Erasmus University Rotterdam

MSc in Maritime Economics and Logistics

2017/2018

Feasibility Study of a Maritime *Jalur Pantai Utara* (Java Northern Coast Line): An Economic Evaluation of a Direct Shipping Line Service Between Jakarta and Surabaya

By

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Declaration of Submission

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Acknowledgements

First and foremost, I would like to thank my personal academic thesis supervisor, Mr. Martijn Streng of the Erasmus Centre for Urban, Port and Transport Economics at Erasmus University Rotterdam, who has always given undivided attention and support in completion of this thesis. He allowed this research to be of my own work, however, have always assisted me in guiding the study towards the right direction whenever he thought I needed it. All his useful comments, support and contributions during our discussions to the progress of this master thesis is deeply acknowledged.

Next, I would like to thank Dr. Simme Veldman of Ecorys who has provided the support in the proposition and early stages of this thesis. Despite him being unable to continue the entire supervision of this thesis, this study could not have been accomplished without his kind help and continuous support.

Furthermore, I would also like to thank my friend and colleague, Mr. Muhammad Luqmanul Hakim, who in conjunction has supported me with the information and data needed to complete this thesis, which is also an indirect joint-research paper that supports his master thesis. Through his useful input, discussions and continuous support, the validation of this research has successfully completed and yielded the anticipated valuable outcomes.

I am also grateful to all my friends and colleagues I have met and had the pleasure to study and work with during this Maritime Economics and Logistics (MEL) 2017-18 academic year at Erasmus University Rotterdam. I thank them for all their hard work, continuous help and support that has contributed to the success of this fruitful year, and I wish them all the best in their future work and career.

I would also like to acknowledge the MEL office staff who has always given me undivided attention help and guidance whenever I needed it, and I am truly grateful for their valuable support and assistance throughout this successful year of study.

Finally, I must express my very profound gratitude to my parents, sister and my girlfriend for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of writing and finishing this thesis. This great accomplishment would not have been possible without them.

Thank You

Gregory Alfred Sudjaka

September 2018

"It always seems impossible until it's done…"

Nelson Mandela (1918-2013)

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Abstract

Within the subject of maritime and transport logistics networks, shipping transport costs are one of the main deciding factors in the proposition of a shipping liner service route. In order to counter the problems and issues faced by existing road transport services such as congestion, traffic and delays in lead times, – particularly within the island of Java in Indonesia – this thesis attempts to propose the feasibility of a direct shipping liner service that exclusively serves between the Port of Tanjung Priok in Jakarta and the Port of Tanjung Perak in Surabaya. Overall, the study looks at how such a service may bring an added value to the existing transportation system, in supplement to the Maritime Toll Road *(Tol Laut)* initiative proposed by the Indonesian government under the presidency of Joko Widodo, which aims to utilise the concept of short-sea shipping to provide effective and efficient connectivity between ports.

In the analysis to propose such a service, this thesis constructs three scenarios with different quantities of cargo transport demand between Jakarta and Surabaya. The first scenario is set with a predefined expected annual transport demand of 24,000 TEU, – which attempts to capture the existing volume of sea transport between the two cities – and two additional hypothetical scenarios of 100,000 TEU and 200,00 TEU are also observed in the anticipation for a significant increase in cargo demand. The different cost components of these scenarios are optimised to achieve the lowest transport cost per TEU possible, which is derived by varying ship sizes, the number of vessels deployed to the service, ship speed and other corresponding factors that make up the total transport costs.

The underlying theory and methodology utilised in this study incorporates the concept of decision making in an operational level which aims to minimise total costs using the general formulation of the transportation problem – given the pre-set constraints and limitations. In conducting the analysis of the problem, five cost components, namely capital costs, operational costs, bunker costs, port dues and terminal handling charges are optimised, where each of these components have a direct relationship to the time spent at each point of the entire proposed service. It is further conceivable that the only directly controllable variable which can be adjusted is the ship sailing speed, which is in direct connection to the bunker or fuel costs.

The results yielded from this study shows evidently that the proposition of a direct service between Jakarta and Surabaya would, in fact, bring an added value to the existing transportation network. The analysis carried out that a service lead time by ship of 2.5 days between Jakarta and Surabaya yields to an optimised transport cost of USD 254.48 per TEU, which is deemed to be viable for proposition under the existing transportation conditions. It is proven that the optimised transportation costs by sea is lower than that incurred by the existing transport services, while at the same time providing short and competitive lead times as compared to other modes of transport.

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List of Abbreviations

BBM	*Bahan bakar minyak*: fossil fuel oils
BPS	*Badan Pusat Statistik*; Indonesian Central Statistical Agency
DWT	Ship deadweight tonnage
ECA	Emission Control Area
FCL	Full container load
GT	Gross Tonnage
HSD	High-speed diesel
IDJKT	Port code for Port of Tanjung Priok (Jakarta)
IDR	Indonesian Rupiah
IDSUB	Port code for Port of Tanjung Perak (Surabaya)
IMO	International Maritime Organisation
JICT	Jakarta International Container Terminal
LCL	Less than container load
LOA	Ship length overall
MEL	Maritime Economics and Logistics
MFO	Marine fuel oil
MSc	Master of Science
Pantura	*Pantai Utara*; Northern Coast
Pertamina	*Perusahaan Pertambangan Minyak dan Gas Bumi Negara*; Indonesian Oil and Natural Gas Mining Company
PT ASDP	*PT Angkutan Sungai, Danau dan Penyeberangan*; Indonesian River, Lake and Waterway Transport Company
PT KAI	*PT Kereta Api Indonesia*; Indonesian Railway Company
PT Kalog	*PT Kereta Api Logistics*; Indonesian Railway Logistics Company
PT Pelindo	*PT Pelabuhan Indonesia*; Indonesia Port Corporations
PT Pelni	*PT Pelayaran Nasional Indonesia*; Indonesian National Shipping Company
SPIL	Salam Pacific Indonesia Line
SSS	Short-Sea Shipping
Temas	Tempuran Emas Line
TEU	Twenty-foot equivalent unit (standard container size)
TPK	*Terminal Petikemas Koja*; Koja Container Terminal
TPS	*Terminal Petikemas Surabaya*; Surabaya Container Terminal
USD	United States Dollar

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Chapter 1 – Introduction

1.1 Background to the Study

Indonesia is a country located in South-East Asia, situated strategically between the Indian Ocean and the Pacific Ocean. Known for its archipelago of thousands of islands scattered throughout the nation, it is recognised as the world's largest island country (Zheng, 2018). Settling geographically strategic between two oceans, the nation lies in the heart of major global and regional trade routes. Moreover, due to the large area of water and the presence of numerous settlements in many populous islands, Indonesia has historically always been a maritime nation over the decades, where trading and inter-island connectivity using ships have a crucial role in the economy of the nation.

A total of more than 100 deep-sea ports currently serve both international, domestic and regional trade routes (Prihartono et al., 2015), where a significant proportion of larger and more developed ports are commonly located in the western islands of Indonesia due to a more developed economic condition. In addition to these ports are hundreds of smaller and minor seaports that are recognised by the country which serve the need for industrial, shipping and other non-commercial maritime related activity (Prihartono et al., 2015). This just shows how important the dependency of the nation's activities is to the presence of seaports and accessibility to maritime resources.

Indonesia is recognised worldwide as a producing country for raw materials and manufacturing goods, hence inter and intra-island connectivity and the transport of domestic goods inevitably become a crucial component towards the nation's economy. As a result, the government of Indonesia under the presidency of Joko Widodo proposed the *Tol Laut* or the "Maritime Toll Road" initiative, which attempts at providing effective, efficient and scheduled connectivity between ports in different islands, especially between eastern and western parts of the island country (Rachman, 2017). In realising this government project, several ports are shortlisted and selected as major hub ports and are expected to service a number of 18 inter and island routes by the end of 2018 (Jannah, 2017). Out of these shortlisted hub ports are the nation's two largest ports; the Port of Tanjung Priok in Jakarta and the Port of Tanjung Perak in Surabaya. These two ports are the only selected hub ports that are situated in the island of Java, which is home to over 145 million inhabitants – making it the world's most populous island in terms of total population and population density (Encyclopaedia Britannica, 2018).

Currently, both the Port of Tanjung Priok and the Port of Tanjung Perak are state-owned and operate a landlord port system where terminal operations and management are often leased out to private entities. As the two largest container ports in Indonesia, jointly the two ports in question handles over 50% of the nation's international and domestic cargo traffic (BPS, 2017). Despite this evidence, however, there are currently no direct regular liner services that exclusively serve cargo shipments between these two ports. In contrast, exclusive and direct container liner services between two ports are very common in Indonesia, however, these services only comprise of ports that are situated in different islands. The existing network is designed as such because sea transport is practically the only means of inter-island connectivity, and transportation within the islands are commonly served by other means of land transport.

In most cases, sea connectivity between Jakarta and Surabaya are part of a loop service, with the two ports commonly being either a start or end port of call for the pooling of cargo before shipments are carried through to the designated destination ports in the surrounding islands. More on this is discussed in Chapter 2 of this study, which highlight some of the typical shipping routes served by the domestic shipping companies that involve servicing the two ports.

As it stands, there are currently three means of transport to ship in large quantities between Jakarta and Surabaya, namely by road, rail and sea. With regards to road transport, the main issue lies in the existing road that connects the two large cities, where despite a promising service lead time and flexibility to provide services on demand, delays and journey uncertainties may occur as a result from heavy congestion, driver fatigue and accidents. On the matter of rail transport, the bottleneck lies on the train carrying capacity, where despite the capability to provide fast service times and relatively frequent services, only around 60 TEU can be carried in a single trip. Due to these underlying reasons, therefore, sea shipping, would perhaps be the most effective and efficient means of transport due to the capability of large-scale volume shipments, despite maybe a slower service time. As previously highlighted and in-line with the discussion later in Section 2.3, current shipping services between the two ports are infrequent and often weigh more towards one leg of the journey (i.e. shipping from Jakarta and Surabaya is faster than from Surabaya to Jakarta) as the leg is part of a loop service. Resultingly, there is therefore a high reliance by shippers towards other alternative transport services, as customers often put more value towards service flexibility and readiness, despite the high service prices charged.

Having observed this current situation, this study attempts at looking to provide a feasibility study of an exclusive direct shipping service line within the island of Java, in particular to serve between the Port of Tanjung Priok in Jakarta and the Port of Tanjung Perak in Surabaya, which may be of supplement to the *Tol Laut* (Maritime Toll Road) government initiative. The possibility of making the service frequent and scheduled is proposed in this thesis to hopefully yield expected and positive results. The research will look at both the quantitative aspects of how much goods are traded between the two points, an economic evaluation of how the services should be deployed, as well as viewing the matter qualitatively by observing how this may impact other economic effects that may result from the proposed direct liner service.

1.2 Research Objectives

The outcomes presented of this research could be a supplementary reference point for the Maritime Toll Road initiative proposed by the Indonesian government in overcoming the existing logistical problems faced in transportation between eastern and western regions of Indonesia. As it stands, the Port of Tanjung Priok in Jakarta mainly has the task to serve western parts of Indonesia, whereas the Port of Tanjung Perak in Surabaya serves regions in the east of Indonesia. Despite this segregation of service regions, sea connectivity between the two ports are still very infrequent as there is high dependency by shippers to transport by road due to its flexibility and relatively short promised lead times by the respective service providers.

The main objective of this research is to investigate the transport costs for shipping between Jakarta and Surabaya by sea and compare how these costs may add value to customers when choosing short-sea shipping, as a substitute alternative to the existing transport services – particularly by road through the Java Northern Coast Road. Based on the existing situation, it is conceivable that road transport between Jakarta and Surabaya faces the continuing issues of high congestion levels and traffic, which inevitably lead to uncertain lead times. This, therefore motivates the proposition of this study, which is to propose a direct sea transport route between the two cities. The results of this feasibility study could therefore be presented to existing shipping companies a probe or guideline evidence in the consideration to establish a direct service route that exclusively serves between Jakarta and Surabaya.

In conducting the analysis carried out in this thesis, the study attempts to justify on the following research question and its respective sub-research questions.

Main Research Question:

Would a regular and direct exclusive shipping line service between Jakarta and Surabaya be economically feasible?

Sub-Research Questions:

i. What are the current trade flows and the available modes of transport that serve between Jakarta and Surabaya?
   - What are the goods typically shipped between Jakarta and Surabaya, how much volume is transported, and what means of transport are available?
   - How much time would it typically take to transport goods between Jakarta and Surabaya by the different means of transport available?
   - Why is there currently no direct liner service that exclusively serve between the Port of Tanjung Priok in Jakarta and the Port of Tanjung Perak in Surabaya? Are the other existing means of transport actually more economically viable?

ii. What are the costs associated to transporting goods between Jakarta and Surabaya by the different modes of transport?
   - How much would it cost to ship cargo (containers) between Jakarta and Surabaya by the existing means of transport available?
   - What are the cost components involved in shipping cargo between Jakarta and Surabaya?
   - In observing the existing means of transport services, what is the current service quality in terms of price, time and reliability?

iii. By analysing the trade flows and cargo volume that persist between Jakarta and Surabaya and considering that a direct liner service between the two ports in question is feasible, consider the following matters:
   - What would be the optimal vessel size to service this proposed route?
   - What would be the optimal service speed, and how frequent should the service be deployed?
   - What would be the generalised costs (including the cost of time) to ship cargo between Jakarta and Surabaya, would this be competitive and how does it compare to the existing means of available transport?
   - How would the proposed service bring an added value to the existing network design?

1.3 Research Design

As proposed, this research aims to investigate the transport costs to ship (containerised) cargo between Jakarta and Surabaya. To support the findings, methodology and expected outcomes, this study incorporates mainly a quantitative research approach with the use of secondary data sources. Data on the existing cargo transport trends between Jakarta and Surabaya are collectively gathered from respective sources such as journals, articles and reports by various references. In addition to this, information on existing vessels in operation are extracted from the Clarksons Shipping Intelligence Network to come up with the typical specifications of the ships that may be deployed in the proposed service. In addition to this, qualitative analysis based on observations on the existing condition of the logistics network in Indonesia is discussed subsequently with the results presented.

The scope of this research is to attempt in capturing the existing market share of sea transport between Jakarta and Surabaya, in which the data on this is mainly gathered from the reports of Sinaga (2012), Latul (2015) and Syaiful (2017). As later highlighted in Section 2.3 of this study, the expected annual cargo volume between Jakarta and Surabaya by all the existing means of transport (i.e. road, rail and sea combined) is predicted to be equivalent to around 1,720,000 TEU, as reported by the references cited above. An ambitious approach in tackling this need would be to come up with a proposition of a service which can fully capture the requirement of this annual capacity. Despite this proposition being perhaps the most significant approach to capture the corridor and fully shift the existing cargo transport by sea, this capacity is too large for the infrastructure of the existing ports to handle. Just to highlight a basic derivation, assuming a constant annual throughput between the two ports of 1,720,000 TEU would result in a monthly throughput of around 140,000 TEU. This implies that assuming a standard round-trip journey between Jakarta and Surabaya of 5 days, for instance, the typical ship size required would be of around 12,000 to 15,000 TEU in capacity, in order to accommodate a demand of around 25,000 TEU for the entire round-trip voyage.

Moreover, even if multiple ships were to be deployed to service the route, this ambitious proposition is further restricted by the fact that even the most advanced terminals in Jakarta and Surabaya can only handle up to 30 containers per hour under optimum conditions, meaning that the service requires a significant amount of time to load and discharge the cargo – perhaps even longer than the voyage time spent at sea between the ports, which is not very practical. To further add to the complications, ships of this size and scale would have draught problems and channel restrictions in Jakarta and Surabaya – even the two ports already being two of the largest ports in Indonesia – which are unable to facilitate ships with draughts of over 12 metres.

Therefore, the main proposition of this study is to tackle the issue of infrequent shipping services and high customer reliance towards road transport, and overcome the problems faced when transporting cargo by road and rail between Jakarta and Surabaya by attempting to propose a frequent and scheduled direct shipping liner service in the hopes to bring an added-value to the existing network condition. Eventually, the results derived from this study could be further utilised as a reference or starting point for further research and development on network design and optimisation – particularly with regards to short-sea shipping and to support the Maritime Toll Route initiative proposed by the Indonesian government.

1.4 Research Limitations

In the attempt to propose such a service, several preliminary assumptions are made to support and assist in the quantitative calculations carried out. Firstly, this thesis observes cargo volumes in terms of Twenty-Foot Equivalent Units (TEUs), as this is the most common unit of calculation in relation to liner shipping. Moreover, as previously mentioned briefly, this study attempts to provide a preliminary proposition of a shipping service between Jakarta and Surabaya by capturing the current predicted market volume of short-sea shipping between the two ports. In combination, the reports by Sinaga (2012), Latul (2015) and Syaiful (2017) predict an annual total annual cargo volume of all mniodes of transport between Jakarta and Surabaya of around 1,720,000 TEU. Despite so, only the sea transport volume of 24,000 TEU (Syaiful, 2017) are considered for this study in the hopes to initially capture the short-sea shipping market between Jakarta and Surabaya by proposing a frequent and scheduled service. In addition to this, hypothetical scenarios where a significantly greater amount of annual volume is expected is also provided and compared with in the results to anticipate for such a case to occur.

Still on the matter of cargo, this study assumes that the cargo flow demand is uniform, meaning that the estimated annual volume is distributed evenly throughout the year. Moreover, the cargo between Jakarta and Surabaya is also assumed to be balanced on both ways, meaning that there would be equal amounts of volume on both legs of the journey. In relation to this, an assumption also holds where the balance of cargo volume carried by the vessel between Jakarta and Surabaya remains constant on both ways, where at each port, the cargo on-board the ship is fully discharged and then fully loaded again.

In addition to this, it is also assumed that the terminals that are in charge of cargo handling operations perform under optimal conditions, meaning that there is a constant and uniform rate of loading and discharge, where the possibility of delays from extenuating circumstances such as shift changes, extreme weather conditions and any performance disruptions or slowdowns in general are neglected. The same assumption also holds for the port performance, where the waiting and service times for the ships that call into the port would be limited to that of the average port servicing times as reported by the respective sources. In actual practice, the possibility for on-time arrival, berthing and port servicing can be done by negotiations between the ship operator and the respective entities through time slot bookings or direct agreements. Port services such as tugs, pilotage and mooring are also be considered to work under perfect conditions and any delays or slowdowns are neglected.

Finally, the calculations presented in this study only represent the seaway-to-seaway costs that are involved when transporting cargo between Jakarta and Surabaya. This means that the optimisation of costs is done from the time when the cargo is accepted in the origin terminal up to the point where it is released from the destination terminal. This, however, is analogous to terminal-to-terminal costs when looking at freight rail services and warehouse-to-warehouse costs with regards to trucking, therefore, the resulting comparison between these modes are deemed to be valid for comparison to come up with the expected and anticipated results.

1.5 Thesis Structure

This thesis is divided into five chapters which discuss the different parts of the research carried out. The description of each chapter and the general structure of the thesis is shown in the table below.

Table 1: *Thesis Research Structure*

Chapter Number and Title	Description of Contents
1. Introduction	Chapter 1 provides an overview and background information to the study and highlights the research questions that are used as a basis for the research.
2. Literature Review	Chapter 2 discusses on the underlying theories, existing data and information that are relevant to this study. This chapter also presents what literature and research has been conducted in relation to the idea of this thesis and looks at how these existing information may be of use in support of this study.
3. Research Methodology Part 1: Framework and Input Variables	Chapter 3 presents the research methodology that is used for this study and discusses on how the input variables in this thesis are derived. The methods involved in this study include the use of statistical regression and correlations from existing data, applying prices and charges from the related services and using empirical formulas, relationships and assumptions which altogether assist and support the study.
4. Research Methodology Part 2: Optimisation Algorithm	Chapter 4 presents the complete calculations of the cost components that are applicable when shipping between the two ports in the scope of research. This chapter discusses in particular on how the shipping costs are carried out using the obtained input research data. Moreover, the algorithm on how the cost and time components of the proposed service are explained. As the objective of this study is to look at the feasibility of the proposed service, the optimisation of cost calculations is carried out also with respect to the time variable of the service.
5. Results and Discussion	Chapter 5 discusses the findings that are carried out from the study. The resulting outcome from the calculations carried out for the proposed container liner service is then compared to the existing means of transport available to look at the competitiveness of the proposed idea of an exclusively direct shipping service between the Port of Tanjung Priok and the Port of Tanjung Perak.
6. Conclusions and Recommendations	Chapter 6 summarises the findings and outlines the general outcome of the study, followed by future recommendations on how the study can be implemented in practice and further improved. Suggestions and recommendations for further related research with respect to the limitations set under this thesis are also proposed, and a conclusion of the whole thesis is presented.

1.6 Note on Currency Exchange Rate

As the input sources for this research mainly come from reports, articles and references sourced from Indonesia, the information on costs and prices are often provided in terms of the Indonesian Rupiah (IDR) currency. To make this thesis more concise and coherent to all readers, a currency exchange rate correction to the United States Dollar (USD) is made for all the calculations and results presented in this study.

For the purposes of this study, the USD/IDR exchange rate follows the maximum exchange rate between mid-June to mid-July 2018 as reported by Xe.com (2018), where 1 USD is equivalent to 14,459.41 IDR.

1.7 Joint Thesis Effort

In order to result in a conducive outcome, the research conducted in this thesis is a supplementary study for a joint thesis effort with another MEL MSc candidate, Mr. Muhammad Luqmanul Hakim, which looks at the market position of the sea transport option between eastern and western parts of Java, which are facilitated by the Port of Tanjung Priok and the Port of Tanjung Perak. While this study focuses purely on the seaway-to-seaway transport costs that are applicable when shipping between Jakarta and Surabaya, his study, entitled *"Assessing Potential Market Share of Short-Sea Shipping as an Alternative Transportation Mode: The Case of Java's Northern Route, Jakarta-Surabaya Corridor"*, further looks at the proposition of a door-to-door analysis by incorporating the pre-carriage and on-carriage costs of transporting cargo between the respective ports and the possible points of origins and destinations that are located in either the eastern or western parts of Java to examine the potential share between different transport modes.

The resulting total transport costs optimised from this study would be an input variable for his study, which is further processed by a logit model to examine the expected transportation modal split between sea, rail and road transport between eastern and western parts of Java. In combination, this joint accomplishment attempts to provide a feasibility study of the propositions made under the research objectives and could be used in the support and further development of the Maritime Toll Road initiative.

