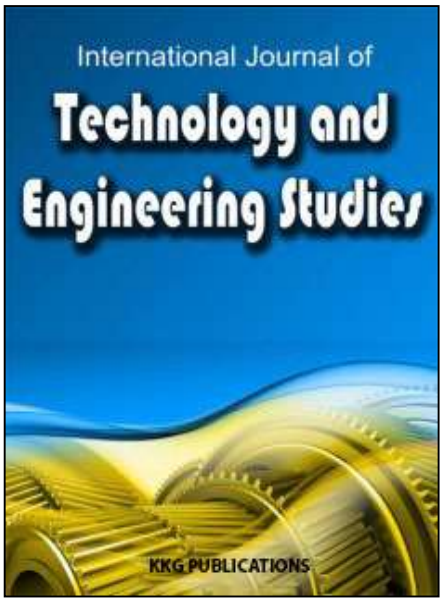

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Sea Shipping Network Structures Identification and Analysis in Indonesia

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SEA SHIPPING NETWORK STRUCTURES IDENTIFICATION AND ANALYSIS IN INDONESIA

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Abstract. This study aims to identify the structure of the sea transportation network in Indonesia, which is hub and spoke network and multicell network as the types of the common transportation network in the logistics system and to analyze the existing network models. This study attempted to identify structures of the existing sea shipping network of liner companies in Indonesia. The method used was the descriptive method, which involved observational studies of people in a sea shipping environment. They were surveyed and interviewed to collect the necessary information and analyze the existing records of liner companies. Secondary data were given by the Directorate General Sea and Transportation of the Minister of Transportation of Indonesia. The results showed that more than 80% of liner companies in Indonesia implemented the hub and spoke call network, while others implemented the multicell network. Indonesia should develop an integrated sea shipping network model to optimize the national logistic system as a maritime country. This study rendered useful insights and suggestions for Indonesian shipping network companies.

INTRODUCTION

A transportation network is a realization of a spatial network, describing a structure which permits either vehicular movement or flow of some commodity. The sea shipping transportation system, a type/form of transportation networks, refers to a network of specialized vessels, the ports they visit, and transportation infrastructure.

Sea shipping networks are built to meet the growing demand in worldwide supply chains in terms of frequency, direct accessibility and shipment duration. Growth of traffic has to be covered either by increasing the number of sequence operated, or by vessel upsizing, or both. As such, increased cargo availability has triggered changes in vessel size, liner service schedules and in the structure of sea shipping.

When designing their networks, shipping lines have to make a trade-off between the requirements of the customers and operational cost factors. A higher demand for service segmentation enhances the expanding complexity of the networks. Shippers require direct services between their preferred ports of loading and unloading. The demand side thus exerts a strong pressure on the shipping schedules, port rotations and feeder linkages. Shipping lines, nevertheless, have to design their liner services and networks in order to optimize ship utilization and gain the most from scale economies in vessel size. Their objective is to optimize their shipping networks by rationalizing coverage of ports, shipping routes and transit time [1], [2]. Shipping lines may direct flows along paths that are optimal for the system, with the lowest cost for the entire network being achieved by indirect routing via hubs and the amalgamation of flows. However, the more efficient the network from the carrier's point of view, the less convenient that network could be for shippers' needs [3].

There are a considerable amount of literature on transportation network models. Consider, for example, studies conducted by [4], [5] and [6]. [7] formulates cost functions and constructs a two-objective model to analyze routing decision on providing shipping services in a hub-and-spoke network as compared to direct or multicall network. Their result studies intended on general network applied for world shipping network. There were few studies about sea shipping transportation network in local region or in maritime country, such as Indonesia.

Indonesia is an archipelagic country with vast water, but the lack of infrastructures to support the flow of goods is actually a challenge for logistics service providers. Currently, in national logistics system, road transport contributes 91.25%, railways (0.63%), and crossing 0.99% [8]. Meanwhile, the sea transportation only contributes for 7.07%, 0.05% of air transportation and river transportation 0.01% [8]. The data show that the role of the land transportation is still very dominant in the national logistics system which cause the expensive distribution costs, 30% of the price. The role of sea transportation is not optimal due to the port infrastructure in Indonesia is still largely inadequate. Based on the Ministry of Transportation, the majority of existing ports currently are only able to accommodate small

