LINER SHIPPING NETWORK DESIGN IN INDONESIA "SEA-TOLL" AGENDA: TANJUNG PERAK CORRIDOR

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ABSTRACT

The Sea – Toll Agenda is one of the most ambitious initiatives of the Indonesian government to reduce the economic disparity between eastern and western regions in Indonesia. This program provides integrated logistics network for maritime sector in the form of subsidized liner shipping operation. However, after four years of implementation, this network is still underperforming, which concerns some operation issues, such as a high Round-Trip-Voyage (averagely 30 days per voyage). In addition, the budget for Sea – Toll operation is increasing around 45% each year because the government attempts to target more ports for this program. This paper intends to offer a proposed network for the Sea – Toll Agenda to improve its performance in terms of vessel operation and total shipping cost. The methodological approach is built based on the LSND (Liner Shipping Network Design) model to unravel the complex problem of establishing network into three decision levels, i.e., strategic, tactical, and operational. The k-means clustering algorithm accommodated our idea to group the set of port involved in the Sea – Toll Agenda into several clusters based on their distance. Then, a TSP (Travelling Salesman Problem) method is performed to yield the most efficient path to connect all ports and generate the Clustering Network. Some network options (Port Aggregation & Butterfly Hub) and scenarios (additional and backflow cargo) are developed from the Clustering Network to obtain the best-proposed network by comparing them with the current Sea – Toll Network in terms of operation planning and shipping cost performance. Our paper finds that the k-means clustering algorithm and the TSP model can generate a Clustering Network that has a lowest total distance (10,776 nm). However, the Butterfly Hub option offers the lowest total cost among others. This option can reduce about 50% of the total cost and save around 60% of the subsidy compared with the current Sea – Toll Network. Moreover, the proposed network can provide a better regularity (14 days round-trip-voyage) using half of the number of vessels operating on the Sea – Toll option. The finding, obtained from the additional and backflow cargo scenarios, suggests that the government should consider to revoke the policy of goods limitation in Sea – Toll Agenda. Both scenarios are capable of improving the network by providing more subsidy saving (10% lower than proposed network) and a competitive unit cost per TEU (770 USD/TEU) compared to the cost from initial Sea – Toll Network (1,830 USD/TEU).

Keywords: Maritime Logistics, Sea-Toll, TSP, K-Means Clustering.

1. INTRODUCTION

The Sea-Toll concept has already been discussed since 2012 which its original plan was connecting five main hub ports using a pendulum route from the western regions to the eastern regions (Transportation Directorate, 2015). Unfortunately, the program was formally launched in 2016 and the pendulum concept was transformed into several route networks, such as hub-and-feeder, circular, and short pendulum route. That happened because the number of ports, which are targeted in this program, increase every year.

The alteration of the network was based on a yearly evaluation. The government had an agenda in maximizing the number of ports which are served by the Sea – Toll Program to expand the subsidized area for a less developed regions (eastern regions and outermost islands). However, the problem arising from such a policy was the length of Round-Trip-Voyage (RTV) because there are some additional ports that should be visited and the vessel should sail in a longer distance. Likewise, both supply and demand to a port destination were low considering a few populations and the small-scale of industry in that area. This condition triggers the government to arrange an efficient Sea – Toll network that can supress the total operation cost.

Table 1. Sea-Toll Network Comparison

Parameters	Before 2016	2016	2017	2018
No. Hub/Main Ports	5	3	3	3
No. Feeder Ports	0	29	39	58
Network Design	Pendulum	Hub - Feeder	Hub - Feeder Circular	Pendulum Circular Hub - Feeder

Realizing the problem between the west and the east development, this paper attempts to answer the following research question "To what extent the Liner Shipping Network Design approach will improve the performance of Indonesia "Sea-Toll" Agenda in Tanjung Perak Corridor in terms of operation planning and total shipping cost?"

2. RESEARCH FRAMEWORK

The paper begins with the study regarding Sea – Toll Agenda context. All findings from the observation is used as input for initial network establishment, such as port involved, goods transported and freight rate scheme. Aside, a set of data, i.e. port location data, is needed for determining an initial distance between ports. Moreover, demand estimation is calculated as the result of a lack of data from some non-commercial ports. This forecasting is used for estimating cargo flow between regions.