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Chapter 2 – Theoretical Concepts and The Existing Transport Situation

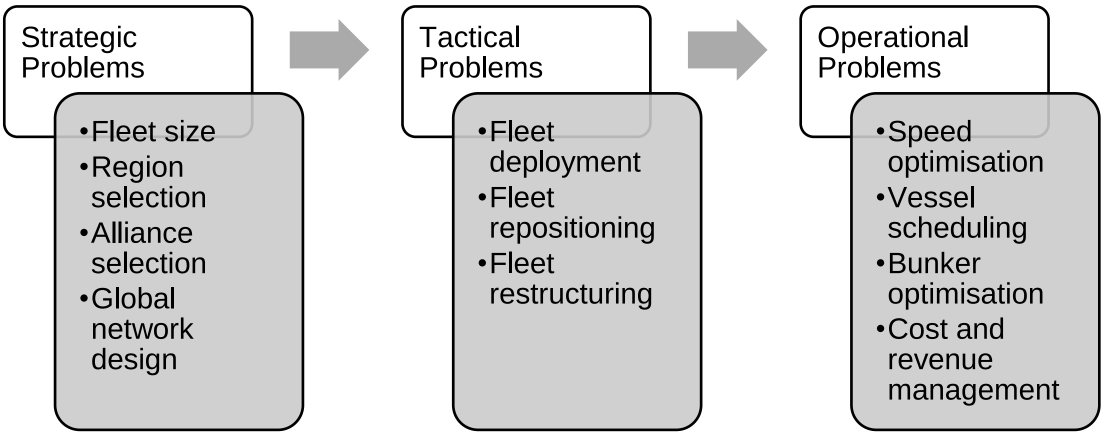
2.1 Route Planning Optimisation and Network Design

The underlying theory and concept behind the proposition and design of this study involves the concerns of route optimisation and network design problems. Brouer et al. (2014) defines a *liner shipping network design problem* (LSNDP) as a method to create a set of sailing routes for a fleet of container vessels, with the objective to maximise freight revenue by minimising the costs of operation. As it is quite difficult due to internal confidentiality between shipping companies in Indonesia with regards to obtaining information on accurate freight rates and prices, this study, therefore, is more concerned towards the cost minimisation component. This problem, in general logistical terms, is commonly known as the transportation problem, which is defined by Reeb and Leavengood (2002) as minimising the total costs incurred, subject to a number of decision variables as well as supply and demand constraints.

2.1.1 Transportation Problem Optimisation

When looking at cost minimisation problems in shipping, there are different levels of optimisation, where planning problems may differ depending on the scope of analysis. Guericke (2014) summarises the studies of Schmidt and Wilhelm (2000) and state that the different planning stages of the problem involve three stages, namely strategic, tactical and operational problems. The diagram showing these different planning stages that concern a liner shipping company is shown in the following figure.

Figure 1: *Levels of Optimisation Planning Problems in Liner Shipping [Source: Guericke, 2014]*



The decisions made to encounter these different levels of problems vary in impact, where decisions of strategic problems are more often made for the long-term, whereas operational problem decisions are solved on a more short-term basis. Strategic decisions are often made by higher-tier members of a shipping company such as board members and executives, and the scope of decision making cascades down to the operational level. The complexity of optimisation also increases when dealing towards operational problems, however, a higher overall impact is felt by the entire network when a decision is made at the strategic level (Guericke, 2014).

The transportation problem that is of concern for this thesis mainly puts greater emphasis at the operational level, where the issue of minimising costs of the proposed shipping service between Jakarta and Surabaya is examined. The general mathematical formulation of the transportation problem as highlighted by Van Riessen (2018) is shown and discussed in the following.

Equation 1: *The Transportation Problem*

$$Minimise \sum_{i} \sum_{j} c_{ij} x_{ij}$$

$$subject\ to$$

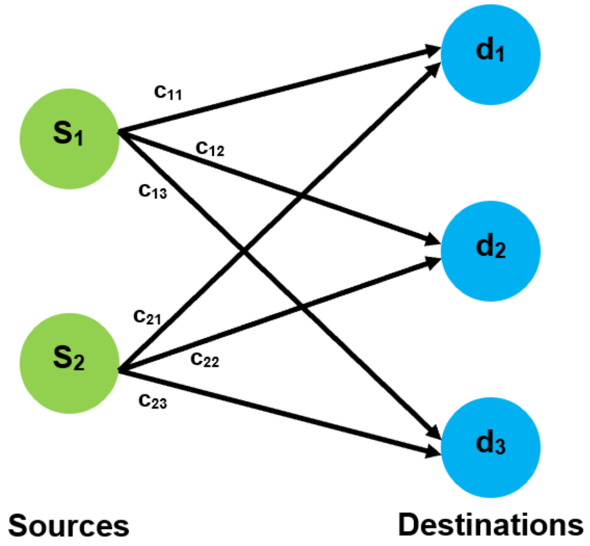
$\sum_j x_{ij} = s_i$ for each origin *i*

$\sum_i x_{ij} = d_j$ for each destination *j*

$x_{ij} \geq 0$ for all *i* and *j*

The illustration of the typical transportation problem as discussed in theoretical logistics concepts is shown in the figure below.

Figure 2: *The Transportation Problem*



Under the mathematical formulation above, x_{ij} represents the cargo volume transported from the port of origin *i* to the port of destination *j*, and c_{ij} represents the corresponding costs to transport the cargo. The first and second constraints respectively indicate the supply and demand constraints of the function, where it implies that the total amount of cargo that is shipped out from point *i* to any point *j* should be equal to the cargo supply at point *i.* Consequently, the total amount of cargo that is received by point *j* from any point *i* should be equal to the cargo demanded at point *j*. The last constraint represents the non-negativity parameter which simply implies that there always has to be a positive flow of cargo between the two points.

In practice, the problem can extend to a number of *i* origins and *j* destinations, however, the route proposed under this thesis simplifies the problem to only a single point of origin and destination, namely Jakarta and Surabaya. The research problem of this thesis is to therefore obtain a minimal total cost of shipping from Jakarta to Surabaya (and vice versa), in which the total costs are made up of the individual components later discussed in Chapter 3. In addition to looking at the total transport costs, the analysis proposed in this study extends to examining the transport costs per unit TEU to achieve a competitive figure when comparing with other existing means of transport between Jakarta and Surabaya.

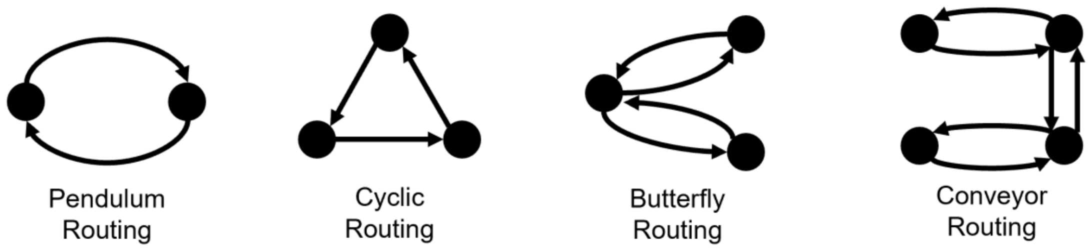
2.1.2 Liner Shipping Network

In general, the market for shipping services is split into two main categories, namely liner shipping and tramp shipping. The former type is where the majority of freight mainly concerns cargo in the form of containers and ships often follow a regular and frequent service – regardless of whether or not there is demand – whereas on the other hand, tramp shipping involves the activity of shipping cargo between specific points of origins and destinations that depend on the availability and demand of cargo (Meijer, 2015). This research limits the scope under the category of liner shipping as the outcome of this thesis is to come up with a proposition of a direct shipping route to service between Jakarta and Surabaya. In general, a liner shipping service is defined as the following.

"*A liner service is defined as a fleet of ships with a common ownership or management that provide a fixed service at regular intervals between named ports and are ready for transit by the predefined sailing dates."*
(Stopford, 2009)

Under this definition, therefore, the liner shipping service proposed under this thesis would consist of a fixed service at regular intervals between the two ports, namely the Port of Tajung Priok and the Port of Tanjung Perak, where the deployed ship(s) are to be ready to sail under a defined service frequency. In practice, liner shipping services vary from large-scale and deep-sea services that transport cargo between continents to short-sea or feeder shipping services that connect deep-sea ports to smaller trade regions within a geographical scope. These services are often distinguished based on the type of ships that are deployed, the difference in cargo demand between the served regions and other economic factors (Guericke, 2014). In the planning of these routes, the service network can further be distinguished based on the type of port rotation (Andersen, 2010), as shown in the figure below.

Figure 3: *Liner Service Network Route Types*



As observed on the figure above, the network route that is of concern to this study falls under the category of pendulum routing, which is the simplest form of network routing that involves alternately servicing between two ports, back and forth. Guericke (2014) further characterises the concept of pendulum routing as services that transport cargo without transhipment. Due to this very basic and simple practicality, the studies of Song and Dong (2013) and Shintani et al. (2007) looked at proposing single liner route service designs which follow this particular concept.

2.1.3 Network Design Problem

In the studies of Mulder and Dekker (2014), the optimisation for a strategic network design of a liner service includes the combination of three separate formulations of problems as defined in the following section. Each of these components are incorporated in the analysis of this study to come up with an optimal solution to the research problem.

(i) Fleet Design Problem

The main objective of the fleet design problem is to determine the optimal composition of the fleet deployed in a proposed network, which includes both the number as well as the sizes of the ship (Mulder and Dekker, 2014). Determining an optimal solution is important for the ship operator as the corresponding capital and operational costs related to the deployed fleet are relatively high.

As this study aims to propose a direct route that exclusively serves between Jakarta and Surabaya, this research combines the data and details from the existing container ship fleet obtained from the Clarksons Shipping Intelligence Network to initially derive a basis ship model using statistical data analysis. From the derived model ships, the analysis would then test several scenarios to come up with the optimal size and number of ships for the proposed route.

(ii) Ship Scheduling Problem

The ship scheduling problem involves the time component analysis of the ships deployed on a route. Mulder and Dekker (2014) indicates that the most important decision variable under this problem is the selection of the optimal sailing speed for each route, as the allocation of a ship to a route is restricted to the time that the ship is serviced at port. Therefore, to accommodate and respond to customer demand along a route, Argawal and Ergun (2008) asserts that in general, the number of ships required for a particular route should be at least equal to the number of weeks taken for a round-trip in order to maintain a weekly schedule at each port of call.

Given a predefined route to analyse between Jakarta and Surabaya, the analysis carried out in this study would test different scenarios in terms of ship scheduling by setting out different service speeds and number of deployments to come up with a competitive cost and schedule. Moreover, for the purposes of simplification, it is assumed that the proposed route between Jakarta and Surabaya is independent to any corresponding network, meaning that the proposed schedules would not require further optimisation for cargo transhipment.

(iii) Cargo Routing Problem

In general, the cargo routing problem involves the determination of two decisions; the choice of which demands to accept, and which routes are used to transport the cargo demand from a port of origin to destination (Mulder and Dekker, 2014). Under this study, however, this problem is significantly simplified as the route in question only involves a set of two ports, meaning that these ports are consequently the ports of origin and destination. Moreover, information on current cargo flows are also gathered based on collective data between Jakarta and Surabaya, hence the proposed route is assumed to accommodate the transport of this defined quantity of cargo volume.

2.2 Existing Transport Connectivity Between Jakarta and Surabaya

This section of the study discusses the different existing means of transport available to ship cargo between the two points. The point-to-point distance between Jakarta and Surabaya is 662 km (Distance Calculator, 2018), however, the actual covered distance may differ depending on the mode of transport being used, which in turn may take different routes. In general, there are currently three different means of transporting large volumes of cargo between Jakarta and Surabaya, namely by road, rail or sea.

2.2.1 By Road

Currently, the fastest and shortest direct road connection between Jakarta and Surabaya is served by the *Jalur Pantai Utara Jawa* or *"Pantura"* for short, literally translated as the Java Northern Coast Road. Connecting 5 provinces in the island of Java, the coastal route is a paved road of over 1,300 km that stretches along the northern coast of Java from the Port of Merak in the west of Java to the town of Banyuwangi in the east (UNESCAP, 2003). Tracing back to its history of existence, the road was built in 1808 by Herman Willem Daendels during the Dutch colonial era in Indonesia. Today, the road is mainly used for inter-city travel for passengers, goods and holidaymakers between cities and regions within the island of Java.

Figure 4: *Java Northern Coast Road Route*
[Source: Wikimedia Commons, 2018]

The name of the road itself is self-explanatory, where the Java Northern Coast Road literally stretches along the northern coast of the island of Java. Being the only paved road that connects almost the total length of the island does have its benefits towards the population. The road passes through almost all the major cities in Java which provides the ease of connectivity for the 70,000 motor vehicles that use the road on a daily basis. This is, however, a very significant figure having note that most of the road passes through small settlements, towns and villages, hence causing localised congestion at certain spots. Furthermore, remote segments of the roads are not well-maintained, which is an additional cause of congestion and prone to accidents. A study by the University of Gadjah Mada (2016) reports that the most congested area of the road stretches between the towns of Tuban and Pasuruan due to a very high potential accident rate. This fact is of relevance to this study as the city of Surabaya lies along this particular section of the route.

Latul (2015) asserts that the traffic of mid-sized and heavy-duty trucks along the Java Northern Coast Road is about 7,200 trucks per day, with an average age of 15 years. This, therefore, makes travelling very inefficient and can delay travel time to up to 3 days due to heavy congestion and traffic. Furthermore, Ade and Nugroho (2012) also asserts that congestion, natural disasters and daily local activities on rural villages along the road can frequently slow down the flow of goods, hence causing cargo owners and consignees to wait longer for their consignments as a result of uncertain lead times.

Moreover, the road also experiences seasonal peaking during the Islamic festivity month of Ramadhan, where friends, relatives and family travel back to their hometowns during the period. With this regard, Sugiharto (2017) reports an increased road utilisation of up to 400% in the Ramadhan of 2017 as compared to the figures recorded in the previous year.

2.2.2 By Rail

Railway services in Indonesia both for passenger and freight transport are state owned and operated by *PT Kereta Api Indonesia* (PT KAI), literally translated as the Indonesian Railway Company. One of its direct operational subsidiaries, *PT Kereta Api Logistics* (PT Kalog) currently operates 5 container train locomotives that serve on routes within the island of Java and Sumatra (Panca, 2018). Among these serviced routes are 2 scheduled rail freight services between Jakarta and Surabaya – the first one being a direct non-stop service between the two cities, and the other having a layover in Semarang, a city in the northern coast of Java. In addition to only providing station-to-station services, PT Kalog also offers other value-added logistics services such as door-to-station, station-to-door as well as door-to-door services which supports their business orientation to be a total solution provider through end-to-end services (Kereta Api Indonesia, 2017).

Despite the availability of this freight rail service, the transport of goods between Jakarta and Surabaya by rail is arguably the least common mode of transport due to the limited capacity of freight train services. Freight capacity of trains are restricted by government regulations and other safety concerns, where despite the fact that rail carriages are capable of flexibility to ship both 20’ and 40’ containers, freight train locomotives are only allowed to tow up to 60 TEU per trip (Kereta Api Logistics, 2013).

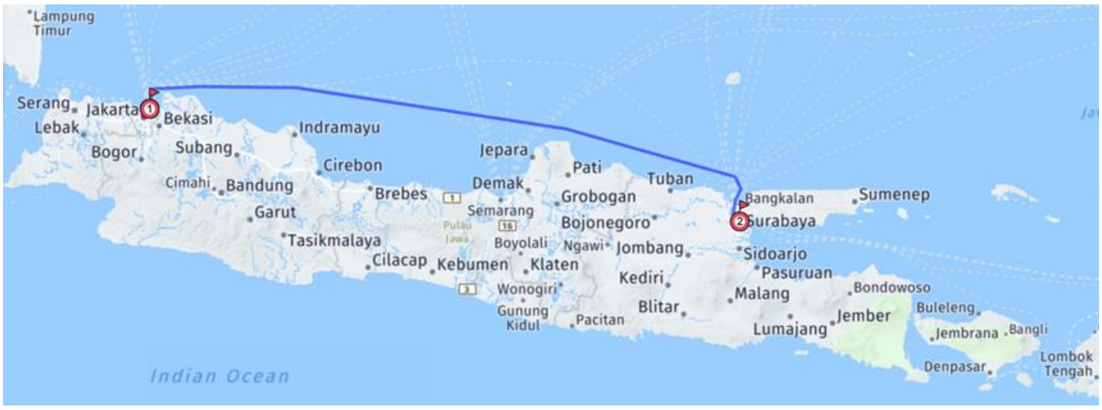
The rail network service provided by PT Kalog is also intermodally integrated with container terminals in the respective ports. In Jakarta, a dedicated rail terminal for containers is situated in the Jakarta International Container Terminal (JICT) at the Port of Tanjung Priok, whereas in Surabaya, freight rail services call at a freight rail terminal in *Terminal Petikemas Surabaya* (TPS) at the Port of Tanjung Perak. The freight train company provides scheduled services between the two locations, were transportation of goods from station-to-station under ideal conditions can take up to two days. Due to the benefits of scheduled services and direct intermodal connectivity, PT KALOG claims to be comparatively more competitive and beneficial to shippers as transport costs are lower compared to other alternative means of transport (Kereta Api Logistics, 2013).

2.2.3 By Sea

The sea distance between Jakarta and Surabaya is 391 nautical miles or 724 km, with the shortest route being sailing through the Java Sea and passing through the Madura Strait. With a typical coastal containership sailing speed of 17 knots, it takes about one day to travel between the two ports, not including port waiting times and any other buffer periods. Despite the relatively short distance, there are currently no existing shipping services that directly serve exclusively between Jakarta and Surabaya, however, passenger transport services by ship, especially during peak periods such as the Ramadhan festivity, is much preferable as the alternative of sea transport avoids the ongoing hassle of congestion on road transport.

This argument underlies one of the main objectives of why this research is conducted, where the study attempts to investigate the idea of a direct cargo transport between Jakarta and Surabaya which makes use of sea transport, as an alternative to reducing or avoiding exiting congestion on roads.

Figure 5: *Nautical Distance Between Jakarta and Surabaya*
[Source: Sea Routes, 2018]



As previously briefly discussed, there are currently no shipping services that exclusively services between the two ports. The most common service routes that involve calling to port in Jakarta and Surabaya are loop services that – in addition to these two ports – further call to ports at the eastern islands of Indonesia such as Sulawesi (Celebes) and Papua. This means that given the current situation, shipping by sea from Jakarta to Surabaya takes a significantly shorter time (around a day) as compared to shipping from Surabaya to Jakarta, as the typical services include intermediary ports of call that are at further distances away. As a result, it is much more convenient for shippers to transportat from Surabaya to Jakarta either by road or rail. Some examples of existing domestic shipping routes and services that call at Jakarta and Surabaya are presented in the table below.

Table 2: *Existing Liner Routes Involving Jakarta and Surabaya*
[Source: Various Sources]

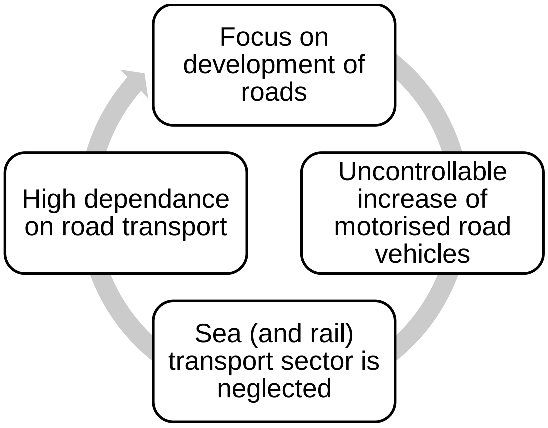
Service Provider	Service Route	Frequency
Meratus Line	Jakarta – Surabaya – Gorontalo – Bitung – Jakarta	4× /month
Tanto Intim Line	Jakarta – Surabaya – Bitung – Jakarta	4× /month
SPIL	Jakarta – Surabaya – Balikpapan - Jakarta Jakarta – Surabaya – Sorong – Jayapura – Jakarta	6× /month 3× /month
Temas Line	Jakarta – Surabaya – Makassar – Bitung – Jakarta Makassar – Surabaya – Jakarta – Makassar	4× /month 4× /month

In addition to these existing services provided by the active shipping lines in Indonesia, in academic research, Ade and Nugroho (2012) have also proposed a study which looks at the potential use of integrated tug barges to service the transport of goods between Jakarta and Surabaya. Despite the obvious success and efficiency of tug barges observed in developed logistical networks such as the Rhine River network in Europe or in North American inland waterways, the realisation of such an idea is still under discussion as this is viewed by transport service providers as an uncommon method of sea transport in Indonesia, and the proposition of tug barges would require further research and capital costs for the construction of these vessels.

2.3 Cargo Volume Flow and Trends Between Jakarta and Surabaya

As discussed in Section 2.2, the current available means of transport of goods between Jakarta and Surabaya is covered by either means of road, rail or sea. According to Sinaga (2012), despite the fact that sea transportation is at least about 30-40% cheaper as compared to rail or truck, trucking still remains as the most preferable mode of transport due to service flexibility and lead times, as these two criteria are considered to be the key factors chosen by shippers as well as consignees in their selection of transport mode. This paradigm that is held by Indonesian shippers and consignees – especially in business cities such as Jakarta and Surabaya – is perhaps the most critical factor in understanding why sea transport is currently underrated as compared to road transport. The thought cycle of this paradigm towards road and sea transport is depicted in the following figure.

Figure 6: *Paradigm on Road vs. Sea Transport*
[Source: Sinaga, 2012]



Observing the illustration above, it is conceivable that there is a cyclical effect where the focus on development of roads and the neglect of sea transport is on opposing sides of the phenomenon. This, again, is backed by the fact that most Indonesian shippers and cargo owners value the concept of transportation flexibility and fast lead times. This proposed research, therefore, attempts to study why this may be the case and aims to carry out a cost where customers may be willing to shift their cargo transport from road to sea – as maritime transport is comparatively more advantageous due to a relatively lower cost per unit (Kotowska, 2014).

The study of Hakim (2018) asserts that trucking costs between Jakarta and Surabaya by truck is around USD 360 per TEU, however, not much information is available on the costs of rail as freight train services are run by a state-owned company which are involved in subsidy schemes. The exact costs on sea transport are also difficult to predict and obtain due to confidentiality and competition between shipping companies and service providers. From existing reports and sources, the annual container volume flow, typical lead times and detailed transport information between Jakarta and Surabaya are shown in the table below.

