Determination of Cargo Loading and Unloading Speed at the Port

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Abstract: The purpose of this study is to develop hypotheses related to factors that influence the speed of loading and unloading of goods at ports, especially in the maritime transportation sector in Indonesia. The approach used in this literature review study is descriptive qualitative. The data collection technique used is literature study or reviewing relevant previous articles. The technique used in this literature review is Comparative Analysis. The data used in this descriptive qualitative approach were obtained from previous studies relevant to this research and sourced from academic online media such as Thomson Reuters Journals, Springer, Taylor & Francis, Scopus Q2-Q4 Emerald, Elsevier, Sage, Web of Science, Sinta 2-5 Journals, DOAJ, EBSCO, Google Scholar, Copernicus, and digital reference books. The results of this literature review are: 1) Human resource competence influences the speed of cargo loading and unloading at ports; 2) Facilities and infrastructure influence the speed of cargo loading and unloading at ports; and 3) Technology influences the speed of cargo loading and unloading at ports.

Keywords: Cargo Loading and Unloading Speed, Human Resource Competence, Facilities and Infrastructure, Technology
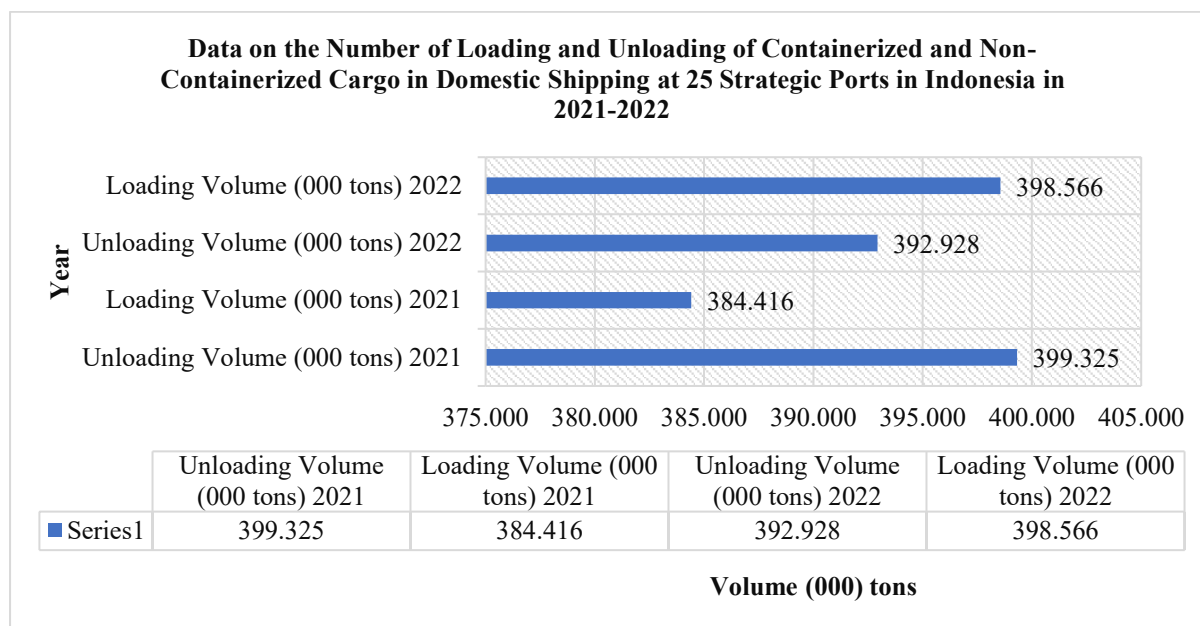
INTRODUCTION

The efficiency of cargo handling at ports is a key determinant of a country's logistics competitiveness and plays a crucial role in the global supply chain. Port efficiency directly impacts maritime transportation costs, as demonstrated by the relationship between various port utilization indicators and container shipping rates at Canadian ports, where higher dock utilization and longer turnaround times increase costs, while higher throughput reduces them (Lei & Bachmann, 2020). Ports are critical nodes in international trade, with 50% of global trade by value being maritime, and their efficiency is crucial for low-income countries and island nations heavily reliant on specific ports (Verschuur, 2022).

