THE CONTAINER SHIPPING FLEET PLANNING PROBLEM UNDER TRADE DISPARITIES OF NATIONAL LOGISTICS SYSTEM IN INDONESIA

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ABSTRACT

In the development of the national logistics system, Indonesian's government planned to build two international ports in Kuala Tanjung and Bitung to support the increasing volume of export and import containers. This development aims to make Indonesia no longer depend on the ports of neighboring countries. Currently, the international cargos are shipped from Indonesian ports to Port of Singapore as an international hub applying hub and spoke network concept. According to the "Sea Tollway" program, vessels with a fixed schedule are assigned to serve these networks. The long shipping routes followed by several problems, including vessel inefficiency caused by demand imbalance between each port. These imbalances are the effect of trade disparities between west and east region of Indonesia. For route with these characteristics, the network and fleet planning are important factors to improve efficiency that has a direct impact on minimizing shipping cost. In this research, we analyze the fleet planning for routes serving international container shipping from six main domestic and two international hub ports in Indonesia, which are Belawan, Tanjung Priok, Tanjung Perak, Banjarmasin, Makassar, Sorong, Kuala Tanjung, and Bitung. We developed the linear programming model modified from the Feeder Network Design Problem (FNDP). To choose the right vessel size for the routes, we added utilization as a factor that must be considered in the model. Finally, by solving the model we get the optimal vessel size and quantity for each route.

Keywords: Hub and Spoke Network, Demand Imbalance, Fleet Planning Problem, Feeder Network Design Problem.

1. INTRODUCTION

Indonesia is an archipelagic country which has more than 17.000 islands spread over from west to east of its teritory (Bahagia et al., 2013). In which maritime transportation is highly needed to connect inter-island economics activities under this geographical condition. Until now, inter-island trade in Indonesia is still experiencing imbalances due to uneven economics infrastructure development and high national logistics costs. Therefore, in order to decrease the national logistics cost and improve inter-island connectivity, the "Sea Tollway" program connecting the six economic corridors identified in the Masterplan for Acceleration and Expansion of Indonesia's

Economic Development (MP3EI) 2011-2025 was developed. The "Sea Tollway" program will use six seaports as the main gateways, such as Belawan, Batam, Tanjung Priok, Tanjung Perak, Makassar and Sorong (Baan et al., 2015).

The growth of international trade has gained a positive rebound in 2017-2018 after experiencing a downturn in 2015-2016. International trade growth averaged at about 10 per cent in 2017, and indicates a higher growth about 12 per cent in 2018 (UNCTAD, 2019). On the other hand, Indonesia has evolved to be the one of the highest GDP countries in the world (Fahmiasari and Parikesit, 2017). Even in 2018, when the world economic growth was at 3.3 per cent, Indonesia had a higher GDP level of 5.1 per cent (IMF, 2018). In this development, the import activities growing faster than export, partly reflected the acceleration in investment growth that was the most rapid since Q4 2012 (The World Bank, 2018). However, the enormous economic growth in Indonesia is not supported by the decent logistics infrastructure. Indonesia is still depending on neighbouring countries in distribution of international trades, which increase the logistics cost.

Indonesia has 2 main domestic ports for serving the international cargo, i.e Tanjung Priok and Tanjung Perak. Tanjung Priok and Tanjung Perak are located in Java region, the largest source of international cargo. International cargo imported to Indonesia should be transhipped on the international hub ports and then continued to one of main domestic port before delivered to the final destination port. The export cargo is also handled with the same mechanism, only in the opposite direction. Currently, the existing international hub port that has dominantly been used by Indonesia to support its international trade is port of Singapore (Lazuardi et al., 2017). Under the current mechanism, the transportation cost can't be efficiently obtained because several destination countries of import and export cargo are closer to be reached directly from the origin ports. In order to manage the cargo shipment efficiently, the operational of "Sea Tollway" program becomes important. Through this program, the Indonesia government also proposed the development of Kuala Tanjung and Bitung as two international hub ports (Baan et al., 2015). Kuala Tanjung and Bitung will serve the import and export cargo for western and eastern Indonesia respectively (Lazuardi et al., 2017). So that the international cargo can be directly transhipped to the international hub closer to the destination, eliminating the process in the main domestic port. By activating Kuala Tanjung and Bitung as own international hub ports, the dependency on neighbouring country ports in distributing international cargo can be reduced.

