Analyzing the implementation of Public Private Partnership on a trans-shipment port within a non-commercial port network

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Abstract: This paper proposes a network model to analyze the Public Private Partnership (PPP) implementation within a non-commercial port network. The network has a trans-shipment port, where the cargo is deconsolidated based on the destination and then shipped directly to the destination node. The PPP implementation is elaborated in a trans-shipment port by changing the tariff and productivity escalation. The impact of PPP is then evaluated based on the total cost, covering transportation, port, time, and port development costs. The network configuration is also investigated due to the implementation of PPP in a trans-shipment port. The proposed model is then tested in the shipping network, which is derived from the actual shipping network. It shows that the PPP possibly generated a lower total cost compared to the baseline conditions (i.e., without PPP). Additionally, the sensitivity analysis is conducted by increasing the tariff to explore the upper and lower bounds of handling tariffs due to the PPP implementation.

Keywords: public private partnership, port, network, trans-shipment.

1. INTRODUCTION

Having approximately 17,000 islands which are distributed at almost 3.2 million km^2 of sea water, Indonesia is considered as the largest archipelago country in the world (Pratama, 2020). Therefore, in order to ensure the accessibility on its whole area, Indonesia relies significantly in sea transportation (Kadarisman & Majid, 2016). This could enhance the national logistic distribution as well as international trade, resulting in vast economic growth (Putra & Djalante, 2016). In accordance with the Indonesian Central Bureau of Statistics, the number of national trades in five main ports in Indonesia, including Belawan, Tanjung Priok, Tanjung Perak, Makassar, and Balikpapan, exceeded 78 million tons in 2019. This value shows approximately 4.1% growth compared to the total domestic trade in 2009. A similar trend also occurred in export growth, which shows a significant increment of 44% over the same observation period. This phenomenon is affected by sea transportation since it accommodates almost 90% of the total cargo deliveries (Lathifah, 2019).

PPP is a collaborative approach between the government and the private sector to deliver an infrastructure project, ranging from planning, construction, and operation to the handover of assets and knowledge at the end of the partnership period. In the case of a PPP application in an Indonesian port, the private sector is allowed to establish a new set of cargo tariffs apart from the existing non-commercial government tariff in exchange for escalated facilities and productivity, which must be provided during the partnership period. This paper delivers a network model to understand the PPP application to a trans-shipment port within a non-commercial port network, in which a tariff and productivity increment occurs. This approach is selected due to the distinctive typology of the network, where the port in which the PPP is applied, acts as a trans-shipment node, connecting the origin and destination node. The cargo is consolidated in the origin prior to a single shipment to the trans-shipment node. The cargo is deconsolidated based on the destination and shipped directly to the destination node. The performance of the network is quantified based on a total cost, covering transportation cost, port cost, time cost, and port development cost.

2. LITERATURE REVIEW

Several studies have discussed the implementation of PPP, specifically on port infrastructure. Aerts *et al.* (2014) conducted a multi-stakeholder analysis to identify the contribution factor of successful PPP implementation on port projects and to assess varying stakeholder perspectives on their importance. Their study highlighted eight factors, which are a clear and detailed concession agreement, effective risk distribution, the project's technical viability, strong partner commitment, an appealing financial structure, well-defined roles and responsibilities, the involvement of a strong private consortium, and an adequate evaluation of costs and benefits.

Panayides *et al.* (2015) explored how institutional factors impact the effectiveness of PPP implementation on port projects, measured by their attractiveness to private investors and the facility's competitiveness in the market. By analyzing a broad dataset of ports, they highlights key institutional elements that influence the success of PPP implementation, such as the quality of regulations, the openness of the market, the simplicity of business establishment, and the enforcement of contracts. These factors are vital in driving port development and fostering economic growth.

Purnama (2022) observed the implementation of PPP in the Port of Patimban, Indonesia, where the government adopted the concept of landlord port financing. Purnama (2022) proposed that this financing option is more optimal compared to other financing alternatives. The government initially provides the land, basic port infrastructure, and public facilities, then leases them to the private sector. The private sector finances the provision of superstructure and port equipment, while the government generates revenue from the lease.

Al Habsi and Ullah (2022) discuss the impact of PPP on maximizing economic and social benefits in the port sector. PPP is considered as a strategic approach for the developing countries in financing infrastructure development, particularly in a seaport expansion. Their study highlighted several advantages of PPP models, such as their ability to mobilize additional funding for infrastructure projects, ultimately enhancing efficiency. Additionally, PPP implementation can improve the utilization of existing ports in developing nations. Moreover, labor productivity within PPP initiatives directly influences efficiency, making it one of the program’s most significant benefits. PPPs also facilitate the optimal use of existing infrastructure and stimulate new activities, attracting a diverse range of businesses.