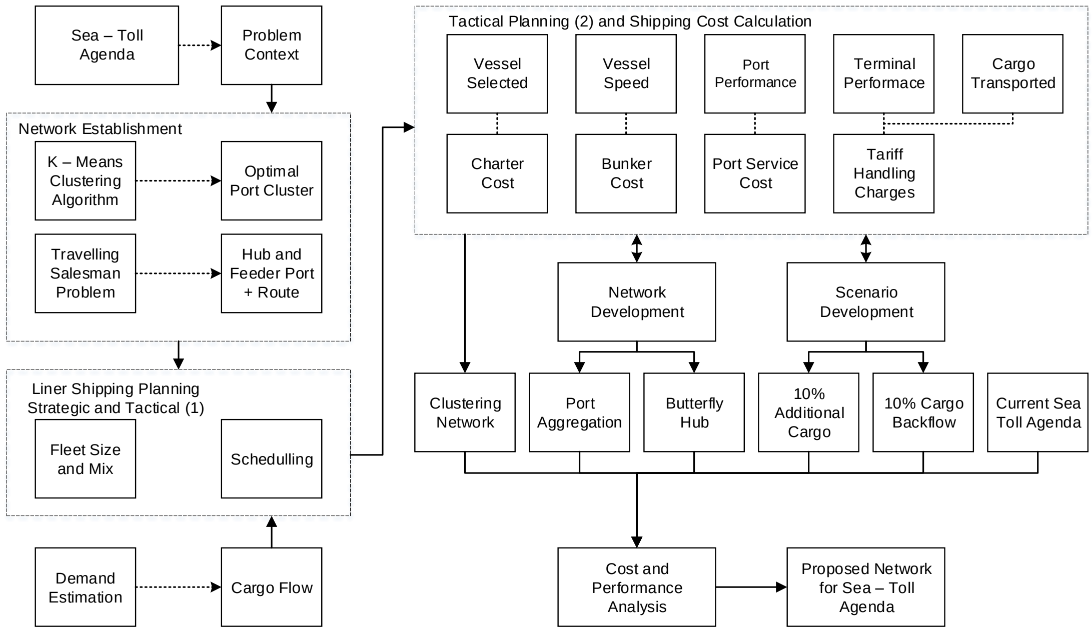

Figure 1. Research Framework

Once the network is established by using K-Means Clustering algorithm and Traveling Salesman Problem, liner shipping planning for each strategic, tactical, and operational level is begun to calculate (Mulder & Dekker, 2013). This activity will reveal clustering network operation and cost which will be compared with other network options and scenarios. The cost and operation performance for those new possible networks will be assessed by the Liner Shipping Network Design problem (Mulder & Dekker, 2018). Lastly, all networks will be analysed to obtain the research objectives.

3. SEA-TOLL AGENDA

In order to adjust the price of basic need within the country, the government establishes one strategic program in maritime logistics sector which is called "Sea – Toll "Agenda. The other crucial goals of the program are intending to ensure goods distribution and growing the trade of indigenous product from a remote region by setting subsidized liner shipping operation (Ministry of Trade Republic of Indonesia, 2014). Thus, the primary role of liner shipping was to deliver the goods and fulfil the demand for nearby population regularly to prevent a shortage. To implement the program, there are three entities involved; the government (Ministry Trade and Ministry Transportation) as the regulator, Pelindo as port operator, and Shipping Lines as vessel operator.

3.1 Port Involved

Some ports are chosen based on distance from an urban region, price index in a nearby area and regularity visitation by commercial shipping line. Because the program intends to reduce the price disparity, therefore, ports with some characteristics; high price index, remote or far from the main city, and rarely visit by commercial shipping, are chosen.

Figure 2. Port Involved in "Sea-Toll" Agenda 2018 (Own Illustration)

3.2 Current Route

Furthermore, the government also sets the route and the price to deliver the container from origin port to destination port. Since implemented in 2016, the route was evaluated and changed every year. The last arrangement for 2018 is including 15 routes which are involved all seaports mentioned and several types of network.