This research was conducted to analyze the fleet planning for routes serving the "Sea Tollway" program that have been obtained previously by Lazuardi et al. (2017). The network was divided in to two shipping routes, i.e west and east route. The west route will serve the international cargo from Belawan and Tanjung Priok through Kuala Tanjung international port. Meanwhile, the international cargo from Sorong, Makassar, Tanjung Perak, and Banjarmasin will be handled by the east route through Bitung port. Previously, Lazuardi et al. (2017) merely provided a maximum ship capacity of each optimal route without considering the optimum vessel size and the number of vessel required because the main objective for the research is obtaining the optimal routes connecting main domestic ports and international hub ports. However, the trade volume disparity of each port can drives inefficiency if we deploy the wrong vessel size because of low utilization. For route with these characteristics, the network and fleet planning are important factors to improve efficiency that has a direct impact on minimizing unit shipping cost. We developed the linear programming model modified from the Feeder Network Design Problem (FNDP) to choose the right vessel size and number of vessel required for the routes. The rest of this paper is organized as follows. Section 2 provides the literature review for liner shipping network and fleet planning problem. Section 3 explains the FNDP model development for this fleet planning problem. Section 4 gives shipping routes data and calculation for optimize the fleet planning problem then followed by the conclusions on the section 5. The last section provides references used in this study.

2. LITERATURE REVIEW

2.1 Liner Shipping Network

Liner shipping operation has unique characteristics, it has fixed route and schedule, the vessel will operate even without cargo. Profitable and quality of shipping will be determined by the operational performance in which scheduling, vessel size, and vessel routing have influence (Lazuardi et al., 2017). The liner shipping operation must consider economic of scale which suggests deploying a larger vessel to get a cheaper cost. However, if the shipping demand of each port varies greatly, the unit cost of each demand shipped will increase significantly. Therefore, this research field becomes very important.

Takano and Arai (2009) studied the optimization of shipping routes with application of hub-and-spoke network concept. The slot allocation is fixed and comply with all demand in the ports. The other study about slot allocation in liner shipping is conducted by Notteboom and Rodrigue (2008). (Notteboom and Rodrigue, 2008) focused on the slot allocation on routes and the impact on the bunker costs of liner shipping routes optimization. Chao (2009) studied the optimization of container shipping network and operations under changing cargo demand and freight rates. It takes into account the issues about empty container repositioning, ship-slot allocating, ship sizing, and container configuration. A mixed integer non-linear programming problem (MINP) and genetic algorithm are formulated to solve this problem. Furthermore, in 2014, Mulder and Dekker (2014), have developed methods for strategic liner shipping network design combining fleet design, ship scheduling, and cargo routing problem. The research considered the constraint of ship availability in order to find the most profitable route with different approaching levels.

In this research, the vessels must deliver spesific amounts of containers among main domestic ports and international hub ports. It must be prevented that the containers are discharged or loaded on the wrong ports (Lazuardi et al., 2017). Therefore, following the previous research by Lazuardi et al. (2017), the combination of feeder network design problem and multiple commodities problem are being used in this research. A constant number of ship capacity is used so that all of containers can be transported properly. The multiple commodities problem is formulated into cargo allocation constraints. As the results, two optimum routes have been obtained. However to obtain the route, the ship capacity was set into 80,447 TEUs. This research will find the optimum ship capacity and number for shipping routes obtained in Lazuardi et al. (2017).

2.2 Fleet Planning Problem

There have been many studies on liner ship fleet planning (LSFP). The research research can be grouped into three groups (Wang et al., 2017):

- research focuses on an optimal vessel design: determining the number and type of vessels needed – strategic level problems
- research focuses on optimal fleet deployment: assigning ships to every route – tactical level problems

- Research focuses on a joint optimal vessel design and fleet deployment - fleet planning problems.

Song and Yue (2016) developed a rational bi-objective fleet deployment model where the two objection respectively are the minimum cost and maximum capacity. The research considered the effect of fleet deployment with minimum waste on capacity. To solve the problem, a genetic algorithm has been proposed. Most of the time, the demand data for liner shipping is uncertain and lacking in visibility. Thus, several research have been developed in this area. Wang et al. (2017) proposed model and algorithm approach with consider the uncertainty of container shipment demand and realistic annual operating cost and transportation capacity. Ng and Lin (2018) studied the liner fleet deployment problem when only conditional shipping demand information is known. It makes determining the exact optimal solution becomes impossible. A set of complementary upper and lower bounds on the optimal cost are derived by exploiting the problem structure. Zhen et al. (2019) developed a model for fleet deployment and demand fulfillment problem for container shipping liners considering the potential containers overload risk. The risk occured because the containers weight are stochastic. A non-linear mixed integer programming (MNLIP) model considering the fleet size, the available berth and also yard resources at the ports is developed to solve the problem.