Table 3: *Cargo Volume and Transport Details Between Jakarta and Surabaya [Source: Various Sources*]*

Mode	Annual Cargo Volume [TEU]	Average Reported Price for Customer [USD/TEU]	Total Transport Cost [USD/TEU]	Reported Depot-to-Depot Lead Time[(1)]	Service Frequency[(1)]
Road	1,680,000[(2)]	690	360[(3)]	2-3 days	Very frequent and flexible
Rail	16,000[(1)]	200	n/a	1-2 days	Regular and scheduled
Sea	24,000[(3)]	220	n/a	5-7 days	Infrequent and scheduled
Total	1,720,000	-	-	-	-

**Sources:* [(1)]*Sinaga (2012),* [(2)]*Latul (2015),* [(3)]*Hakim, (2018),* [(4)]*Syaiful, (2017)*

Note that under the observation of sea transport annual cargo volume, the figure considers all cargo which assigns Jakarta and Surabaya as either a port of origin and/or destination, despite there being any intermediate ports of call. On the matter of transport volume distribution between the different modes, the figures on these annual cargo volumes above are further supported and verified by the report of Supply Chain Indonesia (2016), which asserts that about 11% of cargo transport between Jakarta and Surabaya are shipped by sea. The typical cargo that are shipped between these two points include finished product commodities such as manufactured steel, concrete blocks, cement and fertilisers. In addition to these goods, Jakarta and Surabaya are both surrounded by industrial areas, and the transport of finished consumer products such as motorised vehicles, spare parts, household items and processed food, just to name a few.

Prasetyo and Hadi (2012) assert that the prices charged to customers cover up different cost components that are incurred by the different means of transport. On the matter of trucking, costs typically include the cost for fuel, highway toll charges, office administration and paperwork costs as well as pocket money for the driver throughout the trip which may consist of overnight accommodation (if necessary), food, drink and other daily consumables. Moreover, the high prices charged are also associated with the fact that there may not be guaranteed cargo on the return leg of the journey, and the shippers using the service would therefore need to cover the costs of this empty return leg. With regards to sea transport, the costs covered may include the terminal handling charges, freight charges which include the typical running and bunker costs for a shipping company and other administration costs or overheads. On the other hand, it is quite difficult to track the costs for freight rail services, as freight rail operations are run by state-owned companies that benefit from subsidies and other schemes – hence resulting in a relatively low reported price. Despite this, however, the typical costs include the rail terminal handling charges as well as freight.

As observed, it is apparent that the price charged for shipping a container by road is much higher than that of rail or sea, with a significantly faster lead time and more flexibility in services. Intuitively, this makes sense because customers are willing to pay for a very frequent and flexible (also often door-to-door) services with a short lead time. This information on trucking service lead times, however, may not always be the case as there may be delays due to congestion along the Java Northern Coast Road and actual times may vary unpredictably.

Moreover, it is also apparent from the prices charged above that the existing rail transport is charged to customers at the lowest price as compared to the others, as these services are still provided by government-owned companies. There is also a subsidy scheme involved which drives the possibility of this low price, and capital for railroad infrastructure are already in place and ready for working condition. Despite this, carrying capacity is the main issue with regards to rail transport, and most railway networks between Jakarta and Surabaya are still single-tracked, meaning that further investment and development are required to optimise the existing services. Looking at the performance and condition of existing services, rail services do not seem to be a major competition to shipping services for the time being.

There is, therefore, is a contradictive view with regards to comparing trucking services with shipping by rail and sea, as it is observable that shipping by truck costs much higher – even with a longer lead time as compared to rail. This perception can be argued as such due to the fact that as previously mentioned, most shippers and cargo owners in Indonesia highly value the flexibility of services between the origin and destination. Under this paradigm, therefore, a report by Sinaga (2012) asserts that the shipping and logistical costs in Indonesia – particularly between Jakarta and Surabaya – can be twice more expensive than that of similar distances in neighbouring countries such as Malaysia, Thailand or Vietnam.

2.4 The Application of Short-Sea Shipping

The *Tol Laut* or the Maritime Toll Road initiative is a program set by the Indonesian government in 2014 under the presidency of Joko "Jokowi" Widodo, with the idea of dealing with transportation complications and highly congested land freight transportation. The concept is commonly known technically as short-sea shipping (SSS), where instead of shipping by road, cargo is moved along coastlines between nearby ports by ships. Pardede (2014) highlights that this concept of short-sea shipping has historically been successful in mainland Europe, where 40% of intra-European freight movement is transported by sea using typical vessel sizes of 4,000 DWT. Pardede (2014) further asserts that such a concept would be a perfectly fit in tackling the transportation and logistical problems in Indonesia, – especially within the island of Java – where the ever-increasing congestion in road transport is becoming a major issue. A cost-benefit analysis on the implementation of short-sea shipping as an alternative to road transport in Java is studied by Wuryaningrum et al., (2013), which looks at the potential of how sea transport can reduce road utilisation between Jakarta and Surabaya.

The concept of applying the idea of short-sea shipping in Indonesia is further discussed by Ade and Nugroho (2012), which argue on the following benefits if this concept is successfully implemented in Indonesia, particularly between Jakarta and Surabaya.

- Improve the overall logistics flow of goods, while significantly reducing the level of air pollution caused by road congestion.
- Reducing total transportation costs by shifting from large quantities of individual trucks to transporting in single shiploads.

- Reduce road maintenance costs of the Java Northern Coast Road due to fewer usage of the road by trucks, hence resulting in more use for smaller vehicles and less congestion.
- Terminal handling in ports would increase the efficiency of cargo handling by minimising complex procedures typically found in container warehouses.

Furthermore, the concept of short-sea shipping has inevitably proved to overcome the majority of transportation problems in Europe and the United States (Aulia et al., 2015). Overall, these arguments as well as the problems viewed by the Indonesian government in terms of domestic logistical flow led to the proposition of the Maritime Toll Road initiative.

2.4.1 The Maritime Toll Road Master Plan

The Maritime Toll Road initiative proposed by the government of Indonesia implements the concept of short-sea shipping, which is defined by the European Commission (2014) as the movement of goods using the means of maritime transport over relatively short distances using inland waterways, canals, rivers and enclosed seas – as opposed to cross-ocean or deep-sea ocean shipping. The discussions for the proposition of the initiative began as a plan to strengthen the economic development in the eastern regions of Indonesia. Under existing conditions, western parts of Indonesia are considered to be more developed than that of the eastern parts, therefore, an idea was proposed under the presidency of Joko Widodo in 2014 to assist in the development of these underdeveloped areas through maritime connectivity, as the dominant presence of seas is a natural geographical asset that Indonesia could potentially benefit from. Looking at the potential of this scheme, this thesis looks at the possibility and feasibility of a short-sea shipping scheme between Jakarta and Surabaya, in conjunction to support in the government initiative.

Meijer (2015) further asserts that there is an imbalance of trade between western and eastern parts of Indonesia, as the developed western regions are geographically within direct accessibility to direct international trade routes due to closer proximity with large global transhipment hubs such as Singapore and Malaysia. As a result, the economy in eastern parts of Indonesia tend to strive and remain underdeveloped due to higher prices and unpredictable demand. Through this master plan, therefore, it is hoped that such a realisation can drive Indonesia's domestic connectivity and potentially lead the nation towards a more recognised role in domestic and international shipping (Prihartono et al., 2015).

The general objective of the proposed initiative is to provide connectivity and accessibility for logistical services between the regions in Indonesia, which is done by the proposition of a hub-and-spoke distribution network between larger hub ports and smaller feeder ports (Prihartono et al., 2015). In realising such an integrated network, several hub ports have been selected, which will serve as collection and distribution points for its respective allocated feeder ports. In general, the master plan further distinguishes the differentiation between international hub ports and domestic hub ports, which have different yet vital functions in realising such a plan (Prihartono et al., 2015).

Two international hub ports are shortlisted, namely the Port of Kuala Tanjung in North Sumatra and the Port of Bitung in North Sulawesi, which would exclusively serve as ports for loading and discharge of international cargo. Kuala Tanjung, situated at the far west of Indonesia would feed cargo to and from the Europe-Far East global trade route, while on the other hand, Bitung would do the same for the Trans-Pacific, East Asia and Oceania trading routes due to its strategic proximity in the north-east of Indonesia. In addition to the geographical advantage of these ports being strategically located within the vicinity of international trade routes, these two ports have also been shortlisted due to their potential in economic development. In addition to these two international hub ports, additional large ports in Indonesia would also serve as domestic hub ports for collection and distribution points to smaller feeder ports. Inevitably, these ports also include the Port of Tanjung Priok in Jakarta as well as the Port of Tanjung Perak in Surabaya – being two of the largest ports in Indonesia. The locations of the shortlisted international and domestic hub ports are highlighted in the figure below.

***Figure 7:** Location of Proposed International and Domestic Hub Ports*
[Source: Prihartono et al., 2015]

The initiative aims to provide accessibility and connectivity between the large hub ports and smaller feeder ports within Indonesia through implementing a hub-and-spoke serviced network. Therefore, in addition to the feeder network services that connect the hub ports with their designated feeder ports, these hub ports would also have to be interconnected with each other to achieve a fully working network design. In the attempt to implement such a concept, the Indonesian government has collaborated with academic institutions in Indonesia to develop several proposed main routes that would connect these hub ports. This preliminary study has resulted in an outcome of seven proposed routing alternatives, and under all these planned routes, inevitably, the Port of Tajung Priok in Jakarta and the Port of Tanjung Perak in Surabaya are to be directly connected by a single service (Prihartono et al, 2015).

The collective data presented in Section 2.3 shows that there is, in fact, demand for direct cargo transport between Jakarta and Surabaya – despite the differences in the mode of transportation. In observing the existing conditions, however, the question remains as to what extent could a proposed direct sea transport route between the two ports provide such a service, and would the service bring an added value to the existing network design. This is therefore the pinnacle motivation of this study, and the expected results could be used as a starting point in realising the service route between these two ports.

2.4.2 The Existing Condition of the "Maritime Toll Road"

Despite the plans and propositions of a fully connected logistical transport network between the east and west parts of Indonesia by this initiative, the realisation of the program is currently limited to only several smaller corridors which only connect the respective hubs to their designated feeder ports. As it stands, the proposed main route between the hub ports are not yet in operation as planned, and connectivity between these large hubs are still predominately run by existing shipping companies that operate under their scheduled routes and timetables. Prihartono (2015) argues that this is the case because in order to realise the entire master plan of the concept, there has to be a complete revitalisation for the existing ports, ships and infrastructure to handle the large-scale capacities anticipated by these hub ports. In turn, this would require a significant amount of time to develop, hence the entire master plan of the Maritime Toll Road would take several phases to achieve realisation.

As it stands, Ika (2018) reports the following 15 routes that have been planned by the initiative to be active by the end of 2018. From these 15 routes, 7 are operated (or to be operated) by private companies that go through a bidding process, whereas the remainder are run by state-owned companies.

Table 4: *Maritime Toll Road Proposed Routes by 2018*
[Source: Ika, 2018]

Route Name	Route	Service Type*	Service Operator
T-1	Teluk Bayur – Pulau Nias – Mentawai – Pulau Enggano – Bengkulu	Return	PT ASDP
T-2	Tanjung Priok – Tanjung Batu – Blinyu – Tarempa – Natuna – Midai – Serasan – Tanjung Priok	Loop	PT Pelni
T-3	Tanjung Perak – Belang-Belang – Sangatta – Nunukan – Pulau Sebatik – Tanjung Perak	Loop	PT ASDP
T-4	Tanjung Perak – Makassar – Tahuna	Return	PT Pelni
T-5	Tanjung Perak – Makassar – Tobelo – Tanjung Perak	Loop	Bidding
T-6	Tanjung Perak – Tidore – Morotai	Return	PT Pelni
T-7	Tanjung Perak – Wanci – Namlea – Tanjung Perak	Loop	Mentari Line
T-8	Tanjung Perak – Biak – Tanjung Perak	Loop	Bidding
T-9	Tanjung Perak – Nabire – Serui – Wasior – Tanjung Perak	Loop	Temas Line
T-10	Tanjung Perak – Fak-Fak – Kaimana – Tanjung Perak	Loop	Bidding
T-11	Tanjung Perak – Timika – Agats – Merauke – Tanjung Perak	Loop	Temas Line
T-12	Tanjung Perak – Saumlaki – Dobo – Tanjung Perak	Loop	Meratus Line
T-13	Tanjung Perak – Kalabahi – Moa – Rote – Sabu	Return	PT Pelni
T-14	Tanjung Perak – Loweleba – Adonara - Larantuka	Return	PT Pelni
T-15	Tanjung Perak – Kisar – Namrole – Tanjung Perak	Loop	PT Pelni

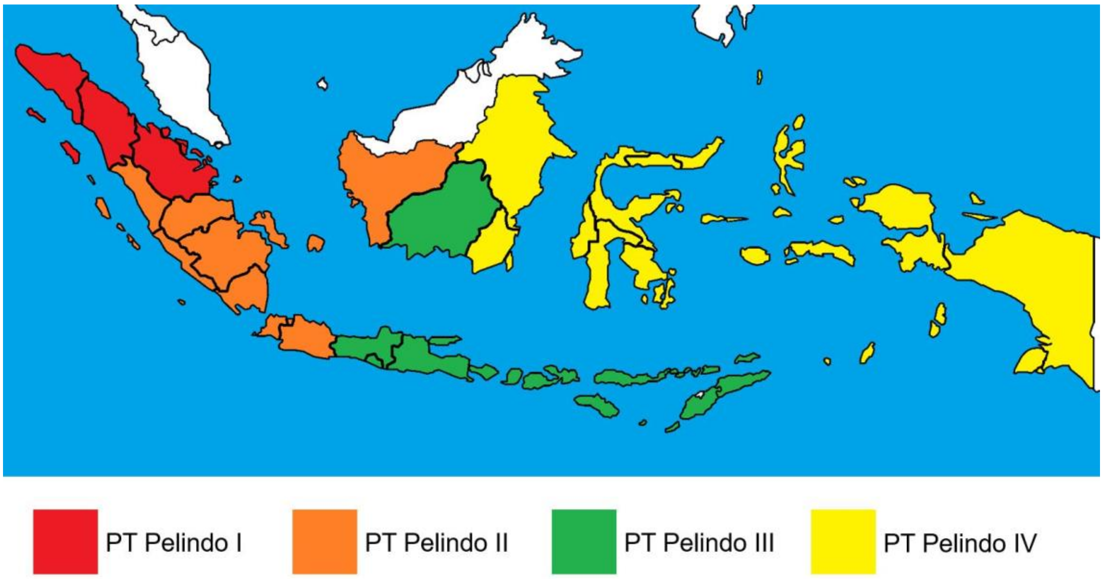
**Return service (pendulum), i.e. A – B – C – D – C – B – A – B – C – …*
Loop service (cycle), i.e. A – B – C – D – A – B – C – D – A – …

As observed from the proposed routes currently under operation, it is apparent that the Port of Tanjung Priok and the Port of Tanjung Perak are, in fact, critical hub ports in the focus of the initiative. Despite so, it is noticeable that although these ports are very crucial as the two largest ports in Indonesia, these two ports in question are not – or at least not yet – connected under the master plan of the Maritime Toll Road initiative. Therefore, the motivation of this research is to initially investigate why this may be the case and propose a feasibility study to look at how a direct shipping line between the two ports in question may be beneficial in support of the initiative.

2.5 Ports in Scope of this Research

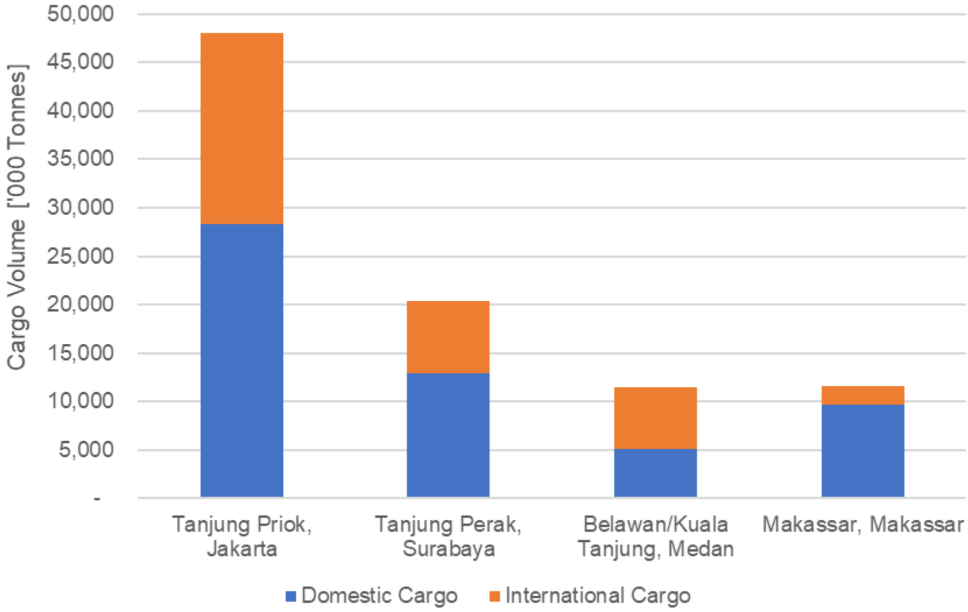
In most cases, commercial ports in Indonesia implement a landlord port governance system, where there is a combination between public intervention and private operations. In general, a landlord port system is a port management scheme where the state-owned port authorities are mainly a regulatory body and landlord, where port operations such as terminals, for instance, are executed by private companies. The state-owned company, PT Pelindo, is the body that acts as port authorities in Indonesia, and they have further sub-divided their company to four independently-run state enterprises which manages different ports in the different regions of Indonesia. The distribution map of the regional management of PT Pelindo is illustrated in the figure below.

Figure 8: *Regional Port Management Distribution Map*
[Source: Wardana, 2013]



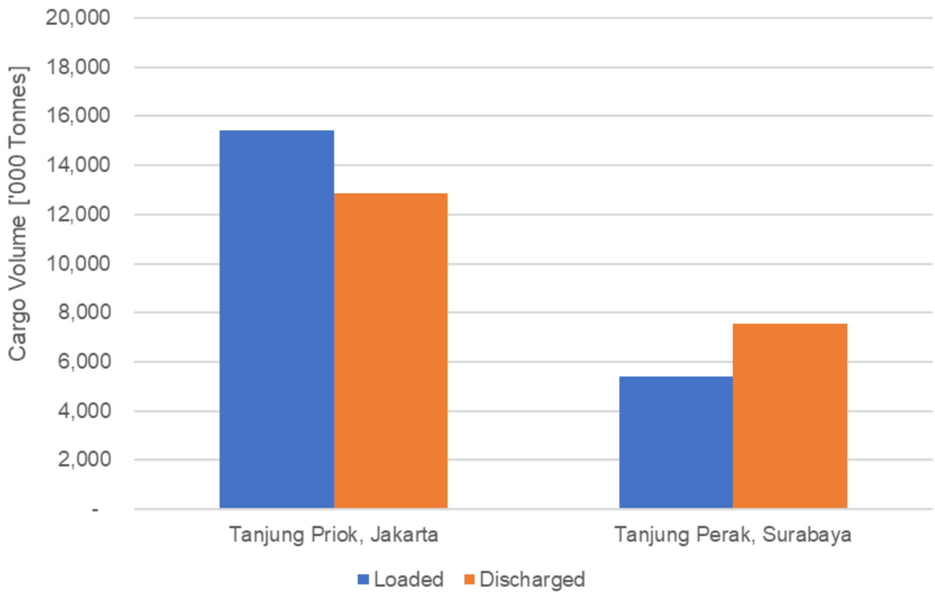
With regards to this thesis, the ports in question, namely the Port of Tanjung Priok and the Port of Tanjung Perak, stands under the governance of PT Pelindo II and PT Pelindo III, respectively. To provide a gist of just how important these two ports are to the transportation network in Indonesia, BPS (2017) reports that the Port of Tanjung Priok and the Port of Tanjung Perak in combination handle more than 50% of both Indonesian domestic and international cargo volumes. As a result, these two ports are arguably considered to be two of the largest and most advanced ports in Indonesia. Data on the cargo volume throughput in the year 2017 of these two ports in comparison of other large ports in Indonesia are shown in the figure below, which highlight how important these ports are in driving the national economy through international and domestic inter-island connectivity.

Figure 9: *Annual Cargo Throughput of Four Largest Ports in Indonesia – 2017*
[Source: BPS, 2017]



As observed, it is conceivable that both domestic and international cargo flow activity in Indonesia is dominated Jakarta and Surabaya. In 2017, the total amount of handled cargo in the Port of Tanjung Priok nearly reached 50 million tonnes, and the Port of Tanjung Perak handled around 20 million tonnes. Moreover, the greater proportion of this total cargo consists of domestic and inter-island cargo, which shows how important domestic connectivity is and the potential relevance of this proposed study in adding value to the existing transport conditions. With particular relevance to this study, the domestic trade volumes handled by the Port of Tanjung Priok and the Port of Tanjung Perak in 2017 are shown in the following figure.

Figure 10: *Domestic Cargo Volume Activity – 2017*
[Source: BPS, 2017]



Despite a larger volume handled in the Port of Tanjung Priok, it is interesting to highlight from the figure above that the difference in loading and discharge activity between the two ports appear to be almost the same, however, in opposing balances. In other words, the Port of Tanjung Priok has more activity in cargo loading, whereas the Port of Tanjung Perak has more activity in cargo discharge, however, the difference between the loading and discharge volumes are almost similar. This, therefore, supports the pre-set condition made in this study, where there would be the assumption of a balance of cargo between the two ports. In practice, this can be observed in cases where ships are often fully laden on the forward leg of the journey and would carry empty containers in the return haul.

By means of sea transport, the Port of Tanjung Priok and the Port of Tanjung Perak are both strategically situated on the north coast of Java at the west and east extremes of the island – hence the proposition of a "Maritime Java Northern Coast Line" under this study as an alternative to land transport. Further details on the ports used in this research are briefly discussed in the following section.

2.5.1 Port of Tanjung Priok, Jakarta

As a port situated in the capital and largest city of the country, the Port of Tanjung Perak in Jakarta is the largest deep-sea port in Indonesia. Having an advantage in international connectivity and exposure, dissimilar to other conventional port authorities in Indonesia, the Port of Tanjung Priok is jointly run under the ownership and operations of PT. Pelindo II, the state-owned port authority, and Hutchison Ports. The port itself is considered to be the busiest port in Indonesia, handling more than 30% of non-oil and gas cargo and more than 50% of the nation's cargo throughput – both in domestic and international trade (Port of Tanjung Priok, 2018).