Table 2. Sea-Toll Route

Route	Port Visited	Network*	Operator
T-1	Teluk Bayur – Pulau Nias – Mentawai – Pulau Enggano – Bengkulu	Pendulum	PT ASDP
T-2	Tanjung Priok – Tanjung Batu – Blinyu – Tarempa – Natuna – Midai – Serasan – Tanjung Priok	Circular	PT Pelni
T-3	Tanjung Perak – Belang-Belang – Sangatta – Nunukan – Pulau Sebatik – Tanjung Perak	Circular	PT ASDP
T-4 Hub	Tanjung Perak – Makassar – Tahuna	Pendulum	PT Pelni
T-4 Feeder	Tahuna – Kahakitang – Buhias – Tagulandang – Biaro – Lirung – Melonguane – Kakorotan – Miangas – Marore – Tahuna	Circular	PT Pelni
T-5 Hub	Tanjung Perak – Makassar – Tobelo – Tanjung Perak	Circular	In Tender
T-5 Feeder	Tobelo – Maba – Gebe – Obi – Sanana – Tobelo	Circular	In Tender
T-6	Tanjung Perak – Tidore – Morotai	Pendulum	PT Pelni
T-7	Tanjung Perak – Wanci – Namlea – Tanjung Perak	Circular	Mentari Line
T-8 Hub	Tanjung Perak – Biak – Tanjung Perak	Circular	In Tender
T-8 Feeder	Biak – Oransbari – Waren – Teba – Sarmi – Biak	Circular	In Tender

Route	Port Visited	Network*	Operator
T-9	Tanjung Perak – Nabire – Serui – Wasior – Tanjung Perak	Circular	Temas Line
T-10	Tanjung Perak – Fak-Fak – Kaimana – Tanjung Perak	Circular	In Tender
T-11	Tanjung Perak – Timika – Agats – Merauke – Tanjung Perak	Circular	Temas Line
T-12	Tanjung Perak – Saumlaki – Dobo – Tanjung Perak	Circular	Meratus Line
T-13	Tanjung Perak – Kalabahi – Moa – Rote – Sabu	Pendulum	PT Pelni
T-14	Tanjung Perak – Loweleba – Adonara - Larantuka	Pendulum	PT Pelni
T-15	Tanjung Perak – Kisar – Namrole – Tanjung Perak	Circular	PT Pelni

3.4 Goods Transported

Aside of route, the government strictly regulated type goods can be transported using Sea – Toll service. The reason was that the government attempted to give the subsidy only to primary needs. Other goods which were not considered in the document of Presidential Decree number 71 the year 2015 was prohibited to use the vessel in the Sea – Toll route.

Table 3. Regulated Goods for "Sea-Toll"

Regulated Goods for Sea – Toll Agenda	
Rice	Fertilizer
Soybeans	Kerosene
Chili	Plywood
Shallot	Cement
Sugar	Construction Steel
Cooking Oil	
Wheat Flour	
Beef	
Chicken Meat	
Chicken Eggs	
Fish	
Seeds (rice, corn, and soybean)	

4. NETWORK ESTABLISHMENT AND SCENARIOS

Some network options are developed to improve the performance of the network established by the clustering method. It is because the clustering approach and the TSP method might produce a suboptimal output. Then, all options will be compared with the current Sea – Toll network operation. Some options that will be considered are the clustering network which established from k – mean clustering and TSP model, port aggregation model, and butterfly route. Further network consideration will try to realize the scenario of additional demand flow. This scheme may happen if the government liberalize the type of cargo that transported by the Sea-Toll program. It means that some shippers will try to deliver more cargo using this program. The following are the detail explanation of each network option for comparison and the scenarios.

4.1 Current Sea-Toll Network

This network is used as the basis performance of overall network. For the calculation, the routes and some vessels are already set based on latest Sea – Toll operation, such as tender, etc. Some parameters, which is not set, will be assumed, i.e. vessel in route which is still in tender process.