However, ports in Indonesia face significant challenges related to slow loading and unloading speeds, which contribute to increased logistics costs and a decline in national competitiveness. This problem is exacerbated by the high risk of propagation delays in Southeast Asia, where ports are more vulnerable to disruptions due to their interconnectivity with other regional ports (Li et al., 2024). Port congestion further exacerbates these issues, leading to unpredictable cargo transit times and rising shipping costs, which impact maritime logistics efficiency (Zhang et al., 2023). Maritime transport governance in Indonesia, as part

of the Global South, is often fragmented, complicating port operation coordination and connectivity with inland regions, which are crucial for improving efficiency (Rahayu et al., 2024).

Efforts to improve cargo handling speed at ports can be enhanced by strengthening the competencies of human resources involved in port operations. Workforce management in maritime ports is crucial, as it directly impacts productivity and competitiveness, especially in the face of labor shortages exacerbated by events such as the COVID-19 pandemic (Moros-Daza & Jubiz-Diaz, 2024). Enhancing port infrastructure and availability is a strategic step to accelerate cargo flow, as demonstrated by various studies. Port infrastructure improvements can significantly boost economic activity by enhancing port productivity, reducing costs, and increasing competitiveness in international markets (Sahoo et al., 2024).

Data on the Number of Loading and Unloading of Containerized and Non-Containerized Cargo in Domestic Shipping at 25 Strategic Ports in Indonesia in 2021-2022

Year	Volume (000) tons
Loading Volume (000 tons) 2022	398.566
Unloading Volume (000 tons) 2022	392.928
Loading Volume (000 tons) 2021	384.416
Unloading Volume (000 tons) 2021	399.325

	Unloading Volume (000 tons) 2021	Loading Volume (000 tons) 2021	Unloading Volume (000 tons) 2022	Loading Volume (000 tons) 2022
■ Series1	399.325	384.416	392.928	398.566

Volume (000) tons

Source: (Central Bureau of Statistics, 2022)
Figure 1. Data on the Number of Loading and Unloading of Containerized and Non-Containerized Cargo in Domestic Shipping at 25 Strategic Ports in Indonesia in 2021-2022

Figure 1 presents data on the number of loading and unloading activities of cargo at 25 strategic ports in Indonesia for the period 2021–2022, distinguishing between containerized cargo and non-containerized cargo. Overall, this data provides a quantitative overview of the workload of domestic ports in Indonesia while reflecting the efficiency and service capacity of ports in supporting the flow of goods distribution.

In 2021, loading and unloading activities showed a relatively high trend in a number of major ports such as Tanjung Priok, Tanjung Perak, Belawan, and Makassar. These ports dominate container cargo traffic as they are major hubs for domestic and international trade. Meanwhile, ports in eastern Indonesia, such as Sorong, Ambon, and Jayapura, tend to handle more non-container cargo, which typically includes bulk goods, essential commodities, and mining products. This difference in cargo dominance reflects the economic characteristics and distribution patterns of each region.

In 2022, there was a significant increase in the number of cargo handling operations at nearly all strategic ports, both for container and non-container cargo. This increase can be interpreted as an indication of the recovery of logistics activities post-COVID-19 pandemic, as global and domestic supply chains begin to return to normal. Additionally, the rise in cargo volume aligns with the improving national economic growth and the increasing demand for interregional goods distribution.

In terms of distribution, the data shows an imbalance between major ports in Java and Sumatra compared to ports in eastern Indonesia. Major ports are able to handle much higher container volumes because they are supported by adequate infrastructure, modern loading and unloading equipment, and higher human resource competencies. Conversely, ports in eastern Indonesia still face facility limitations, resulting in most activities being dominated by non-container cargo with lower efficiency levels.

Thus, Figure 1 emphasizes the importance of improving human resource competencies, providing more equitable facilities and infrastructure, and utilizing modern technology to accelerate the loading and unloading process. This data also highlights the need for the government and port operators to reduce regional disparities through strategic investments in ports outside Java, so that cargo loading and unloading speeds can be more evenly distributed and support national logistics competitiveness.

