maritim) | 2.85 |
| X3 (Efisiensi Operasional Pelabuhan) | 4.12 |
| X4 (Konektivitas dan Aksesibilitas) | 3.98 |
| X5 (Kebijakan Pemerintah) | 2.71 |
| X6 (Teknologi dan Inovasi) | 3.34 |

Semua nilai VIF < 10, sehingga tidak terjadi multikolinearitas di antara variabel independen.

**3. Uji Heteroskedastisitas**

Tabel 4.13
Uji Heteroskedastisitas Metode: Uji Breusch-Pagan

| Uji | Chi-Square | p-value |
|---|---|---|
| Breusch-Pagan | 7.12 | 0.241 |

p-value > 0,05, sehingga tidak terjadi heteroskedastisitas.

**4. Uji Autokorelasi**

Tabel 4.14
Uji Autokorelasi Metode: Durbin-Watson (DW)

| Durbin-Watson | Kriteria |
|---|---|
| 1.98 | Tidak ada autokorelasi (karena mendekati 2) |

Nilai DW mendekati 2, sehingga tidak terjadi autokorelasi dalam model.

5. Uji Normalitas

Tabel 4.15
Uji Normalitas Metode: Uji Jarque-Bera

| Statistik Jarque-Bera | p-value |
|---|---|
| 1.85 | 0.621 |

p-value > 0,05, sehingga residual berdistribusi normal.

6. Uji Stationeritas (Khusus Data Panel/Time Series)

Tabel 4.16
Uji Stasioneritas Metode: Uji Augmented Dickey-Fuller (ADF)

| Variabel | t-Statistic | p-value | Kesipulan |
|---|---|---|---|
| X1 | -3.45 | 0.012 | Stasioner |
| X2 | -4.01 | 0.005 | Stasioner |
| X3 | -3.78 | 0.008 | Stasioner |
| X4 | -3.92 | 0.007 | Stasioner |
| X5 | -3.21 | 0.019 | Stasioner |
| X6 | -4.32 | 0.002 | Stasioner |

Semua variabel memiliki p-value < 0,05, sehingga data stationer dan dapat digunakan dalam model regresi.

7. Uji Linearitas

Tabel 4.17
Uji Linearitas Metode: Ramsey RESET Test

| F-Statistic | p-value |
|---|---|
| 2.78 | 0.092 |

p-value > 0,05, sehingga hubungan antar variabel dalam model bersifat linear.

8. Uji Cross-Sectional Dependence (CSD) (Khusus Data Panel)

Tabel 4.18
Metode: Uji Pesaran CD

| Test Statistic | p-value |
|---|---|
| 1.65 | 0.198 |

p-value > 0,05, sehingga tidak ada ketergantungan antar unit cross-section dalam data panel.

9. Uji Hausman (Pemilihan Model FEM atau REM)

Tabel 4.19
Metode: Uji Hausman

| Chi-Square | p-value |
|---|---|
| 12.57 | 0.014 |

p-value < 0,05, sehingga Fixed Effect Model (FEM) lebih baik dibandingkan Random Effect.

**DISCUSSION**

**Analysis of Variables Influencing Maritime Transportation Performance and Port Infrastructure Development**

1. Factors Influencing Maritime Transportation Performance (Y1)
   a. Port Operational Efficiency (X3) (β = 0.52): The most dominant factor, where increased operational efficiency directly impacts the smooth distribution of maritime logistics.
   b. Maritime Sector Investment (X2) (β = 0.47): Capital inflows into the maritime sector accelerate service growth and enhance port competitiveness.
   c. Technology and Innovation (X6) (β = 0.38): Implementation of smart ports and digitalization improves speed and operational efficiency.
   d. Connectivity and Accessibility (X4) (β = 0.35): Optimal connecting infrastructure facilitates the flow of goods and vessels.
   e. Infrastructure Quality (X1) (β = 0.29): Well-developed infrastructure supports maritime service efficiency.
   f. Government Policy (X5) (β = 0.22): Conducive regulations can enhance port competitiveness, but their impact is smaller compared to technical factors.
   g. Additional Factors (Z) (β = 0.19): Economic stability and fiscal policies also contribute but on a smaller scale.
2. Factors Influencing Port Infrastructure Development (Y2)
   a. Maritime Sector Investment (X2) (β = 0.61): Investment capital is the key driver in accelerating infrastructure development.
   b. Port Operational Efficiency (X3) (β = 0.50): Higher operational efficiency increases demand for infrastructure expansion.
   c. Connectivity and Accessibility (X4) (β = 0.44): Ports with high accessibility tend to develop more rapidly.
   d. Technology and Innovation (X6) (β = 0.39): Automation and digital systems accelerate infrastructure transformation.
   e. Infrastructure Quality (X1) (β = 0.34): High-quality infrastructure still requires development as trade volumes grow.
3. Impact on Additional Factors (Z)

a. Port Infrastructure Development (Y2) (β = 0.58): Infrastructure improvements enhance the competitiveness of the maritime sector.

b. Maritime Transportation Performance (Y1) (β = 0.43): Efficient maritime transportation has a positive effect but is less significant than infrastructure development.

## CONCLUSIONS

The results of this study indicate that port operational efficiency, maritime sector investment, and technology adoption have the greatest influence on maritime transportation performance, while port infrastructure development is highly affected by maritime sector investment and inter-port connectivity. Government regulations play a role in supporting the development of this sector, although their impact is relatively smaller compared to technical factors and investment. Additionally, improvements in maritime transportation performance and port infrastructure have been proven to positively impact maritime economic growth, with infrastructure development having a more significant effect than transportation performance. Therefore, strategic policies focusing on sustainable investment, enhancing operational efficiency, and integrating technology are essential to strengthen the competitiveness of Indonesia's maritime sector on a global scale.

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