3. FNDP MODEL DEVELOPMENT

3.1 Transportation Cost

Shipping cost is the important factor to ensure the operational performance of liner shipping. Commonly, ship operating cost can be classified into four components, i.e maintenance cost, operating cost, voyage cost, and cargo handling cost (Stopford, 2009). Maintenance cost is the cost to cover the maintenance of a vessel according to the standard classification societies and company policy. Operating cost consist of crew, groceries, insurance, lubricating oil, and administration that incurred for the daily operation of the ship. Voyage cost include fuel and port charges. While cargo handling cost incurred when ship has to load or unload container at port. Those costs above are calculated as variable cost, moreover the shipping cost also consist of capital cost as a fixed cost. Capital cost are counted by ship prices at the time of purchase or construction (Lazuardi et al., 2017).

In this research, only costs related to the ship size differences are considered, meanwhile the cargo-related costs are ignored. Ship capital cost, maintenance, and operating cost are calculated as ship charter rate under time charter arrangement. The ship charter rate is applied according to 2015 data of Maersk Broker in Lazuardi et al. (2017) that provide the time charter rate by ship size. Due to the limited charter rate data available, we projected the rate for ships over 5200 TEUs with regression method. Table 1 shows the time charter rate based on ship size used in this research.

Table 1. Time Charter Rate by Ship Size

Ship Size	**Rate**	**harter Rate (IDR/Day)**
650	4969	69.585.876
900	5594	78.338.376
1300	7800	109.231.200
2000	9609	134.564.436

Ship Size	Rate	harter Rate (IDR/Day)
3000	9834	137.715.336
4000	11608	162.558.432
5200	14364	201.153.456
6000	15838	221.801.019
7000	17726	248.232.282
8000	19613	274.663.545
9000	21501	301.094.809
10000	23388	327.526.072
11000	25275	353.957.335
12000	27163	380.388.599
13000	29050	406.819.862
14000	30938	433.251.125
15000	32825	459.682.389

Other cost that has to be calculated for the operational cost is fuel cost. As in Lazuardi et al. (2017), the calculation of fuel consumption is by multiplying fuel consumption of main and auxiliary engine with the total operation time (hour) and engine power for both engines (HP). The assumption of specific fuel oil consumption (SFOC) for main and auxiliary engine are 0.22 Liter/HP.hour and 0.293 Liter/HP.hour, respectively. According to Shell Indonesia, the price of HSD (high speed diesel) which is assumed to be used by both engines is IDR 11.800 per liter. Table 2 shows the calculation of fuel cost per hour based on ship size. Because of limitation of the data, both engines power for ships over 2000 TEUs are projected with regression method.

Table 2. Fuel Cost by Ship Size

Ship Size	ME	AE	Fuel Consumption per Hour	l Cost per hour
499	3700	1400	1224	14.445.560
799	5300	1800	1693	19.982.120
999	6900	2200	2163	25.518.680
2000	10200	2900	3094	36.505.660
3000	14621	3923	4366	51.519.592
4000	18824	4883	5572	65.751.236
5000	23028	5843	6778	79.982.879
6000	27232	6803	7984	94.214.522
10000	44048	10642	12809	151.141.096
15000	65067	15441	18839	222.299.312

Source: Modified from Lazuardi et al. (2017)

3.2 FNDP Development

The total cost function for this research is the modification of Lazuardi et al. (2017), elimininating all cargo-related cost and port charges. Thus the calculation of the total cost will be the addition of ship daily charter rate and daily fuel cost. The following calculation is used to determine the total cost. The objective function is to minimize the total cost.

$$TC = \sum_{t=1}^{T} I_t * V_t * (O_t + F_t) * \sum_{i=1}^{N}\sum_{j=1}^{N} d_{ij} \quad \forall\, i,j \in N \tag{1}$$

Where:
I_t : Binary indicator that shows if ship t is used or not
T : Total type of ship
V_t : The number of ship t deployed
O_t : Daily charter rate for ship of type t (IDR/day) F_t : Daily fuel cost for ship of type t (IDR/day) d_{ij} : Travelling time from port i to port j (day)
N : All ports in the same route including main domestic and international hub port