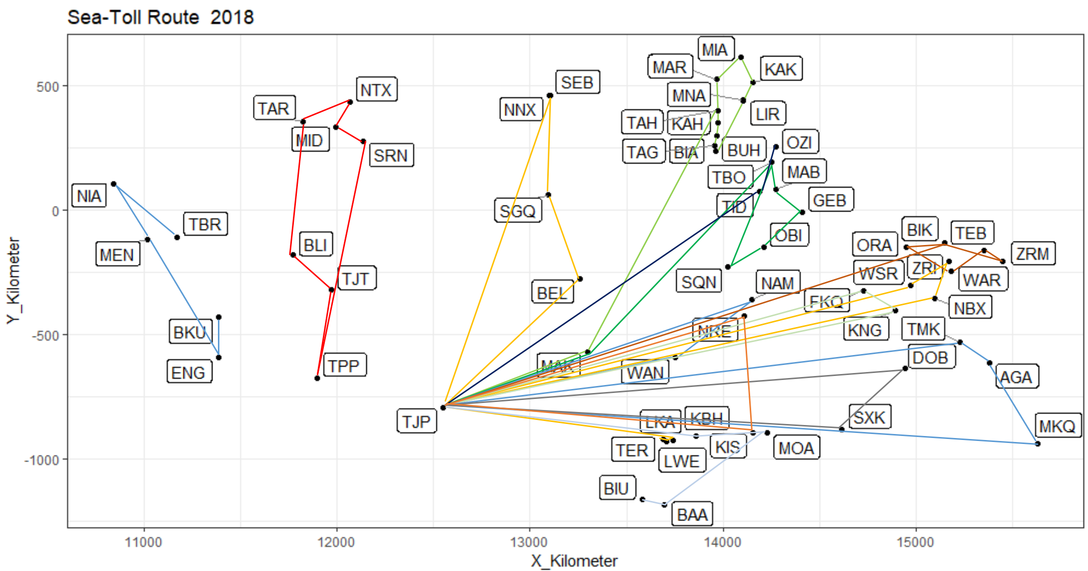

Figure 3. Current "Sea-Toll" Network

Looking at the network, the current Sea – Toll Agenda can be grouped by hub-and-spoke and non-hub-and-spoke route. Some groups of port situated quite far, such as the port in North Sulawesi archipelago and northern of coast Papua, will be reached by one direct service to hub port, then connected by feeder voyage in the circular route. The other routes structure is circular and pendulum, but with the only small number of port calls. Thus, the logical result of this network is the higher number of vessels deployed because of the high number of the route.

4.2 Clustering Network

The location of 49 ports involved in this scope of the thesis is scattered in the eastern region of Indonesia. Providing a direct route will be not considered. It is because the policy will yield a super capital intensive considering the low demand and long-distance journey. Therefore, the k-means clustering algorithm is performed to separate the ports based on their distance.

