POLITICS & INTERNATIONAL RELATIONS | RESEARCH ARTICLE

The multimodal transport analysis for project logistics: Export of Indonesia’s train manufacturer

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Abstract: To compete in the international market, the country with a competitive advantage in the heavy manufacturing industry should increase their logistics efficiency. This paper aims to contribute to the optimisation model for project logistics and proposes the improvement strategy for multimodal transport, especially for project logistics cargo. Mixed-method research consisted of a qualitative study to observe the main criteria for transport analysis and perform a case analysis. In the study case about multimodal transport analysis for exporting 250 units of railway carriages from Indonesia’s manufacturer to Chittagong Port, the optimum cost obtained based on a combination of the single -12 multi axle-line trailer and General Cargo Vessel 28000 DWT with the unit cost US$16,700 per carriages and total shipping duration of 142 days. The multimodal strategies are more complex than unimodal transport that involve suppliers, management, logistics function improvement, and lean transport management adoption.

Subjects: Industrial Engineering & Manufacturing; Transport & Vehicle Engineering; Civil, Environmental and Geotechnical Engineering; Engineering Economics

Keywords: infrastructure; multimodal transport; project cargo; project logistics; multimodal transport; bilateral trade

1. Introduction
The Asia Pacific is considered the most competitive region in the world. Some initiatives to increase Asia Pacific's nation connectivity, such as APEC Connectivity Blueprint (2015–2025), MPAC 2025 (Master Plan of ASEAN Connectivity), China Maritime Silk Road, and Indonesia-Malaysia-Thailand Growth Triangle plan, have goals to increase international collaboration (Duffield et al., 2019). The bilateral or multilateral agreement between countries in APEC members has amplified the economic growth in developing countries. As one of the APEC members, Indonesia was ranked the 71st most complex economy and the 25th largest exporter country in 2017 (OEC, 2018). Indonesia's trade pattern shows dependency on unskilled labour-intensive textile manufacturing products and primary products such as rubber (Sri Hasanah, 2020).

The economic perspective of international trading is based on the commodities' absolute advantages and comparative advantage conditions. Comparative advantages in global trading are based on technological superiority, resource capability, demand pattern, and commercial policies. For a nation to have competitive advantages, it should be displayed in the sustained exports and foreign investment index. These capabilities depend on the demand conditions of related industries, government strategies, and rivalry among existing competitors (Dev Gupta, 2014). Facilitating international trading will require more efficient hard infrastructure, advanced
soft infrastructure, and government support that provides information transparency, business environment, clear regulation, and customs management (Ismail & Mahyideen, 2015).

The determinants of an aggregate bilateral trade in manufacturing and services are influenced by demand bias (income per capita and income inequality in the importing country) and the national product differentiation of the exporting country. The bilateral trade elasticity is ruled by the productivity capability and not the elasticity of substitution or consumption variability patterns. Specifically, the Armington elasticity and the spread of productivity will shape the trade cost elasticity (Das & Sant Anna, 2022). Increasing the competitiveness of manufacturing products of the exporting country involves the optimisation of transport sectors. The transport cost for manufacturing products is estimated at 10% of the product cost. The transport cost is affected by distance and time, product type, economies of scale and energy, empty backhauls, infrastructures and modes, surcharges, and taxes (Rodrigue, 2020).

This paper aims to provide a framework for the multimodal transport model for heavy manufacturing products. The heavy manufacturing product falls into the category of project cargo. The logistics processes for transporting project cargo is defined as project logistics. The project logistics is transporting of cargo or equipment that may be large or out-of-gauge that requires specialised stowage, lifting, handling, and may consist of high value or critical items of a quantity connected to the same project from one point to destination with special tools (Denktaş Şakar et al., 2018). Minimising the project logistics cost will increase the trade competitiveness of manufacturing products.

There are still limited studies related to project logistics; it involves the technical knowledge for heavy haulage and heavy transport and commercial expertise to perform successful project cargo transportation. The authors hope to contribute to the studies related to project logistics planning frameworks.