Afterwads, the constraints for the FNDP model are developed. There are 3 categories of constraint, i.e cargo allocation constraints, ship capacity constraints, and vessel indicator constraints. We eliminate the connectivity constraints from Lazuardi et al. (2017), because the routes are already given and we allocate the cargo based on the port sequence in the route.

a. Cargo Allocation Constraints

The multiple commodities problem is applied in this cargo allocation constraints because we have multiple ports with different amount of demands. We must prevent the port from getting the wrong cargo, therefore commodities owned by one domestic port cannot be mixed with another. Thus, in the equations 2-3, the number of container of commodity c transported to port j by ship v (Pijcv) must equal with the demand of that commodity in port j. Equation 4 shows that for containers that belong to other ports except port j itself, the number of containers go-in port j should be equal to the number of containers go-out from port j. So that the constraints will be:

$$\sum_{v=1}^{V} P_{ijcv} = D_j \quad for\ \forall\, j \in N', c = j \tag{2}$$

$$\sum_{v=1}^{V} P_{jkcv} = D_j \quad for\ \forall\, j \in N', c = j \tag{3}$$

$$P_{ijcv} - P_{jkcv} = 0 \quad for\ \forall\, j \in N', c \neq j, \forall\, v \in V \tag{4}$$

$$P_{ijcv} \geq 0 \quad for\ \forall\, j \in N', \forall\, v \in V \tag{5}$$

b. Ship Capacity Constraint

Ship capacity constraint indicates restriction for total container transported should be equal or less than the ship capacity (Qt). We use a homogeneous vessel in this research, so that there will be only one capacity for each type of ship. Vt is the total number of ship type t deployed.

$$\sum_{c=1}^{C} P_{ijcv} \leq Q_t . I_{vt} \quad for \, \forall \, j \in N, \forall \, t \in T \tag{6}$$

$$\sum_{v \in V} I_{vt} \leq V_t \quad for \, \forall \, t \in T \tag{7}$$

c. Vessel Indicator Constraint

This constraint is used to indicate which type of ship deployed. Binary variable I_t will have value 1 if ship type t is deployed, and 0 if otherwise.

$$I_{vt} \leq MI_t \quad for \, \forall \, t \in T \tag{8}$$

4. FLEET PLANNING FOR INDONESIA INTERNATIONAL CARGO ROUTES

4.1 Shipping Routes and Demand for International Cargo

The shipping routes resulted in Lazuardi et al. (2017) are adopted in this research. There are two major routes serving the international cargo demand of six main domestics' ports in Indonesia, i.e west and east routes. West route consists of Belawan and Tanjung Priok main domestic port and Kuala Tanjung as international hub port. The route will begin from Kuala Tanjung to Belawan, then continued to Tanjung Priok and sail back to Kuala Tanjung. East route covers more domestic ports and travel longer distance, but the demand of each port relatively smaller than port in west route, only Tanjung Perak has the biggest deman damong this east route. The voyage begin from Bitung international port to Sorong, then Makassar, continued to Banjarmasin, Tanjung Perak, and sail back to Bitung. The illustration of the routes are shown in Figure 1, where the west route is drawn with an yellow arrow and the east route is drawn with a green arrow. Following, Table 3 shows the travel time of each ports.

Figure 1. The West and East Indonesia International Cargo Shipping Route

Table 3. Travel Time (Day) of Main Domestic Ports and International Hub Ports in Indonesia

Ports	KTJ	BLW	TPR	TPE	BNA	MKS	SRN	BTG
KTJ	10000	0,170139	3,524306	4,996528	4,795139	5,760417	9,576389	7,979167
BLW	0,170139	10000	3,694444	5,166667	4,965278	5,930556	9,746528	8,149306
TPR	3,524306	3,694444	10000	1,520833	2,131944	2,798611	7,298611	5,267361
TPE	4,996528	5,166667	1,520833	10000	1,138889	1,805556	6,305556	4,274306
BNA	4,795139	4,965278	2,131944	1,138889	10000	1,225694	5,475694	3,444444
MKS	5,760417	5,930556	2,798611	1,805556	1,225694	10000	4,774306	2,743056
SRN	9,576389	9,746528	7,298611	6,305556	5,475694	4,774306	10000	2,03125
BTG	7,979167	8,149306	5,267361	4,274306	3,444444	2,743056	2,03125	10000

This research also use demand information projected in Lazuardi et al. (2017). For the projection, the historical data of the international container volumes in 2008 to 2013 are utilized and forecast it until 2025 by using average growth per year (from the last 6-years data). Because all of international containers would be firstly transhipped in the main domestic ports before transported to the international hub ports, they assumed that the total container volumes per region represent the international container throughput in each main domestic port in its region. For the Jawa region, where there are two biggest domestic ports located, assumed that Tanjung Priok port will have proportion of export and import containers at around 70% and 65% respectively, while Tanjung Perak port will have the rest proportion. It is also assummed that the proportion of export and import containers on each region are 60% and 40%, respectively. Lazuardi et al. (2017) used the demand projection in 2015 as input for Pijc, while in this research the 2020 demand projection data will be employed. Table 4 shows the projection demand of export and import containers of each port for this research.