Three container terminals operate within the port complex, with a total container yard area covering more than 800 hectares and over 2 kilometres of berth length, directly exposed to the Java Sea. Moreover, the berth and channel have water depths of up to 14 metres, which therefore allow Panamax and Post-Panamax container ships to call to port for commercial activity. Ships under this class are already the largest size ships possible to operate in Indonesian ports, making the Port of Tanjung Priok a very important port of call in regional and international trade, especially within the South-East Asia region (Port of Tanjung Priok, 2018).

2.5.2 Port of Tanjung Perak, Surabaya

Located in the city of Surabaya, East Java, the Port of Tanjung Perak is owned and operated by the state-owned enterprise, PT. Pelindo III. Despite having a total of 5 container terminals operate within the port complex – two more than that in Jakarta – the maximum berth and channel depth at the Port of Tanjung Perak is slightly shallower at 10.5 metres, as the main focus of this port is as a hub for smaller feeder ships to service smaller ports at eastern parts of Indonesia (PT. Pelindo III, 2018). Accessibility-wise, the port complex is not directly exposed to the Java Sea, where ships coming in and out of the Port of Tanjung Perak would have to manoeuvre through the Madura Strait, which is a narrow strait that separates the island of Java and Madura.

BPS (2017) reports that the Port of Tanjung Perak ended the year 2017 with a total cargo throughput of around 20 million, with more than two-thirds of this volume comprised of domestic cargo as the port mainly serves as a hub for the smaller and underdeveloped ports in the eastern parts of Indonesia. Again, this is of particular relevance to this study and in-line with the Maritime Toll Road government initiative, hence supporting the proposition of this study.

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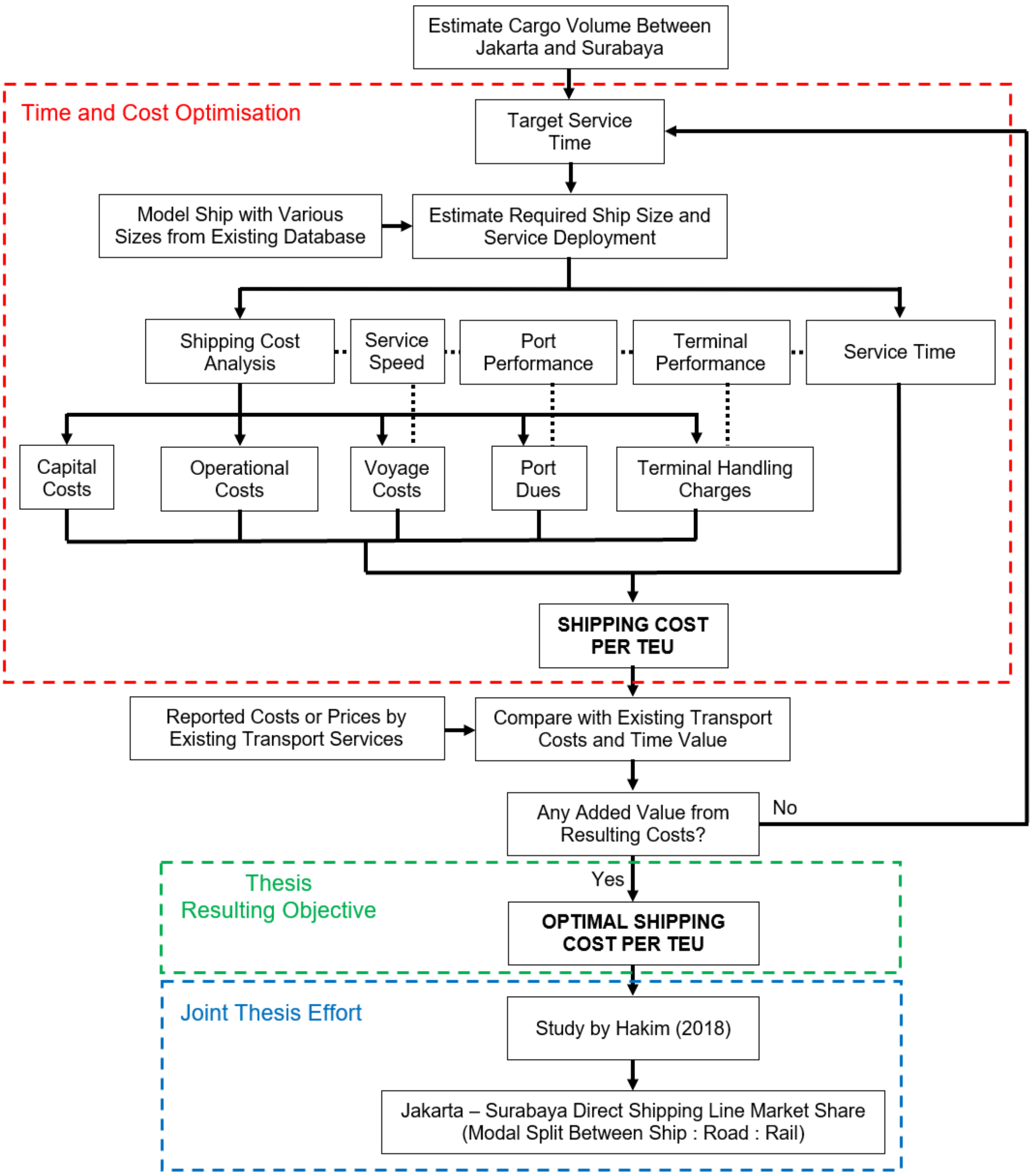
Chapter 3 – Research Methodology Part 1: Framework & Input Variables

3.1 Methodology Framework

The flowchart below illustrates the methodology algorithm that is followed in conducting this study. In conceptual terms, the methodology proposed is an extension of the typical transportation problem that is often discussed upon in theoretical and academic literature, however, this study also aims to derive the corresponding cost components.

Figure 11: *Research Methodology Framework*



As shown above, the methodology of this study aims to optimise sea transportation costs with respect to the exclusive direct shipping service that is proposed between Jakarta and Surabaya. As highlighted in Table 2 of Section 2.2.3, there is currently no existing exclusive direct services between the two ports in the scope of research, however, a shipment by sea from Jakarta to Surabaya (or return leg) would be priced at around USD 220 to customers and would take around 5-7 days, as reported in Table 3 of Section 3.2. In the attempt to bring an added value to this service – either by reducing costs or shortening lead times – this study aims to propose a direct and regular shipping service between the two ports and eventually carry out a cost and time benefit as compared to the existing services.

This chapter presents the research framework that is adopted in the study and discusses the components and input variables that come into play when optimising transportation costs. Five cost components are considered in the cost minimisation objective function of this study, which includes the components of capital costs, operational costs, bunker costs, port dues and terminal handling charges. The algorithm on how these variables are processed in order to yield the resulting transport costs is further discussed and shown methodologically in Chapter 4 of this thesis.

3.2 Estimation of Cargo Volume

As presented in Table 3 of Section 2.3 in this study reported by Sinaga (2012), Latul (2015) and Syaiful (2017), the expected annual cargo between Jakarta and Surabaya is anticipated to be equivalent to an amount of 1,720,000 TEU. This figure, however, is a combined prediction between all the existing transport modes available which includes the means of road, rail and sea. With regards to the sea transport volume, however, an annual total volume of around 24,000 TEU is reported for the operational year 2017 by Syaiful (2017) and is used as the initial cargo estimate for the methodology of this research. As previously mentioned, the service provided between the two ports are currently very infrequent, hence the objective of this research is to propose an added value to the network by making the service frequent.

To further supplement on this study, two additional scenarios to represent the cases of a significant increase in expected cargo volume is also presented, where the annual cargo estimates of 100,000 TEU and 200,000 TEU are presented.

3.3 Basis Ship Model

For the purposes of this thesis, a basis ship model shall be derived from a pool of ships collected from the Clarksons Shipping Intelligence Network. Data from a total of 123 existing container vessels that are owned and operated by domestic shipping lines in Indonesia – in which the majority consists of those owned the four major liner companies, namely (i) Meratus Line; (ii) Salam Pacific Indonesia Line; (iii) Temas Line; and (iv) Tanto Intim Line – are extracted from the database and is used for the quantitative calculations of this study. The ships that are pooled vary in specifications from ship size, service speed, fuel consumption and age. The optimal ship size and ship speed is to be derived based on looking at the cargo flows between Jakarta and Surabaya, as well as quantitatively examining all the other cost factors that may come into play as discussed in this chapter of the thesis. The ship database that is used for this study is presented in Appendix A and is summarised in the table below.

***Table 5:** Summary of Ship Database for Study*
[Source: Clarksons Shipping Intelligence Network, 2018]

Owner	No. of Vessels	Ship Size [TEUs]			Ship Age [Years]		
		Min	Mean	Max	Min	Mean	Max
Meratus Line	37	170	879	2,702	10	21.8	37
SPIL	29	343	1,474	3,534	9	21.7	37
Tanto Intim Line	34	221	841	2,495	11	23.5	36
Temas Line	10	326	1,506	2,702	13	20.9	38
CTP Line	9	420	834	1,157	20	22.2	25
Mentari Line	4	330	464	674	21	23.7	25
Total	**123**	**170**	**1,043**	**3,534**	**9**	**22.3**	**38**

For further calculations, the model ship sizes are corrected for an equivalent GT and overall length (LOA) with each corresponding TEU size, which follows the regression models as shown in Appendix B. The regression model of the GT-TEU correction yields an R^2 value of 97.31%, which indicate that the fit is nearly perfect, and the model is deemed to be valid. On the other hand, the regression model of the ship length-TEU correction results in an R^2 value of 95.63%. Similarly, therefore, the data points almost perfectly follow the model and the correlation is deemed to be valid. The line equations that define the basic ship parameters as a function of the corresponding ship sizes in TEU are shown below.

***Equation 2:** Regression Line - GT vs. TEU*

$$GT = 843 + 10.2662\, TEU$$

***Equation 3:** Regression Line - Ship Length vs. TEU*

$$Ship\ Length = 69.462 + 0.107791\, TEU - 0.00002965\, TEU^2$$

The regression lines of these relationships are represented under the following equations, and the typical ship sizes that are of interest for this study are summarised in the table below. The model ship sizes implemented for this study range from carrying capacities of 100-1,000 TEU, as this is suggested by the study of Ng and Kee (2008), which derived the typical ship sizes that would be optimal for intra-Southeast Asian feeder services. Ships with sizes in between these increments can be interpolated using the same relationship equations as presented above.

***Table 6:** Model Ship Sizes*

Ship Size [TEU]	GT	Ship Length [m]
100	1,870	79.95
200	2,896	89.84
300	3,923	99.14
400	4,949	107.84
500	5,976	115.95
600	7,003	123.47
700	8,029	130.39
800	9,056	136.73
900	10,083	142.46
1,000	11,109	147.61

3.4 Capital Costs

In the study of Veldman (2012), a methodology was presented on predicting the annual capital costs of vessels with sizes of 6,000-20,000 TEUs, which are assessed with a capital recovery factor of 10.19%, an interest rate of 8% and a ship economic lifetime of 20 years. Overall, it was proposed that the annual capital costs range from USD 12.9 m for a ship size of 6,000 TEU up to USD 31.3 million for a ship size of 20,000 TEU (Veldman, 2012). The data which was presented in the study is under the assumption of 350 operational days per year, and the relationship between the annual capital costs and ship size is represented under the following equation. The graph showing the correlation curve is presented in Appendix B.

Equation 4: *Correlation Line - Capital Costs vs. TEU*

$$Annual\ Capital\ Costs = 3{,}446{,}548 + 1{,}675.05\ TEU - 0.0143065\ TEU^2$$

Based on the estimation proposed by Veldman (2012), it is observable that the relationship between annual capital costs and ship size follows a quadratic relationship line with an *R^2 value of* 100%, indicating that the regression line perfectly fits with the data points. Observing that the regression line is somewhat quadratic and curves downward, this relationship is deemed valid to predict the capital costs of smaller sized ships with respect to the interests of this study. Moreover, the fact that the line shows the characteristic of economies of scale (i.e. as ship size increases, the annual capital costs per unit TEU ship size decreases) yields that the relationship holds valid for smaller ship sizes. Using the relationship derived above, the capital costs for the ships considered in this study are shown below. Ships with sizes in between these increments can be interpolated using the same equation as presented above

Table 7: *Model Ship Annual Capital Costs*

Ship Size [TEU]	Annual Capital Costs [USD]
100	3,613,910
200	3,780,986
300	3,947,775
400	4,114,279
500	4,280,496
600	4,446,428
700	4,612,073
800	4,777,432
900	4,942,505
1,000	5,107,292

3.5 Operational Costs

The operational costs that are of interest for this research consists of all related costs that are related to running the ship, which includes maintenance, insurance, administration, crewing and other operational overheads. In some cases, fuel costs may often be calculated under the operational cost component of a ship, however, this study examines fuel costs as a separate component as later presented in Section 3.6.

Referring to the study of Veldman (2012), the annual operational costs for ship sizes of 6,000-20,000 TEU was presented in accordance with literature by Cullinane and Khanna (1999) which show that the cost of ship maintenance and repair, ship insurance, transactional paperwork and administration are roughly about 3.5% of the ship newbuild or second-hand price and vary with ship size. Costs for crewing and overheads, however, are assumed to be a fixed cost as it is predicted to be about USD 400,000 per year despite the increase of ship size. The data on annual operational costs as a function of ship size in TEU as proposed by Veldman (2012) is under the assumption of 350 operational days per year and is represented under the following equation. presented in the curve below. The graph showing the correlation curve is presented in Appendix B.

Equation 5: *Correlation Line - Operational Costs vs. TEU*

$$Annual\ Operational\ \ Costs = 1{,}281{,}369 + 428.417\ TEU - 0.0036607\ TEU^2$$

Similar to the capital costs, it is observable that relationship between annual operational costs and ship size follows a quadratic relationship line with an R^2 *value of* 100%. This means that the regression line generated from the data points perfectly follows the model. An economies of scale effect is also conceivable, which shows that the annual operational costs per unit TEU ship size decreases as the ship size increases, which shows that the relationship is deemed valid for smaller ship sizes that are of particular interest in this study. Using the relationship derived above, the annual operational costs for the ships considered in this study are shown below. Ships with sizes in between these increments can be interpolated using the same equation as presented above.

Table 8: *Model Ship Annual Operational Costs*

Ship Size [TEU]	Annual Operational Costs [USD]
100	1,324,174
200	1,366,906
300	1,409,565
400	1,452,150
500	1,494,662
600	1,537,101
700	1,579,467
800	1,621,760
900	1,663,979
1,000	1,706,125

3.6 Voyage Costs

The main component of voyage costs comprises of the bunker cost for the ship to complete the entire service voyage and is considered to be a major component in the total costs as it can constitute to a significant proportion of the total transportation costs. Several factors have a direct impact on the voyage costs of a journey, which include the sailing speed and fuel consumption of the vessel as well as the fuel costs.

3.6.1 Sailing Speed and Fuel Consumption

The choice of ship sailing speed is a very critical decision in optimising or significantly reducing costs, as fuel costs are one of the most dominant components in the operational costs of a ship. In the period during the financial crisis of 2008 and its aftermath, many shipping companies decide to slow-steam their vessels (i.e. operating at a speed below the designed vessel speed) in order to cut down costs. Lee (2014) addressed even after an improvement in the economic environment after the financial recession, the practice of deliberately slowing down the speed of a vessel is no longer a new concept in shipping and is a very common feature in the industry for companies to lower bunkering costs by reducing fuel consumption. To compensate for this reduction in service speed, a common practice adopted by major shipping companies is to expand their fleet network and offer more frequent services at slower speeds. On this regard, Notteboom and Vernimmen (2009) provide the arguments about the importance of ship speed optimisation in liner shipping networks by comparing how bunker costs vary depending on the number of ship deployments to a particular service.

The steaming speed of a ship can significantly effect the fuel consumption as the common relationship between fuel consumption and ship speed generally follows an exponential function – rather than a linear one. In other words, increasing the speed of a ship would increase its fuel consumption in an exponential manner. It is often the case where the representation of this relationship is expressed in technical terms in the form of a speed-consumption curve. The classical relationship between ship speed and fuel consumption is determined by Wang and Meng (2012) under the following equation.

Equation 6: *Ship Speed - Fuel Consumption Relationship*

$$F(Cons) = kV^n$$

$$where$$

$$k > 0\,;n > 1$$

In this general formula, *F(Cons)* represents the function of the fuel consumption of the ship, and *V* is the ship service speed. Furthermore, as stated in theory where this relationship is exponential (Mersin et al., 2017), the value of *n* should be greater than 1 otherwise the function would be either linear (*n = 1*) or negatively exponential. Wang and Meng (2012) further determines that the value of *n* ranges between 2.7 to 3.3 for small-sized container ships and can increase up to 4.5 for larger ship sizes. These empirical values for this constant are also backed by the theorical formulation by Ronen (1982). Finally, the constant *k* is a constant coefficient that differs depending on the performance of the ship.

For the purposes of this thesis, the constant *k* is derived for each ship from the database by using the provided equation above. Note that in practice, the *k* value for each ship will vary as the data extracted for the database are only point data sets and recorded at a certain point in time. For the purposes of this study, the derivation assumes a value of the *n* coefficient to be 3. An example calculation of this is provided as follows, with the example of Meratus Ultima 1, a 455 TEU ship with a fuel consumption of 15 tonnes per day and a service speed of 14 knots.

$\boldsymbol{Given}$:
$Ship\ Size = 455\ TEU$
$Fuel\ consumption = 15.00\ tonnes\ per\ day$
$Service\ speed, V = 14.00\ knots$
$n = 3$

$\boldsymbol{Solve}$:
$$k = \frac{15}{14^3} = \frac{15}{2{,}744} = 5.466 \times 10^{-3}$$

The calculation above shows the sample calculation for one sample ship from the database, which represents one datapoint for one ship size. To extract a whole data set of the correlation between ship size and *k* values, the similar calculation as of the above is carried out and yields to the following regression line plot as generated in Appendix B.

The model that correlates *k* values and ship size has an R^2 value of 49.08%, which indicate that there is a positive correlation between the two variables. In other words, as ship size increases, the *k* values also tend to increase proportionally. Despite this correlation being only moderately accurate, where only nearly half of the data points fit in the regression line, it is observable that most container vessels in Indonesia are relatively old in age, which contributes to the variance in the fuel consumption of the ship as a result from hull fouling, engine service life and ageing in general. For the purposes of this study, therefore, the regression line is assumed to follow this line as it perceives the average state of container ships currently in operation. The regression line of this relationship is represented under the following equation.

Equation 7: *Regression Line - k vs. TEU*

$$k = 0.0048007 + 0.00000121\ TEU$$

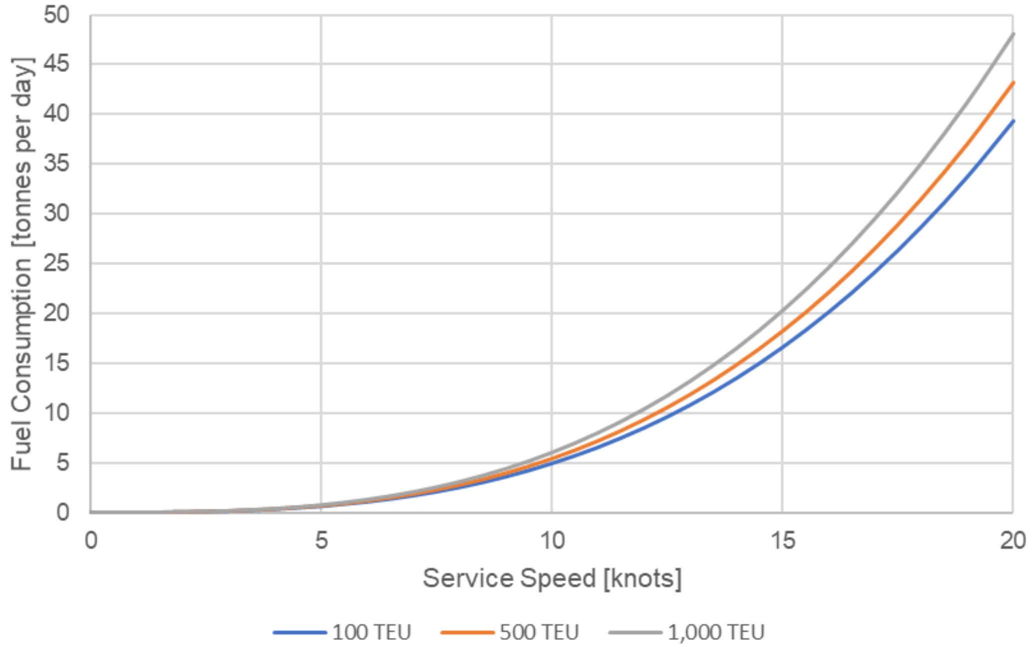
Using the equation above, the following table is derived to show the k-values that correspond to the different ship sizes. Referring back to Section 2.5 of this thesis, only ships of capacities up to 1,000 TEU are considered as this is the size limitation that the ports in the scope of this research can accommodate in terms of draught and terminal handling capacity restrictions. Ships with sizes in between these increments can be interpolated linearly using the same equation as presented above.

Table 9: *Basis Ship Model k Values*

Ship Size [TEU]	*k* Value
100	4.92×10^{-3}
200	5.04×10^{-3}
300	5.16×10^{-3}
400	5.29×10^{-3}
500	5.41×10^{-3}
600	5.53×10^{-3}
700	5.65×10^{-3}
800	5.77×10^{-3}
900	5.89×10^{-3}
1,000	6.01×10^{-3}

As previously explained, the fuel consumption of a ship is often represented in a speed-consumption curve as derived by the equation used by Wang and Meng (2012). Using the *k* values already carried out for the model ships, the speed-consumption curves for these ships are presented in the figure below, where for ships with sizes in between these contours should be interpolated

Figure 12: *Model Ship Speed-Consumption Curves*



3.6.2 Fuel and Bunkering Prices

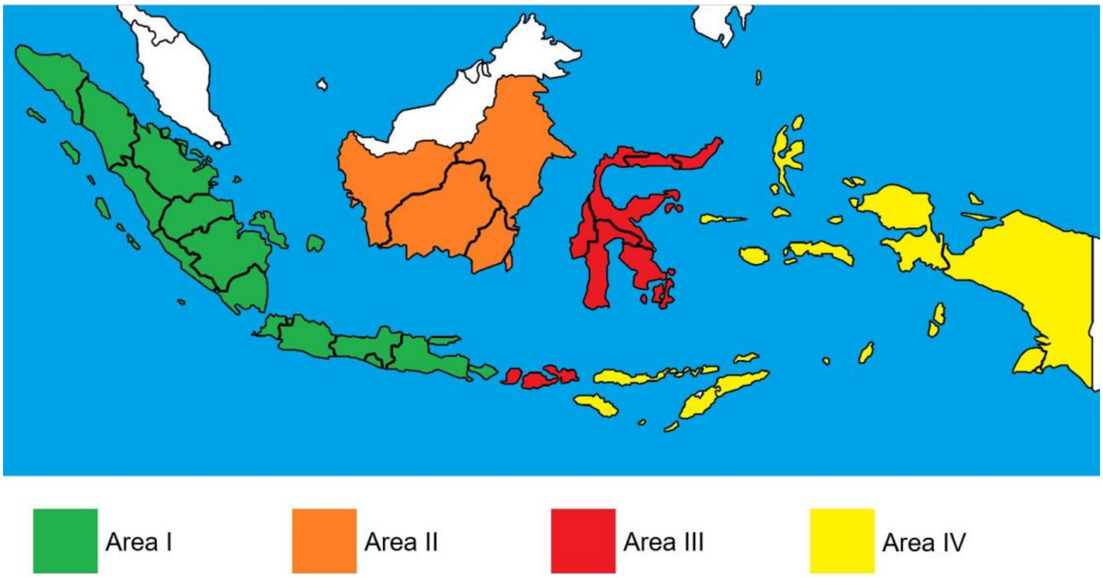
Ship fuel or bunkering is a critical cost component in merchant shipping and can make up to 60% of the total ship operating costs. Moreover, important service level decisions such as the optimum or economic sailing speed can impact on bunkering costs as a reduction in sailing speed can significantly cut down fuel costs.

