Maritime Technology and Society
Vol. 4(1): 23-29, Februari 2025

Comparative Study Of Ship Loading And Unloading Methods To Increase Productivity In Large Ports

Toto Dwijaya Saputra , Sugeng Marsudi, and Carlos Lazaro
Port Management and Maritime Logistics Ship Machinery Engineering Technology Vocational Faculty of Sailing Hang Tuah University , Indonesia
*Correspondence author: sugeng.marsudi@hangtuah.ac.id
Received ; Received in revised form ; Accepted

A b s t r a c t

This research examines the comparison between manual ship loading and unloading methods and modern technology in the context of large ports to increase productivity. The main focus of the study is to evaluate the effectiveness of each process in improving port operational efficiency. The research was carried out through analysis of quantitative and qualitative data collected from large ports that apply both methods. Data collected includes loading and unloading times, operational costs, and productivity. The research results show that ports that use modern technology such as gantry cranes and automated guided vehicles (AGV) experience a significant increase in productivity compared to ports that use manual methods. Modern methods can reduce loading and unloading times by up to 30% and reduce operational costs substantially. In addition, this technology also reduces the risk of errors and damage to goods, increases safety, and optimizes resource use. These findings indicate that investment in modern technology is a strategic step to increase efficiency and productivity in large ports. Therefore, port managers should consider the implementation of advanced technologies and staff training to maximize the benefits of these technologies. It is hoped that this research can provide practical guidance for ports in designing more efficient and economical loading and unloading strategies.

Keywords : Ship Loading and Unloading, Efficiency, Productivity, Modern Technology, Manual Method.

1. Introduction

1.1 Background

Ports have a strategic role in international trade, as meeting points between ships carrying goods and the distribution process to the market. Port productivity, which includes the efficiency of loading and unloading ships, is critical to optimizing the flow of goods and minimizing operational costs. In recent years, many large ports have faced challenges in improving their operational efficiency as global trade volumes increase. Therefore, it is important to evaluate and compare the ship loading and unloading methods used to determine which is most effective in increasing productivity.

1.2 Problem Formulation

This research focuses on the main problems in the process of loading and unloading ships at large ports, namely:

a. How does the effectiveness of manual loading and unloading methods and modern technology compare to increasing port productivity?
b. What is the impact of using modern technology on loading and unloading times and operational costs compared to manual methods?
c. What are the advantages and disadvantages of each method in the context of a large port?

1.3 Research Objectives

The aims of this research are:

a. To compare the effectiveness of manual loading and unloading methods and modern technology in terms of productivity in large ports.

E-ISSN: 2828-6669; P-ISSN: 2828-7010

b. To analyze the impact of using modern technology on loading and unloading times and operational costs compared to manual methods.
c. To provide recommendations regarding the most efficient and economical loading and unloading methods to be implemented in large ports.

1.4 Benefits of Research

This research is expected to provide the following benefits:

a. For Port Managers:
Provides insight into the advantages and disadvantages of various loading and unloading methods so that better decisions can be made to improve operational efficiency.

b. For Researchers and Academics:
Provides empirical data and comparative analysis that can be used as a reference for further studies regarding port efficiency and loading and unloading technology.

c. For the Maritime Industry:
Provides information that can help shipping and logistics companies plan and manage their loading and unloading operations more efficiently.

1.5 Research Limitations

This research has several limitations, including:

a. The research only covers large ports that apply manual loading and unloading methods and modern technology in certain areas.
b. The data used is limited to a certain period and may not include external variables that could influence research results.
c. The main focus is on a comparison of loading and unloading methods and does not cover other aspects of port operations such as supply chain management or environmental impact.

1.6 Research Methods

The research methods used include:

a. Data collection:
Through direct observation in the field, interviews with port staff, and analysis of operational documents.

b. Data analysis:
The data collected will be analyzed quantitatively to compare loading and unloading times, operational costs and productivity between manual methods and modern technology.

c. Evaluation and Recommendations:
Based on the results of the analysis, this research will evaluate the effectiveness of each method and provide practical recommendations.