2. Literature review
Improving the competitiveness of the value chain in manufacturing sectors needs a good collaboration between the production site and distribution department. The integration function requires establishing a system consisting of transport characteristics, a suitable technique for vehicle routing, the need for outsourcing, insurance, and contracts in transport services (Prokhorova et al., 2016). The need for integration transport functional influences the development of intermodal, multimodal, and trans-modal transportation concepts. Multimodal transport is the transport system that carries equipment or materials using at least two different transport modes under one contract and is managed by one operator for exporting. In comparison, intermodal transport is a transport system that exchanges at least two transport modes where a different contract is involved in reaching the final destination, while trans-modal transportation is the freight movement within the same transportation modes (Rodrigue, 2020).

The multimodal transportation concept offers advantages such as reducing the complexity of liabilities in the intermodal transport mode, coordinating only with one operator for a contract of carriage, fixing the limitation of liability of the operator, and one single contract of carriage from starting point to the final destination, increasing shipment’s monitoring during each stage and increasing efficiency in the cost and schedule coordination for the entire process.

Many researchers have mostly studied the transport model for container commodities and dry bulk cargo. Stoilova (2018b) discusses the performance evaluation of intermodal transport using multicriteria analysis with determination criteria, such as transport cost, transport time, flexibility, reliability and sustainability. The decision for selecting transport mode, estimating passenger satisfaction, evaluating transport projects, and alternative fuel selection uses prioritisation ranking using the PROMETHEE method. The same methods can be performed for the selection of transport route for containers carriage between two points by taking multicriteria by using sequences activities: (1)
Selection of variants of alternatives; (2) define the quantitative and qualitative criteria, such as environmental criteria (CO₂ emission), economic criteria (transport cost and infrastructure charges), additional transport fare, transport duration, transhipment operation needs, security, reliability, stability; (3) determine weightage criteria using Shanon Entropy, DEMATEL, AHP, and equal weight (4) determine to prioritise ranking using Compromise programming (Stoilova, 2018a).

Chen et al. (2019) propose the method for optimising the multimodal transport network by considering safety stock, transhipment price, and demand information of intermodal network under Real Time Information. This strategy enables the distribution department to update demand information within an interval of time between ordering points, allows the production department to match production scale to market demand and manage emergency order points and safety stock. Meanwhile, the distribution department can maintain safe multimodal transport with an effective response to stochastics demand using real-time data. The other study conducted by Tuzkaya et al. (2014) proposed a methodology to perform optimisation models using ANP and multilevel programming that can be applied to multimodal, multicommodity, and multi-echelon transport networks. This study has shown that the selecting transport mode should not solely rely on the consideration of cost and time because it may cause inefficiency and lapse in the medium or long term,

Islam et al. (2013) conducted a study related to the performance evaluation of the online benchmarking tools for the European freight transport chain in 27 countries across Europe. The studies show that online benchmarking is useful for logistics operators to grasp feedback related to pros and cons of new transport model, allows logistics managers to provide or procure the logistics services, and provides valuable input for transport policymakers. The main evaluation criteria for this benchmarking are transport cost, transport time, flexibility, reliability, quality, and sustainability (Islam et al., 2013). The growth of the Internet of Things (IoT) has proven to play an important role in multimodal transport in evaluating multimodal transport for containerised exports. Dua and Sinha (2019) suggest that opinion mining using Exploratory Factor Analysis (EFA) and statistical analysis using SEM (Structural Equation Modeling) to obtain customer feedback is necessary to enhance the quality of multimodal transport in Indian markets. The authors proposed the integrated digital ecosystem for multimodal transport to improve the expectations perceived by logistics stakeholders.

The previous studies mainly discuss the container’s multimodal transport and have not yet specifically discussed the project logistics. This study develops a framework for optimising heavy freight multimodal transport operations.

3. Material and methods

3.1. Methodology

The research hypothesis for this study is as follows:

*The optimum cost for heavy freight multimodal transport should start from determining sets of alternatives of transport mode that meet the operational and technical criteria with transport duration criteria meet project schedule constraint.*

The following research question is to be discussed in this study:

(1) What are the technical, operational, and commercial criteria for selecting a suitable transport mode?
(2) How to optimise the project logistics cost?
(3) How to improve the performance of the project logistics value chain?
Figure 1 shows the sequence of activities from data collection, formulation of possible alternatives, multimodal transportation cost and duration analysis, sensitivity analysis and proposed strategy for improving multimodal transport for project logistics.