Ship fuels and bunker in Indonesia can only be sold by PT Pertamina, the state-owned oil and natural gas corporation. The two most common bunkers available for ships that are sold in large ports such as Jakarta and Surabaya are the High-Speed Diesel (HSD) and the more common Marine Fuel Oil (MFO). At the moment, Indonesia is not yet classified as an Emission Control Area (ECA) by the International Maritime Organisation (IMO), therefore the most common and cheapest bunker alternative, MFO, is used for the propulsion engines that are installed in coastal container vessels. This fuel type is therefore used for the purposes of this study.

Prices for marine fuels are set by the PT Pertamina, and the selling price of these industrial fuels are also set based on four regions where the fuels are sold (see list and figure below) and released every half-month.

- Area I : Sumatra, Java, Bali and Madura
- Area II : Kalimantan (Borneo)
- Area III : Sulawesi (Celebes) and West Nusa Tenggara
- Area IV : Maluku, East Nusa Tenggara and Papua

Figure 13: *Pertamina Regional Categorisation for the Sale of Industrial Fuels*
[*Source: Info Harga BBM Pertamina; "BBM Price Information Website", 2018]*



With regards to this research, Jakarta and Surabaya are both situated the island of Java (categorised under Area I), and the prices of MFO for shipping released for the first half of 2018 and the average over the observation are shown in the following table. The prices published by Pertamina are shown in IDR per litre, however, the charges for bunkering in shipping are often expressed and sold in terms of price per tonne. Therefore, a conversion from litres to tonnes is carried out, and noting that the specific density for most MFO are not less than 900 kg/m^3, it is assumed that 1 tonne of MFO is equivalent to an amount of around 1,100 litres of MFO.

Table 10: *MFO Prices in Area I*
[Source: Info Harga BBM Pertamina; "BBM Price Information Website", 2018]

Period	MFO Selling Price	
	[USD per litre]	[USD per tonne]
1-14 January 2018	0.533	585.78
15-31 January 2018	0.540	594.15
1-14 February 2018	0.548	602.51
15-28 February 2018	0.548	602.51
1-14 March 2018	0.525	577.41
15-31 March 2018	0.525	577.41
1-14 April 2018	0.548	602.51
15-30 April 2018	0.563	619.25
1-14 May 2018	0.593	652.72
15-31 May 2018	0.624	686.20
1-14 June 2018	0.685	753.14
15-30 June 2018	0.677	744.77
Observation Period Maximum	**0.685**	**753.14**

As the data presented above only shows the prices available up to a limited period, the maximum selling price over the observation period is used for this study as it would yield to the maximum possible costs incurred. Therefore, a bunker selling price of 753.14 USD is used for the input variable of the bunker prices.

3.7 Port Dues and Services

Port dues and service charges comprise of all the fees levied against a ship operator by a port authority for the use of a port and the respective services that allow the ship to commence operational activity within the area of that port. In most cases, these include payable components such as port charges, berthing fees and other maritime services such as mooring, pilotage and tugboat fees.

Most ports in Indonesia run using a landlord port system, however, maritime services are commonly only offered by the corresponding state-owned port authorities. With regards to the two ports in question of this study, the Port of Tanjung Priok and the Port of Tanjung Perak are state-owned by PT Pelindo II and PT Pelindo III, respectively, and it is under their authority to set prices for these maritime services. The details on these charges for the Port of Tanjung Priok and the Port of Tanjung Perak are shown in detail in the following section.

3.7.1 Port Dues in Tanjung Priok, Jakarta

The following table presents the port dues that are incurred by all merchant ships that use the facilities and services served by the Port of Tanjung Priok in Jakarta.

Table 11: *Port Dues - Port of Tanjung Priok, Jakarta*
[Source: Port of Tanjung Priok, 2017]

Charges	Tariff [USD]		Unit
Port Charges	0.0050		Per GT / visit
Berthing Fees	0.0041		Per GT / 24 hours at berth
Mooring Fees	LOA 0-50 m	8.88	Per ship / movement
	LOA 51-100 m	16.77	
	LOA 101-150 m	24.64	
	LOA 151-200 m	32.50	
	LOA >201 m	40.37	
Pilotage (Primary Charge)	14.75		Per ship / movement
Pilotage (Additional Charge)	0.0041		Per GT / ship / movement
Tug (Primary Charge)	0-3,500 GT	34.99	Per ship / hour
	3,501-8,000 GT	87.47	
	8,001-14,000 GT	138.50	
	14,001-18,000 GT	182.23	
	18,001-26,000 GT	291.57	
	26,001-40,000 GT	291.57	
	40,001-75,000 GT	291.57	
	>75,001 GT	393.63	
Tug (Additional Charge)	Below 75,000 GT	0.00055	Per GT / ship / hour
	Above 75,000 GT	0.00076	

3.7.2 Port Dues in Tanjung Perak, Surabaya

The following table presents the port dues that are incurred by all merchant ships that use the facilities and services served by the Port of Tanjung Perak in Surabaya.

Table 12: *Port Dues - Port of Tanjung Perak, Surabaya*
[Source: Meratus Line, 2017]

Charges	Tariff [IDR]		Unit
Port Charges	0.0080		Per GT / visit
Berthing Fees	0.0041		Per GT / 24 hours at berth
Mooring Fees	41.64		Per ship / movement
Pilotage (Primary Charge)	41.64		Per ship / movement
Pilotage (Additional Charge)	41.64		Per GT / ship / movement
Tug (Primary Charge)	0-3,500 GT	26.66	Per ship / hour
	3,501-8,000 GT	66.32	
	8,001-14,000 GT	105.00	
	14,001-18,000 GT	138.16	
	18,001-26,000 GT	151.89	
	26,001-40,000 GT	151.89	
	40,001-75,000 GT	151.89	
	>75,001 GT	298.43	
Tug (Additional Charge)	Below 75,000 GT	0.0021	Per GT / ship / hour
	Above 75,000 GT	0.0031	

3.8 Terminal Cargo Handling

As the two largest ports in Indonesia, container terminals in the Port of Tanjung Priok and the Port of Tanjung Perak serve both international and domestic routes. With regards to this matter, it is often the case where tariffs between international and domestic cargo are different, therefore a clear separation must be made when carrying out the necessary calculations. Tariff structures at different ports and terminals are set by the state-owned port corporations of Indonesia, PT Pelindo II and PT Pelindo III (the landlord of the Port of Tanjung Priok and the Port of Tanjung Perak, respectively), which are published to ports and terminals by announcement circulation notices.

As this study only concerns the flow of domestic cargo between the two ports in scope, the information and specifications used for this research are derived from the collected data from domestic container terminals in the two ports. The most fundamental container moves included in payments for container handling charges include stevedoring, crane lift on-lift off and terminal truck haulage, therefore this study only considers these three common moves. It is also assumed that both container terminals in the scope of research are capable of fully handling cargo using the available equipment (i.e. container quay cranes and other terminal equipment), and stevedoring using on-board equipment from the vessel is not required. In practice, there may be additional moves and hence extra charges that may come into action such as container shifting, extra movements, stack cancellation or other administrative errands, however, these moves are deemed irrelevant as they are not considered to be a significant action in the study.

In this research, the data obtained from the two terminals below are used in carrying out the calculations. The tariff structures collected below are based on the latest gathered information from the respective sources and are subject to change over time. Moreover, under the existing port infrastructure conditions, Meratus Line (2017) reports that these two terminals – having located in two of the largest ports in Indonesia – are capable of handling 30 boxes per hour under optimum conditions. For this study, however, a terminal handling capacity of 25 boxes per hour is assumed to come up with a more realistic scenario which considers extra time for buffer or technical imperfections.

3.8.1 Terminal Petikemas Koja – "Koja Container Terminal"

The container terminal in Jakarta selected for this particular study is *Terminal Petikemas Koja* (TPK) or the Koja Container Terminal, which serves as a terminal for both international and domestic cargo in the Port of Tanjung Priok of Jakarta. The container terminal is jointly operated between the state-owned PT Pelindo II in cooperation with Hutchison Ports Indonesia. With a total area of 21.80 hectares and a total berth length of 650 metres with a channel depth of 14 metres, the terminal claims to be ready in the anticipation of fourth-generation container vessels. Overall, operations in the terminal are assisted by 8 container quay cranes, 25 rubber-tyre gantries, 50 terminal trucks and other terminal equipment that altogether contributed to an annual throughput of more than 1 million containers in 2016 (TPK Koja, 2018). Concerning the calculations of this study, the terminal handling charges for cargo handling in the Koja Container Terminal are shown in the figure below.

Table 13: *TPK – Cargo Handling Charges*
[Source: Port of Tanjung Priok, 2017]

Charges		**Tariff [USD]**		**Unit**
		20'	**40'**	
Stevedoring	FCL	44.95	67.43	Per box
	LCL	96.34	147.97	
	Empty	28.01	42.01	
Lift On-Lift Off	Laden	12.97	19.45	Per box
	Empty	8.16	12.24	
Haulage	Laden	6.29	9.34	Per box
	Empty	3.67	5.26	

3.8.2 Terminal Petikemas Surabaya – "Surabaya Container Terminal"

On the other hand, the terminal in Surabaya selected for this study is *Terminal Petikemas Surabaya* (TPS) or the Surabaya Container Terminal. Dissimilar to the Koja Container Terminal, the area for domestic and international cargo handling operations at this terminal are separated where the area for international cargo dominates the total area, with an operational yard space of 35 hectares, as compared to only 4.7 hectares for domestic operations. The table below shows the tariffs charged for cargo handling of domestic cargo in the Surabaya Container Terminal.

Table 14: *TPS – Cargo Handling Charges*
[Source: Terminal Petikemas Surabaya, 2017]

Charges		Tariff [IDR] 20’	40’	Unit
Stevedoring	FCL	50.35	75.52	Per box
	LCL	96.34	147.97	
	Empty	27.53	41.29	
Lift On-Lift Off	Laden	12.45	18.67	Per box
	Empty	6.22	9.34	
Haulage	Laden	7.26	10.86	Per box
	Empty	4.08	6.12	

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Chapter 4 – Research Methodology Part 2: Optimisation Algorithm

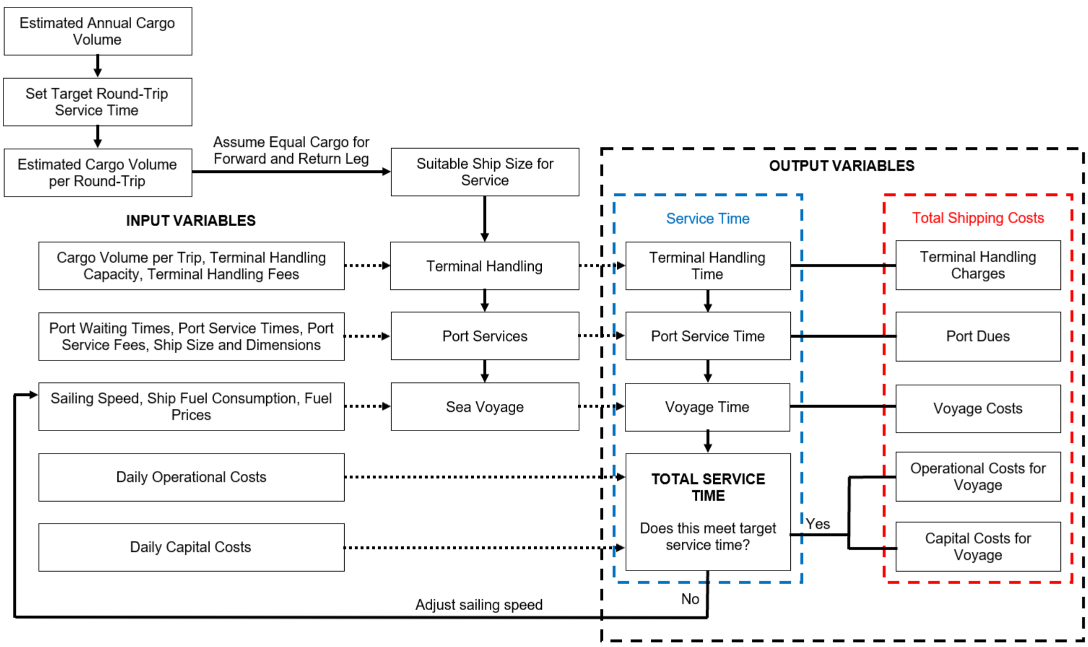
4.1 Optimisation Method

Complementary to Chapter 3 of this study, this chapter explains how the transportation costs for the proposed direct shipping route between Jakarta and Surabaya are optimised. In calculating the transport cost components considered in this study as highlighted in Sections 3.3 to 3.8, the total costs are optimised based on a set target time which is initially set as a reference point. The methodology of how this optimisation is carried out is highlighted in the following section. For computational purpose, a working spreadsheet is also generated which is used for the optimisation algorithm.

4.1.1 Algorithm Methodology

The general framework of the methodology should follow the sequence as explained in this section, as some time and cost components can only be calculated as a result from the dependency of other components and are uncontrollable by the ship operator.

Figure 14: *Optimisation Algorithm Framework*



In brief, the first component to carry out after determining a suitable ship size is to calculate the terminal handling cost and time. This is done first as terminal handling considered to be the start and finish activity of the whole round-trip, and its derivable parameters are uncontrollable by the ship operator and fully dependant on the number of containers to be discharged.

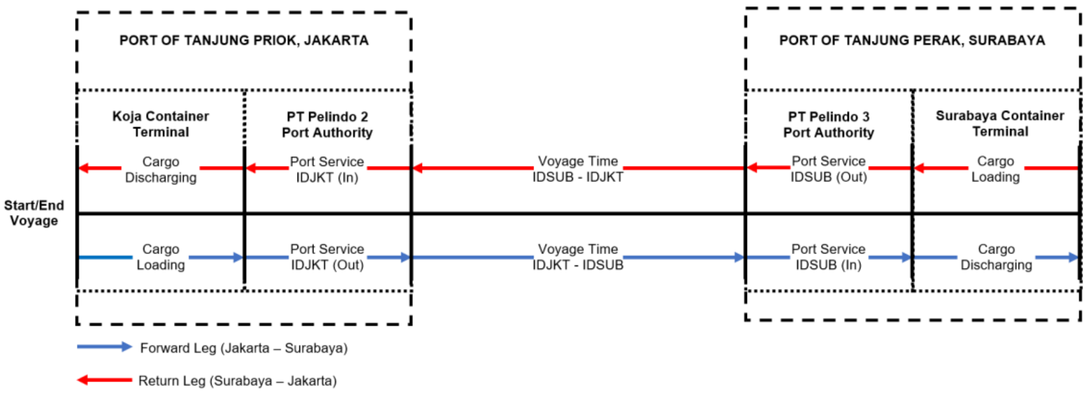
After this derivation is completed, the next component to calculate is the port service parameters, which include port dues are charged to the ship operator as well as the port service time. Port dues are a function of the ship size and the time that the ship is serviced, and the port service time depends fully on the performance of the port, which includes port waiting times, pilotage and tug services. Again, the time variable under this component is uncontrollable by the ship operator, therefore it is important that this component is carried out before determining any controllable variables to meet the target service time.

Finally, the last component to carry out is the sea voyage parameters, which in this study exclusively comprises of when the time is out at sea. Having already derived the terminal handling time and port service time, the sea voyage time can therefore be controlled by the ship operator to meet with the requirements of the set target service time. In total, the sum of the terminal handling time, port service time and the voyage time is equal to the total trip time. This total trip time is to be matched with the target service time by changing the ship speed, as this is the only controllable variable that can be changed by the ship operator.

This total trip time would then be used to calculate the capital and operational costs contributable to the round-trip voyage, hence, the total transport costs can be derived by summing all the attributable cost components.

In order to simplify calculations and to consider the cost components of both the Port of Tanjung Priok and the Port of Tanjung Perak in one algorithm, the target time set considers the round-trip time, which is defined under the figure below and the following equation.

Figure 15: *Round-Trip Journey Time Scheme*



$$Round\ Trip\ Time = Voyage\ Time + Port\ Service\ Time + Cargo\ Handling\ Time$$

Having understood this concept of round-trip time, the target service time would therefore be equivalent to half of the round-trip time and incorporates the total period from which the first cargo is first loaded on the port of origin up to the point where the last cargo is discharged at the port of destination.

In summary, the table below presents the dependencies of the cost and time components that are involved in calculating the total transport costs between Jakarta and Surabaya.

Table 15: *Dependencies of Cost and Time Components*

Component	Cost	Time
Terminal Handling Services	Number of TEUs to be loaded and discharged; terminal handling charges	Number of TEUs to be loaded and discharged; terminal crane capacity
Port Services	Ship size and dimensions; port service charges	Ship size and dimensions; port service and waiting times
Sea Voyage	Fuel consumption	Ship speed; target service time
Capital Costs	Voyage time	n/a
Operational Costs	Voyage time	n/a

4.1.2 Proposed Service Times for Analysis

For the purposes of this thesis, six "tests" are simulated to represent the scenario of six different target service times that can be considered to be competitive when compared to the services offered by the existing means of services. The six proposed services range from a single-leg service time of 2 days up to 4.5 days, in increments of half days.

A fastest service time of 2 days is proposed because this is deemed to be the fastest possible duration to which a ship can sail between Jakarta and Surabaya – taking into account the port service and waiting times, terminal handling capacities and other factors that may come into consideration. Moreover, a 2-day service speed is somewhat comparable to the existing service time that is provided by trucking and rail services, which is reported to be around this duration (Sinaga, 2012; and Latul, 2015). The service time analysis is then gradually increased by increments of half days up to 4.5 days. A service time of 4.5 days is selected as the extreme of this analysis as this is comparable to the existing sea shipping service as reported by Sinaga (2012), which takes on average 5-7 days to ship between Jakarta and Surabaya.

As discussed in Table 3 of Section 2.3, it is reported that sea shipping services between Jakarta and Surabaya are very infrequent, despite following a serviced schedule. Therefore, the expected results from this analysis is to investigate whether there is an added-value to making this proposed service scheduled and frequent.

4.2 Setting Target Service Time to Estimate Suitable Ship Size

Under the methodology framework presented in Figure 11 of Section 3.1 and the optimisation flowchart in Figure 14 of Section 4.1, the initial step in the attempt to optimise the transport costs between Jakarta and Surabaya is to set a target service time in order to estimate a desirable ship size to accommodate the proposed service route. For practical and operational reasons, it is further considered that a typical operational year consists of 350 days. In the context of shipping operations, the connectivity between two ports is commonly referred to as a leg, where in this study, a round-trip journey would consist of 2 legs, which are the single journeys from Jakarta to Surabaya and vice-versa. Having estimated annual cargo volume between the two ports as shown in Table 3 of Section 2.3, the number of containers per round trip and per leg can be derived using the following equations. It is important to highlight, however, that the calculations carried out below are assuming that cargo flow between Jakarta and Surabaya is at a constant rate and that there are equal amounts of volume in the forward and back leg of the voyage. As presented in section 3.2, the estimated annual cargo volume used for this methodology is 24,000 TEUs per year.

Equation 8: *TEU per Round-Trip*

$$TEUs\ per\ Round\ Trip = Annual\ Cargo\ Volume\ \times \frac{Target\ Round\ Trip\ Time\ [days]}{350\ days}$$

Equation 9: *TEU per Leg*

$$TEUs\ per\ Leg = \frac{TEUs\ per\ Round\ Trip}{2}$$

After carrying the expected number of TEUs per round trip for a set target time, a suitable ship size is selected by applying a load factor of 0.7 (Network for Transport Measures, 2018), which indicate that a ship designed to carry an amount of *x* TEUs would only be utilised up to 70% of the design capacity. This is also what is observed in practice, as there are often "breathing spaces" or buffer required to adjust for technical operations of the ship such as strength and stability, etc. This derived value is then rounded up to the nearest 50 TEU in order to simplify calculations for the model ship size as presented in Section 3 of this study. The formula for this calculation to estimate a suitable ship size is presented as follows.

Equation 10: *Suitable Ship Size*

$$Suitable\ Ship\ Size = \frac{TEUs\ per\ Leg}{0.7};\ Round\ up\ to\ nearest\ 50\ TEU$$

Using the relationship above, and the results for the suitable ship size with respect to the set target service times and corresponding expected cargo volume are presented in the table below.

Table 16: *Suitable Ship Sizes for Different Target Service Times*

Test	Round Trip Target Time [Days]	Service Target Time [Days]	Expected Cargo Volume [TEU]		Suitable Ship Size	
			Per Round Trip	Per One Leg	[TEU]	[GT]
1	4	2	275	138	200	2,896
2	5	2.5	343	172	250	3,410
3	6	3	412	206	300	3,923
4	7	3.5	480	240	350	4,436
5	8	4	549	275	400	4,949
6	9	4.5	618	309	450	5,463

4.3 Calculating Terminal Handling Charges and Time

The next component to calculate with respect to the interest of this study transportation costs is the terminal handling charges and time for the five different scenarios in question. As the time of terminal handling is dependent on the number of containers that need to be loaded and discharged, this is therefore the first component that should be calculated as the time is fixed and not in control of the ship operator.