Based on several studies regarding PPP implementation in port projects above, this study can fill in the gap in the field of study by providing a different approach in observing the impact of PPP implementation on port projects. The impact is identified by comparing the total shipment cost prior and under PPP implementation which are generated from the network model. Moreover, the topology of the network is also considered distinct due to the consolidation process in the trans-shipment port, connecting the origin and destination of the shipment.

3. METHODOLOGY

The proposed network consists of the main port, trans-shipment port, and smaller ports around the trans-shipment port. The trans-shipment port connects shipments from a main port as the origin to several smaller ports as the destination. This shipment to the smaller ports was consolidated in the main port and then shipped to the trans-shipment port. The process is continued with a de-consolidation process in the trans-shipment port, then shipped in a smaller vessel to the destination. The schematic diagram of the network is presented in Figure 1.

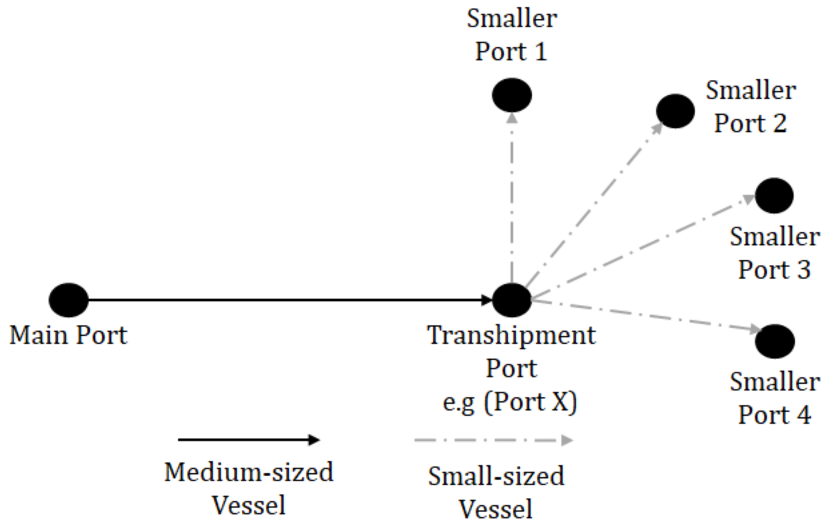

Figure 1. The schematic diagram of the port network

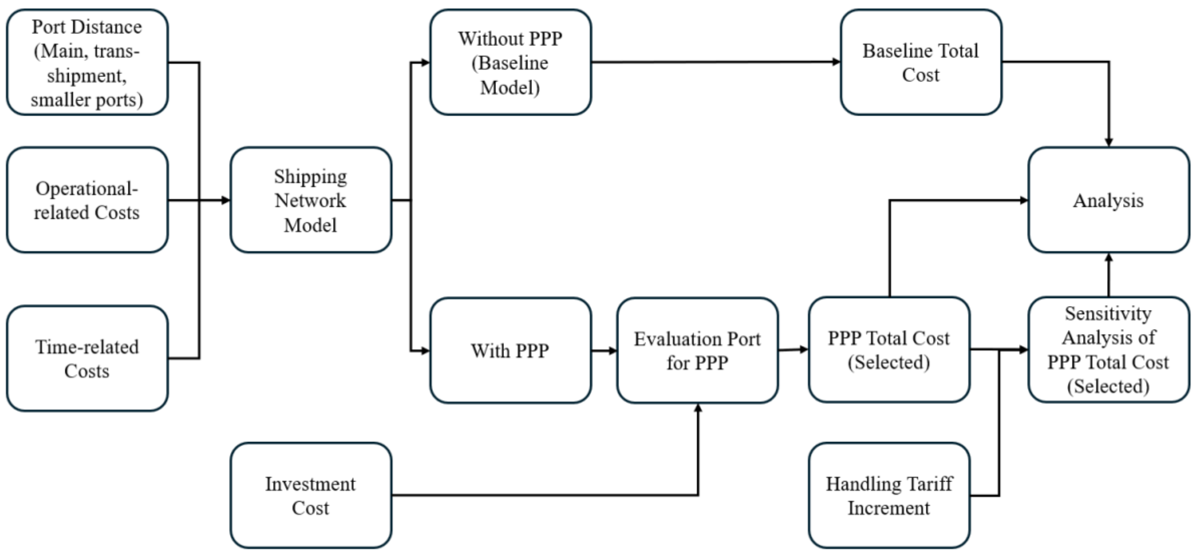

Figure 2. The general research framework

The methodology for this research follows the general flowchart presented in Figure 2, which initially begins with the parameter input for the baseline model, consisting of Unit Transportation Cost for Small-Sized Cargo Ship and Medium-Sized Cargo Ship; Cargo Handling Tariff; Average speed of Small-Sized Cargo Ship and Medium-Sized Cargo Ship; Cargo Handling Productivity; and Cargo Time Cost. All those parameters are used to generate the total cost of the network based on the shipping network model, which has a trans-shipment port (refer to Figure 1). The total cost of the network is the sum of the operational, time, and investment costs, as follows:

1) Operational Cost

   The operational cost consists of:

   - Transportation cost
     - Main-to-Trans-shipment Port: Throughput * Distance * Unit Transportation Cost for Medium-Sized Cargo Ship
     - Trans-shipment-to-Smaller Port: Throughput * Distance * Unit Transportation Cost for Small-Sized Cargo Ship
   - Cargo Handling cost: Throughput * Cargo Handling Tariff

2) Time Cost

   The time cost consists of:

   - Transportation time cost
     - Main-to-Trans-shipment Port: Throughput * Time Cost of Cargo * Distance / Average Speed of Medium-Sized Cargo Ship
     - Trans-shipment-to-Smaller Port: Throughput * Time Cost of Cargo * Distance / Average Speed of Small-Sized Cargo Ship
   - Cargo Handling time cost: Throughput * Time Cost of Cargo / Cargo Handling Productivity

3) Investment Cost

   The investment cost is only applied to the smaller port since, in this research, the PPP is implemented at the trans-shipment port, and it is assumed that the associated cost is invested by the private sector. The cost indicates the investment required to upgrade the facility of the smaller port to serve as a trans-shipment port. The investment is limited to upgrading the jetty, yards, and heavy equipment.