Based on the above background, the following research questions are formulated: 1) Does human resource competence influence the speed of cargo loading and unloading at ports?; 2) Do facilities and infrastructure influence the speed of cargo loading and unloading at ports?; and 3) Does technology influence the speed of cargo loading and unloading at ports?

METHOD

This study uses a descriptive qualitative approach with a literature review design. The purpose of this approach is to explore and synthesize previous findings related to factors that influence the speed of loading and unloading of goods at ports, particularly human resource competencies, facilities and infrastructure, and technology. Research data were obtained from secondary sources such as international and national academic publications, including Scopus, Web of Science, Springer, Taylor & Francis, Elsevier, Emerald (Q2–Q4), Sage, Thomson Reuters, DOAJ, EBSCO, Copernicus, Google Scholar, and Sinta 2–5 journals. In addition to articles, additional sources such as digital books and policy documents were also used to enrich the analysis.

Data collection procedures were conducted through literature searches using keywords such *as cargo handling speed*, *human resource competence in ports*, *port facilities and infrastructure*, and *port technology*. Articles published within the last ten years were prioritized to ensure that the findings reviewed remained relevant. Selection was made by reading the titles, abstracts, and full texts to ensure compliance with the inclusion criteria, while duplicate and irrelevant articles were excluded. Data analysis was conducted using comparative analysis, which involves comparing and synthesizing findings across studies to identify consistent patterns, differences, and research gaps. The credibility of the results was maintained through data triangulation, by comparing findings from various databases and types of publications and verifying the consistency of the results with frequently cited literature.

RESULTS AND DISCUSSION
Results

Based on the background and problem statement above, the results of this study are as follows:

Cargo Loading and Unloading Speed at the Port

The cargo handling speed at a port is a measure of the port's efficiency in handling the flow of goods from ships to land and vice versa within a certain period of time. This speed is crucial for the smooth distribution of logistics, as the faster the loading and unloading process is carried out, the lower the operational costs of ships waiting at the dock. Factors influencing cargo handling speed include the availability of labor, cargo handling equipment technology, port management, and weather conditions. With optimal speed, a port can enhance its competitiveness and attract more ships to berth (Farezan & Gufron, 2023).

The indicators or dimensions of the port cargo loading and unloading speed variable include: 1) Ship waiting time: The length of time a ship waits before receiving loading or unloading services. The shorter the waiting time, the better the port's performance; 2) Ship Berthing Time: The duration that a ship remains at the dock for loading or unloading. Efficiency is achieved when the berthing time is relatively short but the cargo volume is high; 3) Loading and Unloading Equipment Productivity: The number of containers or tonnage of cargo that can be handled by the equipment in a given time period. This reflects the technical capacity of the port's equipment; 4) Cargo throughput: The total volume of cargo successfully handled within a certain period reflects the smooth flow of logistics at the port (Kayadoe & Dien, 2022).

The cargo handling speed of ports has been studied by several researchers, including: (Anggraeni et al., 2025), (Dewanto & Rumita, 2022), (Sulistyowati & Wijaya, 2022b).

Human Resource Competency

Human resource (HR) competencies in ports refer to the abilities, skills, knowledge, and attitudes possessed by workers in performing their duties. Competent HR can operate loading and unloading equipment effectively, understand safety procedures, and master modern logistics systems. The level of HR competencies also includes managerial skills, communication, and information technology proficiency. These competencies are important because without quality human resources, even modern facilities cannot be utilized optimally (Fajriyani et al., 2023).

The indicators or dimensions within the human resource competency variable include: 1) Technical Skills: The ability of human resources to effectively operate cranes, forklifts, and other logistics systems; 2) Procedural knowledge: Workers' understanding of loading and unloading standard operating procedures (SOPs), customs regulations, and occupational safety standards; 3) Managerial and communication skills: The ability to coordinate teams, resolve problems, and maintain communication between units; 4) Information Technology Proficiency: The ability to use port management software, tracking systems, and modern logistics applications (Ghafar et al., 2024).

Human resource competencies have been studied by several researchers, including: (Claudia & Sangen, 2020), (Alfarizi, 2021), (Khusna et al., 2022).

