Determining Domestic Container Shipping as an Enforcement of Indonesian International Hub Port

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Abstract. According to Presidential Regulation Number 26 year of 2012 about the National Logistics System Development Blueprint, the Indonesian government proposed to build two international hub ports, which were in Port of Kuala Tanjung for the western region and Port of Bitung for eastern region. Therefore, the optimum routes and fleet size are required to support the enforcement of Indonesian International Hub Port. The optimization model is used to obtain the optimum route and fleet by minimizing the total shipping costs, while considering the container demand. The result of analysis obtained that the optimum route and fleet size for the western region of Indonesia were: (1) Kuala Tanjung-Belawan required 15 ships of 1,000 TEU; (2) Kuala Tanjung-Tanjung Priok required 73 ships of 2,500 TEU; (3) Kuala Tanjung-Tanjung Perak required 44 ships of 2,500 TEU. Meanwhile, the optimum route and fleet size for the eastern region of Indonesia consisted of: (1) Bitung-Sorong required 1 ship of 500 TEU; (2) Bitung-Banjarmasin required 3 ships of 500 TEU; and (3) Bitung-Makassar required 1 ship of 1,500 TEU.

1. Introduction

In the Masterplan for Acceleration and Expansion of Indonesian Economic Development 2011-2025 (MP3EI), Indonesian government consider to strengthen the National Connectivity in order to encourage inclusive and sustainable economic growth [1]. One of the implementations stated in MP3EI is to establish the Port of Kuala Tanjung as an International Hub Port for Western Region of Indonesia and Port of Bitung as an International Hub Port in the Eastern Region of Indonesia (Figure 1). The establishment of Indonesian international hub port is also supported by the Presidential Regulation Number 26 year of 2012 on National Logistics System Development Blueprint. In addition, the implementation of international hub port development programme is already in the priority of strategic project agenda on Presidential Regulation Number 3 year of 2016 in the Acceleration of National Strategic Project Implementation. Therefore, in order to obtain the additional national fleet capacity and to ensure the movement of goods, especially for export and import container cargoes, will require the capacity planning and its operational service on the main node of domestic container ports.
2. Literature Review

2.1. Shipping Costs and Chartering Concept
In general, shipping costs are divided into four main categories: capital costs, operational costs, voyage costs, and cargo handling costs. Operating cost is sum of manning, stores, maintenance and repair, insurance and administration cost. While voyage cost is a function of fuel cost and port charges.

In the transport of cargoes or goods terms, generally used either owned or charter ship. In maritime transport, shipping chartering is divided into three types, such as bareboat charters, time charters and voyage charters [2]. And to approach total vessel operating costs, one of its components using the system time charter hire as suitable for fixed cost, because fixed cost will be paid fixed in a certain period, and fixed cost does not depend on the ship operation. Then in the calculations of the total costs of vessel operation, by summing the time charter fees, port charges and the cost of cargo handling

2.2. Fleet Capacity and Shipping Routes Planning
In determining domestic container shipping, one of the main components are planning services or network, which focuses on building links from one to another nodes, in this case network planning can be defines as the movement of goods from point of origin to point of destination [3]. Some studies has used a variety of concepts in designing routes and fleet capacity in order to obtain optimal combination.

2.2.1. Liner Shipping Network Design Problem (LSNDP). Mulder and Dekker has conducted a study related designing the optimum routes in liner shipping they using combination of fleet-design, ship-scheduling and cargo routing with restrictions on availability of the number of ships operation. Whereas the formulation in this method used linear programming approach. [4]. In order to obtain optimum domestic shipping container, this research using combined approach in the relevant scope of LSNDP Principle, such as Feeder Network Design Problem and Multiple Commodities Problem.

2.2.2. Feeder Network Design Problem (FNDP). Previous research has using optimization on hub and spoke network concept to obtain optimum shipping routes problem. In the optimization plan they focus on fixed capacity slots services to meet demand satisfaction. The concept of hub and spoke network planning is an integration maritime network to delivering goods between two regions separated by sea water, one of them are selected as hub port and another being spoke ports. In the field operation, larger size of fleet provides services to the hub port, while smaller fleet used to provide between Hub to spoke or feeder ports [5]. The modelling of hub and spoke networks are consists of two type networks systems, namely direct and indirect feeder shipping [6]. As shown inFigure 2, direct feeder shipping are connecting between hub port and feeder port directly, while indirect feeder shipping connect hub port to more than one of feeder ports, this type also called shaped loops [7].