The baseline model captures the existing condition where PPP has not been implemented in a certain port. The baseline model generates the network's total cost where one port serves as a trans-shipment port. The next step is the update on cargo handling tariff and productivity, as well as vessel speed parameter, to portray the PPP implementation on the trans-shipment port. This update is used as an input to generate the total cost of the PPP model. The PPP model calculates the total cost assuming that one port implementing PPP is a trans-shipment port. Every possible port is iteratively tested as a trans-shipment port by assuming that another trans-shipment port exists with PPP implementation. This is conducted to check whether there is a change in network configuration due to the PPP implementation. Because the implementation of PPP possibly increases the cost incurred, which then possibly reconfigures the network structure.

The total cost of the PPP port is then compared to the baseline model, where if the total cost of the PPP model is higher than the baseline model, this means the PPP implementation might not be beneficial. In contrast, if the total cost of the PPP model is lower than the baseline model, implementing the PPP is considered beneficial in reducing the total cost. Further analysis is conducted through incremental cargo handling tariffs to check the sensitivity of the selected port. This process generates several total costs as the various cargo handling tariffs are tested. These costs can be compared not only to the baseline condition but also to the potential port assessed in the previous step as having a role in trans-shipment. This analysis can also be used to investigate the maximum value of proposed cargo handling tariffs without damaging the benefit of PPP implementation.

4. RESULTS AND DISCUSSION

This research then applied the proposed model in the shipping network derived from the actual shipment network in Eastern Indonesia. Let's assume there are five ports in the shipping network model, with Port X as a trans-shipment port, connecting shipment from a main port as the origin to several smaller ports around Port X as the destination (See Figure 1). Generally, four smaller ports can act as the origin and destination. However, it is commonly found on a small island that cargo shipment is mainly entered into the seaport to fulfill its primary needs, without any goods shipped from the port to other ports. Therefore, we have assumed that only a single-directional shipment exists, from origin to destination, without the shipment in the opposite direction. The shipments to the smaller ports are consolidated in the main port and then shipped to Port X. The process continues with a de-consolidation process in Port X. Then the shipments are shipped in a smaller vessel to the destination, which is the smaller ports (refer to Figure 1 for the schematic diagram). The annual cargo throughput in the network is presented in Table 1, and the distance between ports is shown in Table 2.

Table 1. Annual cargo throughput from the main port (tons).