Referring back to Tables 13 and 14 of Sections 3.8.1 and 3.8.2 respectively, the methodology presented in this study only considers the calculation for 20' loaded containers, as it would ultimately yield to the highest shipping cost conceivable under the assumed circumstances of the scenarios. The summary of the handling charges considered for this calculation is shown in the following table.

Table 17: *Terminal Handling Charges for Calculation*

Terminal Handling Activity	**Tariff for 20' Container Handling [USD]**	
	Jakarta	**Surabaya**
Stevedoring	44.95	50.35
Lo-Lo (Lift on-Lift off)	12.97	12.45
Haulage	6.29	7.26

Provided the terminal handling charges presented above and assuming that both terminals are capable of handling 25 boxes per hour under the operational conditions, the time and cost calculations for this component can be carried out using the following equations and is summarised in the table below.

Equation 11: *Terminal Handling Charges*

$$Terminal\ Charges = TEUs\ per\ Round\ Trip \times (Stevedoring + LoLo + Haulage)$$

Equation 12: *Terminal Handling Time*

$$Handling\ Time = \frac{TEUs\ per\ Round\ Trip}{Jakarta\ Crane\ Capacity} + \frac{TEUs\ per\ Round\ Trip}{Surabaya\ Crane\ Capacity}$$

Table 18: *Summary of Terminal Handling Charges and Times*

Test	**Volume per Round Trip [TEU]**	**Terminal Handling Charges [USD]**			**Terminal Handling Time [Hours]**
		Jakarta	**Surabaya**	**Total Charges**	
1	275	17,658.92	19,266.00	36,924.92	22.00
2	343	22,025.48	24,029.96	46,055.44	27.44
3	412	26,456.27	28,863.97	55,320.24	32.96
4	480	30,822.83	33,627.93	64,450.76	38.40
5	549	35,253.62	38,461.94	73,715.56	43.92
6	618	39,684.40	43,295.96	82,980.36	49.44

Based on the calculations carried out above, it is apparent that slowing down the service time of the proposed services would mean that more cargo is to be handled on each round-trip voyage. The result of this increase in need for cargo handling would therefore increase the total handling charges for the service as well as the time spent in the terminal.

4.4 Calculating Port Dues and Port Service Times

Having derived the terminal handling charges and cargo handling time, the next component to carry out is port dues and port service times. As explained briefly previously, port dues are dependent on the ship size, dimensions and the time when the ship is serviced to manoeuvre in and out of the berth. This would therefore require the services of pilotage, tugs and mooring services. For a typical small-sized coastal ship in the scope of this research, the typical service time to manoeuvre in and out of the berth is 6 hours for both ways (Meratus Line, 2017). This would therefore imply that it takes approximately 3 hours to manoeuvre in and another 3 hours to manoeuvre out of each port.

An additional component to consider with regards to port service times is the waiting time at the port to wait for an available berth. Meratus Line (2017) reports that the average waiting times in the Port of Tanjung Priok and the Port of Tanjung Perak are 16 hours and 8 hours, respectively. This therefore implies that a ship would spend, on average, 24 hours waiting for a berth for a round trip. In total, therefore, the ships under this research would spend a total of 36 hours serviced by the port, which includes waiting times and the duration to manoeuvre in and out of the berths.

Referring back to Tables 11 and 12 of Sections 3.7.1 and 3.7.2 of this study, respectively, the port dues for both the Port of Tanjung Priok and the Port of Tanjung Perak are summarised as follows. Also note the ship sizes that shown in Table 16 of Section 4.2, hence the tariffs used in this algorithm would only cover that which are under the corresponding ship dimensions.

Table 19: *Summary of Port Charges for Calculation*

Charges	Ship Dimensions	Tariff [USD] Jakarta	Tariff [USD] Surabaya	Calculation Unit
Port Charges	All ships	0.0050	0.0080	Per GT / visit
Berthing Fees	All ships	0.0041	0.0041	Per GT / 24 hrs at berth
Mooring Fees	LOA 0-50 m LOA 51-100 m LOA 101-150 m	8.88 16.77 24.64	All ships 41.64	Per ship / movement
Pilotage (Primary)	All ships	14.75	15.56	Per ship / movement
Pilotage (Additional)	All ships	0.0041	0.0031	Per GT / ship / movement
Tug (Primary)	0-3,500 GT 3,501-8,000 GT	34.99 87.47	26.66 66.32	Per ship / hour
Tug (Additional)	<75,000 GT	0.00055	0.00207	Per GT / ship / hour

The calculations for the port charges applicable to each of the 5 scenarios proposed in this study are carried out based on the tariffs and calculation units as presented above. As previously mentioned, a port service time of 6 hours (in and out) is used for each port, and it is also important to further understand that during the round-trip, each port will handle 1 visit and 2 movements (i.e. once to manoeuvre in and once to manoeuvre out). Moreover, as derived in Table 18 of Section 4.3, it is important to note that it requires more than 24 hours for test ship number 6 to be serviced at each terminal, therefore the calculations for berthing fees should take into account for twice the time. Other ships under the scope of the research, however, do not berth for more than 24 hours at each port, hence the calculations for berthing fees would only be counted once. To summarise the calculations, the following table presents the equations used for each port charge component at each port.

Table 20: *Equations for Port Charges Calculation*

Port Charge Component	Calculation Equation (For Each Port)
Port Charges	$Port\ Charges = Tariff\ \times Ship\ GT\ \times 1\ Visit$
Berthing Fees	$Berthing\ Fees = Tariff\ \times Ship\ GT \times No.of\ 24\ Hours\ at\ Berth$
Mooring Fees	$Mooring\ Fees = Tariff\ \times Ship\ Length\ \times 2\ Movements$
Pilotage (Primary)	$Primary\ Pilotage = Tariff \times 2\ Movements$
Pilotage (Additional)	$Additional\ Pilotage = Tariff \times Ship\ GT\ \times 2\ Movements$
Tug (Primary)	$Primary\ Tug = Tariff \times 6\ Hours$
Tug (Additional)	$Additional\ Tug = Tariff \times Ship\ GT \times 6\ Hours$

Using the equations to calculate the port service charges for each port, the total port service summary on costs and time is shown in the table below.

Table 21: *Summary of Port Service Charges and Times*

Test	Ship Size			Port Service Charges [USD]			Port Waiting and Service Time
	[TEU]	[GT]	[m]	Jakarta	Surabaya	Total Charges	
1	200	2,896	89.83	336.55	381.73	718.28	36 hours
2	250	3,410	94.56	347.82	400.76	748.57	36 hours
3	300	3,923	99.13	673.98	657.72	1,331.70	36 hours
4	350	4,436	103.56	700.99	676.75	1,377.73	36 hours
5	400	4,949	107.83	712.25	695.78	1,408.03	36 hours
6	450	5,463	111;96	746.19	737.47	1,483.66	36 hours

As ships of this size are considerably small compared to the typical ocean-going container vessels, it can be assumed under the methodology of this study that despite an increase in ship size, the port service times would remain the same for all the proposed ships. Therefore, the only matter to note under this calculation is that there is an increase in port service charges (i.e. port dues) as the proposed service times are slowed down, and this is a result from the increasing ship size and dimensions deployed in the respective services.

4.5 Optimising Service Speed and Calculating Voyage Bunker Costs

The calculations for terminal handling and port service have yielded the respective costs and charges as well as the time spent by the ship while undergoing such services. Again, it is important to note that the components that have already been carried out are not under the control of the ship operator and is fixed in terms of time. Referring back to the optimisation algorithm in Figure 14 of Section 4.1 and the voyage scheme in Figure 15, this step of the algorithm is done by adjusting the ship service speed in a way such that the target service time is achieved – having already carried out the terminal handling and port service times. The following table presents the current times spent by the ships in the terminal and port in comparison with the target service time.

Table 22: *Voyage Times Available to Meet Target Time*

Test	Ship Size [TEU]	Round-Trip Target Time [Days]	Total Terminal Handling Time [Hours]	Total Port Waiting and Service Time [Hours]	Voyage Time Available to Meet Target Time [Hours]
1	200	4 (96 hours)	22.00	36.00	38.00
2	250	5 (120 hours)	27.44	36.00	56.56
3	300	6 (144 hours)	32.96	36.00	75.04
4	350	7 (168 hours)	38.40	36.00	93.60
5	400	8 (192 hours)	43.92	36.00	112.08
6	450	9 (216 hours)	49.44	36.00	130.56

The distance between the Port of Tanjung Priok and the Port of Tanjung Perak is 391 nautical miles, therefore to cover a round-trip under the same route path, a ship would have to cover 782 nautical miles. Under this research methodology as well as in practice the sailing speed is perhaps the only variable that is controllable by the ship operator, and as discussed in Section 3.6 is a critical factor in the calculation of total costs. Given the voyage time available to meet the required target time, the optimal ship speed can then be computed using the following formula and set to meet the target time set. For practical reasons, the ship speed is rounded to the nearest half knot to simplify the incurred calculations.

Equation 13: *Optimal Ship Speed*

$$Optimal\ Ship\ Speed = \frac{782\ nautical\ miles}{Voyage\ time\ available};\ Round\ to\ nearest\ half\ knot$$

Using the equation above, the results of this ship speed optimisation is summarised in the table below.

Table 23: *Round-Trip Time Summary after Sailing Speed Optimisation*

Test	Ship Size [TEU]	Ship Speed [Knots]	Round-Trip Target Time [Hours]	Total Terminal Handling Time [Hours]	Total Port Service Time [Hours]	Total Voyage Time [Hours]	Total Trip Time [Hours]
1	200	21.0	96.00 (4 days)	22.00 (0.92 days)	36.00 (1.5 days)	37.24 (1.55 days)	95.24 (3.97 days)
2	250	14.0	120.00 (5 days)	27.44 (1.14 days)	36.00 (1.5 days)	55.86 (2.33 days)	119.30 (4.97 days)
3	300	10.5	144.00 (6 days)	32.96 (1.37 days)	36.00 (1.5 days)	71.09 (2.96 days)	140.05 (5.84 days)
4	350	8.5	168.00 (7 days)	38.40 (1.60 days)	36.00 (1.5 days)	86.89 (3.62 days)	161.29 (6.72 days)
5	400	7.0	192.00 (8 days)	43.92 (1.82 days)	36.00 (1.5 days)	111.71 (4.65 days)	191.63 (7.98 days)
6	450	6.0	216 (9 days)	49.44 (2.06 days)	36.00 (1.5 days)	130.33 (5.43 days)	215.77 (8.99 days)

Having calculated the total trip time, the bunker costs for the voyage can therefore be derived by using the ship fuel consumption relationship equations as presented in Section 3.6.1 as follows.

Equation 14: *Fuel Consumption of Selected Model Ships*

$$Fuel\ Consumption = kV^n$$

$$where$$

$$k = 0.0048007 + 0.00000121\,TEU;\ n = 3$$

Using the calculation measures above, the fuel consumption generated by the proposed ships to service the route is summarised in the table below.

Table 24: *Fuel Consumption of the Ships for the Proposed Services*

Test	Ship Size [TEU]	Ship Speed [Knots]	*k* Value	Fuel Consumption [Tonnes per Day]
1	200	21.0	5.04×10^{-3}	46.70
2	250	14.0	5.10×10^{-3}	14.00
3	300	10.5	5.12×10^{-3}	6.97
4	350	8.5	5.22×10^{-3}	3.81
5	400	7.0	5.28×10^{-3}	1.81
6	450	6.0	5.35×10^{-3}	1.15

The fuel consumption presented above is also known as the fuel consumption produced by the main engine of the vessel, which main function is to propel the ship during the sea voyage of the journey. In practice, therefore, the fuel consumptions presented above should only apply during the sea voyage of the journey where the ship is sailing at sea. however, for the purpose of this research, it is assumed that the fuel consumption should apply for the total trip time, which also incorporates the duration of the trip where the ship is service by the ports and terminals.

An additional fuel consumption component, namely the auxiliary engine fuel consumption should in practice take into account. The main function of this engine is to maintain power on-board the ship for auxiliaries such as electricity, equipment, HVAC (heating, ventilation and air-conditioning) and other necessities not involving the propulsion of the vessel. Auxiliary engines should run throughout the operation of the vessel, which therefore applies to the whole duration of the round-trip journey which includes the time when the ship is being serviced in the ports, terminals and at sea. The type of fuel used for this function are commonly High-Speed Diesel (HSD) fuels, which cost higher than that of the Marine Fuel Oils (MFO) used for the main engine of the vessel. Despite so, the fuel consumption of the auxiliary engines is significantly less than the main engine, therefore the costs of fuel for the main engine is assumed to outweigh the fuel costs for the auxiliary engines.

Despite this being not a very accurate way to measure the actual bunker costs, this assumption holds valid for this research as by doing so, the results would yield the highest bunker cost attainable as a “worst-case” scenario for the proposed service. Moreover, the additional fuel that is consumed by the excess days that should not be taken into account can be considered as reserve fuel for the ship, which may perhaps also include the fuel required for the auxiliary engine.

Under Section 3.6.2 of this study, it is determined that the average MFO price over the period of observation is carried out to be IDR 9,156,499.99 per tonne. Having known this value, the total bunker costs for the round-trip voyage can be calculated under the following formula and is presented in the table below.

Equation 15: *Bunker Costs*

$$Bunker\ Costs = Fuel\ Consumption\ \times Round\ Trip\ Service\ Time\ \times Fuel\ Price$$

Table 25: *Summary of Voyage Duration and Total Bunker Costs*

Test	Ship Size [TEU]	Ship Speed [Knots]	Fuel Consumption [Tonnes per Day]	Round-Trip Time [Days]	Total Bunker Costs [USD]
1	200	21.0	46.70	4	140.688.41
2	250	14.0	14.00	5	52,731.97
3	300	10.5	6.97	6	27,012.04
4	350	8.5	3.81	7	16,914.22
5	400	7.0	1.81	8	10,921.49
6	450	6.0	1.15	9	7,825.96

The results from this analysis on voyage time optimisation and bunker costs yield that slowing down the proposed service time would allow the corresponding ships to sail at a slower speed, hence exponentially reducing the fuel consumption of the vessel. In turn, this wold therefore lead to a significant reduction in bunkering costs. All in all, an important outcome can be drawn where there is a trade-off between service speed and fuel costs, where a faster service speed would require the need for fuel – hence higher bunkering costs. This concept is in-line with the general fuel consumption methodology as presented by Wang and Meng (2012).

4.6 Calculating Voyage Capital and Operational Costs

As presented in Sections 3.4 and 3.5 of this study, the annual capital and operational costs for the ship voyage is derived from the study of Veldman (2012) and scaled down to determine the costs that are incurred by the ships in the scope of this research. The study by Veldman (2012) proposes a methodology to calculate the annual capital and operational costs that are attributable to a ship, under the assumption of 350 operational days per year. Recalling the following line equations that are used to calculate the annual capital and operational costs in USD, the annual capital and operational costs for the ships used are proposed in the table below.

Table 26: *Capital and Operational Costs for the Ships in the Proposed Services*

Test	Ship Size [TEU]	Annual Capital Costs [USD]	Annual Operational Costs [USD]
1	200	3,780,985.74	1,366,905.97
2	250	3,864,416.34	1,388,244.46
3	300	3,947,775.42	1,409,564.64
4	350	4,031,062.95	1,430,866.51
5	400	4,114,278.96	1,452,150.09
6	450	4,197,423.43	1,473,415.36

Having known these values and knowing the round-trip duration of the proposed serviced, the capital and operational costs that are attributable to that particular voyage can be calculated using the following formulas.

Equation 16: *Voyage Capital Costs*

$$Voyage\ Capital\ Costs = Annual\ Capital\ Costs \times \frac{Voyage\ Duration}{350\ days}$$

Equation 17: *Voyage Operational Costs*

$$Voyage\ Operational\ Costs = Annual\ Operational\ Costs \times \frac{Voyage\ Duration}{350\ days}$$

The summary of capital and operational costs that are attributable to the proposed services are shown in the table below.

Table 27: *Summary of Voyage Capital and Operational Costs*

Test	Ship Size [TEU]	Total Voyage Duration [Days]	Voyage Capital Costs [USD]	Voyage Operational Costs [USD]
1	200	4	43,211.27	15,621.78
2	250	5	55,205.95	19,832.06
3	300	6	67,676.15	24,16397
4	350	7	80,621.26	28,617.33
5	400	8	94,040.66	33,192.00
6	450	9	107,933.75	37,887.82

4.7 Summary of Optimisation Methodology

To summarise the optimisation methodology, this chapter has calculated the cost and time variables of the various components that apply in the proposal of a direct shipping liner route between the Port of Tanjung Priok and the Port of Tanjung Perak. Following the derivation, it is carried out that the total transport costs are the sum of several attributable components, which are terminal handling charges, port service dues, voyage bunkering costs, capital costs and operational costs. On the time dimension of the optimisation, it is calculated that the total round-trip time includes the time the ship cargo is handled in the terminals, the time in which the ship is manoeuvred in and out of the berth, port waiting times as well as the time spent sailing at sea en-route to the designated destinations. The results of the optimisation carried out is discussed in the next chapter of this study, which also includes the calculation of the hypothetical scenario where a significantly greater expected annual cargo volume is estimated.

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Chapter 5 – Results and Discussion

5.1 Resulting Total Transport Costs

Following the optimisation algorithm as explained in Chapter 4 of this study, the following section presents the resulting total shipping costs (including its components) and service times for the proposed exclusive direct shipping line service between Jakarta and Surabaya. Do note again that these derived costs are based on an estimated annual volume between Jakarta and Surabaya of 24,000 TEU (Meratus Line, 2017) and also assuming perfect operational conditions where the estimated service times by the ship, port and terminal are not delayed or incur any extenuating circumstances. The basic calculations carried out are also based on the conditions where only one ship is deployed for the service, as this is deemed to be the less costly option of deployment. This assumption is deemed valid as it appears that only small sized shipments are required, and there is only need for a single vessel to be deployed for the service. Despite so, a calculation where two ships are deployed for the service is also discussed in Section 5.3 for verification purposes.

The table below presents the summary of all the ships deployed on the proposed services as well as the transport cost components that are attributable to each voyage. Note that the table below presents the results of the calculation where only a single ship is deployed for the service.

Table 28: *Results Summary of Optimisation*

	Test	1	2	3	4	5	6
Voyage Details	**Return Voyage Time**	4 days	5 days	6 days	7 days	8 days	9 days
	Service Time	2 days	2.5 days	3 days	3.5 days	4 days	4.5 days
	TEU per Round-Trip (Single Leg)	275 (138)	343 (172)	412 (206)	480 (240)	549 (275)	618 (309)
	Ship Size [TEU]	200	250	300	350	400	450
	Sailing Speed [Knots]	21	14	10.5	8.5	7	6
Attributable Costs [USD]	**Capital Costs**	43,211	55,206	67,676	80,621	94,040	107,934
	Operational Costs	15,622	19,832	24,164	28,617	33,192	37,888
	Bunker Costs	140,688	52,731	27,012	16,914	10,921	7,826
	Port Dues	718	749	1,332	1,378	1,409	1,484
	Terminal Handling Charges	36,925	46,055	55,320	64,451	73,716	82,980
	Total Transport Costs	**237,165**	**174,574**	**175,504**	**191,981**	**213,278**	**238,111**

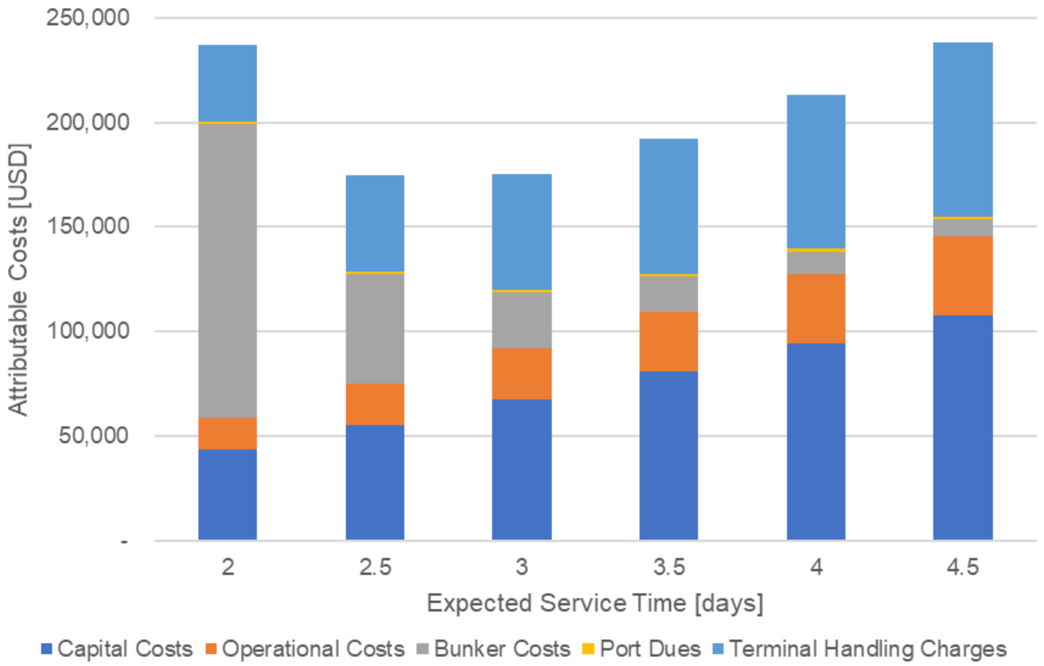
Provided the resulting costs that are an outcome of the derived optimisation, several preliminary conclusions with respect to the attributable transport costs can be drawn. First of all, assuming that there is a constant demand of transport between Jakarta and Surabaya, intuitively it can be seen that the choice of service time between the two ports have a direct effect on the amount of volume to be carried per trip. It is observed that slowing down the service speed would increase the number of containers carried per trip – hence the need for a larger ship. As more containers are to be handled by an increasing ship size, this would therefore imply that larger terminal handling costs would be incurred. Moreover, a larger ship size would also result in greater capital and operational costs, as these are presumed to be fixed costs which are a direct function of ship size.

There is also a gradual increase in port dues as a result from the increasing ship sizes deployed, nonetheless, this component can be considered as a very minor cost component as it is very small compared to the other significant costs.

Despite this, however, a longer service time would allow slowing down the service speed, which, as explained in Section 3.6,1 can significantly reduce bunkering costs as the relationship between fuel consumption and ship speed is exponential. This is observable in the simulation carried out, where there is a significant decrease in the voyage bunker costs when servicing at a longer service time by slowing down the vessel. Overall, therefore, it is conceivable that there is a trade-off between how fast the service is expected to be with bunkering costs.

