Siber Journal of Transportation and Logistic (SJTL)
E-ISSN: 2987-1050
P-ISSN: 2987-1026
+62 822 1012 3600 https://research.e-siber.org siberpublisher.info@gmail.com
DOI: https://doi.org/10.38035/sjtl.v3i2

Strategic Integration of Transport Modes for Global Supply Chain Optimization

Muhammad Zulfan Nur[1], Muhammad Tohir[2]
[1]Institut Transportasi Dan Logistik Trisakti, Jakarta, Indonesia, zulfann94@gmail.com
[2]Institut Transportasi Dan Logistik Trisakti, Jakarta, Indonesia, mtohir817@gmail.com

Corresponding Author: zulfann94@gmail.com[1]

Abstract: Multimodal transportation, which involves the use of two or more modes of transport under a single contract, has evolved into the backbone of global supply chain efficiency. This journal presents an in-depth analysis of the theoretical foundation, operational principles, as well as the strategic implications and challenges in the implementation of multimodality, based on a synthesis of literature from leading experts in the fields of logistics and transportation. The discussion includes the central role of containerization, the development of transshipment infrastructure, the adoption of information technology, as well as the regulatory and policy frameworks that support it. The main focus is on how multimodality fundamentally changes the paradigm of goods movement, from fragmented to integrated, in order to achieve cost, time, reliability, and sustainability optimization.

Keyword: Multimodal Transport, Logistics, Supply Chain, Containerization, Intermodal, Efficiency, Sustainability

INTRODUCTION

Economic globalization has driven the complexity and interconnectedness of supply chains to an unprecedented level. In this era, the efficient, fast, and economically viable movement of goods has become a crucial factor for business competitiveness and the economic growth of a country. The inherent limitations of a single transportation mode (such as high costs for air transport, low speed for sea transport, or limited capacity for land transport) have triggered the development of more comprehensive solutions: multimodal transportation. Multimodal is not just a combination of modes, but a systematic approach that integrates the comparative advantages of each mode to create a cohesive logistics flow.

Rodrigue, Comtois, and Slack (2013) in their seminal work, The Geography of Transport Systems, emphasized that multimodal is a reflection of the evolution of transportation systems towards specialization and integration. This system allows for the efficient movement of cargo from the point of origin to the destination through a series of different modes, yet under singular coordinated management. The importance of multimodal is also reflected in reports from international organizations such as the World Bank (2020), which consistently highlights the positive correlation between the quality of infrastructure and multimodal operations with a country's logistics performance (as viewed from the Logistics Performance Index/LPI). This journal will elaborate in detail on how multimodal operates, what driving factors are present, and the challenges and opportunities faced in its development.

METHOD

This research describes events in a descriptive qualitative manner or phenomena occurring in the field. The data obtained from this approach consists of words spoken or written by people and observable behavior. Paradigms and perspectives influence qualitative methods. In addition, qualitative research focuses on the processes to be studied and has a clear explanation so that its meaning can be easily understood.

RESULTS AND DISCUSSION

Understanding the essence of multimodal transport requires a clear distinction from related concepts such as intermodal, unimodal, and co-modal. UNCTAD (2001), in its publication on multimodal transport law, defines multimodal transport as "the carriage of goods using at least two different modes of transport, under a single multimodal transport contract, from a place in one country where the goods are taken over by the multimodal transport operator to a designated place for delivery in another country." The crucial point here is the single contract and the single responsibility of the multimodal transport operator for the entire journey.

- Unimodal (Single-Modal): Using one mode of transportation from start to finish, for example, only a truck from the warehouse to the store.
- Intermodal: Using two or more modes of transportation, but each segment has separate transportation contracts and often separate handling. Although the cargo may remain in a single container unit, responsibility shifts at each transshipment point. Notteboom and Rodrigue (2009) highlight that intermodal tends to focus more on the technical efficiency of moving containers between modes, while multimodal encompasses broader integration of the entire supply chain under one control.
- Co-moda: Similar to intermodal, often refers to the use of different modes in a single journey without strict integration or a single contract.

