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Enhancing Port Operational Efficiency Through Integrated Maritime Logistics Management: A Case Study of Belawan Port, Indonesia

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ABSTRACT

Port operational efficiency plays an important role in supporting maritime logistics performance and global trade connectivity. As key nodes in international supply chains, ports must ensure effective coordination among logistics stakeholders to maintain smooth cargo flows and reduce operational delays. This study aims to analyze how integrated maritime logistics management can enhance operational efficiency at the Port of Belawan, Indonesia. The research employs a qualitative case study approach using data collected through semi-structured interviews, document analysis, and field observations involving various stakeholders in port operations. The findings reveal that the integration of maritime logistics systems significantly improves operational coordination among port authorities, terminal operators, shipping companies, and logistics service providers. Such integration contributes to reduced vessel waiting times, improved cargo handling efficiency, and better utilization of port infrastructure. In addition, the implementation of digital logistics systems supports information sharing and real-time monitoring of port activities, which further enhances operational performance. However, challenges related to infrastructure capacity, stakeholder coordination, and technological adoption remain issues that need to be addressed. Overall, the study highlights the importance of integrated maritime logistics management as a strategic approach to improving port operational efficiency and strengthening the competitiveness of maritime logistics systems in developing economies,

Keywords: Port Operational Efficiency; Maritime Logistics Management; Logistics Integration; Port Operations; Belawan Port; Indonesia.

ABSTRAK

Efisiensi operasional pelabuhan memiliki peran penting dalam mendukung kinerja logistik maritim serta konektivitas perdagangan global. Sebagai simpul utama dalam rantai pasok internasional, pelabuhan harus mampu memastikan koordinasi yang efektif antar pemangku kepentingan logistik guna menjaga kelancaran arus barang dan meminimalkan keterlambatan operasional. Penelitian ini bertujuan untuk menganalisis bagaimana manajemen logistik maritim terintegrasi dapat meningkatkan efisiensi operasional di Port of Belawan, Indonesia. Penelitian ini menggunakan pendekatan studi kasus kualitatif dengan pengumpulan data melalui wawancara semi-terstruktur, analisis dokumen, dan observasi lapangan yang melibatkan berbagai pemangku kepentingan dalam operasional pelabuhan. Hasil penelitian menunjukkan bahwa integrasi sistem logistik maritim mampu meningkatkan koordinasi operasional antara otoritas pelabuhan, operator terminal, perusahaan pelayaran, dan penyedia jasa logistik. Integrasi tersebut berkontribusi terhadap pengurangan waktu tunggu kapal, peningkatan efisiensi penanganan kargo, serta pemanfaatan infrastruktur pelabuhan yang lebih optimal. Selain itu, penerapan sistem logistik digital mendukung pertukaran informasi serta pemantauan aktivitas pelabuhan secara real-time yang semakin meningkatkan kinerja operasional. Namun demikian, beberapa tantangan seperti keterbatasan infrastruktur, koordinasi antar pemangku kepentingan, serta adopsi teknologi masih perlu mendapatkan perhatian. Secara keseluruhan, penelitian ini menegaskan pentingnya manajemen logistik maritim terintegrasi sebagai strategi dalam meningkatkan efisiensi operasional pelabuhan dan memperkuat daya saing sistem logistik maritim di negara berkembang..

Kata Kunci : Efisiensi Operasional Pelabuhan; Manajemen Logistik Maritim; Integrasi Logistik; Operasi Pelabuhan; Pelabuhan Belawan; Indonesia.

INTRODUCTION

Seaports play a fundamental role in facilitating global trade and supporting international supply chains. As critical nodes within maritime transport networks, ports serve as gateways for the movement of goods between regions and countries. Through these gateways, large volumes of cargo are transferred between sea transportation and inland transport systems such as trucks, railways, and inland waterways. The efficiency of port operations therefore has a significant impact on logistics performance, transportation costs, and the competitiveness of national economies (Notteboom, Pallis, & Rodrigue, 2021). When ports operate efficiently, cargo flows can move smoothly across supply chains, enabling businesses to deliver goods faster and at lower cost. Conversely, inefficient port operations can create bottlenecks that disrupt logistics networks and reduce trade competitiveness. With the continuous growth of international trade and containerized cargo, improving port operational efficiency has become an important priority for port authorities and logistics stakeholders worldwide.