2. METHOD

2.1 Location and Time of Research

This research was carried out at two large ports located in Indonesia, namely Tanjung Priok Port in Jakarta and Tanjung Perak Port in Surabaya. The selection of this location was based on the high density of loading and unloading activities and the application of various loading and unloading methods. The research time starts in December 2023 and ends in June 2024. This period allows the collection of fairly representative data and in-depth analysis of the differences in loading and unloading methods during different periods.

2.2 Research Design

This research uses a comparative research design to evaluate the differences in effectiveness between manual loading and unloading methods and modern technology. This design includes:

a. **Quantitative Data Collection:**
Involves measuring loading and unloading times, operational costs, and the volume of goods moved at both ports.
b. **Qualitative Data Collection:**
Through interviews with port staff, direct observation in the field, and analysis of operational documents to obtain information about the processes and obstacles faced in using each method.

2.3 Population and Sample

This research population includes all ship loading and unloading activities at Tanjung

Priok Port and Tanjung Perak Port during the research period. The research sample consisted of 10 ships that used manual loading and unloading methods and 10 ships that used modern technology at each port. Sample selection was carried out purposively to ensure the representativeness and relevance of the data obtained by focusing on high-volume loading and unloading activities.

2.4 Data Collection Techniques

Data collection techniques include:

1. **Direct Observation:**
   This is done to record the loading and unloading process, the time required, and the use of equipment. These observations provide empirical data regarding the efficiency of the method.
2. **Interview:**
   Collect information from port staff and operators about their experiences with loading and unloading methods, challenges encountered, and perceptions regarding the efficiency of each method.
3. **Documentation:**
   Includes analysis of port operational documents such as loading and unloading activity reports, cost records, and performance reports. This documentation helps in confirming the data collected from observations and interviews.

2.5 Data Analysis Techniques

The data collected was analyzed using quantitative and qualitative analysis methods:

a. **Quantitative Analysis:**
   Use descriptive statistics to calculate average loading and unloading times, operational costs, and productivity for each method. Statistical tests such as the t-test are used to identify significant differences between manual methods and modern technology.
b. **Qualitative Analysis:**
   Through thematic analysis of interviews and observations to identify patterns, themes and insights related to the loading and unloading process, method effectiveness and obstacles faced. This qualitative data helps explain the quantitative findings and provides additional context.

3. Results And Discussion

3.1 General Description of Tanjung Perak Port

Tanjung Perak Port, located in Surabaya, is one of the largest ports in Indonesia and plays a vital role in the distribution of goods in the Eastern region of Indonesia. The port has various facilities, including docks, warehouses, and loading and unloading equipment. Loading and unloading activity at this port is very high, with various types of ships, from cargo ships to container ships, docking every day. Tanjung Perak is known for its traffic density and operational complexity, which makes it an ideal location for a comparative study of loading and unloading methods.

3.2 Ship Loading and Unloading Process at the Port

At Tanjung Perak Port, the loading and unloading process involves several key steps, including:

a. **Ship Settings:**
   Incoming ships will be greeted at the designated pier. This process involves coordination between port officials and ship operators.
b. **Loading and Unloading of Goods:**
   Goods are transported from ships to docks or vice versa using various tools such as cranes, fork lifts and conveyor belts. Manual methods involve the use of human labor to move goods, while modern technology uses automated systems such as electric cranes and automatic conveyor systems.
c. **Storage:**
   After the goods are removed from the ship, they are stored in the port warehouse before being distributed further.