Stopford (2009) in Maritime Economics emphasizes that the evolution from unimodal to multimodal transport is driven by the need to reduce total logistics costs, speed up transit times, and improve shipping reliability, especially for international trade. A single multimodal contract simplifies the administrative process, reduces the risk of errors, and places the handling responsibility on a single entity, providing greater certainty for shippers.

The success of multimodal transport implementation largely depends on the synergy of several key pillars:

1) Containerization: The main enabler

The containerization revolution, which began in the mid-20th century, is an essential foundation for multimodal development. Levinson (2006) in The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger, persuasively describes how ISO standard containers changed the face of global logistics. Containers enable:

- Standardization: Facilitating the handling of intermodal cargo without the need to unpack the contents.
- Transshipment Efficiency: Drastically reduces loading and unloading time at ports and terminals.
- Cargo Protection: Reducing the risk of damage, theft, or loss of goods.
- Economies of scale: Allows for the transportation of large volumes of cargo in one unit,

reducing the cost per unit.

Without containerization, the multimodal concept with fast and efficient transshipment will be difficult to realize.

2) Transshipment and Hub Infrastructure

Transshipment points, such as modern container ports, intermodal rail terminals, and cargo airports, are vital nodes in multimodal networks. This infrastructure should be designed to facilitate the intermodal exchange of cargo with maximum speed and efficiency:

- Container Port: Serve as the main gateway for sea cargo to land/rail modes. They require sophisticated equipment such as gantry cranes and large storage areas. Slack (1999) describes how ports have evolved from simply loading and unloading sites to integrated logistics centers (port hubs).
- Intermodal Rail Terminal: Connects the rail network with road modes (trucks) for final distribution. The design of these terminals should allow for fast loading and unloading operations and good road connectivity.
- Inland Depots/Dry Ports: Inland facilities that serve as port extensions, allowing customs clearance and cargo consolidation/deconsolidation to take place further away from the port, reducing congestion and improving efficiency. Roso and Henttu (2007) examined the role of dry ports in multimodal networks.

Continued investment in the development and modernization of this infrastructure is essential to support multimodal growth.

3) Information and Communication Systems (ICT)

Physical integration between modes must be supported by seamless information integration. ICT plays a crucial role in this:

- Supply Chain Visibility: Track cargo position in real-time across the entire travel chain.
- Document Management: Digitization of shipping documents (bills of lading, manifests, customs declarations) reduces bureaucracy and speeds up information flow.
- Operational Coordination: Facilitate effective communication and coordination between different mode operators, logistics providers, and customers.
- Route and Schedule Optimization: Advanced software can analyze data to optimize multimodal route selection and delivery schedules.

Chopra and Meindl (2019) in Supply Chain Management: Strategy, Planning, and Operation emphasize that information is a key driver in modern supply chain efficiency, and this is particularly relevant in complex multimodal contexts.

4) Regulatory and Policy Framework

To function effectively, multimodal transportation requires a clear and harmonized legal and regulatory framework at both national and international levels:

- UN Convention on International Multimodal Transport (1980): Although not yet universally applicable, this convention provides an important foundation for the development of multimodal law, regulating operator liability, transportation documents, and claims.
- Bilateral/Multilateral Agreements: Facilitate cross-border movements and ensure recognition of documents and operational standards between countries.

- Government Incentives: Policies that encourage the use of more sustainable modes (e.g. rail and sea transportation for long distances) through subsidies, tax breaks, or targeted infrastructure development.

Inconsistent regulations between jurisdictions can be a significant barrier to smooth multimodal operations.

One of the key drivers of multimodal adoption is the potential for cost savings. By combining the low cost advantages of ocean and rail modes for long distance segments, with the speed and flexibility of land/air modes for short distance (first/last mile) segments, total transportation costs can be minimized. Lambert and Stock (1993), in their classic view of logistics management, have long identified cost balancing as a key element in mode decisions. For example, for large cargo shipments from Asia to Europe, a combination of sea-rail mode (Trans-Siberian railroad or new land lines such as the Modern Silk Road) is often more cost-effective than air mode, and faster than pure sea mode.