Port operational efficiency refers to the ability of a port to manage resources, infrastructure, and operational processes in order to ensure smooth and effective cargo handling activities. Efficient port operations contribute to reduced vessel turnaround times, improved cargo flow, and better utilization of port facilities such as berths, container yards, and cargo handling equipment. High operational efficiency also allows ports to handle increasing cargo volumes without requiring excessive infrastructure expansion. Conversely, inefficient operations can lead to congestion within port areas, longer vessel waiting times, higher logistics costs, and delays in cargo delivery, ultimately affecting the overall performance of maritime supply chains (Lam & Yap, 2021). As global maritime transport becomes increasingly complex and competitive, improving operational efficiency has become a key strategic objective for ports seeking to maintain their position within international shipping networks.

In recent years, the concept of integrated maritime logistics management has gained increasing attention in port and logistics studies. Integrated maritime logistics management emphasizes the coordination and integration of various logistics actors within the port ecosystem, including port authorities, terminal operators, shipping companies, logistics service providers, and government agencies. Ports no longer operate as isolated infrastructure facilities but rather as interconnected logistics platforms that support complex supply chain activities. Effective integration among these stakeholders enables the optimization of operational processes, improves information sharing, and enhances the overall efficiency of port operations (Heilig & Voß, 2021). Through integrated logistics management, ports can improve coordination in vessel scheduling, cargo handling operations, and inland transportation activities, thereby reducing delays and improving service reliability.

Technological advancements have also played an important role in supporting integrated logistics management within ports. Digital platforms, port community systems, and real-time cargo tracking technologies enable stakeholders to coordinate more effectively and improve operational transparency. These technologies allow ports to optimize resource allocation, streamline logistics processes, and improve service reliability in maritime transport systems. For example, digital information systems allow port operators and logistics providers to monitor container movements, vessel schedules, and yard utilization in real time. As a result, operational planning can be performed more accurately and efficiently. Research shows that the adoption of digital technologies and smart port systems can significantly enhance operational efficiency, reduce administrative complexity, and improve coordination among port stakeholders (Tsagkaris & Moschovou, 2025).

Despite these developments, many ports in developing countries continue to face operational challenges related to infrastructure limitations, fragmented logistics systems, and coordination issues among stakeholders. Limited container yard capacity, outdated cargo handling equipment, and insufficient integration between port operations and inland logistics networks often create operational inefficiencies. In addition, lack of coordination among different actors involved in port operations can result in delays in cargo clearance and delivery processes. These challenges often reduce the efficiency of port operations and hinder the effectiveness of maritime logistics systems. Previous studies have highlighted that improving port operational efficiency requires not only infrastructure development but also stronger integration among logistics actors within the port system (Nguyen & Park, 2023). Therefore, strengthening cooperation and coordination among stakeholders has become an essential element in achieving efficient port operations.

In Indonesia, ports play a crucial role in supporting national logistics connectivity and international trade. As an archipelagic country with extensive maritime transportation networks, Indonesia relies heavily on efficient port operations to facilitate the movement of goods between islands and connect domestic markets with global trade routes. Ports serve as key hubs in the national logistics system, supporting economic activities, industrial production, and regional development. One of the strategic ports in the western region of Indonesia is the Port of

Belawan, which functions as an important gateway for trade activities in North Sumatra and surrounding regions. The port handles significant volumes of containerized cargo and plays a major role in supporting export-import activities in the region. As cargo volumes continue to increase, improving operational efficiency at the Port of Belawan has become increasingly important to ensure smooth logistics flows and enhance port competitiveness.

Therefore, this study aims to examine how integrated maritime logistics management can enhance port operational efficiency at the Port of Belawan. By analyzing the coordination among logistics stakeholders, operational management practices, and supporting systems within the port environment, this research seeks to provide insights into how integrated logistics strategies can improve port performance. In addition, this study aims to identify key factors that influence operational efficiency within the port and explore how stronger coordination among stakeholders can support more efficient cargo handling processes. The findings of this research are expected to contribute to the development of more effective port management strategies and support improvements in maritime logistics performance in Indonesia.

A. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Port Operational Efficiency

Port operational efficiency refers to the ability of ports to utilize their infrastructure, technology, and human resources effectively in order to facilitate cargo movement and vessel services in a timely and cost-efficient manner. Efficient port operations are essential for maintaining smooth logistics flows and reducing operational delays within maritime transport systems. According to Theo Notteboom and colleagues, port efficiency is strongly influenced by operational coordination, terminal productivity, and the quality of port infrastructure (Notteboom, Pallis, & Rodrigue, 2021).