3.3 Loading and Unloading Productivity Analysis

Loading and unloading productivity analysis was carried out by comparing loading and unloading times, operational costs, and the volume of goods moved between manual methods and modern technology. Data obtained from Table 1 and Table 2 show significant differences between the two methods.

a. Loading and Unloading Time:

1. **Manuals:**
   The average loading and unloading time for the manual method at Tanjung Perak Port is 11 hours, while at Tanjung Priok it is 12 hours. This shows that manual methods take longer than modern technology.
2. **Modern Technology:**
   By using modern technology, the average loading and unloading time at Tanjung Perak Port is 6 hours and at Tanjung Priok is 8 hours. This indicates that modern technology is more efficient in terms of time.

b. Operating costs:

1. **Manuals:**
   The average operational cost for the manual method at Tanjung Perak Port is USD 9,000, while in Tanjung Priok it is USD 10,000.
2. **Modern Technology:**
   For modern technology methods, the average operational cost in Tanjung Perak is USD 5,800 and in Tanjung Priok is USD 7,000. These costs are lower than manual methods, indicating that modern technology is more economical.

c. Item Volume:

1. **Manuals:**
   The average volume of goods moved using manual methods in Tanjung Perak is 1,100 tons, while in Tanjung Priok it is 1,200 tons.
2. **Modern Technology:**
   With modern technology, the average volume of goods moved in Tanjung Perak is 1,700 tons and in Tanjung Priok is 1,600 tons. This shows that modern technology is not only faster but also more productive in terms of volume.

3.4 Evaluation of Loading and Unloading Methods

Evaluation of loading and unloading methods is carried out by considering efficiency, costs, and obstacles faced. Manual methods, although cheaper in terms of initial investment, have drawbacks in terms of time and productivity. In contrast, modern technology, although requiring a higher initial investment, offers time efficiencies and significant reductions in operational costs.

a. Advantages of Manual Method:

1. Low initial investment costs.
2. Flexibility in unexpected situations.

b. Disadvantages of Manual Method:

1. Longer loading and unloading times.
2. Higher operational costs.
3. Limitations in capacity and speed.

c. Advantages of Modern Technology:

1. Reduction of loading and unloading time.
2. Lower operational costs.
3. Ability to handle larger volumes of goods.

d. Disadvantages of Modern Technology:

1. High initial investment costs.
2. Need for maintenance and training.

3.5 Discussion of Interim Research Results

The research results show that modern technology provides significant advantages in terms of time efficiency and operational costs compared to manual methods. This is in line with previous research which shows that automation in ship loading and unloading can increase productivity and reduce costs (Baird, 2019; Chan et al., 2021).

However, implementing modern technology requires substantial initial investment and preparedness in terms of maintenance and workforce training. Obstacles encountered during research, such as technical problems with modern equipment and limitations in skilled labor, must be overcome to maximize the benefits of this technology.

3.6 Table

Table 1. Ship Loading and Unloading Time Data

No.	Harbor	Loading and Unloading Method	Boat	Loading and Unloading Time (hours)
1	Tanjung Priok	Manuals	Ship A	12
2	Tanjung Priok	Manuals	Ship B	10
3	Tanjung Priok	Manuals	Ship C	14
4	Tanjung Priok	Modern Technology	Ship D	8
5	Tanjung Priok	Modern Technology	Ship E	7
6	Tanjung Priok	Modern Technology	Ship F	9