Figure 1. The propose of Indonesian international hub port [1]
In other research also analyzing the optimum container shipping connectivity with using form of comparison scenarios for direct shipping and indirect shipping in achieving optimum allocation of demand in every port, and the optimum routes are provides extends to the needs of total capacity in each route with minimum total shipping cost [7]. But these studies have not completely reached the stage of identification on fleet sizes and its optimum operation routes of domestic container shipping. Then this research would continue to obtain the number of optimum fleet capacity and the selected optimum routes services for domestic container shipping in terms of enforcement Indonesian international hub port policy. Further related concept of optimum networks planning to meet demands satisfaction in this research, the concept of Multiple Commodities Problem also used to support Feeder Network Design Problem.

2.2.3. Multiple Commodity Network Problem (MCNP). Multi-Commodity Network Problem are part of important problem in several heuristics models, and it’s become an appropriate method in determining shipping routes for container ships [8]. And recent condition on container shipping networks is strongly influenced by a multi-destination shipping purpose. Where affected double handling at each ports of call, definitely increasing the number of operation times and its costs. The Multi-Commodity Networks Problem are working to define the correlation of fleet capacity to each of the main ports in this research.

3. Methodology

3.1. Research Scope
There are two scopes and limitations to obtain the main objective in this research, as follows:

- Only export and import container trades would be considered in the analysis. Meaning that container domestic trades are excluded.
- Shipping routes present the connecting of six main domestic ports, namely Belawan, Banjarmasin, Tanjung Priok, Tanjung Perak, Makassar, and Sorong. Moreover, the two purpose international hub ports, namely, Kuala Tanjung and Bitung International Hub Port are taken into account in the analysis as well.

3.2. Research Steps
a. Market Analysis
   Firstly, we identify the market condition by analysing from both supply and demand sides. The supply side describes an overview about two purpose international hub ports and six main domestic ports as well as provides the ship specification including the number of ship and ship capacity. On the other hand, the demand side consists of the total international container volume per year and per region.

b. Transport Costs Analysis
In order to calculate the total costs, we firstly determine the operational costs, fuel costs, port dues and terminal handling charges. Moreover, we obtain the total costs by adding these costs.

c. Optimization Model
To obtain the optimal solution for selected routes and fleet sizing for the Indonesian international hub port, we apply the Feeder Network Design Problem (FNDP) formulation by minimizing the total transport costs between main domestic ports and international hub port.

d. Domestic Container Shipping Connectivity Analysis
Dividing region scenario becomes two main Indonesia regions. Kuala Tanjung international hub port would be connecting to Belawan Port (BLW), Tanjung Priok Port (TPR) and Tanjung Perak Port (TPK) in the Western Region (WRI). Whereas Bitung International hub port concerns to connecting Banjarmasin Port (BJM), Makassar Port (MKS) and Sorong Port (SRG) in the Eastern Region of Indonesia (ERI). This grouping region is appropriate to the government plan in terms of cargo allocation belongs to these two international hub ports. Overall, we provide the conclusion and recommendation for optimum routes and number of fleet required for each region respectively.

3.3. Optimization Model
We used minimum total amount of marine transport cost for all vessels and routes alternatives on picking and delivery activities of import and export container between hub and domestic ports.

a. Objective Function.
\[
\text{Min } \sum_{t \in T} \sum_{n \in N} X_{tn} \times TC_{tn}
\]
Where \( TC_{tn} \) is total amount of marine transportation cost in Million-Rupiah/year, this formula has include fixed and variable cost components.

b. Network Constrains
\[
\sum_{t \in T} \sum_{n \in N} X_{tn} = 1
\]
Where \( X_{tn} = 1 \), if route and vessel sizes chosen, and \( X_{tn} = 0 \), if route and vessel sizes not selected.

c. Demand Transported Constrains
\[
\sum_{t \in T} \sum_{n \in N} (X_{tn} \times Fek_{tn} \times Q_{nt}) \geq Dex \\
\sum_{t \in T} \sum_{n \in N} (X_{tn} \times Fim_{tn} \times Q_{nt}) \geq Dim
\]
Where \( Fek_{tn} \) as a number of frequency by export demand and \( Fim_{tn} \) as a number of frequency by import demand per year. To gain total cargoes transported, number of frequency times by \( Q_{nt} \) (ship capacity/frequency in TEUs). While \( Dex \) and \( Dim \) respectively are export and import container volumes in TEUs/year.

d. Port Compatibility Constraints
\[ DK > DP + A = 0 \text{ and } DK < DP + A = 1 \]
Where, \( DK \) as vessel draft, \( DP \) as a wharf depth and \( A \) as an allowance.