Table 4. The Projection of Export and Import Container (TEUs) per Week by Port in 2020

Port	Export	Import
Belawan	26.360	17.573
Tanjung Priok	78.464	48.573
Tanjung Perak	33.627	26.155
Banjarmasin	674	449
Makassar	932	621
Sorong	359	239

Source: Lazuardi et al. (2017)

4.2 Results of the Fleet Planning Model for Indonesia International Cargo Routes

This sub-section presents the results of the fleet planning model for Indonesia international cargo routes. Moreover, we build and run the model by using Opensolver provided by Microsoft Excel. As described before, we analyze two shipping routes, which are the western and eastern route. The results of fleet optimization of each route are described in the following.

4.2.1 Western Shipping Route

In the western route, the transported containers are for Belawan and Tanjung Priok port. The import containers will be shipped from Kuala Tanjung international port to the destination port, otherwise the export containers are transported from origin domestics port to Kuala Tanjung. The order of shipping destinations on the western route starts from Kuala Tanjung to Belawan, transporting import containers for Belawan and Tanjung Priok. The route continues to Tanjung Priok, transporting import containers for Tanjung Priok and export containers from Belawan. Finally the ship will be back to Kuala Tanjung by bringing the export containers from both Belawan and Tanjung Priok.

We evaluate the total shipping cost of each type of ship, start from 2000 TEUs to 20000 TEUs for this route. The result in Table 5 shows that the minimum shipping cost will be gained by deploying 15000 TEUs ship. The demands of Belawan and Tanjung Priok are not vary greatly, thus employing ship with high capacity will have low impact in utilization. As in Table 5, the greatest utilization is 0.78 gained by deploying ship with capacity 3000, 5000, and 0.78 TEUs. The pattern of shipping cost itself does not always decrease with increasing capacity, but rather experiences several peaks of decline. So that in the specified range of vessel capacity, the lowest shipping cost lies in 15000 TEUs. The optimal number of ship for 15000 TEUs ship capacity is 7 ships.

Table 5. The Optimization Result of Western Route International Cargo Shipping

Ship Capacity (TEUs)	**otal Shipping Cost (IDR)**	**Optimal Number of Ship**	**Average Utilization**
2000	395.801.458.085	53	0,77
3000	355.379.651.484	35	0,78
4000	347.247.322.852	27	0,76
5000	329.068.552.152	21	0,78
6000	330.232.290.427	18	0,76
10000	321.446.488.438	11	0,75
15000	299.723.341.043	7	0,78
18000	305.848.484.464	6	0,76
20000	338.476.993.519	6	0,68

The amount of cargo transported by each voyage is described by Table 6 below. By shipped capacity constraint, we prevent the total cargo transported exceeds the ship capacity. Thus, all of shipment will be under 15000. Both import and export demands in Belawan and Tanjung Priok are fulfilled by deploying 7 ships.

Table 6. The Optimal Cargo Allocation for each Shipment in Western Route

Vessel	Import		Eksport		Cargo Shipped (Pijcv)				Ship Capacity
	BLW	TPR	BLW	TPR	KTJ	BLW	TPR		
1	15000	0	15000	0	15000	15000	15000	<=	15000
2	2573	12427	2506	12494	15000	15000	14933	<=	15000

Vessel	Import		Eksport		Cargo Shipped (Pijcv)				Ship Capacity
	BLW	TPR	BLW	TPR	KTJ	BLW	TPR		
3	0	15000	0	15000	15000	15000	15000	<=	15000
4	0	15000	0	15000	15000	15000	15000	<=	15000
5	0	6146	8854	6146	15000	6146	15000	<=	15000
6	0	0	0	15000	15000	0	0	<=	15000
7	0	0	0	14824	14824	0	0	<=	15000

Total Cargo Shipped	17573	48573	26360	78464
	=	=	=	=
Cargo Demand	17573	48573	26360	78464

4.2.2 Eastern Shipping Route

The eastern shipping route started from Bitung international port to Sorong, bringing all of import cargo for Sorong, Makassar, Banjarmasin, and Tanjung Perak. From Sorong, the voyage continued to Makassar by transporting import cargo for Makassar, Banjarmasin, and Tanjung Perak also the export cargo from Sorong. Afterwards, the voyage will head to Banjarmasin transporting import cargo for Banjarmasin and Tanjung Perak, also export cargo from Sorong and Makassar. The voyage continued to Tanjung Perak delivering import cargo for Tanjung Perak and carrying export cargo from Sorong, Makassar, and Banjarmasin. Finally, the ship will head back to Bitung carrying export cargo from all of domestic ports in eastern route.