3.2. Selection criteria for suitable transport mode

3.2.1. Land transport mode

The decision-making process for selecting suitable heavy haulage configurations, lifting equipment, and vessels should consider technical, commercial, and operational criteria. The project logistics involve land transportation starting from the manufacturer’s location to the Port of Loading (POL), cargo handling activities at POL, marine transportation, cargo handling activities at Port of Discharging (POD), and land transport to the customer destination, selecting the suitable transport mode for project cargo that unique requires specific technical and operational consideration. The decision-making process for selecting suitable heavy haulage configurations and the suitable vessel should consider the technical, operational, and commercial criteria. Table 1 shows the land transport selection criteria for the project cargo haulage.

MAT (Multi Axle Trailer) is an appropriate transport mode, especially for transport out of gauge cargo with weight above 60 Ton. The transport is considered stable if the total force projected is still within the triangle or rectangular stability area. There is a probability of damage to the trailer and cargo tripping risk if the configuration trailer is not within the stability area (Escribano-Garcia et al., 2021). The cargo securing purpose is to resist the transverse tipping and longitudinal sliding caused by acceleration and braking forces (IMO, 2011). The above criteria are important to minimise the risk of a trailer accident. The heavy freight transportation system required strong maritime logistics. The long-haul distance transportation mode made the intermodal/multimodal transport more preferable, especially when the handling cost increased, total transport distance increased, pre- and post-haulage cost increased, marginal cost increased, and reduced the truck drivers (Hanssen et al., 2012).

3.2.2. Marine transport mode

Maritime logistics is the process of planning, implementing, and managing the movement of goods and information involved in the ocean carriage. Maritime logistics consists of a logistic integration system that involves not only the activities related to maritime transportation such as contracting, shipping sea voyages, moving cargo, and loading/unloading but also the other logistics services such as stripping/stuffing, storage, warehousing, inventory management, distribution centre, quality control, testing, assembly, packaging, repacking, repairing, inland connection and reuse (Lee et al., 2015). Table 2 shows the marine transport selection criteria for heavy freight.
The multimodal transportation unit cost ($MM_{UC}$) is the sum of land transport unit cost ($LT_{UC}$) and sea transportation unit cost ($ST_{UC}$) as follows:

$$MM_{UC} = \sum ST_{UC} + LT_{UC}$$

(1)

$$ST_{UC} = \sum (CC + OC + VC + CHC) \frac{Q}{Q}$$

(2)

$$= \sum (EC + LC + OPC) \frac{Q}{Q}$$

(3)

Where:

- **EC** : equipment cost (rental charges, lashing materials, maintenance and repair charges)
- **LC** : labour cost (mechanics, driver, operators, lashing team)
- **OPC** : operating cost (fuel cost, permit fee, toll fee, and escorting charges)
- **CC** : capital cost (the current vessel value with an additional 2% of inflation rate)
- **OC** : operating cost (manning cost, maintenance cost, repair cost, insurance, and provision cost)
- **VC** : voyage cost (fuel cost, port charges, and penalty cost caused by broken stowage)
Table 2. Marine transport selection criteria