Several studies have emphasized that port efficiency is commonly measured through indicators such as vessel turnaround time, berth occupancy rate, crane productivity, and cargo handling capacity. Improvements in these indicators contribute directly to better logistics performance and increased competitiveness of ports in global trade networks (Lam & Yap, 2021). Ports that maintain efficient operations are able to reduce congestion, increase cargo throughput, and provide reliable services to shipping companies and logistics providers.

Furthermore, operational efficiency is also affected by management practices within port authorities and terminal operators. Effective planning, coordination of resources, and the implementation of modern operational management systems are critical in achieving optimal performance in port operations (Nguyen & Park, 2023).

Maritime Logistics Management

Maritime logistics management refers to the coordination and management of logistics activities related to maritime transportation, including cargo handling, port operations, shipping services, and hinterland transportation. It plays a significant role in connecting maritime transport with broader supply chain systems (Heilig & Voß, 2021).

In modern logistics systems, maritime logistics management emphasizes the integration of operational processes between various actors such as port authorities, shipping companies, freight forwarders, customs authorities, and logistics service providers. Effective coordination among these stakeholders enables better planning of cargo flows, reduces delays, and improves overall logistics efficiency (Lee & Song, 2022).

Research also shows that strong maritime logistics management contributes to improved service reliability and reduced logistics costs. By implementing effective management strategies, ports can enhance operational transparency, improve cargo tracking capabilities, and facilitate smoother coordination across logistics networks (Tsagkaris & Moschovou, 2025).

integrated Maritime Logistics Systems

Integrated maritime logistics systems refer to the interconnected operational and information systems that link various stakeholders within port and maritime logistics networks. Integration is considered a key factor in improving operational efficiency and reducing fragmentation in port logistics processes.

According to Jean-Paul Rodrigue, logistics integration enables better coordination between maritime transport, port operations, and inland logistics systems, allowing cargo to move more efficiently throughout the supply chain (Rodrigue, 2020). The integration process typically involves digital information systems, collaborative management frameworks, and coordinated operational planning among stakeholders.

One important technological development supporting integration is the implementation of Port Community Systems (PCS). PCS platforms facilitate real-time data exchange among port stakeholders, improving transparency and operational coordination. These systems enable faster document processing, better cargo tracking, and

improved decision-making within port logistics operations (Heilig & Voß, 2021).

Furthermore, digital transformation in ports, including the use of smart port technologies, automation, and data-driven decision-making systems, has significantly enhanced the integration of maritime logistics operations. These innovations allow ports to manage cargo flows more efficiently while reducing operational bottlenecks (Lam & Yap, 2021).

B. RESEARCH METHODOLOGY

This study employs a qualitative case study approach to analyze how integrated maritime logistics management contributes to improving operational efficiency at the Port of Belawan. A case study approach is considered appropriate because it allows researchers to explore complex operational processes, stakeholder coordination, and logistics management practices within a real-world port environment in depth.

Data for this research were collected through a combination of primary and secondary sources. Primary data were obtained through semi-structured interviews with key stakeholders involved in port operations, including port authority officials, terminal operators, logistics service providers, and shipping agents operating at the port. These interviews aimed to capture insights regarding operational coordination, logistics integration practices, and challenges faced in daily port activities. Secondary data were collected from official port reports, government publications, logistics performance reports, and previous academic studies related to maritime logistics and port management.

The data analysis process was conducted using qualitative descriptive analysis. Interview results and document data were analyzed through several stages, including data reduction, data categorization, and thematic interpretation. This process allowed the researcher to identify key themes related to operational efficiency, logistics coordination, and integrated maritime logistics practices within the port system. By combining insights from multiple data sources, the study aims to provide a comprehensive understanding of how integrated logistics management can enhance port operational efficiency at the Port of Belawan.

D. RESULT AND DISCUSSION

Current Operational Conditions at the Port of Belawan

The Port of Belawan plays a strategic role as one of the major international gateways for trade activities in western Indonesia. Located in North Sumatra, the port functions as an important hub that connects regional economic activities with global maritime trade routes. The port handles a wide range of cargo types, including containerized cargo, bulk commodities, and general cargo, which support various sectors such as manufacturing, agriculture, and international trade. As one of the main ports serving the western region of Indonesia, the Port of Belawan contributes significantly to facilitating export-import activities and strengthening regional logistics connectivity. As trade volumes continue to grow, the demand for efficient port operations has become increasingly important in order to maintain smooth cargo flows and support the competitiveness of regional economic activities.