As for the western route, we also evaluate the total shipping cost of each type of ship, start from 2000 TEUs to 20000 TEUs. The shipping cost pattern also experiences fluctuation along with the increase in ship capacity. The optimal shipping cost for the route is gained by deploying 2 ship with capacity 18000 TEUs, as shown in Table 7. The deviation of utilization obtained by each ship is higher than western route, because of higher demand variation in eastern domestic ports. Placing Tanjung Perak in the last sequence is the best decision because it will balance the shipment. In Table 7 we can also see that each of peak in declining shipping costs is always followed by an increase in average utilization.

Table 7. The Optimization Result of Eastern Route International Cargo Shipping

Ship Capacity (TEUs)	**Total Shipping Cost (IDR)**	**Optimal Number of Ship**	**Average Utilization**
2000	244.589.466.792	18	0,81
3000	221.701.935.104	12	0,81
4000	210.611.158.221	9	0,81
5000	228.097.643.024	8	0,73
6000	200.291.263.868	6	0,81
10000	212.686.398.365	4	0,73
15000	233.726.257.354	3	0,65
18000	185.502.088.321	2	0,81

Ship Capacity (TEUs)	otal Shipping Cost (IDR)	Optimal Number of Ship	Average Utilization
20000	205.291.810.605	2	0,73

The amount of cargo transported by each voyage is described by Table 8 below. Each shipment will carry cargo below from ship capacity. The total import and export demands of each domestic port are fulfilled by employing 2 vessel with the capacity of 18000 TEUs. Both eastern and western route prefer to use ship with bigger capacity to deliver the shipment, because the daily operational cost is high so reducing the total voyage will be preferable decision.

Table 8. The Optimal Cargo Allocation for each Shipment in Eastern Route

Vessel	Import				Eksport			
	SRN	MKS	BNA	TPE	SRN	MKS	BNA	TPE
1	0	0	0	18000	0	0	0	18000
2	239	621	449	8155	359	932	674	15627

Total Cargo Shipped	239	621	449	26155	359	932	674	33627
	=	=	=	=	=	=	=	=
Cargo Demand	239	621	449	26155	359	932	674	33627

Vessel	Total Cargo Shipped (Pijcv)						Ship Capacity
	SRN	MKS	BNA	TPE	BTG		
1	18000	18000	18000	18000	18000	<=	18000
2	9464	9584	9895	10120	17592	<=	18000

5. CONCLUSION

Indonesia government program of developing Kuala Tanjung and Bitung as international hub ports will reduce the dependence on neighboring countries. Thus, the two shipping routes, western and eastern route, are evaluated to serve the international cargo shipment from six main domestic ports to the proposed international hub. The western route will consist of Kuala Tanjung international port, Belawan and Tanjung Priok, whilst the eastern route will consist of Bitung international port, Sorong, Makassar, Banjarmasin, and Tanjung Perak. The optimal ship capacity and quantity are evaluated to obtain minimum shipping cost.

Both of western and eastern routes prefer to deploy bigger vessel with minimum voyage to serve the shipment. It can be caused by high daily operational cost, though average ship utilization is also considered. The optimal ship for the western route is 7 ships with 15000 TEUs capacity, while for the eastern route is 2 ships with 18000 TEUs capacity. Both routes have average vessel utilization of above 75%, it means the unit cost of shipment is still economical. The result from both western and eastern routes indicates that the shipping cost experiences fluctuation along with the increase in ship capacity, and each of peak in declining shipping costs is always followed by an increase in average utilization. Thus, we can conclude that the average ship utilization affects the total shipping cost.

The result of this research indicates that both routes require bigger ship to transport the international cargo. It has to be evaluated in the future research, whether the use of larger ships in accordance with the port capability, especially for eastern port. Moreover, the western and eastern routes can be evaluated and rebuilded in order to gain better average ship utilization.

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