| Criteria          | Description                                                                                                                                                                                                 |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Technical Criteria| • Proper stowage plan based on the cargo manifest, individual cargo weight, cargo dimension, cargo footprint, and cargo sensitivity,                                                                           |
|                   | • If required, the ship deck strength should support the distribution load, the load spreading beam, or the supporting system (Leach, 2002).                                                          |
|                   | • The availability of a derrick or vessel crane to lift the heavy cargo. The working radius is calculated based on the centre point of cargo at the wharf and the stowage location (House, 2005). |
|                   | • The vessel loaded draft to check with water depth within the port infrastructures.                                                                                                                         |
|                   | • The vessel should maintain stability during loading by lifting or RoRo operation to prevent ship capsizing (Daal, 2016).                                                                                   |
| Operational Criteria| • Lifting operation: during heavy lifting operation, it is required to ensure all the mooring lines are tensioned, fenders should be pre-rigged, and gangway should be lifted from the quayside, the deck area should be clear of obstructions, and any ship’s side rails should be lowered or removed, and any barges secured to the shipsides should be cast-off (House, 2005). The SWL of the lifting machine, lifting gears, and appliances should be checked to meet the required lifting capacity. |
|                   | • RoRo operation: The RoRo operation ensures that the CoG of the cargo lines up with the vessel’s centerline. The transporter usually performs ballasting operations to maintain the vessel draft and the vessel stability for smooth operation (Daal, 2016). |
| Commercial Criteria (Wijnolst & Wergeland, 2009; Stopford, 2013) | • The marine transportation cost consists of capital cost (CC), operating cost (OC), cargo handling cost where (CHC), and voyage cost (VC).                                                               |
|                   | • CC consists of the ship’s depreciation over its economic life and the interest payment.                                                                                                                     |
|                   | • OC consists of manning cost (M), maintenance and repairs (MN), stores, supplies and lubricating oils (ST), insurance cost (I), and management overhead, including administrations (A).                                      |
|                   | • VC consists of bunker cost (B), port charges (PC), and canal dues (CD), if any.                                                                                                                          |
|                   | • CHC consists of the cargo loading charges (L), cargo discharging (D), cargo land transport from the fabrication area to the port of loading (TL), and cargo claim charges (CL) if any claim arises. |

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4. Result and discussion: Multimodal transport of railway carriage

4.1. Alternatives transport scenario

The project logistics cost consists of land transportation from door to POL, cargo handling and port charges in POL, custom clearance, administration cost, and shipping from Tanjung Perak Port, Indonesia, to Chittagong Port, Bangladesh, and port charges, and cargo handling cost in Bangladesh. Table 3 shows the port specification criteria.

The cargo properties are railway carriage products with dimensions 22.8 m (length) × 3.25 m (width) × 4.03 m (height), with a total quantity of 250 units. The production of each railway carriage consists of three stages: fabrication, finishing, and testing, with total completion for one product estimated at 186 days or 6 months. The manufacturer capacity is 20 products per month, for the Bangladesh project has taken 75% off manufacturer capacity. In a month, the production of 15 carriages is completed. The project will be fully completed in the 23rd month after the production starts. The study case for the multimodal transportation is exporting carriage train, starting from the manufacturer location in Madiun, East Java, transported to the POL (Port of Loading) in Jamrud Terminal, Tanjung Perak Port Surabaya for an estimated about 180 km as shown in Figure 2. There is an option for temporarily storing the trains in the open yard through a jacked-down steel/concrete block while waiting for the vessel schedule. This option will cause internal shifting charges to move the train from the open yard to the wharf for loading operation.

The formulation of alternatives for this study case is as follows:

4.1.1. Option 1 uses a 12-axle line trailer from the manufacturer’s yard directly to POL

The alternative for land transport mode using MAT is based on the assumption of usage of five sets of MATs, each roundtrip can take five railway carriages. The required configuration of MAT is a single-12 axle line trailer pulled by two trucks. The component cost for option 1 includes (1) equipment cost (multi-axle, prime mover, lashing, maintenance and repair, fuel cost); (2) labour cost (driver and operator, stevedoring cost); (3) administrative: toll fee, permit fee, guard and security cost, and overhead cost. The total duration is estimated based on total loading time at the manufacturer yard, transport duration from door to POL, discharging duration at the POL, reverse trip, and driver resting time which is estimated around 19 hours or 1 day for one roundtrip.