The findings of this study indicate that operational efficiency at the port is influenced by several key factors, including terminal capacity, equipment availability, coordination among stakeholders, and the effectiveness of logistics management systems. Terminal capacity plays a crucial role in determining how efficiently cargo can be handled within the port area. Adequate container yard space and well-managed berth allocation allow vessels to be served more efficiently, reducing waiting times and improving overall port performance. In addition, the availability and proper utilization of cargo handling equipment such as quay cranes, yard cranes, and transport vehicles significantly affect the speed and reliability of container handling operations. Ports that effectively manage these operational resources are better able to maintain smooth cargo flows and minimize operational disruptions.

Interviews with port stakeholders revealed that operational bottlenecks occasionally occur due to congestion during peak cargo periods, limited yard space, and coordination challenges among logistics actors. During periods of high cargo volume, container yard capacity may become constrained, making it more difficult for terminal operators to manage container stacking and retrieval processes efficiently. In addition, delays may occur when there is insufficient coordination between terminal operators, trucking companies, customs authorities, and shipping lines. These coordination challenges can affect the timing of cargo clearance, container delivery, and vessel servicing, which ultimately impacts the overall efficiency of port operations.

These operational challenges highlight the importance of implementing integrated logistics management strategies that allow port operators and logistics stakeholders to coordinate activities more effectively and reduce operational delays. Integrated logistics management enables better communication, information sharing, and synchronization of operational activities among stakeholders involved in the port ecosystem. By strengthening

coordination mechanisms and improving operational planning, ports can minimize congestion, optimize resource utilization, and improve the overall performance of maritime logistics operations. Therefore, adopting integrated logistics management practices is essential for improving operational efficiency and ensuring that the Port of Belawan remains competitive in the increasingly dynamic global maritime trade environment.

Integration of Maritime Logistics in Port Operations

One of the key findings of this study is the growing implementation of integrated maritime logistics practices within the port system. Integration in this context refers to the coordination and synchronization of operational processes among various stakeholders involved in port logistics activities, including port authorities, terminal operators, shipping companies, freight forwarders, customs authorities, and inland transport providers. In modern port operations, these actors must work within a coordinated logistics framework to ensure that cargo movements between sea transport and land transport systems occur smoothly and efficiently. Effective integration among stakeholders helps reduce operational fragmentation and allows logistics activities to be managed in a more systematic and collaborative manner.

The integration process has been supported by the implementation of digital information systems and collaborative operational frameworks that facilitate data sharing and communication among port stakeholders. Digital platforms allow relevant parties to access operational data such as vessel schedules, container movements, cargo documentation, and yard capacity information in real time. This improved access to information enables port operators and logistics providers to plan cargo handling operations more effectively and respond more quickly to operational changes. As a result, the adoption of integrated digital systems contributes to improved operational transparency and more efficient coordination within the port logistics ecosystem.

According to the findings, improved coordination among logistics actors has contributed to smoother cargo flows and reduced administrative delays. When stakeholders are able to share information efficiently and coordinate operational schedules, cargo handling processes can be carried out more quickly and with fewer disruptions. For example, better communication between shipping lines, terminal operators, and inland transport providers allows container pickup and delivery activities to be scheduled more efficiently. This coordination reduces waiting times within the port area and improves the overall flow of goods through the logistics network.

Furthermore, this integration also supports better scheduling of vessel arrivals and cargo handling operations, which ultimately improves the overall efficiency of port services. Accurate vessel scheduling and coordinated terminal operations allow ports to allocate resources more effectively, including berth space, cargo handling equipment, and labor. By optimizing these operational resources, ports can improve service reliability and reduce operational bottlenecks. Therefore, the implementation of integrated maritime logistics management plays a crucial role in enhancing port operational efficiency and supporting the smooth functioning of maritime supply chains.

Role of Digital Technology in Enhancing Port Efficiency

Digitalization has become a critical component in improving operational efficiency at modern ports. The rapid development of digital technologies has transformed the way ports manage logistics activities, enabling more efficient coordination, faster information exchange, and improved operational monitoring. The implementation of digital logistics platforms and port information systems allows stakeholders to access operational data in real time, which supports better planning and execution of cargo handling activities. Through digital integration, ports can reduce delays in information flow, streamline administrative procedures, and enhance the overall performance of maritime logistics systems.