To illustrate the composition of the attributable costs in relation to the total transport costs, the figure below shows the breakdown of the cost components with respect to the total costs. Note that the costs highlighted in the following figure are the costs that are attributable to the entire round-trip journey of the proposed services

Figure 16: *Total Transportation Cost – Breakdown per Component*

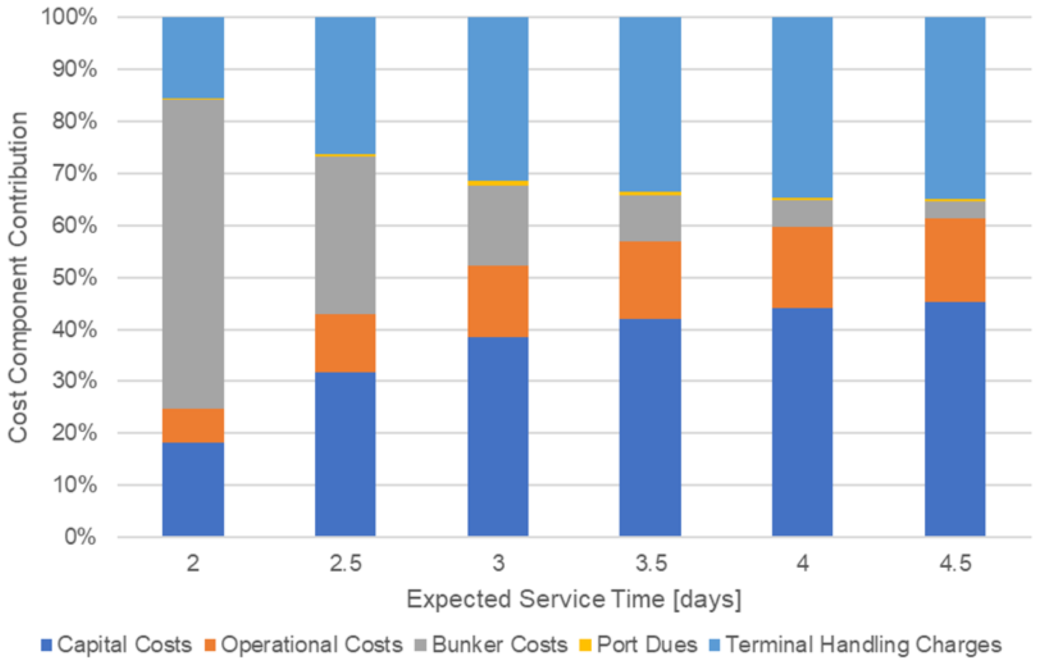


In observing the results shown in the figures above which depicts the contributions of each cost component that make up the total transport costs, several interesting outcomes can be drawn. The first interesting aspect to remark is that the relationship between the total transport costs and the service times are only somewhat proportional from an expected service time of 2.5 days and longer. A service time of 2 days would incur a total cost of USD 237,165, however, just by slowing down the service by a half day, this cost significantly decreases to USD 174,574. From this point onwards, the total cost gradually increases up to a total cost of USD 238,111 for a 4.5-day service time.

This then draws to another interesting remark, where despite a lower total cost incurred when slowing down the service time, apparently the total transport costs for a 4.5-day service would actually be higher than that of the 2-day service. As the simulation holds, slowing down the ship would effectively decrease the voyage bunker costs, however, the major contribution to this higher cost would be a result from the larger ship that is deployed for the service, which in turn incurs an increase in capital costs, operational costs and the terminal handling charges due to more containers being handled over the voyage. As a larger ship is deployed – and despite a longer service time – these costs outweigh the significant reduction in bunker costs, hence resulting in larger total transport costs.

To further illustrate the cost breakdown, the figure below shows the cost component contribution as a percentage proportion to the total transportation costs that are attributable to the corresponding service times.

Figure 17: *Proportionality of Cost Components to Total Transport Costs*



The cost proportionality figure above again shows that slowing down the expected service time would result in an increasing proportion of capital costs, operational costs and terminal handling charges, which is a result from the larger ship that is deployed for the service. These gradual increases in proportion, however, is balanced out by a significant decrease in the contribution of bunker costs, as a longer service time allows the ship to slower its speed and reduce fuel costs. Port dues, on the other hand, are again seen as a very minor component and do not contribute significantly much to the total transportation costs.

Overall, however, despite the differences in cost component proportionalities for the different service times, a conducive outcome can be drawn as shown in Figure 16, where deploying a direct shipping line service between Jakarta and Surabaya with a service time of 2.5 days would yield the lowest total transport costs. This outcome yields as the most optimal solution in the proposed problem, where the deployment of this service with the proposed ship size, sailing speed and voyage details would result in a total transport cost of USD 174,574.

5.2 Resulting Transportation Costs per TEU

After carrying out the total transport costs for the proposed services, the next analysis is the conversion of these costs to yield the unit transportation costs per TEU. The process to convert the total transport costs into unit costs is a single step process, where the total costs are to be distributed evenly to the amount of TEU that are shipped within the proposed services. This section provides the thorough analysis of the resulting transportation costs per TEU that correspond to the different expected service times.

5.2.1 Transportation Costs per TEU

In conjunction with the results presented in Section 5.1, the following table shows the resulting transportation costs per TEU under the six different service scenarios.

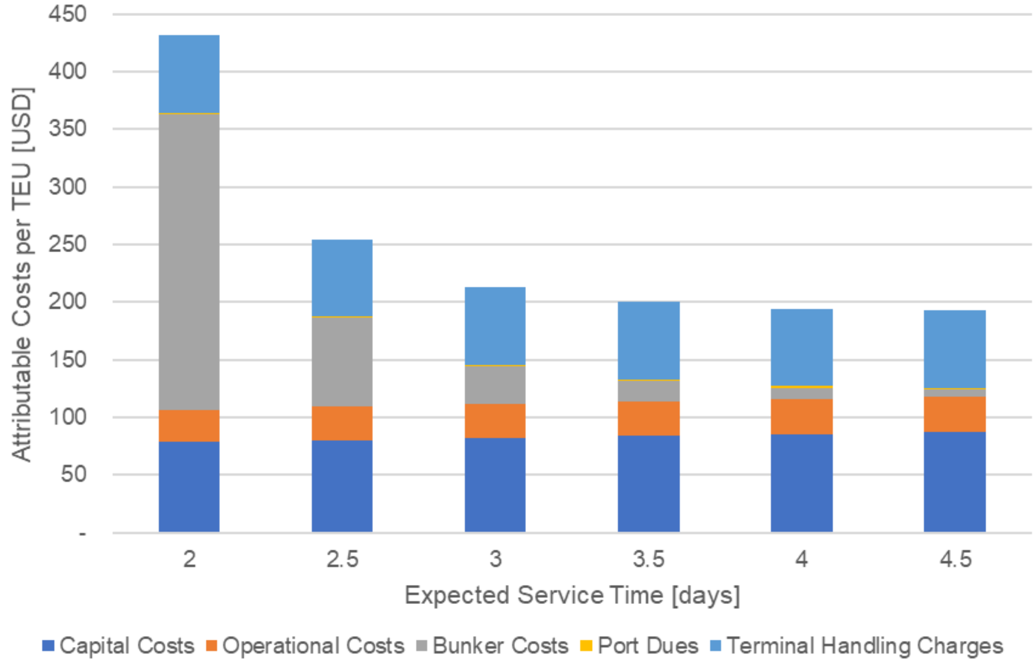
Table 29: *Summary of Transport Costs per TEU*

Test	**1**	**2**	**3**	**4**	**5**	**6**
Service Time	2 days	2.5 days	3 days	3.5 days	4 days	4.5 days
TEU per Round Trip	275	343	412	480	549	618
Round Trip Cost [USD per TEU]	862.42	508.96	425.98	399.96	388.48	385.29
Single Leg Cost [USD per TEU]	**431.21**	**254.48**	**212.99**	**199.98**	**194.24**	**192.65**

It is observable based on the results above that the cost to ship a container for a single leg from Jakarta to Surabaya (or the return leg) would decrease with longer service time. Intuitively, this would make sense and is analogous to other typical freight, shipping or mail services, where customers or service users would be offered a higher price for express services or faster delivery times and lower prices for standard and longer service times.

Despite this reduction in transportation costs per unit, the proportionality of each cost component would exactly follow the proportions as shown in Figure 17, as the relationship for the total voyage are directly comparable to the unit costs. The figure below shows the attributable cost components that make up the total transport costs per TEU deduced above.

Figure 18: *Transportation Cost per TEU – Breakdown per Component*



In contrast to the observations seen for the total transportation costs of the entire service where there is an increase in total transport costs when slowing down the expected service time, the opposite is observed with respect to the transport costs per TEU. Rather than an increase in total costs for the total voyage, a reduction in transport costs per TEU is observed when the expected service time of the proposed service is longer. This therefore verifies that the characteristics of economies of scale are in fact applicable, where increasing the size of the ship would ultimately reduce the transportation costs per TEU.

The first remark to highlight with regards to the transport cost per TEU is to observe that the terminal handling charges for each TEU shipped – despite the difference in service times – remain the same as this is a fixed charge for the container to be handled by the terminals. Again, similar to the analysis carried out for the service, port dues come out to be a very minor part of the transport costs. On the other hand, capital and operational costs per TEU appear to increase slightly with the longer proposed service times as a result of a larger ship that is required to accommodate the service, however, the most significant cost reduction is seen in the bunkering costs. Therefore, it is conceivable that bunkering costs is a decisive factor with in the contribution towards total shipping costs.

On the contrary to the results presented for the total transportation costs for the service which directly yields to an optimal transport cost at a 2.5-day service speed between Jakarta and Surabaya, the resulting costs per TEU carried out do not yield to an exact optimum that can be directly computable. As shown in the figure above, the transport costs per TEU continuously decrease with a slower service time – hence the longer the service time, the lower the shipping cost. This is in-line with the concept argued by Karsten et al. (2015), where low costs are likely to result in a prolonged transit time. Therefore, the optimum transport cost should be compared with the time value of shipping the cargo, which in turn relates do customer expectations and demands. The costs and the respective service times should also be examined in contrast to the typical costs and service times by the existing means of transport to contest on a competitive service.

As the analysis carried out provides the results in terms of transport costs, it is quite difficult to benchmark and compare this to the costs and performances of the existing modes of transport as this is often reported in terms of the price charged to customers as previously shown in Table 3. As the existing conditions hold, it is arguable that the main competition of the proposed route would be the existing transport services provided by trucking services, which promise a lead time of 1-2 days at a reported cost of around USD 690. Hakim (2018) investigates that under this price, the estimated transport costs by truck between Jakarta and Surabaya is around USD 360, meaning that the difference between the two is the profit obtained by the truck service provided. With this relatively high price, however, these services provide high flexibility as the services can be made to order and on demand by the customer. This would therefore pose as the contestable factor that the proposed shipping service can provide.

Freight train services, on the other hand are currently not considered as a main competition as they are limited to the carrying capacity per trip, despite a very low reported price of around USD 170 and a relatively short lead time. On the contrary, this mode would be a major competition if a replenishment and investment to existing rail services is made. For the time being and for the purposes of this study, however, this does not seem to be the case.

As the results carried out from the optimisation show, the total transport costs per TEU for a 2.5-day service at USD 254.48 would already be very competitive as compared to the existing trucking transport, in which Hakim (2018) reports to be around USD 360. Therefore, say, if the shipping company would charge customers double this cost at around USD 500 or so, this would still be very competitive and significantly less than the prices charged by existing truck services. In addition to support this argument, the proposed sea transport service is also guaranteed to arrive to the designated destination port at 2.5 days, compared to trucking services which may face road problems such as congestion or driver fatigue that may result in delays in lead time. Despite this, the only drawback of this service is that the ship would only be able to pick-up cargo at a port of origin once every 5 days, which mean that the containers would have to be pooled at a port before shipment to the port of destination. This, however, may not be a major problem as it is very common in Indonesia that the shippers and cargo owners would be the ones that follow the scheduling and voyage timetables set by the shipping company to get their cargo at the port of loading prior to the departure of the ship. Furthermore, the argument by Agarwal and Ergun (2008) also supports this solution as they assert that regular schedules of up to a week for a particular route would be acceptable to enable shipping companies to provide customers with a reasonably high level of responsiveness.

The type of cargo that are shipped would also have to be set as a deciding factor in selecting the most optimum service option.

This cost competitiveness also holds for the longer proposed service times, however, again it should be considered that there is a trade-off between service time and the total costs incurred.

5.2.2 Time Value of Transport

To further argue in support to the cost and time comparisons, a time value of transport for the different service time scenarios can be used as an optimisation gauge for the optimum result, which is the difference in total costs when incrementally slowing down the expected service time. Overall, this difference in costs represent how much cost savings can be obtained when slowing down the service time.

Table 30: *Optimisation by Cost Savings – Time Value of Transport*

Test	**1**	**2**	**3**	**4**	**5**	**6**
Service Time	2 days	2.5 days	3 days	3.5 days	4 days	4.5 days
Shipping Cost [USD per TEU]	431.21	254.48	212.99	199.98	194.24	192.65
Cost Saving per Half Day Slower [USD]	n/a	176.73	41.49	13.01	5.74	1.60

On this matter, it is carried out based on the optimisation results that the most significant change in costs is visible when the service time is slowed down by half a day from 2 days to 2.5 days, where a cost saving of USD 176.73 is yielded. On the other hand, slowing down the service time by half a day from 2.5 days to 3 days would only result in a cost saving of USD 41.49 and even lower costs savings when slowing down the service time even more.

As a result, based on this analysis, a service time of 2.5 days would be the optimal solution as it yields to the most significant cost savings possible under the provided circumstances.

5.3 Deployment of Multiple Ships to the Proposed Service

Based on the discussions and analysis already carried out, the presented results have yielded that providing a direct shipping service between Jakarta and Surabaya with a service time of 2.5 days would be the most optimal solution to the problem. Despite so, this is under the assumption where only one vessel is deployed for the service, meaning that the service would only call at each port once every five days. According to Guericke (2014) vessel type and size deployed on a single service would determine the volume carried for a certain round-trip, whereas the number of vessels determine the frequency of the service under a fixed schedule subject to the service speed of the vessel.

In practice, therefore, it can be seen that shipping lines would often deploy multiple ships to a service in order to meet with customer demands, which mean that there would be more frequent calls to a port for that particular service. Referring to the study of Argawal and Ergun (2008), in order to run a daily schedule at each port, the number of ships required within a service should be equal to the number of round-trip days for a ship to complete a cycle. In order to verify whether or not this option would further save costs of the service, this section presents the calculations for a scenario where service time is still kept at 2.5 days, however, multiple ships are deployed which mean that the entire service can pick up cargo at either on a more frequent basis – instead of only once every 5 days where only a single ship is deployed. This option would be more beneficial from the point of view of the customer, as it guarantees a more frequent pick-up and delivery of their cargo, however, this section attempts to look at the prospect of this alternative from the viewpoint of the ship operator.

Following the same optimisation algorithm and still with the estimated cargo volume of 24,000 TEU per year between Jakarta and Surabaya, a similar approach is carried out by splitting the expected cargo per round-trip service to the number of ships that are deployed. To give an illustration on how this is done, the following table compares the transport costs for the cases where either a single ship or two ships are deployed to the service, however, the similar approach also applies when deploying more ships into the proposed service. As the service time of 2.5 days has yielded the most optimal solution, this scenario is selected to be used for the comparison study. The table below presents the comparison to illustrate the option where deploying 2 ships to the service is set, however, the similar relationship also holds when deploying more ships. This analysis is further expanded to scenarios where 5 ships are deployed, and cases where more ships are deployed are discussed later in this section.

Table 31: *Results Summary for Single vs. Multiple Ship Deployment*

	Scenario	1 Ship Deployed	2 Ships Deployed		*n Ships Deployed*
			Per Ship	Total	…
Voyage Details	**Service Time**	2.5 days	2.5 days		…
	Call Frequency at Each Port	Once per 5 days	Once per 5 days	Once per 2.5 days	…
	TEU per Round-Trip	343	172		…
	TEU per Single-Leg	172	86		…
	Ship Size [TEU]	250	150		…
	Sailing Speed [Knots]	14	11.5		…
Attributable Costs [USD]	**Capital Costs**	55,206	52,821	105,642	…
	Operational Costs	19,832	19,222	38,444	…
	Bunker Costs	52,731	28,534	57,068	…
	Port Dues	749	688	1,376	…
	Terminal Handling Charges	46,055	23,095	46,189	…
	Total Transport Costs	**174,574**	**124,360**	**248,720**	**…**
	Transport Cost per TEU	**254.48**	**362.57**		**…**

The service frequency at each port with respect to the number of ships deployed is explained under the following formula.

Equation 18: *Service Frequency*

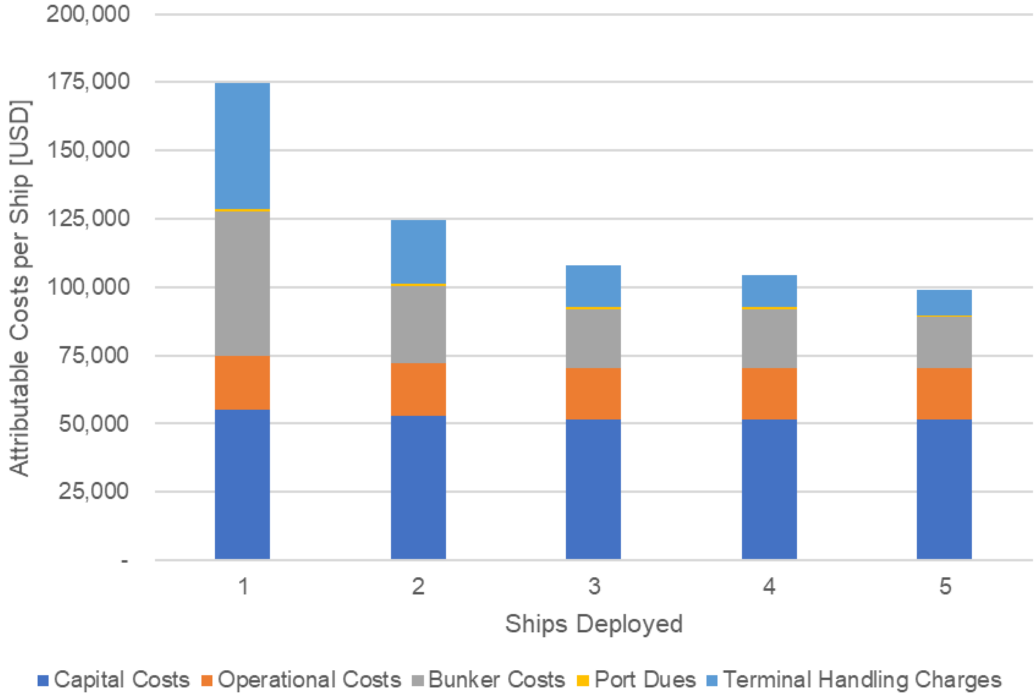
$$Service\ Frequency = Once\ every\ \left(\frac{Round\ Trip\ Time\ per\ Ship}{No.of\ Ships\ Deployed}\right)\ days$$

As explained above and presented in the table, the deployment of an extra ship to the service while still retaining a service time between the two ports at 2.5 days would imply that there would be a ship available at each port to load and discharge cargo once every 2.5 days. This means that the service would be more flexible to customer demand, as each ship would be ready at each port every 2.5 days, instead of every 5 days in the initial scenario. Overall, therefore, the deployment of more vessels into the proposed service would result in more service calls to a port, hence the capability for the service to load and discharge cargo in a more frequent basis.

Moreover, considering the same cargo volume estimation required per year, a multiple ship deployment would mean that ships of smaller sizes are able to accommodate the service. A smaller ship incurs in lower capital and operational costs, as it was presented in Sections 3.4 and 3.5 that these costs are a function of ship size. The terminal handling charges for each ship would be distributed evenly to the number of TEU per ship as the cargo is now split into several ships, however, the total terminal handling charge for the entire service would remain the same as the same amount of cargo is handed in total (note that the slight difference in the table above is a result of the cargo volume being rounded up for simplification purposes). In turn, a smaller ship size would mean that there would be less cargo handling time per ship, hence allowing the vessel to sail at a slower speed and reduce bunker costs.

The cost structure per ship as shown table presented above and the results of the cost calculations for multiple ship deployment are given in the figure below and expand up to the scenario where 5 ships are deployed. Note that under the derived calculations, the capital costs and operational costs per ship for the scenarios where 3 or more ships are deployed remain constant at around USD 52,000 and USD 19,000, respectively, as these proposed services deploy equally sized ships of 100 TEU and this is the smallest available ship size under the model ship data as presented in Section 3.3.

Figure 19: *Cost per Ship Deployed for Multiple Ship Deployment*

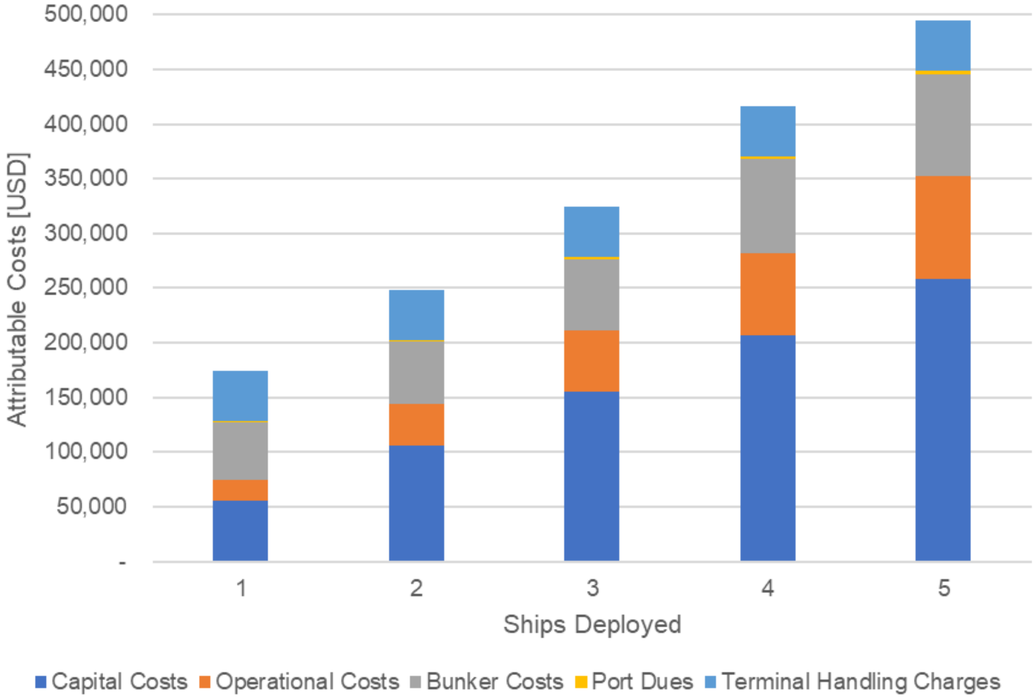


When downscaling of the required ship size for the option to deploy multiple ships in the service, it is observable that deploying multiple ships would actually cut down the total transport costs per ship, however, doing this does not benefit the entire service as the total transport costs for the service would significantly increase as a result having multiple ships deployed instead of only one. It is therefore conceivable that the relationship between the total transportation costs and service deployment is not linear, as shipping larger amounts of cargo with a larger ship would prove to be more cost-saving than to split the shipments with two smaller ships.