Facilities and Infrastructure

Facilities and infrastructure at a port include all physical facilities that support operational activities, ranging from docks, warehouses, access roads, cranes, container yards, to supporting transportation systems. Facilities are tools directly used in the loading and unloading process, while infrastructure is the basic infrastructure that enables these facilities to function. The availability and quality of facilities and infrastructure significantly impact the smooth flow of goods and logistics efficiency (Natal, 2020).

Indicators or dimensions found in the facilities and infrastructure variable include: 1) Availability of docks and warehouses: The sufficiency of docks and warehouses to accommodate the flow of ships and goods; 2) Loading and Unloading Equipment Capacity: The number and condition of equipment, such as container cranes, reach stackers, and transport trucks; 3) Land Transportation Accessibility: Quality of roads and railways and connectivity to the hinterland as a distribution route for goods; 4) Supporting infrastructure conditions: Includes electricity, water supply, security systems, and IT facilities that support port operations (Untailawal et al., 2024).

Infrastructure and facilities have been studied by several researchers, including: (Asih, 2023), (Harahap & Susanto, 2020), (Satriawan et al., 2024).

Technology

Technology in ports refers to the application of systems, devices, and digital or mechanical innovations to enhance productivity. Technology includes the use of automated cranes, computer-based terminal management systems, the Internet of Things (IoT), and blockchain for customs document transparency. The use of technology enables ports to operate faster, more accurately, and more safely, while reducing costs and minimizing human error (Ardian & Ali, 2020).

The indicators or dimensions included in the technology variable are: 1) Equipment automation: Implementation of automated cranes, automated guided vehicles (AGVs), and smart conveyors to speed up loading and unloading; 2) Terminal management system (TOS): Use of software to manage ship schedules, container flow, and goods distribution in real time; 3) Document digitization: Utilization of e-documents, blockchain technology, and online customs systems to streamline administrative processes; 4) Internet of Things (IoT) integration: Installation of sensors, GPS, and smart devices to monitor equipment, containers, and environmental conditions in the port (Susanto et al., 2024).

Technology has been studied by several researchers, including: (Sawitri et al., 2023), (Widjanarko et al., 2023), (Ali et al., 2024).

Previous Research

Table 1. Previous Research

No	Author (Year)	Research Results	Similarities With This Article	Differences With This Article
1	(Heryanto et al., 2025)	Human Resource Competency Variables Influence the Speed of Loading and Unloading Goods at Probolinggo Port	This article shares similarities in examining Human Resource Competency as the independent variable and the Speed of Loading and Unloading Goods at the Port as the dependent variable	The research was conducted at Probolinggo Port
2.	(Sulistyowati & Wijaya, 2022a)	Human Resource Competency Variables Influence the Speed of Cargo Loading and Unloading at PT. IPC Terminal Peti Kemas Area Pontianak The Digital Transformation variable influences the Speed of Loading and Unloading Goods at PT. IPC Terminal Peti Kemas Area Pontianak	This article has similarities in researching the variable of Human Resource Competence as the independent variable and researching the variable of Cargo Loading and Unloading Speed at the Port as the dependent variable.	The research was conducted at PT. IPC Terminal Peti Kemas Area Pontianak
2	(Rusmiyanto & Dessixson, 2022)	-Infrastructure and Facilities influence Cargo Loading and Unloading Speed at Tanjung Emas Port in Semarang -Natural factors influence the speed of cargo loading and unloading at Tanjung Emas Port in Semarang	This article shares similarities in studying the variables of Facilities and Infrastructure as independent variables and the variable of Cargo Loading and Unloading Speed at the Port as the dependent variable	The research was conducted at Tanjung Emas Port in Semarang

| 3 | (Wibowo et al., 2025) | -Technology Variables Influence the Speed of Cargo Loading and Unloading at Tanjung Priok Port in Jakarta

-The Idle Time variable influences the Speed of Cargo Loading and Unloading at Tanjung Priok Port in Jakarta | This article shares similarities in studying the Technology variable as the independent variable and the Cargo Loading and Unloading Speed variable as the dependent variable | The research was conducted at the Port of Tanjung Priok in Jakarta |

Discussion

Based on the research problem, research findings, and relevant previous studies, the discussion in this research includes:

1. The Influence of Human Resource Competence on Cargo Loading and Unloading Speed at the Port

Based on a literature review and relevant previous research, it was found that human resource competence has a significant influence on cargo loading and unloading speed at the port.