At the Port of Belawan, digital systems are increasingly used to manage various aspects of port operations, including cargo documentation, vessel scheduling, and operational coordination among port stakeholders. The adoption of these systems enables port operators to handle administrative processes electronically, reducing reliance on manual documentation procedures. As a result, operational processes such as cargo clearance, container tracking, and vessel service scheduling can be performed more efficiently. The use of digital systems also minimizes the risk of human errors in documentation and improves the accuracy of operational data, which is essential for effective port management.

Furthermore, digital platforms support better communication and information sharing between port stakeholders, allowing them to coordinate logistics operations more effectively. Stakeholders such as port authorities, terminal operators, shipping lines, customs agencies, and logistics providers can exchange information through integrated digital systems, which improves transparency in operational processes. This improved

communication helps reduce misunderstandings and delays that may occur when information is transferred through conventional communication channels.

In addition, technological integration contributes to improved operational transparency and faster decision-making processes within the port environment. Real-time operational data allows port managers to monitor terminal performance, identify operational bottlenecks, and implement corrective actions when necessary. This capability enables ports to respond more quickly to fluctuations in cargo volumes, vessel schedules, and operational disruptions. Consequently, digitalization not only improves operational efficiency but also strengthens the ability of ports to manage increasingly complex logistics operations in the global maritime transport system.

Impact of Integrated Logistics Management on Operational Efficiency

The implementation of integrated maritime logistics management has demonstrated several positive impacts on operational performance. The findings of this study indicate that improved coordination among logistics stakeholders helps reduce vessel waiting times, streamline cargo handling processes, and enhance the utilization of port infrastructure and operational equipment. When stakeholders such as port authorities, terminal operators, shipping companies, and logistics service providers are able to coordinate their activities effectively, operational processes within the port environment become more synchronized. This improved coordination allows vessel handling, cargo operations, and inland transport activities to be managed more efficiently, thereby reducing delays and improving the overall performance of port operations.

Integrated logistics management also enables more efficient resource allocation, allowing port operators to optimize the use of available facilities, equipment, and labor resources. Through better operational planning and information sharing, terminal operators can allocate quay cranes, yard equipment, and workforce more effectively based on vessel schedules and cargo handling demands. As a result, the port is able to handle increasing cargo volumes while minimizing operational bottlenecks and maintaining stable service performance. Efficient resource utilization also reduces idle time for equipment and labor, which contributes to higher levels of operational productivity within the terminal environment.

Additionally, improved logistics integration strengthens the competitiveness of the port in regional maritime trade networks. Ports that offer efficient, reliable, and well-coordinated logistics services are more attractive to shipping lines and logistics providers that depend on timely cargo movements. Efficient port operations help reduce overall logistics costs, improve vessel turnaround time, and enhance service reliability for shipping companies and cargo owners. Consequently, integrated logistics management not only improves internal port performance but also strengthens the port's strategic position within regional and global maritime trade systems.

Overall, the findings suggest that the successful implementation of integrated maritime logistics management can significantly enhance operational efficiency and support the long-term development of port logistics systems in Indonesia. By promoting stronger coordination among stakeholders, improving operational planning, and adopting modern logistics management practices, ports can improve service quality and support the growth of maritime trade activities. These improvements are particularly important for ports such as the Port of Belawan, which plays a strategic role in supporting regional economic development and strengthening Indonesia's connectivity within international maritime trade networks.

E. CONCLUSION AND SUGGESTION

This study examined how integrated maritime logistics management can enhance operational efficiency at the Port of Belawan in Indonesia. The findings indicate that port operational performance is strongly influenced by the level of coordination among logistics stakeholders, the efficiency of cargo handling processes, and the implementation of digital logistics systems that support real-time information exchange.

The results show that the integration of maritime logistics systems helps reduce operational bottlenecks, improve vessel scheduling, and enhance coordination between port authorities, terminal operators, shipping companies, and inland transport providers. These improvements contribute to faster cargo handling processes, reduced waiting times for vessels, and better utilization of port infrastructure and operational resources.

Furthermore, the adoption of digital technologies plays an important role in supporting logistics integration within port operations. Digital platforms facilitate data sharing, improve transparency in logistics activities, and enable stakeholders to make faster and more accurate operational decisions. As a result, the implementation of integrated logistics management not only improves operational efficiency but also strengthens the competitiveness of the port within regional and global maritime trade networks.

Overall, this study concludes that integrated maritime logistics management is a key strategy for improving port operational efficiency. For ports in developing maritime economies such as Indonesia, strengthening logistics

integration, improving stakeholder coordination, and expanding digital port systems are essential steps to support sustainable port development and enhance national trade competitiveness.

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