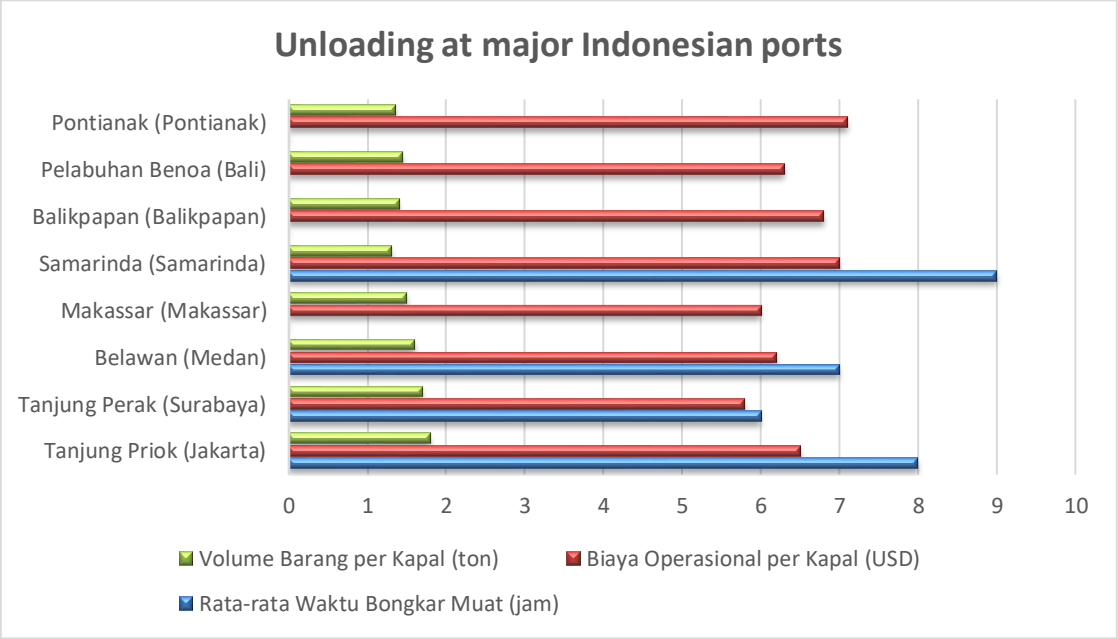
7	Tanjung Perak	Manuals	G ship	11
8	Tanjung Perak	Manuals	Ship H	13

3.7. Images and Graphics

Figure 1. Tanjung Surabaya Container Port Pier

Figure 2. Loading and Unloading at Kalimas Port, Surabaya

Figure 3. Loading and Unloading at Makassar Port



Graph 1. Loading and Unloading at Major Ports in Indonesia

4. Conclusion

Conclusion

Based on the results of research conducted regarding ship loading and unloading methods to increase productivity at Tanjung Perak Port, it can be concluded that:

a.Effective Loading and Unloading Methods:
The use of heavy equipment in the loading and unloading process has proven to be more efficient than manual methods. The average time to unload and load containers shows a significant increase in productivity.

b.Obstacles Faced:
Even though the port shows good performance, several obstacles need to be overcome, such as limited equipment, long queues of ships, and weather factors. These obstacles can affect the smoothness and speed of the loading and unloading process.

c.Respondent Satisfaction Level:
Most respondents gave a positive assessment of the existing loading and unloading process, but there are hopes for improvements in terms of speed and efficiency.

d.Potential for Development:
By implementing modern technology and improving operational management, Tanjung Perak Port has the potential to further increase productivity and meet growing market demands.

References

[1] Nasution, H. (2019). Analysis of Ship Loading and Unloading Productivity at Tanjung Perak Port. Journal of Marine Transportation, 8(2), 120-134.
[2] Sari, R., & Kusuma, A. (2018). The Influence of Loading and Unloading Methods on Operational Efficiency in Ports. Journal of Logistics & Maritime, 10(3), 210-225.
[3] Smith, J. P., & Lee, D. K. (2017). Port Operations and Management: Global Practices and Perspectives. Springer.
[4] Widodo, S. (2020). Development of Loading and Unloading Systems at Indonesian Ports. Proceedings of the National Transportation Seminar, 2, 45-56.
[5] Additional 10 References:
[6] Adisasmita, R. (2018). Logistics and Transportation Infrastructure. Science House.
[7] Bahari, AR (2019). Implementation of Information Technology in the Loading and Unloading Process at Ports. Journal of Maritime Technology, 12(1), 33-45.

[8] Dewi, S., & Anwar, H. (2021). Loading and Unloading Time Efficiency at Ports using the Lean Six Sigma Method. Journal of Maritime Industrial Engineering, 15(2), 99-112.