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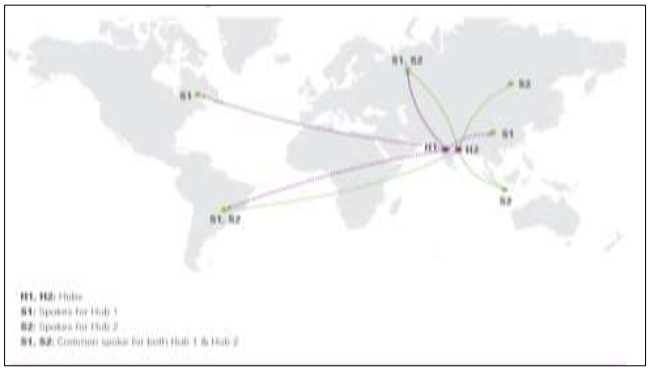
vessels below 1,000 TEUs. In fact, to reduce the logistics cost, other developed countries are using large-sized ships.

Therefore, we need to pay attention to supply chain system in Indonesia by optimizing sea transportation, improving port infrastructures and implementing a distribution strategy through sea shipping transportation network. This study aims to identify the structure of sea transportation network in Indonesia, which is hub and spoke network and multicall network as the types of common transportation network in the logistics system, and analyzing the existing network models.

LITERATURE STUDY

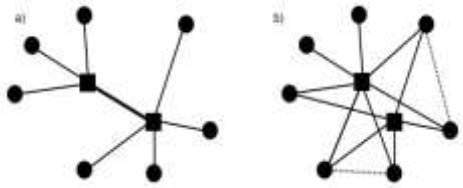
According to [9], people use ocean shipping container to maximize the profits. Hub & Spoke has a major role in shipping containers. Hub is the main consolidator in the multi-resource area and Spoke is the destination or a branching of each hub. So it is simpler to say that hub is the central area and spokes are destination. Hub area can be a port for sea transportation, airports for air transportation, or can be a collecting goods terminal.



Source: KPMG in India analysis – Hub and spoke operating model, 2012

Fig. 1. Example of hub and spoke network

For sea or harbor transportation hub and spoke network is a network pattern which has one or more ports as hub ports in the destination area based on the location and request of delivery goods [7]. The transported cargo will be consolidated in the hub port and then transported by large ships (mother vessel) which provide services between hub ports in both regions. Meanwhile, to provide service between hub port and the small port using a small-sized vessel (feeder vessel). According to [10], hub and spoke itself is divided into two types. Both types are often found in a lot of logistics companies in the world. The hub and spoke is divided by shape or topology, or we can say it is divided by the distribution channel. The distribution is as follows:



Source: [10]

Fig. 2. Type of Hub and spoke network: a) Type 1, b) Type 2

a. Hub and Spoke Type 1

Type 1 distribution system adheres to pure hub and spoke methods, where the secondary areas can only be connected by primary area. So if the secondary area which is located in the primary area A wants to send the goods to the secondary in the primary area B, the goods must first pass through the primary area A to be delivered to the primary B, then distributed to the secondary which is aimed. Likewise, if the secondary area 1 which is located in the primary area A wants to send goods to the secondary area 2, which is also located in the primary area A, then the goods must pass through the primary area A so that each secondary area has no connection.

The companies that are suitable to use hub and spoke type 1 are the logistics companies whose product prices are not too expensive and have a very wide distribution area such as JNE, FedEx, ESL, Tiki and DHL. These companies compete to

provide the best service and prices for their customers. So that with a low price, they can provide delivery services over the country or even the whole world. To minimize costs, the items collected will be gathered on the primary region, then sent to another primary area and then distributed to the secondary area. For example the delivery service in JNE. The goods which are going to be shipped from all over Jakarta are gathered in Tomang (JNE Center), then sorted and sent to Surabaya to be distributed from Surabaya to Banyuwangi, Madiun, Pacitan, and others.

b. Hub and Spoke Type 2

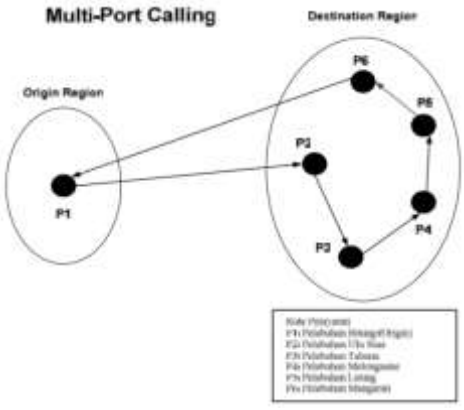
In hub and spoke type 2, several secondary areas have a connection with each other. So the process of the distribution of secondary areas does not always have to pass through the primary area. In addition, several secondary areas are also under several primary areas. So the distribution system is more flexible and does not take time as long as type 1.