Multimodal allows companies to strike an optimal balance between speed and cost. For cargoes that are not too time-sensitive to be transported entirely by air, but too urgent to be transported only by sea, a combination of sea-air or rail-land modes can be an ideal solution. Reliability is enhanced through flexibility in the face of single-mode disruptions. If one mode is disrupted (e.g., traffic jam, port closure), there is potential to divert to another mode. Mentzer et al. (2001) emphasize that reliability and consistency of delivery time are determinants of customer satisfaction in the supply chain.

With increasing awareness of the environmental impact of economic activity, multimodal offers a greener solution. Transportation modes such as trains and ships have a much lower carbon footprint per ton-kilometer compared to trucks or planes. McKinnon (2018) in his book Decarbonizing Logistics, extensively discusses how modal shift from road to rail or water can significantly reduce greenhouse gas emissions and energy consumption in freight transportation. Multimodal facilitates the use of more energy-efficient modes for longer trip segments, contributing to corporate and national sustainability targets.

By shifting cargo volumes from road to rail or sea modes, multimodal can help reduce traffic congestion on major roads. This not only improves the efficiency of goods movement, but also reduces travel time and pollution. For ocean and rail modes, large carrying capacity enables efficient bulk shipping.

Multimodal opens up access to markets that may be difficult to reach with just one mode. By combining different modes, companies can reach inland or remote locations more efficiently, expanding their geographic reach and increasing business opportunities.

Differences in customs regulations, paperwork, and operational procedures between countries or even between modes within a single country can be a significant barrier. Frankel (1987) in his analysis of the economics of maritime transportation, has long highlighted regulatory fragmentation as a problem in international trade. Regional and global harmonization and standardization efforts are still needed.

CONCLUSION

Multimodal transportation has established itself as a vital backbone of modern global supply chain architecture. This journal asserts that multimodal is not simply the merging of different transportation modes, but rather a strategic and integrated approach designed to optimize the movement of goods from end-to-end. As discussed, the foundation of multimodal success relies heavily on four key pillars: containerization that revolutionizes cargo handling, efficient transshipment infrastructure, information and communication systems (ICT) that ensure visibility and coordination, and a supportive regulatory and policy framework.

Experts in the field, from Rodrigue to Notteboom to McKinnon, have consistently highlighted the advantages of multimodality in achieving cost efficiencies, improved speed and reliability, and significant contributions to environmental sustainability through reduced carbon emissions. The ability of multimodality to shift cargo volumes from less efficient modes to more environmentally friendly modes, such as rail and sea, makes it a crucial solution to the challenge of climate change.

However, multimodal implementation is not free from various obstacles, including the lack of regulatory harmonization, limited infrastructure in some regions, and the complexity of coordination between various stakeholders. These challenges require collaborative efforts from government, industry and international institutions to create a more conducive environment for multimodal development.

Looking ahead, the future of multimodal will be more closely linked to digitalization (including IoT and blockchain), automation, and the development of strategic multimodal corridors. This transformation will continue to strengthen multimodal's role as a catalyst for efficiency and competitiveness in global trade, ensuring faster, cheaper, and greener movement of goods. By addressing existing challenges and embracing innovation, multimodal will continue to be a key pillar in building resilient and sustainable supply chains in the future

REFERENCES

Chopra, S., & Meindl, P. (2019). *Supply Chain Management: Strategy, Planning, and Operation*. Pearson.

Frankel, E. G. (1987). *The World Shipping Industry*. Croom Helm.

Lambert, D. M., & Stock, J. R. (1993). *Strategic Logistics Management*. Irwin.

Levinson, M. (2006). *The Box: How the Shipping Container Made the World Smaller and the World Economy Bigger*. Princeton University Press.

McKinnon, A. C. (2018). *Decarbonizing Logistics: The Role of Freight Transport*. Kogan Page.

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). Defining Supply Chain Management. *Journal of Business Logistics*, 22(2),