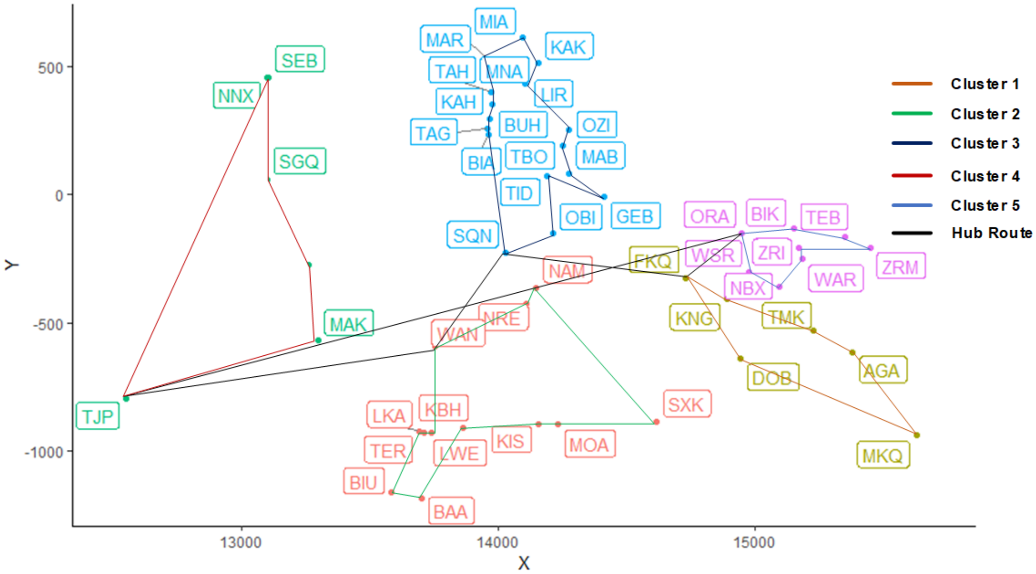

Figure 4. Clustering Network

The solution from k-means suggests the network to group in five clusters. We choose the TSP method as an approach to yield the route. Then, six circular routes are generated. The clustering network reduces a half route from current Sea – Toll Agenda. The reduction will impact in some operational planning such as minimum vessel deployed. However, the distance in one cluster possibly can be higher than the current network. It is because the additional bunker cost (high speed to maintain schedule) or additional chartering cost (more vessel to add the frequency).

4.3 Clustering Network with Port Aggregation

After establishing the clustering network, some considerations are taking into account, such as cargo flow estimation to the port destination. In this network, we will ignore some ports which have a demand less than ten containers a month. Then, we assume there will be another service using local shipping line to the port destination.

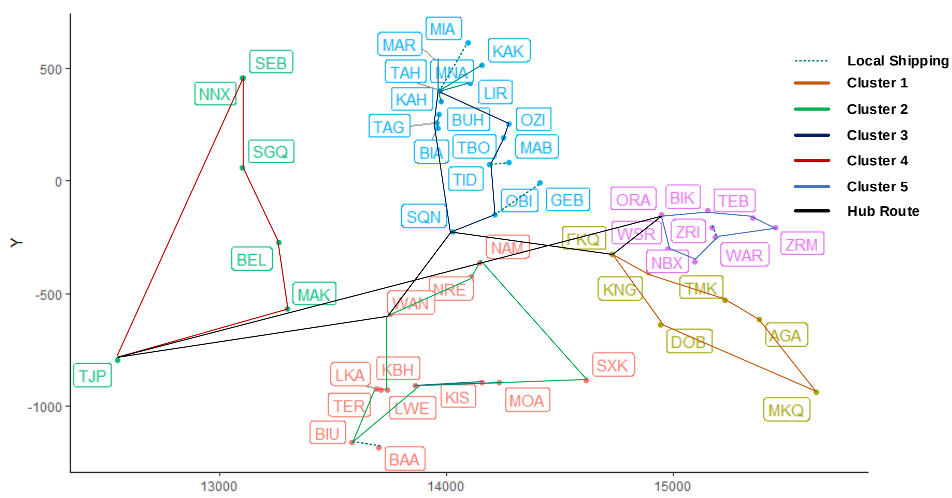

Figure 5. Clustering with Port Aggregation

In the Port Aggregation Network, we will introduce second level feeder port which plays a role in providing service for ignored port. We assume there is a local shipping line delivering the cargo directly to the destination. The assumption is based on the study by Muhana (2017). He investigated the importance of local shipping (*pelayaran rakyat*) to provide the service between ports, some of them are low demand ports.

4.4 Clustering Network + Port Aggregation with Butterfly Hub

From the last network development (reducing of feeder port), we consider that the main hub has a long travel distance. Therefore, we develop a Butterfly Hub which will deploy two vessels to provide a service for the main hub. This network structure will have a route that combines Clustering Network and Port Aggregation.

In this network, main hub route will be separated become two routes. The route selection is evaluated by examining all route combination possibilities concerning the total distance. The reason choosing distance as a parameter is because it is related with the shipping cost performance, especially bunker cost. The distance closely related with bunker consumption which will influence the fuel cost.