The companies that use type 2 hub and spoke usually are airline or other transportation companies, such as Transjakarta. For example in airlines, to make the flight from Jakarta to Australia destination can be reached by three flight routes. First is Jakarta-Singapore-Australia (Singapore is the primary transit area, while Jakarta and Australia are the secondary areas). The second is Jakarta-Bali-Australia (Bali is the primary transit area, while Jakarta and Australia are the secondary areas). The third is Jakarta-Australia or direct flight (Jakarta and Australia are secondary areas). So the two primary areas have the same secondary areas (Bali and Singapore oversee Jakarta and Australia) and the direct flight which linked the two secondary areas (Jakarta and Australia).

According to [11], the geographical location of the Republic of Indonesia (RI) is very strategic because it lies at the intersection between the two continents, Asia and Australia, as well as two Oceans, the Pacific and Indian Ocean. Because Indonesia is an archipelagic country, the role of sea and air transportation is very important for Indonesia. The higher the economy activity of a region and the more integrated the region's economy, the higher the activity of loading and unloading and demanding the large capacity and technologically modern sea port infrastructures. The unprevalence of economic activity in a country causes various classes of ports in the country. Indonesia's main ports (Tanjung Priok, Tanjung Perak, and Belawan) are located in the western region with higher economic activities than the eastern region.

One of the factors that determine the development of port is the international shipping lanes that will be passed by ships from around the world [11]. The ships come from the Indian Ocean heading to Far East Asia will cross Indonesia territorial through the Strait of Malacca, Sunda Strait, Lombok Strait, and Timor Strait. Most of the ships go through the Strait of Malacca and the Sunda Strait because they are the closest. While the ships going through the other two entrances are not too many and usually are large ships like supertanker. These conditions will obviously be very beneficial for Tanjung Priok Port and Belawan Port, while Tanjung Perak Port will be the distribution port for the eastern region of Indonesia. In order to fix the condition of our national port, National Transportation System (SISTRANAS) mentioned that Indonesian port hub is divided into international hub, national hub, and spokes, Tanjung Priok and Tanjung Perak will be the international hub.

Multicall network is a network pattern in which the goods shipment activity does not require any hub port or the connecting port [12]. The cargo is directly transported from the port of origin to the port of destination, both large and small harbor port [12]. The network patterns can be seen in the following figure:



Source: [12]

Fig. 3. Example of multicall network

Multical network distribution system used in a ship has several requirements for the planning of the transportation route in the multiport concept that are as follows:

- The ship has to return to the origin port. The ship will be refuelled in the destination port.
- Every destination port only will be visited once by the ship.

The activity for multiport calling is not relying on other ship so the activities of basic commodities supply will continue according to the schedule.

METHOD AND MATERIALS

This research is collecting primary and secondary data and information about sea transportation. The primary data is collected directly by researcher while the secondary data is obtained from related institutes or publications. The collecting data activity starts with collecting the secondary data by listing all the ministries and associations that have data about the transportation network and the shipping companies with local and international routes. The ministries and associations are:

- Minister of Transportation
- INSA (Indonesian National Shipowners' Association)
- Coordinating Ministry for Maritime Affairs
- Indonesian Logistics Association
- ALFI/ILFA (Asosiasi Logistik dan Forwarder Indonesia/ Indonesian Logistics & Forwarders Association).

From the data collected by ALFI/ILFA, there are 672 shipping companies in Indonesia. Next step is doing survey to the companies on the list. Direct, phone, or by email interview is done to get the primary data. The questions are about the services that the company provides, the infrastructures and equipment of the companies, especially the numbers of the vessels, routes, sailing frequencies, shipping volume, and other related information. The secondary data are gathered by the company websites or from Directorate General Sea and Transportation of Minister of Transportation of Indonesia. Total there are 167 primary and secondary data which have been obtained.

The next step of the research is making the structure of sea transportation network model from each company and the whole structure of logistics network model to get the proportion of each sea shipping transportation network, hub and spoke network and multicall network. Analysis of the identification result is descriptive analysis. Furthermore, the study also synthesizes the weaknesses and shortcomings of each type of network and what are the implications of sea shipping transportation network of the national logistics system in Indonesia as a maritime country.

RESEARCH FINDING

According to the 167 data gathered, data processing is done to get proportion of each sea shipping transportation network, the hub and spoke and multicall network. Figure 4 shows the data proportion.