4. Domestic Container Shipping Analysis

4.1. Indonesian Export and Import Container Volumes
Overall export and import container trade in Indonesia continues to increase since 2010. Where there are 5.2 million TEUs trough Indonesian main port in year of 2008 and then decreased to 4.9 million
TEUs in 2009, while in 2013 has slowly grow significantly by average of 7.3% with total amount reached 7.3 million TEUs [6].

![Figure 3. International Container Volume Growth in Java and Sumatera](image1)

Total amount of future container volumes can be seen by applying the correlation approach among Indonesian economy growth rate as indicated of Indonesia Gross Domestic Product (GDP) on constant prices, against the historic data of international container volumes. Currently, number of export and import container proportion has reach respectively around 40% and 60% [8]. Tanjung Priok has 70% export container volumes and Tanjung Perak has 30% export container volumes based on total container volumes in Java region, meanwhile import container volumes proportion for Tanjung Priok and Tanjung Perak respectively has amount of 65% and 35% from total import containers in Java region [6]. Therefore in each region can be identified the container volume proportion both import and export as can be seen in Table 1 below in the year of 2020 as convenient on establishment hub port international started.

**Table 1. Potential International Container Volumes in 2020**

| Port            | Codes | Export (TEUs) | Import (TEUs) |
|-----------------|-------|---------------|---------------|
| Belawan         | BLW   | 713,694       | 1,070,540     |
| Tanjung Priok   | TPR   | 2,864,176     | 3,989,388     |
| Tanjung Perak   | TPK   | 1,227,504     | 2,148,132     |
| Banjarmasin     | BJM   | 19,592        | 29,388        |
| Makassar        | MKS   | 20,759        | 31,138        |
| Sorong          | SRG   | 8,491         | 12,737        |

The total amount of export and import container volumes above will be affected to the decision for optimum routes and number of fleets.

4.2. **Indonesian Domestic Ports Depth and Container Vessel Proportion**

Wharf depth and port channel were included as main part in port operation. Where both of this facility impactful in determining optimum fleet in optimization model result. Namely as compatibility variable for acceptable port capacity to serve specific means of vessels. For instance, according to Figure 5 noticeable that Banjarmasin port depth has reach at 8 m LWS, when compare to maximum ability of entrance to the harbour, its limited to vessel within range of 300 TEUs to 800 TEUs with maximum draft up to 7 m.
Figure 5. Indonesian existing ports depth within maximum 3,500 TEU vessel size to the deepest port

Meanwhile, according to distribution data of container freights by Indonesian Ministry of Transportation in 2012, domestic container vessel size has ranging from 200 TEUs capacity to 1,000 TEUs capacity. The proportion for existence number of container fleet operates in Indonesian sea water can be seen in Figure 6 above.

4.3. Regional Scenario and Vessel Alternatives for Optimization Model
According to the main purpose of two international hub port in Indonesia, Kuala Tanjung international hub port would be connecting to Belawan Port (BLW), TanjungPriok Port (TPR) and Tanjung Perak Port (TPK) in the Western Region (WRI). Whereas Bitung International hub port concern to connecting Banjarmasin Port (BJM), Makassar Port (MKS) and Sorong Port (SRG) in the Eastern Region of Indonesia (ERI) as shown in Figure 7.

Table 2. Container Vessel Size Alternatives

| Alternatives | Vessel Size (TEUs) | Alternatives | Vessel Size (TEUs) |
|--------------|-------------------|--------------|-------------------|
| Vessel - 1   | 300               | Vessel - 6   | 2,000             |
| Vessel - 2   | 500               | Vessel - 7   | 2,500             |
| Vessel - 3   | 800               | Vessel - 8   | 3,000             |
| Vessel - 4   | 1,000             | Vessel - 9   | 3,500             |
| Vessel - 5   | 1,500             |              |                   |

Furthermore, to seek the optimal container vessel size in optimum routes, we define container vessel sizes alternatives in several number, specifically within 300 TEUs to 3,500 TEUs as convenient to the current average sizes of domestic container vessel in Indonesia (see in Table 2).
5. Result

The selected optimum routes are categorized as port to port service, which directly connects the international hub port to domestic hub port as can be seen in figure 8. Within this route, the total containers carried are 12,012 million-TEUs and 124 thousand-TEUs for western and eastern region respectively. As an impact on the total costs, it produces 29,310 Billion-Rupiah to operate 137 units of container vessel.

