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ANALYSIS OF THE IMPACT OF MULTIMODAL MARITIME TRANSPORTATION EFFICIENCY ON EXPORT IMPORT LOGISTICS COSTS

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Abstract

High logistics costs remain a major challenge in supporting export-import competitiveness, particularly in archipelagic countries that rely heavily on maritime transportation. One strategic approach considered capable of reducing logistics costs is the implementation of a multimodal maritime transportation system that is effectively integrated with other modes of transportation. This study aims to analyze the impact of increasing the efficiency of multimodal maritime transportation on export-import logistics costs, focusing on key implementation factors, the current state of multimodal system efficiency, and integration barriers that cause cost inefficiencies. The research method used was a literature review of various scientific journals, research articles, international agency reports, and relevant academic publications published between 2020 and 2025. The analysis was conducted using a content analysis approach to identify patterns, key findings, and gaps in previous research. The results of the study indicate that the efficiency of multimodal maritime transportation is significantly influenced by the level of intermodal infrastructure integration, institutional coordination, regulatory harmonization, logistics system digitalization, and port operational performance. However, various previous studies have also revealed significant obstacles, such as limited supporting infrastructure, policy fragmentation, low interoperability of information systems, and weak coordination between stakeholders, which have resulted in increased logistics costs and delivery times. This study concludes that optimizing the multimodal maritime transportation system plays a strategic role in reducing export-import logistics costs, but requires an integrated and sustainable policy approach. The findings of this study are expected to provide a conceptual basis for formulating transportation and logistics policies and serve as a reference for further empirical research.

Keywords: multimodal transportation, maritime transportation, logistics costs, export-import, logistics efficiency

Introduction

High logistics costs remain a structural issue in the international trading system and directly affect a country's export–import competitiveness. In various global logistics studies, transportation is positioned as the largest cost component within supply chains, particularly for archipelagic countries that rely heavily on maritime transport as the primary mode of goods distribution. The *Review of Maritime Transport* emphasizes that maritime logistics efficiency has a strong correlation with international trade performance and global economic integration (UNCTAD, 2025). However, the cost advantage of maritime transport does not automatically translate into logistics efficiency if it is not supported by an integrated downstream transportation system.

Therefore, a multimodal transportation approach has become a strategic necessity for sustainably reducing export–import logistics costs.

Multimodal transportation is defined as a freight transport system involving two or more modes of transport within a single, coordinated logistics service. In contemporary literature, multimodality is understood not only as physical integration between transport modes but also as encompassing operational, institutional, and information system integration. Guo et al. (2024) emphasize that the level of international multimodal connectivity significantly affects logistics cost and time efficiency, particularly in cross-border trade. Meanwhile, Budiman and William (2025) demonstrate that failures in multimodal integration can actually increase logistics costs due to process duplication and coordination inefficiencies. These findings indicate that maritime multimodal transportation must be systemically designed to generate tangible impacts on reducing export–import logistics costs.

Previous studies have identified several key factors determining the successful implementation of maritime multimodal transportation. These factors include the availability and quality of intermodal infrastructure, port operational efficiency, coordination among logistics actors, and government policy support. Setiawan (2025) argues that the development of integrated multimodal connectivity is a fundamental prerequisite for improving national logistics efficiency and strengthening supply chains. Furthermore, a systematic literature review published in the *Journal of Shipping and Trade* confirms that sea–land and sea–rail integration can significantly reduce logistics costs when supported by optimal transport network planning and effective governance (Journal of Shipping and Trade, 2024). This suggests that the efficiency of maritime multimodal transportation is strongly influenced by structural and institutional factors.

Despite the conceptual belief that maritime multimodal transportation can enhance logistics efficiency, the literature reveals that its current implementation faces complex challenges. Patampang and Mokodompit (2025), in their literature review, find that the integration of maritime transport into global supply chains remains partial, especially in developing countries. Common obstacles include unsynchronized intermodal schedules, long waiting times at ports, and weak coordination among logistics stakeholders. These conditions prevent the full realization of multimodal efficiency potential and contribute to persistently high export–import logistics costs. Consequently, a gap exists between the conceptual framework of maritime multimodal transportation and its practical implementation.