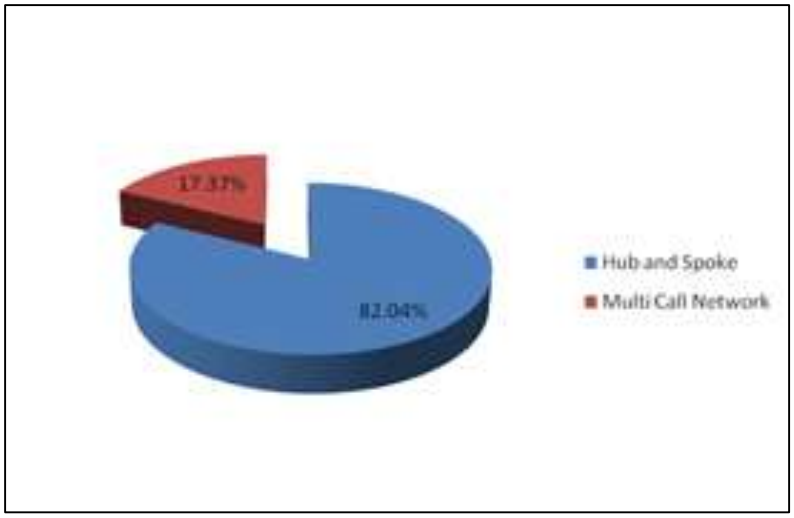


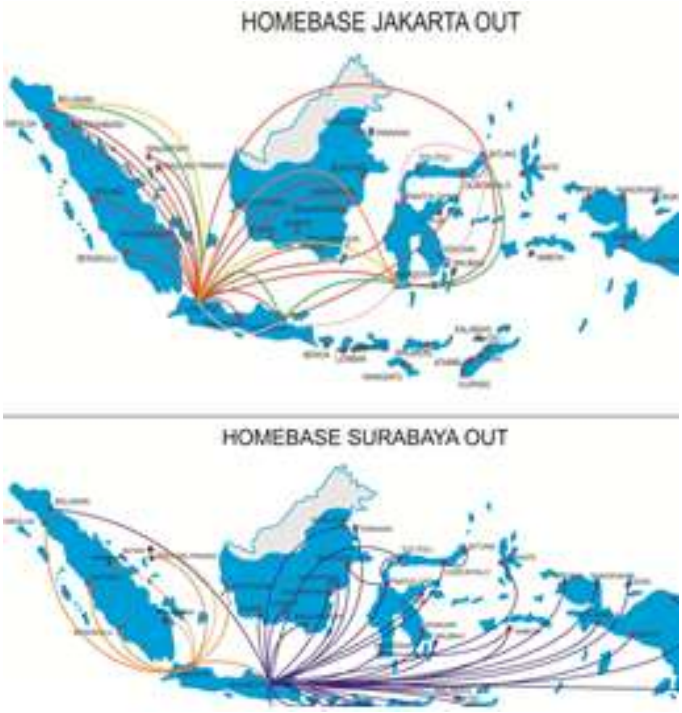
Fig. 4. Proportion of sea shipping network structures in Indonesia

The results showed that more than 80% of liner companies in Indonesia implemented the hub and spoke call network, while others implemented the multicall network. This confirms the results of [7] research which states that most of container carriers continuously provide their services using hub-and-spoke networks.

A. Hub and Spoke Network

Hub-and-spoke network takes economic advantage in scale utilization of conveyance. It can also improve customer service through increased delivery frequency [13]. When using a direct distribution system, small suppliers have to wait until the amount reaches the maximum capacity of cargo transports to

minimize transportation costs because the transportation costs for transports with a maximum charge amount equal to the transportation cost for cargo transports with no maximum amount. If the system uses a hub-and-spoke, cargo transported is consolidated in the hub ports and then transported by large ships / mother vessel which provide services between hub ports, while to provide service from the port to the spoke using a small boat / feeder vessel [12]. This optimizes the existing capacity. The following is a mapping of a hub and spoke network:



Source: Indonesian National Shipowners' Association (INSA)

Fig. 5. Hub and spoke network structures in Indonesia

Hub-and-Spoke system will ease tracking of goods that will be distributed. All distribution channels have to go through the hub port before being distributed to the spokes. This system also delivers efficiency to shorten the distance for consumer communication lines with the manufacturer so as to improve the quality of service and being able to reduce the distribution complexity [13].