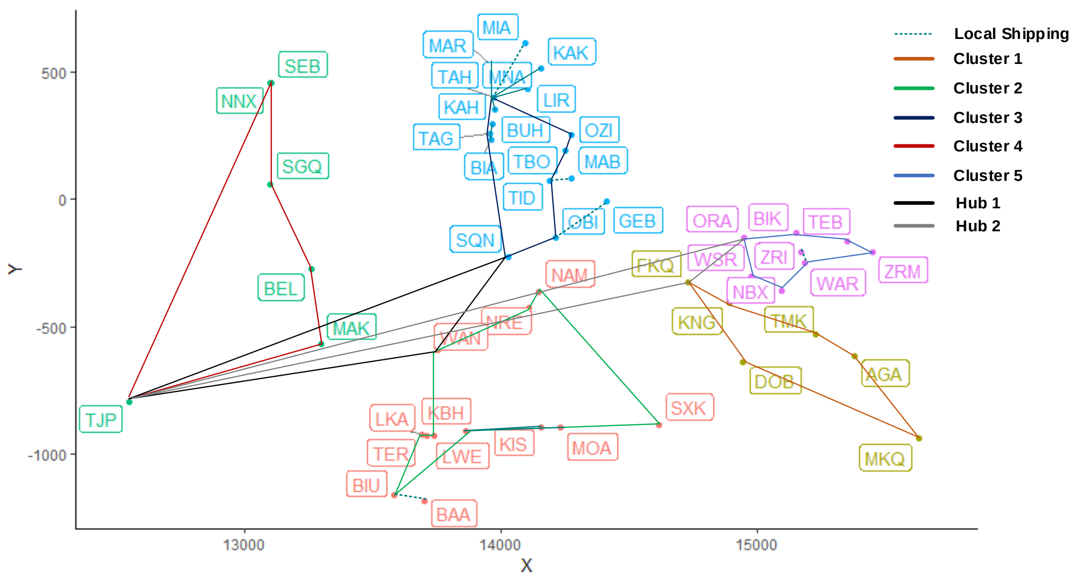

Figure 6. Clustering Network + Port Aggregation with Butterfly Hub

4.5 Butterfly Hub Network with 10% Additional Cargo (Scenario 1)

After we perform the comparison between four network options (Sea – Toll, Clustering, Port Aggregation, and Butterfly Hub), this scenario will use latest network option, which is the Butterfly Hub, to see the impact of 10% additional cargo because of liberalization goods transported. This scenario will be named Scenario 1.

4.6 Butterfly Hub with 10% Backflow Cargo (Scenario 2)

This scenario is a continuation of Scenario 1 (10% additional cargo). In this scenario, we will see the impact of 10% additional backhaul cargo that delivered to the main port (Tanjung Perak). This scenario will examine based on Butterfly Hub operation and it will be called as Scenario 2.

The scenario is based on the possibility of the growth from the outer island because of trade. Moreover, because of the Sea – Toll Agenda, the outermost island obtain an infrastructure to sell their product to the main market (Java).

5. DATA

To run the model and obtain the result, some data are required as an input. This section will present the data and its source. Some data will be estimated as because of a limitation to finding a reliable source, such as cargo flow value. Therefore, some proxies are applied to predict the real data. Table 4 below provides the list of data and its source.

Table 4. Data and Sources

Data	***Source***
Sea – Toll Agenda regulatory framework	Trade Law Number 7 about Market Integration, Ministry of Trade, Republic of Indonesia
Sea – Toll Agenda operational plan	Ministry of Transportation Regulation regarding Cost and Revenue Component for Subsidy Activity in Maritime Transport.
Port Location	Google Maps
Ship Particular	Clarkson Market Intelligent
Cargo Flow in Sea – Toll Agenda	Directorate of Maritime Transport Report 2017, Ministry of Transportation Republic of Indonesia
Population	Indonesia National Statistics Bureau
Average Daily Expenditure	World Bank, Global Consumption Database
Consumption rate	World Bank, Global Consumption Database
Price of Sea – Toll Goods	Early Warning System Ministry of Trade Republic of Indonesia
Shipping Line Service	Each Shipping Line Website
Berthing Fees	Pelindo III Port Data, Adopted from Adiliya (2017)
Anchoring Free	Pelindo III Port Data, Adopted from Adiliya (2017)
Pilotage Fees	Pelindo III Port Data, Adopted from Adiliya (2017)
Tug Fees	Pelindo III Port Data, Adopted from Adiliya (2017)
Terminal Handling Charge	Pelindo III Port Data, Adopted from Adiliya (2017)
Fuel Price	Fuel Price Information Website (Pertamina)
Charter Cost	Pelindo III Port Data, Adopted from Adiliya (2017)
Freight Rate for Sea – Toll Network	Ministry of Transport Regulation regarding Public Service Obligation

6. RESULT

This section will be dedicated for presenting the shipping cost in every option and scenario. The result becomes an indicator to decide the proposed network for Sea – Toll Agenda. For the general point of view, Table 5 presents the summary of the total cost, revenue, and subsidy for every network in USD/year.