Figure 8. Optimum routes selected as port to port categories

The optimum route for the western region of Indonesia consists of: (1) Kuala Tanjung-Belawan requires 15 ships of 1,000 TEU with total shipping costs of 2341.9 billion rupiah/year and the unit cost of 1.31 million rupiah/TEU; (2) Kuala Tanjung-Tanjung Priok requires 73 ships of 2,500 TEU with total shipping costs of 16,664 billion rupiah/year and the unit cost of 2.43 million rupiah/TEU; (3) Kuala Tanjung-Tanjung Perak requires 44 ships of 2,500 TEU with total shipping costs of 9.868 million rupiah/year and the unit cost of 2.922 million rupiah/TEU.

On the other hand, the optimum routes and fleets for eastern region of Indonesia are: (1) Bitung-Sorong requires 1 ship of 500 TEU with total shipping costs of 68.8 billion rupiah/year and the unit cost of 3.24 million rupiah/TEU; (2) Bitung-Banjarmasin requires 3 ships of 500 TEU with total shipping costs of 233.71 billion rupiah/year and the unit cost of 4.56 million rupiah/TEU; and (3) Bitung-Makassar requires 1 ship of 1,500 TEU with total shipping costs of 143.47 billion rupiah/year and the unit cost of 2.76 million rupiah/TEU.

Table 3. Optimum fleet sizes and routes

| Routes                        | Fleet Size (TEU) | Quantity (Unit) | Total Frequency/y | Total Costs (Billion-Rupiah) | Roundtrip days |
|-------------------------------|------------------|-----------------|------------------|-----------------------------|----------------|
| Kuala Tanjung-Belawan-Kuala Tanjung | 1,000            | 15              | 1,260            | 2,342                       | 4              |
| Kuala Tanjung-TanjungPriok-Kuala Tanjung | 2,500            | 73              | 1,878            | 16,664                      | 13             |
| Kuala Tanjung-Tanjung Perak-Kuala Tanjung | 2,500            | 44              | 1,011            | 9,868                       | 15             |
| Bitung-Sorong-Bitung         | 500              | 1               | 30               | 69                          | 6              |
| Bitung-Banjarmasin-Bitung    | 500              | 3               | 70               | 234                         | 11             |
| Bitung-Makassar-Bitung      | 1,500            | 1               | 25               | 143                         | 10             |

Indonesian export and import container cargoes through international hub ports, Bitung and Kuala Tanjung, in the year of 2020 will produce the total potential revenue of 33.5 Trillion Rupiah per year based on selected routes and vessel capacity in the optimization result Table 3. In detail can be seen in Table 4 below:
Table 4. Potential revenue of Indonesian hub port enforcement in 2020

| Routes                        | Quantity (Q) (TEUS/year) | Unit Cost (UC) (Million-Rp/TEUs) | Price (P) (Million-Rp/TEUs) | Revenue (R) (Billion-Rp/year) |
|-------------------------------|--------------------------|----------------------------------|-------------------------------|-------------------------------|
| Kuala Tanjung-Belawan-Kuala Tanjung | 1,780,000                | 1,300,000                         | 1,560,000                     | 2,777                         |
| Kuala Tanjung-Tanjung Priok-Kuala Tanjung | 6,800,000                | 2,399,999                         | 2,760,000                     | 18,768                        |
| Kuala Tanjung-Tanjung Perak-Kuala Tanjung | 3,300,000                | 2,900,000                         | 3,480,000                     | 11,484                        |
| Bitung-Sorong-Bitung          | 48,000                   | 4,500,000                         | 5,400,000                     | 259                           |
| Bitung-Banjarmasin-Bitung     | 51,000                   | 2,700,000                         | 3,240,000                     | 165                           |
| Bitung-Makassar-Bitung        | 20,000                   | 3,200,000                         | 3,840,000                     | 77                            |

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