In some cases the system of hub-and-spoke precisely produces a longer distance when the goods could be immediately distributed without the need to go through a hub port. Hub can be a problem in the distribution network itself. The total distribution capacity is limited by the capacity of the hub. Delays in the hub will cause delay in the overall network. That's why it is necessary to have good scheduling system by expert workers because the scheduling system in the hub is quite complex.

B. Multicall Network

Multi call system network has the advantage of time efficiency because the operating schedule of the ship is not dependent on other vessels so the supply can run smoothly. Risk of cargo lost or damaged can be avoided.

Compared with hub-and-spoke system of which all schedules are dependent on the ship master schedule at the hub port, ship schedules multicall distribution network which is more flexible. But sometimes by using multicall network system will not lead to optimal utilization of ships capacity because the products are distributed directly to the port of destination. If you want to maximize the capacity of the ships, it will increase the waiting time, thereby reducing the efficiency of existing distribution channels and greater transportation costs are caused by the unoptimal capacity usage.

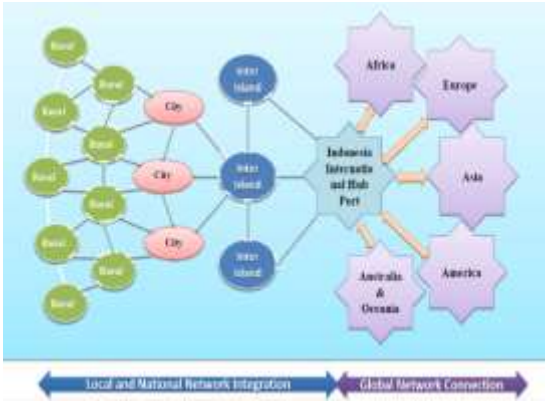
By using multicall network system, in some cases it can shorten the distance distribution because distribution can be done directly to the port of destination without passing through a longer route. The following is an example of the network structure on the Indonesian multicall ship-owners' company:

Source: Indonesian shipowners' company

Fig. 6. Multicall network structures in East Indonesia

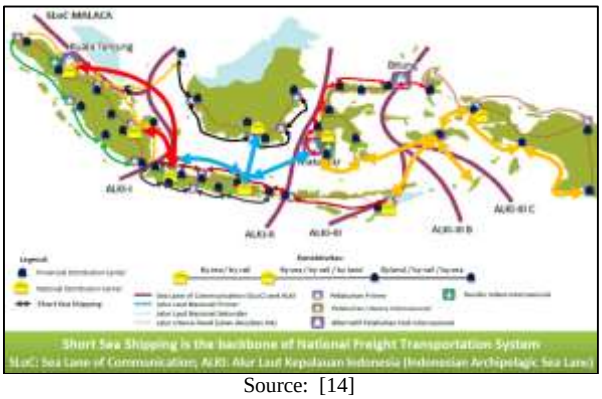
Application of Hub and Spoke Network and Multicall Network in Logistics of Indonesia

One of Indonesian logistics missions according to Presidential Decree in 2012 is to realize the nodes of national logistics and establishing connectivity in rural and urban areas, as well as between regions, islands, and international scale harbors through collaborative multi-stakeholder [14], The mission is in accordance with the conditions of Indonesia, where there are the "hub ports" nationwide until 2008 to serve megaships or large transport ships. One indicator of the pragmatic development of the logistics sector of a country is the establishment of international scale "hub port" which functioned as a control center of national flow of goods through the "port" [15]. A hub port serves as a port for moving freight from one mode to other modes [16].



Source: [14]

Fig. 7. Blueprint of national logistics system (SISLOGNAS) network



Source: [14]

Fig. 8. Blueprint of short sea shipping according SISLOGNAS

Source: [14]

Fig. 9. Blueprint of logistics for distribution network according SISLOGNAS

Among the alternative network designs - hub and spoke and multicall network, the best alternative must go through several tests based on certain methods. [17] proposed the use of an operating model for the delivery of goods (shipping) to determine the optimal fleet and ship deployment plans in an application of hub and spoke. [18] formulated multicall network and hub and spoke with the aim of minimizing traffic travel length (in time). [13] discussed the network design for the delivery of goods problem which considered the empty container to create a model in multicall network and hub and spoke.

In Indonesia, a study by [19] to the Port of New Sorong and Port of Sorong using optimal allocation optimization model shows, hub and spoke system approach is the best for the port. Hub and spoke system at the Port of New Sorong and Port of Sorong in research is divided into two stages, the delivery of containers from the commodity-producing region to the port of feed and from port of feed to the port of collectors. The optimization model is verified using Lingo software. The high number of ports in Indonesia, as well as large-scale port development plan make both hub and spoke network and multicall network design to be optimized with certain models.