4.1.2. Option 2 uses a combination of rail transport and a multi-axle trailer

Option 2 using a combination of the locomotive to transport cargo from the manufacturer (Madiun Station) to Prapat Kurung Station (nearest station to Tanjung Perak) and MAT from Prapat Kurung station to Tanjung Perak. The component cost for option two includes (1) equipment cost (locomotive rental, MAT charter, temporary support, lashing fee, lifting equipment cost), (2) labour cost (driver and operator, stevedoring cost); (3) administrative: toll fee, permit fee, guard and security cost, and overhead cost—this alternative using one locomotive with the capacity to carry 20 railway carriages. The duration is estimated based on a total of transport from the manufacturer

| Specification           | POL                  | POD                     |
|-------------------------|----------------------|-------------------------|
| Port Name               | Tanjung Perak Port   | Chittagong Port Indonesia |
| Maximum Port Draft      | −10 m LWS           | −9.4 m LWS              |
| Railway at Port         | Not available        | Integrated railway system |
station to Prapat Kurung Station (vice versa), transfer duration, duration of loading and discharging of cargo to MAT, transport duration from station to POL, cargo discharge duration from MAT at the port of loading which is estimated to be around 125 hours or 5.2 days for one roundtrip.

4.1.3. **Marine transportation alternatives**

There are several alternatives for transporting heavy manufacturing products, such as general cargo vessels (GC), RoRo vessels (RR), heavy lift vessels (HL), and integrated tug and barges (BA). The difference in size and capacity of the ship influences the cargo holding capacity, affects the number of loaded cargo, and vessel frequency will be different. The broken stowage is calculated as the difference between the total capacity of the cargo hold and the total cargo volume. The penalty cost is calculated based on each vessel’s broken stowage as part of the voyage cost. Thus, it is necessary to check each alternative based on the categories for vessel capacity: Category 1 within range $5,000 < x < 10,000$ DWT; Category 2 within range $10,000 \leq x < 20,000$ DWT; and Category 3 within range $20,000 \leq x < 35,000$ DWT. Table 4 shows the vessel specification for marine transportation.

Table 5 shows the marine transportation cost of these alternatives. The total cost (TC) is accumulative of Fixed Cost (FC), VC (Voyage Cost) and CHC (Cargo Handling Cost). The unit cost is the total cost divided by the total quantity transported.

Table 6 shows the multimodal transport unit cost for combining sea transport cost (ST) and land transport cost (LT) for each possible alternative transport mode. The multimodal unit cost for exporting 250 units shown in Table 6 shows that the highest transport cost resulted from the option RR1, where marine transport using a vessel with capacity below 10,000 DWT and the lowest cost based on the GC3 option by utilising of General Cargo Vessel Category 3 (GC3) within range $20,000 \leq x < 35,000$ DWT and land transport using MAT from manufacturer yard to POL.

Figure 3 shows the sensitivity analysis on how the target analysis is affected based on the changes in the quantity of demand. The multimodal transport unit cost will be reduced with the growth of the number of quantities of products.

4.2. **Discussion: Improvement strategy for multimodal transport**

The previous studies mostly discussed multimodal for container freight. In contrast, not many related studies to project logistics. Apart from that, there are major differences between container market demand and project cargo demand. The infrastructure project development influences
| Code | DWT (ton) | Lpp (m) | Breadth (m) | Depth (m) | Draft (m) | GT (ton) | NT (ton) | Speed (loaded) knots | Speed (empty) knots |
|------|-----------|---------|-------------|-----------|-----------|---------|----------|----------------------|----------------------|
| GC1  | 7966      | 110     | 28          | 70        | 64.25     | 2721    | 11       | 13                   | 11                   |
| GC2  | 15,569    | 122     | 23          | 70        | 63.75     | 24,060  | 13       | 11                   | 11                   |
| GC3  | 25,792    | 158     | 27          | 85        | 79.25     | 11,927  | 11       | 11                   | 11                   |
| H1   | 10,000    | 145     | 38          | 70        | 59.52     | 2,681   | 13       | 13                   | 13                   |
| H2   | 14,112    | 160     | 32          | 8.5       | 12,642    | 3,792   | 11       | 13                   | 13                   |
| H3   | 30,000    | 170     | 46          | 12.0      | 31,726    | 9,517   | 11       | 13                   | 13                   |
| R1   | 1,440     | 21      | 14.2        | 6.9       | 10,471    | 13,586  | 16       | 16                   | 16                   |
| R2   | 11,400    | 156     | 23          | 7.3       | 9,478     | 4,676   | 14       | 14                   | 14                   |
| R3   | 25,000    | 191     | 31          | 9.6       | 47,715    | 5,600   | 14       | 14                   | 14                   |
| R4   | 7969      | 86      | 27          | 4.5       | 33,87     | 1,267   | 5        | 7                    | 7                    |
| R5   | 1,399     | 101     | 37          | 5.0       | 4,780     | 1,704   | 5        | 5                    | 5                    |
| RR4  | 30,095    | 130     | 40          | 7.5       | 5,980     | 10,860  | 5        | 5                    | 5                    |