To improve cargo loading and unloading speed at ports through human resource competence, every port service provider or company must do the following: 1) Technical skills: Port workers, such as crane operators, *forklift operators*, and *straddle carrier operators*, need to master the operation of heavy equipment with precision and speed. Continuous training and certification should be a priority to ensure they can work safely and efficiently; 2) Knowledge and procedures: The entire team must have a thorough understanding of safety procedures, customs regulations, and complex logistics workflows. This knowledge enables them to anticipate problems, reduce errors, and ensure the smooth operation of every stage of the process; 3) Managerial and communication skills: Managers and supervisors must have the ability to coordinate teams effectively, allocate resources optimally, and resolve conflicts quickly; 4) Information technology proficiency: In the digital age, the use of *port management systems*, cargo tracking software, and automation technology is essential.

If every port service provider and company can consistently apply these four aspects of human resource competencies, it will have a positive impact on the speed of cargo loading and unloading at the port, including: 1) Vessel waiting time: With competent human resources, the planning and preparation process before the vessel arrives becomes faster and more accurate, thereby reducing the time the vessel has to wait in the anchorage area; 2) Ship berthing time: High technical skills and good team coordination will speed up the ship mooring process and enable cargo handling operations to begin immediately after the ship berths; 3) Productivity of loading and unloading equipment: Skilled operators can operate equipment at optimal speeds with minimal errors, thereby increasing the volume of goods handled per hour; 4) Volume of cargo handled: Improved efficiency at every stage, from planning to execution, will enable the port to handle larger volumes of cargo in a shorter time.

The findings of this study align with previous research conducted by (Heryanto et al., 2025), (Sulistyowati & Wijaya, 2022a), which states that there is an influence between human resource competence and cargo loading and unloading speed at the port.

2. The Influence of Facilities and Infrastructure on the Speed of Loading and Unloading Goods at the Port

Based on a literature review and relevant previous studies, it was found that facilities and infrastructure have a significant influence on the speed of cargo loading and unloading at ports.

To improve the speed of loading and unloading goods at ports through facilities and infrastructure, every port service provider or company must do the following: 1) Availability

of docks and warehouses: Docks that are long and deep enough allow more ships to dock and be served simultaneously. Additionally, the availability of adequate warehouses and storage areas is crucial for storing newly unloaded or to-be-loaded goods, preventing congestion that hinders workflow; 2) Loading and unloading equipment capacity: Modern equipment with high carrying capacity and operational speed, such as container *cranes*, *gantry cranes,* and *forklifts,* directly accelerate the loading and unloading process; 3) Road transport accessibility: Well-connected infrastructure, such as smooth highways, sturdy bridges, and integrated railway lines, is vital; 4) Supporting infrastructure conditions: Aspects such as adequate lighting for night operations, equipment maintenance facilities, and good drainage systems are essential supporting elements that must not be overlooked.

If every port service provider and company can consistently implement the four aspects of facilities and infrastructure, it will have a positive impact on the speed of loading and unloading of goods at the port, including: 1) Vessel waiting time: With adequate berthing facilities, vessels do not need to wait long outside the port, which drastically reduces operational costs for shipping companies; 2) Vessel berthing time: Advanced and efficient cargo handling equipment enables vessels to be served more quickly, thereby significantly reducing berthing time at the port; 3) Productivity of loading and unloading equipment: Modern and well-maintained equipment can operate at peak performance, increasing the number of containers or tonnage of goods that can be moved per hour; 4) Cargo volume handled: All these efficiency improvements will enable the port to handle significantly larger cargo volumes within the same timeframe, enhancing the port's capacity and competitiveness.

The findings of this study align with previous research conducted by (Rusmiyanto & Dessixson, 2022), which states that there is an influence between infrastructure and cargo handling speed at ports.

3. The Influence of Technology on Cargo Loading and Unloading Speed at Ports

Based on a literature review and relevant previous studies, it was found that technology has a significant influence on the speed of cargo loading and unloading at ports.