Vessel size is growing rapidly while the demands of the cargo cannot be increased simultaneously [20]. [20] later explained, to reduce transportation costs and achieve economic scale, it takes a route where the size of the vessel can grow and connect with more than two ports which is then referred to as multicall networking network. However, this route gives impact to the longer sailing time and the decrease of operation and efficiency of investment. When large ships reach a certain size, hub and spoke network is applied to improve the operation and efficiency [20]. In this type of network, large ship just visits the port on the main route, while the cargo is collected on feeder routes. [20] explains, the selection of the two types of networks is based on large ships, cargo claims, the distance, freight rates and shipping costs between ports in the same region; so that the size of the vessel and cargo demand give direct impact on the optimization of routes and other special elements in the route. Research of [20] basically integrate both networks and produce an integrated model with the aim of maximizing the profit rate of investment.

[7] in their research found that, the hub and spoke network, economic conditions can be realized by consolidating cargo through a hub to mother vessel. But, routing the entire cargo through the hub cannot be realized in all conditions. Although the average shipping costs per TEU decreased by using the network hub and spoke, goods from feeder ports must be transshipped through the hub and incur extra distance shipping, delivery time, port fees, and costs of loading and unloading [7]. This research basically built a two-objective model to minimize shipping costs and inventory costs to determine whether service delivery through a hub or direct towards the destination is effective. The cost function formulated in this study relies on flow. Besides, the shipping costs include capital, operating costs, fuel costs and port costs, while the cost of inventories includes the cost of waiting and delivery charges. The two-objective model not only provides the flexibility for operators in the decision making process, but also provides tools to analyze trade through shipping and inventory costs.

Optimization models based on existing research can be applied to the logistics system in Indonesia Sea lane [21,22], but with approaches and adjustment to the conditions in Indonesia. National Logistics System (SISLOGNAS) itself through the blueprint has set short sea shipping, to close the infrastructure gap in the logistics needs of the community channel of Indonesia. Meanwhile, interconnection management system or internodal between port infrastructure, transportation, and warehousing is still minimal and bad [15]. [15] in the "Blueprint for Planning and Development in National Logistics Sector" explained, when a ship docked at the Port of Tanjung Priok, for example, the only access to transportation was land transportation with limited highway infrastructure, causing traffic around the Port Tanjung Priok every day. In addition, it also described the presence of non-technical aspects that must be passed which resulted in the increasing cost of the distribution of goods.

According to [10], multicall network is a type of traditional goods distribution, but several companies still use this type, especially companies engaged in the exploration of nature resources such as oil company, gas company, and coal mining company. Dangerouus hazard companies also use this type of distribution. These companies use multicall network because this type is the most suitable for their products. The reasons are:

- The products distributed are dangerous products. So the unloading process along the shipping process is risking the workers and the area where the unloading process takes place (primary area).
- The nature of the product being distributed. Products like this are usually volatile or explosive if the temperature is not stable, so the loading and unloading system is not very suitable.
- Products are distributed in large quantities, so that the hub and spoke system will only be a waste of time.
- Product-specific. So that distribution tools such as tanks, etc. must comply with the conditions of the product. For example tank made of a certain metal may not be used to distribute gas "A".

CONCLUSION AND RECOMMENDATIONS

Hub & Spokes is one of the networks to make logistics delivery. Hub is a consolidation of primary areas and spokes is the branching area of destination hub. Hub & Spokes are widely used in sea transport, especially for the container transport. Indonesia has international hub in Tanjung Priok and Tanjung Perak. Multicall network is the sea distribution system directly from the port of origin to the port of destination without passing through a hub port.

Systems of hub-and-spoke and multicall networking each have advantages and disadvantages. Their implementation can be adapted to the needs of logistic actors, the level of port infrastructure itself and the ability of experts (human resources). The use of the Multicall network logistics method and Hub and Spoke in a company depends on the type of products distributed and the distribution area.

Indonesian logistics mission to realize the logistics and connectivity node is manifested through the development of hub ports as the center control of the flow of goods. In the design of the network, there are two alternative networks that have been applied in the world, the hub and spoke and multicall network. Both should be tested and adapted with the National Logistics System (SISLOGNAS) blueprint to obtain an optimal model while integrating both these networks, taking into account the constraints, the technical and non-technical aspects, and other variables.

Declaration of Conflicting Interests

There are no conflicts of interest.

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— This article does not have any appendix. —