Table 5. Shipping Cost Calculation

Parameter	*Unit*	*Sea Toll Network*	*Clustering Network*	*Port Aggregation*	*Butterfly Hub*
Total Cost	USD/Year	24,260,741	14,730,406	14,165,721	11,816,957
Bunker Cost	USD/Year	13,884,351	7,865,805	6,916,513	4,991,386
Port Cost	USD/Year	323,678	126,071	107,808	110,102
Terminal Handling Cost	USD/Year	1,139,852	2,054,184	2,052,670	2,052,670
Charter Cost	USD/Year	8,912,860	4,684,346	4,684,095	4,258,164
Additional Service Cost	USD/Year	-	-	404,636	404,636
Revenue	USD/Year	5,077,738	5,077,399	5,039,337	5,039,337
Subsidy	USD/Year	18,332,701	9,653,007	9,126,380	6,777,621
Unit Cost	USD/TEU	1,837	1,115	1,077	898

It is clear that in terms of subsidy Butterfly Hub is the most preferable network among all options. Developing the network from the clustering option reduces the subsidy gradually. This result is in line with the decline of total shipping cost.

In terms of unit cost, the Butterfly Hub yields the lowest unit cost per TEU, around 900 USD/TEU. This network can reduce about 50% of unit cost comparing with the Current Sea – Toll Network. It is because, with the similar number of containers transported, Butterfly Hub can keep a lower cost than their options.

The first scenario simulates the possibility when the government revokes the policy concerning the limitation of goods. We assume that there will be 10% more containers within the network. By using the most preferable option (Butterfly Hub Network), the regulation will increase by about 500,000 USD of total revenue per year, yet it will also increase the total cost by around 700,000 USD. Therefore, this scenario will result in the higher subsidy for the route.

When the second scenario is applied (10% additional backflow cargo), we found that the network performs better in terms of revenue. There is extra revenue, around 800,000 USD in a year, without any significant additional costs. The bunker cost remains at the same level because backflow cargo only changes the proportion of empty and full container. Accordingly, the terminal handling cost is increasing because of the additional full container movement. The summary of the shipping cost calculation can be seen

Table 6. Shipping Cost Comparison in Two Scenarios

Parameter	*Unit*	*Butterfly Hub*	*Scenario 1*	*Scenario 2*
Total Cost	USD/Year	11,816,957	12,313,348	12,533,682
Bunker Cost	USD/Year	4,991,386	5,192,374	5,192,374
Port Cost	USD/Year	110,102	111,749	111,753
Terminal Handling Cost	USD/Year	2,052,670	2,264,543	2,318,685
Charter Cost	USD/Year	4,258,164	4,259,021	4,259,021
Additional Service Cost	USD/Year	404,636	485,662	651,849
Revenue	USD/Year	5,039,337	5,565,929	6,353,869
Subsidy	USD/Year	6,777,621	6,747,419	6,179,813
Unit Cost	USD/TEU	898	846	771

7. CONCLUSION

Butterfly Hub option is the considered as a proposed network for Sea Toll - Agenda. This network offers a lowest total shipping cost for all components. Comparing with the current Sea – Toll Network, this option can reduce about 50% of total cost and save around 60% of the government subsidy for the Sea – Toll Agenda. Butterfly Hub route structure allows the decrease in bunker cost (65% fuel cost saving). It is because the container flow is separated into two routes and lead to a reduction of optimum vessel speed. This network will provide service once in two weeks using total seven vessels (one vessel per route). This operation provides a better regularity by using less vessel than the current Sea – Toll Network (16 vessels).

8. ACKNOWLEDGEMENT

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