To improve the speed of cargo loading and unloading at ports through technology, the following actions should be taken by every port service provider or company: 1) Equipment automation: The use of automatic container *cranes*, *automated guided vehicles* (AGVs), and *automated stacking cranes* (ASCs) can minimize human error and enable 24/7 operations. This automation speeds up the movement of goods from ships to land and vice versa; 2) Terminal management system: TMS is software that manages all port operations, from ship scheduling, container placement, to movement on the ground. With TMS, planning becomes more accurate and workflows more coordinated; 3) Document digitization: The use of *paperless* systems for documents such as cargo *manifests*, waybills, and customs permits speeds up administrative processes. Instead of waiting for physical documents, all data can be accessed instantly by relevant parties, reducing delays; 4) Internet of Things integration: Sensors and IoT devices can be installed on containers and equipment to monitor their location, condition, and status in *real time.* This data enables faster and more proactive decision-making, such as identifying problems or optimizing movement routes.

If every port service provider and company can consistently implement these four aspects of technology, it will have a positive impact on the speed of cargo loading and unloading at ports, including: 1) Vessel waiting time: With an integrated system, licensing and preparation processes can be completed before the vessel arrives, drastically reducing waiting time in the water; 2) Vessel berthing time: Automation and precise planning enabled by TMS allow vessels to be served more quickly, significantly reducing berthing time at the dock; 3) Productivity of loading and unloading equipment: Automated equipment can operate at peak speed and efficiency non-stop, increasing the volume of goods handled per hour and reducing loading and unloading cycle times; 4) Cargo volume handled: All these efficiency improvements

ultimately enable the port to handle significantly larger cargo volumes within the same timeframe, enhancing the port's capacity and competitiveness in the global market.

The findings of this study align with previous research conducted by (Wibowo et al., 2025), which states that there is an influence between technology and cargo loading and unloading speed at ports.

Conceptual Framework

Based on the problem formulation, relevant previous research, and the results and discussion of the above research, including:
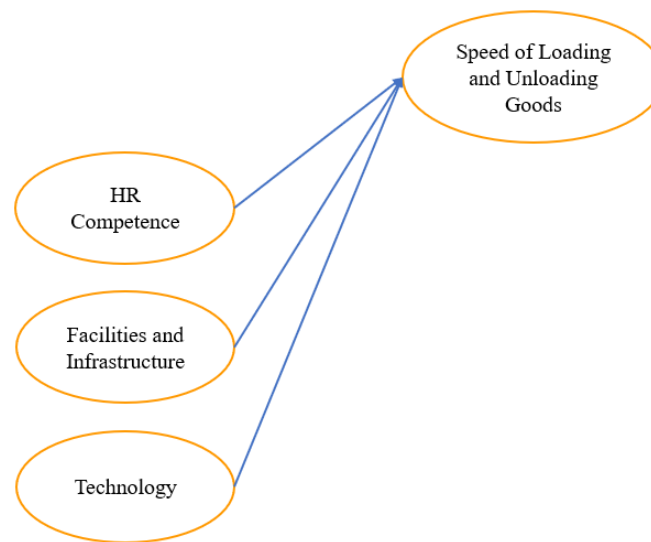

Figure 2. Conceptual Framework

Based on Figure 2 above, human resource competencies, facilities and infrastructure, and technology influence the speed of cargo loading and unloading at the port. In addition to the independent variables mentioned above that influence the dependent variable (the speed of cargo loading and unloading at the port), there are other variables that influence the speed of cargo loading and unloading at the port, including:
1) Corporate Governance: (Zega, 2023), (Angelliza Chantica et al., 2022), (Ardiany & Rahim, 2020).
2) Loading and Unloading Equipment Capacity: (Susanto et al., 2021), (Gultom et al., 2022), (Susanto et al., 2021).
3) Work Environment: (Ali et al., 2024), (Saputra & Mahaputra, 2022), (Putri et al., 2023).

CONCLUSION

Based on the results and discussion above, the following conclusions can be drawn:
1) Human resource competence influences the speed of cargo loading and unloading at the port;
2) Facilities and infrastructure influence the speed of cargo loading and unloading at the port;
3) Technology influences the speed of cargo loading and unloading at the port.

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