Port	Main Port	Port X	Port 1	Port 2	Port 3	Port 4
Main Port	**-**	**45,000**	**8,500**	**105**	**4,000**	**1,500**

Table 2. Distance between Port (Nautical Miles).

Port	Main Port	Port X	Port 1	Port 2	Port 3	Port 4
Main Port	-	290	240	256	312	371
Port X	290	-	64	67	37	95
Port 1	240	64	-	34	107	146
Port 2	256	67	34	-	63	152
Port 3	312	37	107	63	-	111
Port 4	371	95	146	152	111	-

In the existing condition, Port X and Ports 1-4 are operated and regulated by the government, implying that those ports are non-commercial. The port operational tariffs for all non-commercial ports are standardized by the government, including ship berth and anchorage, as well as cargo (un)loading and storage. Implementing PPP on Port X results in managerial shifts, in which the private sector acts as the port operator, and the government roles as the regulator stakeholders. This shift obliges the private sector to operate, maintain, and develop the port facilities for a specific period based on the agreement in exchange for revenue from their port service. The private sector must provide services based on the minimum output requirements set by the government. The private sector can determine the tariff of services, meaning that the tariff can be above the non-commercial port tariff through an agreement between several stakeholders, namely the government, consignee, freight forwarders, and ship owners.

In accordance with the proposed methodology, the baseline model of the existing condition is first calculated to obtain the total cost. The baseline model is then updated to the PPP model, in which several parameters, e.g., Tariff and productivity, are adjusted to match the condition. Let us assume that Port X is an existing trans-shipment port implementing the PPP, resulting in the PPP cost. This research limits the parameter change, which only covers the changes in cargo handling tariff and productivity, as well as potential updates on the medium-sized cargo ship used in delivering cargo from a main port to the trans-shipment port. In the case of Port X selected, all change only occurs in Port X, where the parameters on Port 1-4 remain the same as the baseline model. The parameter of both models is presented in Table 3.

Table 3. Total cost of baseline and PPP model.

Item	Unit	Value on each Model		Reference
		Baseline	PPP	
Unit Transportation Cost for Small-Sized Cargo Ship	USD /ton / Nautical Mile (NM)	0.2	*No Change*	Wang (2023) with adjustments
Unit Transportation Cost for Medium-Sized Cargo Ship	USD /TEUs / NM	0.08	*No Change*	Wang (2023) with adjustments
Cargo Handling Tariff	USD/ton	0.60	3.00	The Decree of Indonesian Transportation Ministry no 15/2016 regarding Tariff for Non-Commercial Port (Decree 15/2016) with adjustments
Average speed of Small-Sized Cargo Ship	NM/hour	10	*No Change*	Rodrigue (2024) with adjustments
Average speed of Medium-Sized Cargo Ship	NM/hour	14	20	Rodrigue (2024) with adjustments
Cargo Handling Productivity	ton/hour	8	200	Assumption
Cargo Time Cost	USD/hour/ton	1	*No Change*	Sjafruddin et al, 2009 with adjustments

As shown in the table above, several parameters (see the parameters in bold) are changed from the baseline to the PPP model, reflecting the possible PPP agreement between the government and the private sector. The cargo handling tariff and productivity are changed from baseline to the PPP model, portraying the commercial tariff proposed by the private sector in exchange for enhanced cargo handling productivity. The parameters related to a small-sized cargo ship, which are unit transportation cost and average speed, are not changed since both models use the same small-sized cargo ship to deliver cargo from the trans-shipment port to the destination. The average speed of medium-sized cargo has changed since the PPP port may attract larger vessels due to its increased performance.

In accordance with the methodology, the PPP model covers several iterations where each of the possible ports (Port 1-4) is tested as the other trans-shipment port. This is conducted to determine if there is a change in network configuration when the PPP is implemented in Port X. We assume that the network is reconfigured in the case that the other trans-shipment port provides a lower cost than the current trans-shipment port implementing PPP. We also included the investment cost to upgrade all facilities in the other trans-shipment port. For instance, we iteratively calculate the annual cost for other ports by assuming they act as the other trans-shipment port (see Table 4). We then compare the cost provided by Port X, which is acted as the current trans-shipment port implementing PPP, with the other trans-shipment ports. The network configuration change in the case of the other trans-shipment ports shows a lower cost than Port X, representing a condition where the other port serves as a better trans-shipment port than Port X. In this case, it means that under all the model's limitations and scope, PPP implementation on Port X generates a minor benefit. In contrast, if implementing PPP on Port X as a transshipment port provides a lower cost, it generates significant benefits.