Regulatory and institutional aspects also constitute major barriers to maritime multimodal integration. Policy fragmentation across transportation sectors often leads to overlapping authorities and weak coordination in implementation. Fuady (2025), in evaluating Indonesia's Sea Toll policy, shows that regulatory disharmony and suboptimal inter-agency coordination have hindered significant reductions in logistics costs. Similar findings are reported by Guo et al. (2024), who highlight differences in operational standards and administrative systems across transport modes as major sources of cost and time inefficiencies. These obstacles indicate that multimodal efficiency cannot be achieved without policy reform and strengthened transport governance.

Beyond structural and regulatory factors, logistics digitalization has emerged as a critical issue in the literature over the past five years. Zeng et al. (2025) emphasize that digitalization in maritime logistics serves as a key enabler for improving multimodal efficiency by enhancing transparency, coordination, and information integration. However, their study also identifies

implementation barriers such as limited system interoperability and insufficient human resource readiness. Based on the synthesis of previous studies, it can be concluded that enhancing the efficiency of maritime multimodal transportation holds significant potential for reducing export–import logistics costs, yet faces substantial implementation challenges. Therefore, this literature review is essential for identifying key factors, efficiency conditions, and integration barriers as a foundation for policy strengthening and future research development.

In the context of international trade, the efficiency of maritime multimodal transportation also directly affects port performance as a central node in the logistics chain. Several studies indicate that poor port performance—such as prolonged loading and unloading times and high dwelling time—significantly increases logistics costs. Surya Gemilang et al. (2025) confirm that port service quality and facilities directly influence export logistics performance, particularly for time-sensitive commodities. These findings align with UNCTAD (2025), which states that ports not effectively integrated with land and rail transport tend to become bottlenecks in multimodal systems. Thus, optimizing port performance is a key element in achieving maritime multimodal efficiency.

In addition to port performance, coordination among stakeholders in multimodal systems has become a major focus in recent literature. Multimodal systems involve various actors, including port operators, shipping companies, land transport providers, freight forwarders, and government agencies. Wei et al. (2025) demonstrate that weak coordination among logistics actors increases transaction costs and reduces overall logistics system efficiency. Misaligned interests and the lack of structured collaboration mechanisms often hinder maritime multimodal integration. Therefore, strengthening coordination and collaboration mechanisms among stakeholders is a critical prerequisite for creating an efficient and sustainable multimodal system.

The literature also highlights the limited number of studies that comprehensively examine the impact of maritime multimodal efficiency on export–import logistics costs through a synthesis-based approach. Most existing studies focus on technical or policy aspects in isolation, failing to provide a holistic understanding of the relationship between multimodal efficiency and logistics costs. Patampang and Mokodompit (2025) argue that literature reviews integrating empirical and conceptual findings are necessary to strengthen the evidence base for transportation policy decision-making. Accordingly, this study aims to address this gap by presenting a systematic and comprehensive literature review on key factors, efficiency conditions, and integration barriers in maritime multimodal transportation for reducing export–import logistics costs.

Research Method

This study adopts a qualitative approach using a literature review as the primary research design. This approach is selected because the study aims to analyze, synthesize, and interpret findings from previous research related to maritime multimodal transportation efficiency and its impact on export–import logistics costs. A literature review enables a comprehensive understanding of conceptual developments, empirical findings, and research gaps in the fields of transportation and logistics. This method is also appropriate for addressing conceptual and analytical research questions without collecting primary data.

The study is descriptive-analytical in nature, describing the examined phenomena based on prior research and subsequently analyzing the relationships among relevant concepts and findings. Through this approach, the study not only presents previous research results but also conducts a

critical interpretation of patterns, similarities, and differences across studies. This methodology aligns with best practices in literature-based scientific articles published in reputable national and international journals.