Table 4. Vessel specification (alternative for marine transportation)
project cargo demands. Thus, the punctuality of the actual project cargo transport schedule affected the project schedule realisation. The project logistics stakeholders involve the manufacturing company, transporter, and cargo buyer. Integration between the manufacturing company and the cargo transporter is crucial. Examining existing distribution operation systems and involving the value engineering concept may be necessary to improve logistics performance. Value engineering (VE) is a systematic application conducted by a multidiscipline that identifies the function, business processes, and services generated through innovation and creative thinking and is reliable at the lowest overall costs (Mukhopadhyaya, 2009). The VE concept is determined to set a certain target costing with specified functionality and desired profitability; the VE application consists of processes observing the current process, setting the target, achieving the target, and maintaining the most optimum costs. The desired target can be achieved with appropriate transportation management. Figure 4 shows the transportation strategy for multimodal transport project logistics.

It shows the VE approach in four stages: observing the existing operational system, determining the key performance indicators and goals, implementing strategy, and finally achieving certain performance goals. The transportation strategy for heavy project cargo shall adopt the Lean model by using JIT (Just In Time) to optimise time, quantity, quality and space allocation for manufacturing the product (Achahchah & Routledge, 2019). In this study, the proposed strategy such as follows: (1) ensuring carrier/supplier management with performance-based contract to increase the logistics performances and proactive monitoring and management (Srivardis & Normar, 2015); (2) improving the organisational logistics function group performance (Islam, 2005); (3) performing lean transport management to reduce waste and costs (Achahchah & Routledge, 2019). The sustainability supply chain management (SSCM) studies indicate the need to improve supplier development in the value chain (Agan, Yavuz; Acar, Mehmet Fatih; Neureuther, 2018). The appropriate contract management is required to manage the legal binding issues between the supplier, carriers, and other arising legal issues.

Another potential issue for a multimodal model is when the system facing disruption such as port congestion or pandemic Covid 19 will incur a higher cost and additional time than the unimodal transport model (Rosyida et al., 2019). COVID 19 is a safety regulation that prevents the virus from spreading and impacting container and bulk shipments. Although there are no studies on its impact on project cargo shipping, it affects the charterers. Any delay at cargo loading/discharging, restrictions, quarantine, detention and other possible issues might not be included in the charter party prior to the pandemic. It elevates the complexity for ship owners to meet the agreed duration of laytime and increase change order (deviation, rotation, and

| Code | FC   | VC   | CHC  | TC   | UC   |
|------|------|------|------|------|------|
| GC1  | $834,000 | $2,394,000 | $368,000 | $3,596,000 | $14,384 |
| GC2  | $722,000  | $2,694,000  | $366,000  | $3,782,000  | $15,128 |
| GC3  | $604,000  | $2,482,000  | $365,000  | $3,451,000  | $13,804 |
| HL1  | $1,696,000 | $1,754,000  | $389,000  | $3,839,000  | $15,356 |
| HL2  | $1,913,000 | $3,609,000  | $388,000  | $5,910,000  | $23,640 |
| HL3  | $3,339,000 | $6,006,000  | $389,000  | $9,734,000  | $38,936 |
| RR1  | $562,000  | $23,848,000 | $389,000  | $24,799,000 | $99,196 |
| RR2  | $416,000  | $7,115,000  | $388,000  | $7,919,000  | $31,676 |
| RR3  | $469,000  | $5,599,000  | $389,000  | $6,457,000  | $25,828 |
| BA1  | $1,455,000 | $5,550,000  | $370,000  | $7,375,000  | $29,500 |
| BA2  | $784,000  | $8,611,000  | $368,000  | $9,763,000  | $39,052 |
| BA3  | $960,000  | $11,940,000 | $370,000  | $13,270,000 | $53,080 |
Table 6. The unit cost and duration for exporting railway carriages