Table 4. Total cost of baseline and PPP model.

Trans-shipment Port*	Total Annual Cost (Million USD)	
	Baseline Model	PPP Model**
Port X	2.89	2.75
Port 1	-	3.29
Port 2	-	3.51
Port 3	-	3.70
Port 4	-	5.19

*Port is individually assigned as a trans-shipment Port

** The cargo handling tariff is assumed to be 3 USD/ton (i.e, 5 times higher than the baseline)

Based on the table above, it can be observed that PPP implementation in Port X generates an approximately 5% reduction of annual total cost. The total cost in this model is analyzed on an annual basis as the consequence of annual cargo throughput input (see Table 1). It implies that under all model's limitations and assumptions, PPP implementation on Port X brings benefit to the existing network. Since the model is run using one-year hypothetical throughput data, such fluctuation in throughput data can shift the result and its interpretation. The table also shows that the iteration on Port 1-4 generates a higher total cost than Port X, meaning that all changes due to PPP implementation do not affect the status of Port X as the trans-shipment port within the network.

Furthermore, the PPP model is re-run for various values of cargo handling tariffs in order to recommend the range of optimal tariffs. Practically, the private sector involved in the PPP can propose cargo handling tariffs that remain profitable while still being competitively comparable to the non-commercial tariffs. If the total cost from Port X is higher than Port 1-4, the associated value of cargo handling is considered as the upper bound of the tariff, which is proposed by the private sector. Note that since the re-run is applied only on Port X, the total cost of Port 1-4 remains the same with the iteration result shown in Table 4. The value of cargo handling tariff on the PPP model in Table 3 is 3 USD/ton, which is 5 times higher than the non-commercial tariff adapted on the baseline model. This value generates a lower total cost on Port X than the remaining iterations (refer to Table 4). The model is re-run using a multiplier greater than 5 against the non-commercial tariff in order to identify the multiplier range, as presented in Table 5.

Table 5. The result of PPP model with increment of cargo handling tariff.

Trans-shipment Port	Total Annual Cost (Million USD) with cargo tariff increment			
	5 times*	10 times	15 times	20 times
Port X	2.75	2.94	3.10	3.28

* Cargo handling tariff increases 5 times compared to baseline

In accordance with the table above, the recommended maximum value of multiplier from the non-commercial tariff is 20, meaning that if the proposed tariff is 20 times higher than the non-commercial tariff, Port X no longer generates the lowest total cost as the selected trans-shipment port. The government can consider this approach in formulating the PPP agreement with the private sector so that the PPP implementation can be beneficial in terms of upgraded port performance through the increment of productivity and capacity, but at the same time, the tariff escalation does not significantly increase the total network cost.

5. CONCLUSION

This study proposes an approach to assess the implementation of PPP in a non-commercial port network based on the change to the total network shipping cost. This approach can be applied to a network with a trans-shipment port, which connects the shipment from a main port as the origin, to several smaller ports around the trans-shipment port as the destination. The shipments to the smaller ports were consolidated in the main port and then shipped to the trans-shipment port. The process is continued with a de-consolidation process in the trans-shipment port, then the cargo is shipped in a smaller vessel to the destination.

The model generates a total network cost consisting of operational, time, and investment costs of the whole shipment from the origin to the destination. The baseline model portrays the existing condition, where PPP has not been implemented, and applied tariffs are standardized for non-commercial ports. The baseline model is then updated to the PPP model, in which the tariff productivity and capacity of the PPP-implemented port are changed. To assess the PPP implementation, the total cost of baseline and PPP model are compared. Furthermore, the PPP model can be re-run with various tariffs to understand the range of tariffs which can be proposed by the private sector.

The model is tested using a hypothetical shipping network derived from an actual network. The numerical test generates a lower total cost on the PPP model compared to the baseline model, indicating that the PPP implementation is considered beneficial to the network. The model can assist the policy maker to formulate the agreement with the private sector in terms of approval of the proposed tariff, productivity, and capacity of the port so that the implementation of PPP can be beneficial to the port user.

In terms of future research, the model can be further developed to consider market extension due to facility and performance upgrade as the impact of PPP implementation. The market extension can lead to demand, vessel size, as well as network coverage increase. The model can also be extended to consider other aspects such as environment or economics as the addition to the technical aspect covered in this study. In the long run, the model can also be expanded to evaluate PPP implementation in the operational and technical level, so that the policy maker can obtain a thorough viewpoint of the program.

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