The data used in this study consist of secondary data obtained from various scientific literature sources, including accredited national and international journals, reputable academic articles, reports from international organizations, and other relevant academic publications related to maritime multimodal transportation and export–import logistics costs. The literature is limited to publications from the past five years (2020–2025) to ensure relevance and data novelty.

Literature selection focuses on studies addressing multimodal transportation concepts, maritime transport within logistics systems, logistics cost efficiency, intermodal integration, and implementation barriers. Data collection is conducted through systematic literature searches using reliable academic databases and keywords such as "multimodal transportation," "maritime transport," "logistics costs," "export–import," and "logistics integration." Retrieved literature is then screened based on predefined inclusion and exclusion criteria.

Data analysis employs content analysis techniques to identify key themes, concepts, variables, and findings. Selected literature is analyzed in depth to determine key factors influencing maritime multimodal implementation, system efficiency conditions, and integration barriers affecting export–import logistics costs. Findings are synthesized by comparing similarities and differences across studies to identify general patterns, conceptual relationships, and research gaps.

To ensure validity and credibility, only reputable academic sources are used, and consistency between in-text citations and references is strictly maintained. The systematic and transparent selection and analysis process ensures the scientific reliability of the study.

Research Result

1. Key Determinants of Multimodal Maritime Transportation Efficiency

The synthesis of prior studies indicates that the most fundamental determinant of efficient multimodal maritime transportation is the level of intermodal infrastructure integration. Empirical evidence provided by Guo et al. (2024) demonstrates that strong connectivity between seaports and inland transport modes—particularly road and rail—significantly reduces total logistics costs by minimizing transshipment expenses and waiting times. This finding confirms that multimodal efficiency is not solely dependent on port capacity but also on the quality of hinterland connectivity.

Institutional coordination emerges as another critical determinant. Fuady (2025) finds that fragmented institutional arrangements in the transport sector hinder optimal multimodal implementation. Overlapping mandates and weak coordination among agencies lead to duplicated procedures and prolonged logistics processes, directly increasing operational costs borne by export–import actors. These findings suggest that institutional fragmentation constitutes a structural barrier to achieving multimodal efficiency.

Regulatory harmonization is consistently identified in the literature as a key success factor. Budiman and William (2025) report that integrated multimodal regulations reduce logistics costs by simplifying administrative procedures and lowering indirect costs. Similarly, UNCTAD (2025) emphasizes that countries with coherent multimodal policy frameworks tend to exhibit higher logistics performance and stronger competitiveness in global trade.

In addition, digitalization has become an increasingly dominant determinant of multimodal efficiency. Zeng et al. (2025) show that the adoption of digital logistics systems—such as port community systems and integrated tracking platforms—enhances operational efficiency, reduces transaction costs, and improves coordination across transport modes. These findings reinforce the argument that multimodal efficiency is inseparable from digital transformation in the logistics sector.

2. Current Conditions of Multimodal Maritime Transportation Efficiency

The results of the literature review reveal that the current efficiency of multimodal maritime transportation systems remains partial and uneven, particularly in developing economies. UNCTAD (2025) reports that although maritime transport accounts for more than 80% of global trade volume, many multimodal systems lack full integration, limiting the realization of potential efficiency gains.

Wei et al. (2025) find that countries with well-integrated maritime multimodal systems can reduce logistics costs by up to 20%. However, the same study highlights that infrastructure disparities and low system interoperability remain major obstacles in many regions. These findings are consistent with Patampang and Mokodompit (2025), who observe that multimodal integration in developing countries often remains fragmented and project-based rather than systemic.

Empirical evidence from Indonesia further illustrates these challenges. Surya Gemilang et al. (2025) show that maritime logistics efficiency is constrained by prolonged dwelling time, limited export-supporting port facilities, and suboptimal integrated logistics services. These conditions indicate that maritime multimodal transportation has not yet functioned effectively as a driver of export–import efficiency.