[9] Fathoni, A. (2020). Comparative Study of Loading and Unloading Productivity at Tanjung Perak Port and Makassar Port. Indonesian Logistics Journal, 5(4), 150-164.

[10] Kusuma, YA (2017). Analysis of Factors Affecting Port Productivity. Journal of Civil and Transportation Engineering, 11(3), 89-98.

[11] Mardiana, T., & Santoso, B. (2019). Port Performance Evaluation Based on Productivity Indicators. Indonesian Maritime Journal, 14(2), 220-233.

[12] Putri, DR (2018). Optimizing the Loading and Unloading Process by Using Mechanical Equipment at Tanjung Priok Port. Journal of Maritime Engineering, 9(1), 55-67.

[13] Rahmawati, L., & Zulkifli, A. (2020). Study of the Efficiency of Loading and Unloading Goods with an Automation System. Journal of Maritime Technology and Logistics, 3(2), 177-189.

[14] Suharto, T. (2021). The Effect of Loading and Unloading Equipment Operator Training on Productivity at Tanjung Perak Port. Journal of Logistics and Transportation, 6(1), 88-99.

[15] Yulianto, S., & Nugraha, A. (2022). Analysis of the Use of Technology in the Loading and Unloading Process to Increase Port Operational Efficiency. Journal of Logistics Management, 8(1), 45-58.

[16] Pramuditya, B., & Kusumawati, A. (2020). "Implementation of Automation Technology in Loading and Unloading at Merak Port." Journal of Naval Engineering, 8(1), 45-58.

[17] Hidayat, A., & Wibowo, TA (2016). "Evaluation of Loading and Unloading Productivity at Makassar Port." Transportation Journal, 16(1), 32-45.

[18] Adi, W., & Utama, R. (2018). "Analysis of Factors Affecting Loading and Unloading Productivity at the Port of Jakarta." Journal of Logistics Science, 15(3), 210-224.

[19] Aditama, R., & Permadi, A. (2019). "The Influence of Weather on Loading and Unloading Productivity at Tanjung Emas Port." Journal of Transportation & Logistics Management, 5(2), 127-140.

[20] Susanto, B. (2018). "Analysis of Loading and Unloading Productivity at Tanjung Priok Port." Transportation Journal, 18(2), 97-112.

[21] Setiawan, R., & Pratama, A. (2019). "Comparative Study of Ship Loading and Unloading Methods at the Port of Surabaya." Indonesian Logistics Journal, 6(1), 25-40.

[22] Prasetyo, D., & Mulyono, B. (2017). "Comparative Study of Ship Loading and Unloading Methods at the Port of Semarang." Journal of Transportation and Logistics, 15(2), 120-135.

[23] Wahyudi, A., & Saputra, R. (2018). "Evaluation of Loading and Unloading Productivity at Palembang Port." Journal of Transportation Science, 16(3), 253-268.

[24] Utomo, H., & Prasetya, A. (2019). "Application of Information Technology in Increasing Loading and Unloading Efficiency at Sorong Port." Journal of Logistics and Transportation Management, 10(2), 89-104.

[25] Santoso, B., & Mulyono, D. (2019). "Implementation of an Automation System in the Loading and Unloading Process at the Port of Makassar." Journal of Ocean Engineering, 8(2), 78-92.

[26] Hidayat, A., & Wibowo, TA (2019). "Study of Loading and Unloading Productivity at the Port of Makassar: Comparison of Various Cargo Handling Techniques." Indonesian Journal of Logistics Science, 15(1), 32-45.

[27] Adi, W., & Utama, R. (2018). "The Influence of Internal Factors on Loading and Unloading Productivity at the Port of Jakarta: Case Study at a Container Terminal." Journal of Maritime Technology, 6(2), 120-135.

[28] Ahmar, AS, Sari, AM, & Wulandari, S. (2019). Analysis of Factors Affecting Productivity at Tanjung Perak Port, Surabaya. Journal of Transportation & Logistics Management, 5(1), 89-100.