| Code | Real cargo loaded | Duration (days) | Waiting period (days) | Duration (days) | Multimodal Transport Unit Cost | Waiting period (days) | Duration (days) | Multimodal Transport Unit Cost |
|------|------------------|----------------|-----------------------|----------------|--------------------------------|-----------------------|----------------|--------------------------------|
| GC1  | 10               | 495            | 2                     | 497            | $ 17,300                       | 5                     | 500            | $ 19,500                       |
| GC2  | 18               | 285            | 4                     | 289            | $ 18,000                       | 5                     | 290            | $ 20,200                       |
| GC3  | 46               | 133            | 9                     | 142            | $ 16,700                       | 12                    | 145            | $ 18,900                       |
| HL1  | 28               | 189            | 6                     | 195            | $ 18,300                       | 8                     | 197            | $ 20,400                       |
| HL2  | 30               | 190            | 6                     | 196            | $ 26,500                       | 8                     | 198            | $ 28,700                       |
| HL3  | 40               | 152            | 8                     | 160            | $ 41,800                       | 11                    | 163            | $ 44,000                       |
| RR1  | 37               | 119            | 7                     | 126            | $ 102,100                      | 10                    | 129            | $ 104,300                      |
| RR2  | 60               | 168            | 12                    | 180            | $ 34,600                       | 16                    | 184            | $ 36,800                       |
| RR3  | 121              | 112            | 24                    | 136            | $ 28,700                       | 33                    | 145            | $ 30,900                       |
| BA1  | 8                | 1256           | 2                     | 1258           | $ 32,400                       | 5                     | 1261           | $ 34,600                       |
| BA2  | 18               | 558            | 4                     | 562            | $ 42,000                       | 5                     | 563            | $ 44,100                       |
| BA3  | 35               | 328            | 7                     | 335            | $ 56,000                       | 9                     | 337            | $ 58,200                       |
5. Conclusion and future research

The multimodal transportation concept for project logistics provides several benefits, such as reducing the complexity of liability for intermodal transport by using one single contract for an entire route with potential for cost reduction and time. However, the drawback of this model is the higher risk when the planner may lack the technical experience and legal knowledge considerations when unknown regional/local standards are applied, which might disrupt the cargo operations. The logistics cost calculation started by complying with the technical criteria and meeting relevant international standards and code requirements before the transport cost analysis. Some constraints for selecting alternative transport, such as cargo properties, port infrastructures limitation, cargo hold maximum capacity, vessel stability, and trailer stability.

detention; UNCTAD, 2021). The COVID 19 impact to project logistics operation still requires further study.
criteria, are the basic decision-making for formulating a suitable transport model. Observation of the technical and commercial criteria by investigating the study case for exporting 250 units of railway carriages from the manufacturer to Chittagong Port resulted in the optimum cost based on a combination of the single –12 multi axle-line trailer as land transport mode from manufacturer to POL and marine transport from POL to POD use General Cargo Vessel within range 20,000 ≤ x < 35,000 DWT. The unit cost per carriage is US$16,700, and the total duration is 142 days. This study does not stop until achieving a minimum cost at transport duration within the project schedule. Implementing a transport strategy to achieve the most competitive cost will lead to more opportunities for bilateral trading. The multimodal strategies need responsible managers capable of managing suppliers, contract management, familiar with organisational logistics function and lean operational management (JIT manufacturing). The involvement of outsourcing partners for cargo freight forwarding can be a solution to ensure the project cargo’s safe delivery. Forecasting for multimodal transport uncertainties might help since multimodal transport is more complex than unimodal transport; thus, the multimodal concept will need additional time and costs to adapt to the disruption situation.

For the future research, the authors believe it is necessary to observe and discuss the impact of COVID 19 on the project logistics performance and its contract compliance, especially for non-container vessels (multipurpose performance, tug and barge, general cargo vessels, and ro-ro vessels) that alternately can perform the delivery of project cargo.

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