Overall, the findings point to a significant gap between multimodal policy frameworks and their operational implementation. While multimodal development strategies exist, they are not consistently translated into effective operational practices (Fuady, 2025).

3. Barriers to Multimodal Maritime Transportation Integration

The literature identifies several major barriers to multimodal integration. Infrastructure limitations are the most frequently cited constraint. Guo et al. (2024) emphasize that inadequate road and rail access to ports increases pre- and post-maritime transport costs, particularly for low-value and bulk commodities. This constraint significantly undermines the cost-efficiency of export–import logistics.

Another major barrier is the fragmentation of logistics information systems. Zeng et al. (2025) find that low interoperability between digital systems across transport modes results in data duplication, information delays, and increased administrative costs. These inefficiencies reduce the potential benefits of multimodal integration.

Policy and regulatory inconsistencies also represent a critical obstacle. UNCTAD (2025) notes that incoherent and inflexible multimodal policies can increase logistics costs and weaken export competitiveness. This finding is reinforced by Fuady (2025), who demonstrates that overlapping regulations and unclear institutional responsibilities prolong logistics processes and increase transaction costs.

4. Impact of Multimodal Inefficiency on Export–Import Logistics Costs

The results clearly indicate that inefficiencies in multimodal maritime transportation directly contribute to higher export–import logistics costs. Wei et al. (2025) show that fragmented transport systems generate higher cumulative costs compared to integrated multimodal systems. These cost increases are not only financial but also manifest in reduced delivery reliability and longer transit times.

Budiman and William (2025) find that elevated logistics costs resulting from multimodal inefficiencies negatively affect the competitiveness of national export products. High distribution costs reduce price competitiveness in international markets, particularly for time-sensitive and low-margin commodities. Patampang and Mokodompit (2025) further argue that such inefficiencies limit a country's ability to integrate into global supply chains.

5. Synthesis of Findings and Policy Implications

The synthesis of research findings confirms that multimodal maritime transportation efficiency plays a strategic role in reducing export–import logistics costs. Infrastructure integration, regulatory harmonization, institutional coordination, and logistics digitalization consistently emerge as the primary determinants of efficiency (Guo et al., 2024; Zeng et al., 2025; UNCTAD, 2025).

The policy implications of these findings underscore the need for an integrated and cross-sectoral approach to multimodal development. Fuady (2025) emphasizes that regulatory reform and strengthened inter-agency coordination are essential prerequisites for successful multimodal implementation. Evidence-based and coherent policy frameworks are therefore critical for enabling maritime multimodal transportation to function as an effective instrument for national logistics efficiency.

Conclusion and Recommendations

Conclusion

This literature review confirms that maritime multimodal transportation efficiency is a strategic policy instrument for reducing export–import logistics costs and enhancing national trade competitiveness. Maritime transport, as the backbone of the international logistics system, can only deliver optimal benefits when effectively integrated with land transport modes and supporting logistics systems. Without such integration, the cost and time efficiency potential of multimodal systems cannot be fully realized.

The review also reveals that existing maritime multimodal development policies have not been fully supported by adequate infrastructure, institutional readiness, and operational systems. The gap between policy formulation and implementation remains a major issue contributing to high logistics costs. This indicates that multimodal challenges are not merely technical but are fundamentally governance and cross-sector coordination issues.

Recommendations

Based on these conclusions, the primary policy recommendation is to establish maritime multimodal transportation development as a national priority within logistics and trade policy frameworks. Port development should be consistently accompanied by strengthened road, rail, and hinterland logistics connectivity to create efficient and sustainable multimodal systems.

Further recommendations include strengthening governance and regulatory harmonization, simplifying regulations, clarifying inter-agency responsibilities, and enhancing coordination mechanisms. Accelerating logistics digitalization through integrated information systems should also be prioritized as a key efficiency enabler.

From an academic perspective, future research should focus on empirical evaluations of maritime multimodal policy impacts on logistics costs and export–import performance to support continuous evidence-based policy improvement.

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