The relationship holds as it is conceivable that the capital and operational costs for each additional ship – despite them being smaller in size – are the major contributing factors to the increase in total costs as they are directly multiplied by the number of ships that are deployed. As the relationship between these costs and ship size are not linear, the deployment of multiple ships would apparently reduce the capital and operational costs per ship, however, when viewing the costs to the entire service, this would actually increase the total costs. To further illustrate this relationship, the figures below shows the comparison of the costs per ship and the total costs for the service with the option of deploying a single ship or multiple ships to accommodate the service.

By directly multiplying the costs per ship deployed as shown in the previous figure, the figure below presents the total transportation costs for the entire service under the different schemes where multiple ships are deployed.

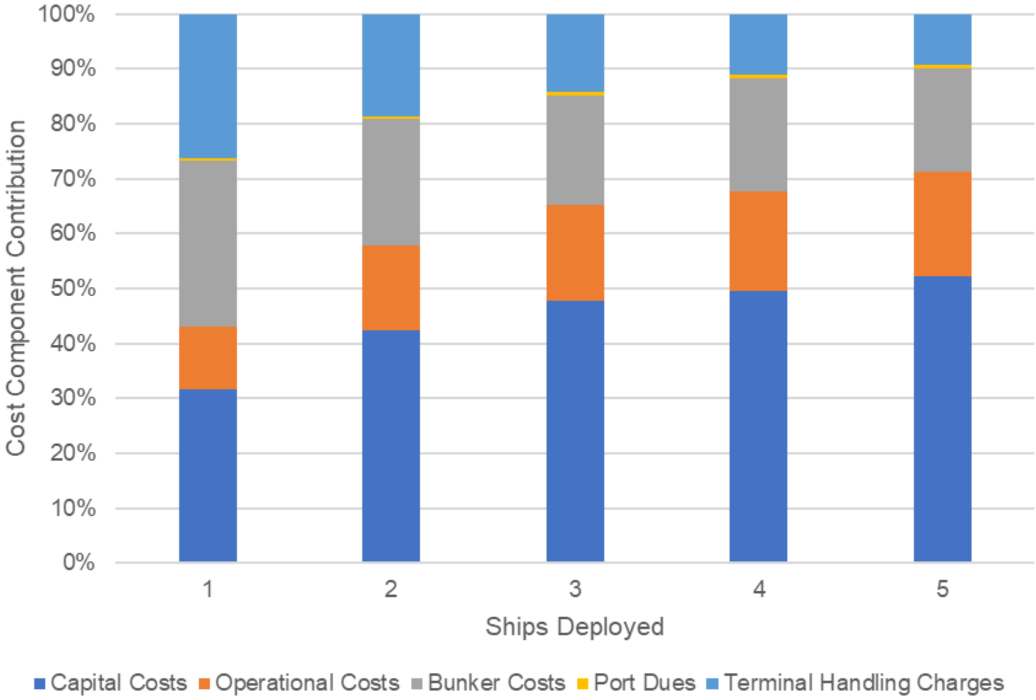
Figure 20: *Total Transport Costs for Multiple Ship Deployment*



As presented, it is conceivable that deploying multiple ships would actually increase the total costs for the entire service, despite a lower cost per ship. The results yielded from this analysis exhibit the characteristics of economies of scale and diseconomies of scope, where the option to deploy a single large vessel to the service would reduce the transportation costs for the entire service, however, fragmenting the service to be aided by multiple smaller vessels would actually be costlier, despite a lower transport cost per ship. Under these circumstances, therefore, it can be concluded that there is a trade-off between service frequency (i.e. how frequent a ship calls at each port) and the total costs for the service – meaning that a larger cost is incurred if the service is set more frequently.

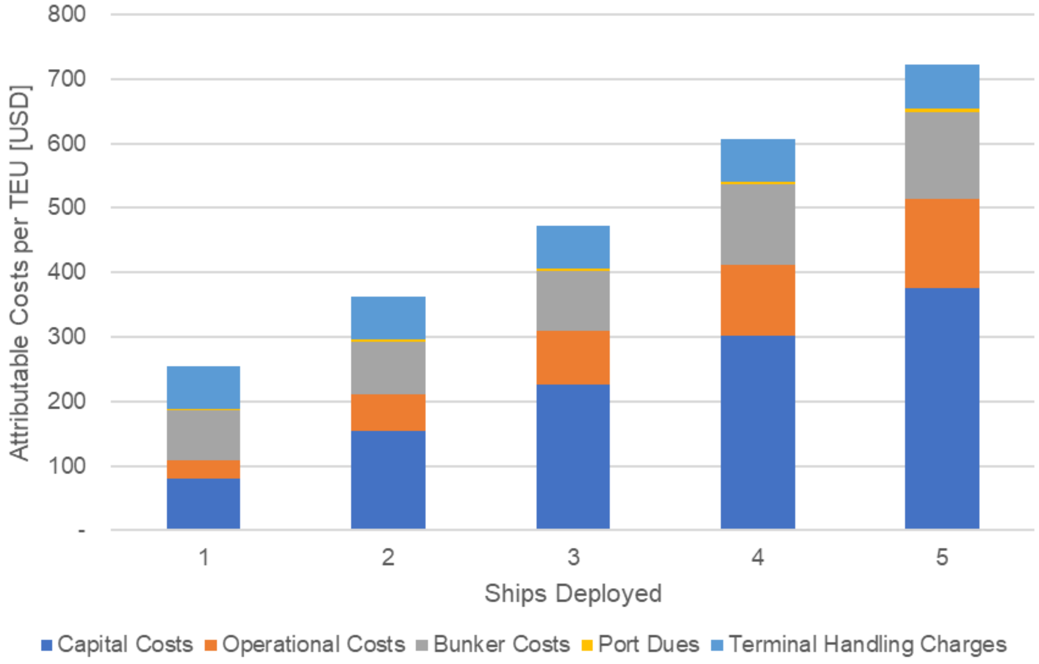
To highlight further on this matter, the figure below compares the proportionality of each cost component between the option to deploy one or two vessels with respect to the total transport costs of the respective voyages. Note that this proportionality relationship also holds valid when looking at the transportation costs per TEU.

Figure 21: *Proportionality of Cost Components for Multiple Ship Deployment*



In conjunction to an increase in the total transportation costs when deploying multiple ships, it is further observed that the deployment of multiple ships would result in a greater proportion of capital and operational cost in contribution to the total costs. These cost components are the main drivers in the increase in total costs from deploying multiple ships, hence the proportionality of terminal handling charges and bunkering costs would decrease to even out the cost component contributions. This is also due to the reason that despite more ships. Scaling this proportionality down, the figure below shows the transportation cost components per TEU. As the same number of container volumes are handled for the entire service, the distribution of the cost components per TEU is identical to that of the total transportation costs, despite the fact that multiple ships are deployed.

Figure 22: *Transportation Cost per TEU for Multiple Ship Deployment*



The option for multiple ships and service frequency can further be optimised by the ship operator which provides such a service by revenue management and pricing strategies. Under the matter of costs, – which is the primary focus of this study – a conclusion can be drawn where the deployment of one ship for the service would in fact be the least costly and hence yield as the optimal solution.

5.4 Hypothetical Scenarios for Large Volume Transport Demand

In addition to the calculations that have been carried out to the corresponding cases, this section presents the calculations of two additional hypothetical scenarios to compare the transportation costs that may be incurred when a large volume of transport demand is expected. For the purposes of this study, hypothetical estimated annual cargo volume estimate between Jakarta and Surabaya of 100,000 TEU an 200,000 TEU are used for the basis of the calculations. This range of estimation is still within the estimated 1,720,000 TEU annual cargo volume by Sinaga (2012), Latul (2015) and Syaiful (2017), which in turn would cover up a slightly higher market share of this total volume by all modes of transport. To keep in competition with the existing services offered by the different modes of transport, a target service time of 2.5 days is still kept, however, as the cargo volume is significantly greater, this would allow the option and need to deploy multiple vessels to the services.

In the selection of the cargo volume to the hypothetical scenario amount, a maximum annual cargo volume 200,000 TEU is considered as this would be the maximum volume that the existing port infrastructure in Jakarta and Surabaya are capable of handling without imposing consequences to jeopardise the set target service time. To illustrate such a problem, a larger amount of volume of 250,000 TEU is tested under the methodology, and the results yielded that even with the deployment of 5 ships to the service, each ship would have to spend about 57 hours in the terminals for cargo handling and would need to sail at a speed of about 30 knots to keep up with the target service time. In practice, this would not be viable as the normal operational sailing speeds for container vessels are between 20-25 knots. Moreover, with the same round-trip time of 5 days and deploying 6 ships into the service would imply that a ship would call at each port once every 20 hours (0.83 days), which in practice would not be practical due to the infrastructure limitations of the ports and terminals.

5.4.1 100,000 TEU Estimated Annual Cargo Transport Demand

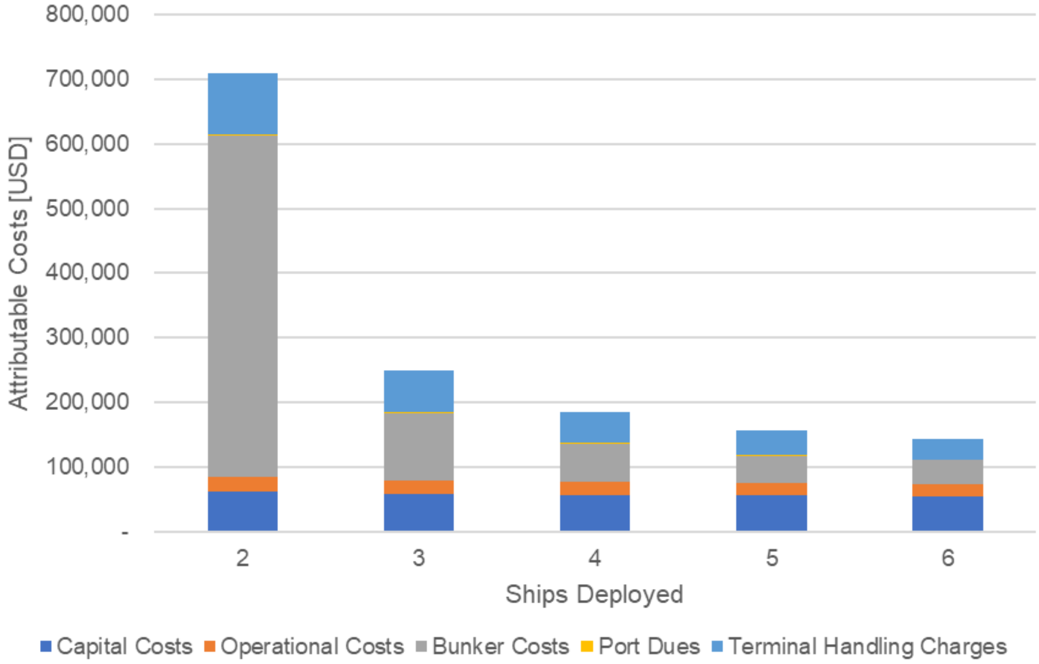
The results of the hypothetical scenario where an annual cargo of 100,000 TEU is estimated are presented in the table below, which shows the transportation cost while retaining the competitive 2.5-day service time. For presentation purposes, the table shows the scenarios where 3 and 4 ships are deployed, however, this analysis is expanded to the scenarios of 2 to 5 ships and is discussed afterwards.

Table 32: *Results Summary for 100,000 TEU Hypothetical Scenario*

	Scenario	3 Ships Deployed Per Ship	3 Ships Deployed Total	4 Ships Deployed Per Ship	4 Ships Deployed Total	n Ships Deployed
Voyage Details	Service Time	2.5 days		2.5 days		…
	Service Frequency	Once per 5 days	Once per 1.67 days	Once per 5 days	Once per 1.25 days	…
	TEU per Round-Trip	477		358		…
	TEU per Single-Leg	239		179		…
	Ship Size [TEU]	350		300		…
	Sailing Speed [Knots]	17.5		14.5		…
Attributable Costs [USD]	Capital Costs	57,587	172,760	56,397	225,587	…
	Operational Costs	20,441	61,323	20,137	80,547	…
	Bunker Costs	105,434	316,302	59,281	237,122	…
	Port Dues	1,378	4,133	1,332	5,327	…
	Terminal Handling Charges	64,048	192,144	48,070	192,278	…
	Total Transport Costs	**248,887**	**746,662**	**185,215**	**740,861**	**…**
	Transport Cost per TEU	**261.25**		**259.22**		**…**

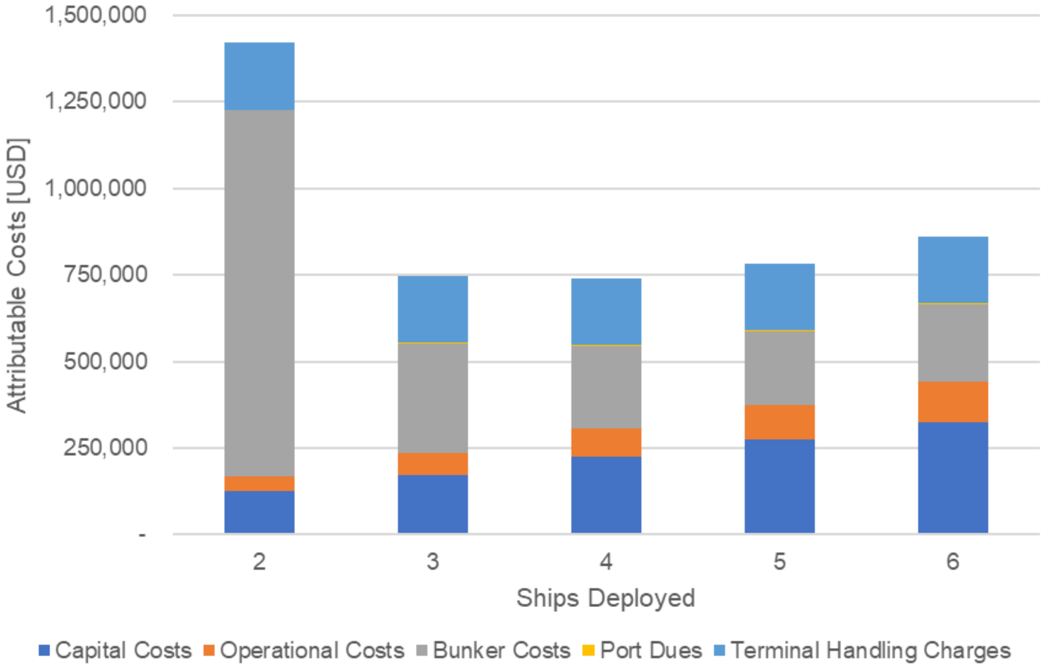
Under the analysis of this hypothetical scenario, it is observable by this comparison calculation that deploying more vessels under this case would effectively reduce the transport costs and is contradictive to that of presented in Table 31, where the deployment of two vessels are costlier than deploying one. Despite this, however, this relationship where the total transportation costs would reduce as more ships are deployed do not hold for larger amounts of vessel deployment, as explained based on the figures shown below.

Figure 23: *Cost per Ship Deployed for 100,000 TEU Hypothetical Scenario*



As shown in the figure above, it is conceivable that the same relationship as presented in Section 5.3 with regards to multiple ship deployment holds valid, where the costs per ship would decrease as more ships are deployed. Despite so, a contradictive view is observed when looking at the entire service, where as a result of this significant increase in cargo transport demand in the proposed hypothetical scenario, the total transport costs for the entire service would also decrease as more ships are deployed as presented in the figure below.

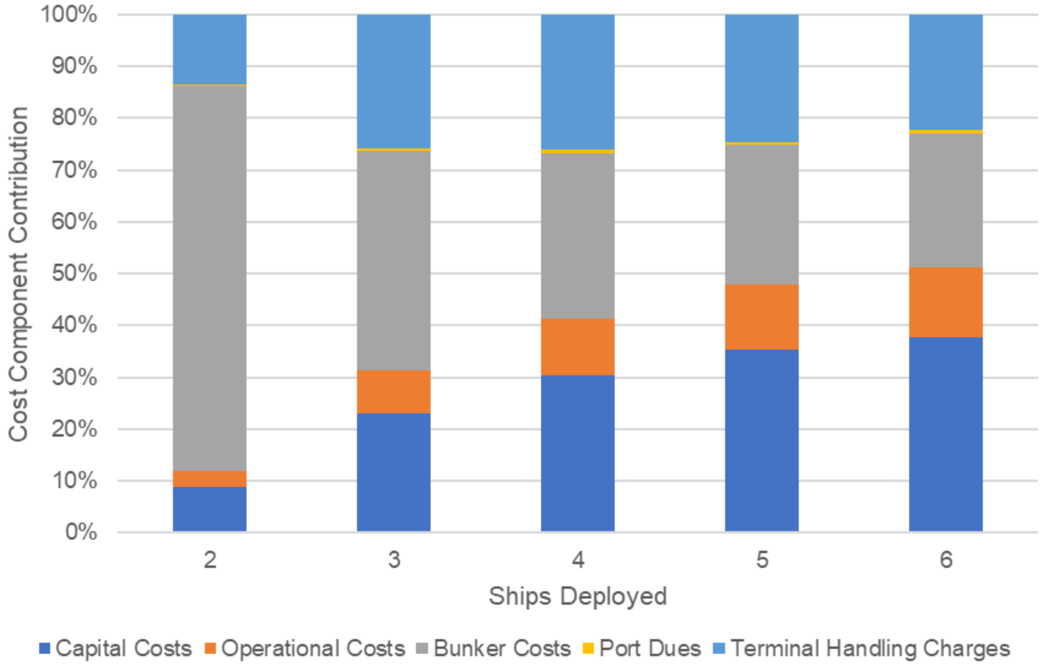
Figure 24: *Total Transport Costs for 100,000 TEU Hypothetical Scenario*



Under the observation of this figure, it is observable that the total costs for the service would tend to decrease as more vessels are deployed into the service. Overall, therefore, it is conceivable under the scenarios presented that at larger volumes for transport demand, deploying more vessels would significantly reduce costs – up to a certain extent – as it is carried out that this relationship only holds up to the point where 4 vessels are deployed, and there is an increase in total costs when 5 vessels are deployed.

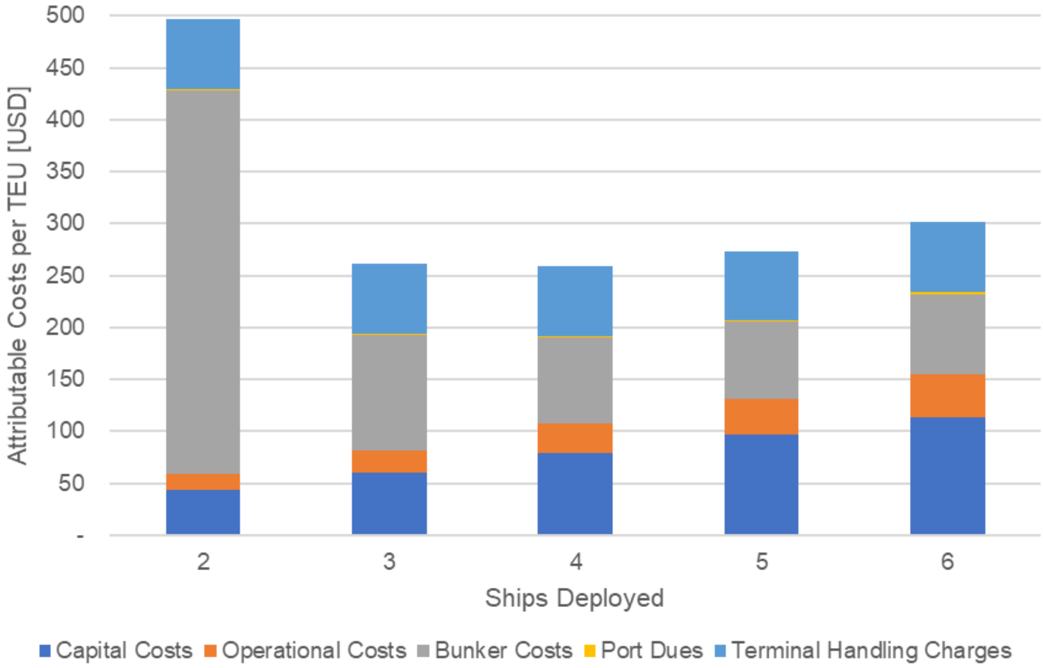
Again, it can be seen that the total terminal handling charges remain the same for all cases, as the same amount of cargo is handled for the entire service. Bunker costs, as the theory holds, still remain as the most variable cost component as deploying more ships allow a reduction in speed, hence significantly cutting down the costs for fuel. Despite this decrease in bunker costs, however, it is further observable that the components of capital and operational costs increase and outweigh the other cost components as more ships are deployed, which in turn is the main cause of the total cost increase when 5 vessels are deployed. To further illustrate on the proportionality of these cost components, the figure below presents the cost contributions of each component with respect to the total costs of the entire service.

Figure 25: *Cost Proportionality for 100,000 TEU Hypothetical Scenario*



As the relationship holds, it is again conceivable that the contribution of capital and operational costs with respect to the total costs would increase with more ships being deployed, however, the contribution of bunker cost decrease as a result from the possibility to significantly cut down bunker costs by slowing down the service speed. Similar to the previous scenarios, these cost proportionalities also hold for the transport costs per TEU for the corresponding cases, and these costs are shown in the figure below.

Figure 26: *Transportation Cost per TEU for 100,000 TEU Hypothetical Scenario*



A first important highlight to make is that the cost per TEU results in the case where 4 ships are deployed are the highest among all the tested scenarios and would not be practically viable as the ships would have to sail at a service speed of 29.5 knots. As shown in the figure above, it is observable that the optimum result, quantitatively, would be yielded in the case where 4 ships are deployed into the service, which results to a cost per TEU of USD 259.22.

5.4.2 200,000 TEU Estimated Annual Cargo Transport Demand

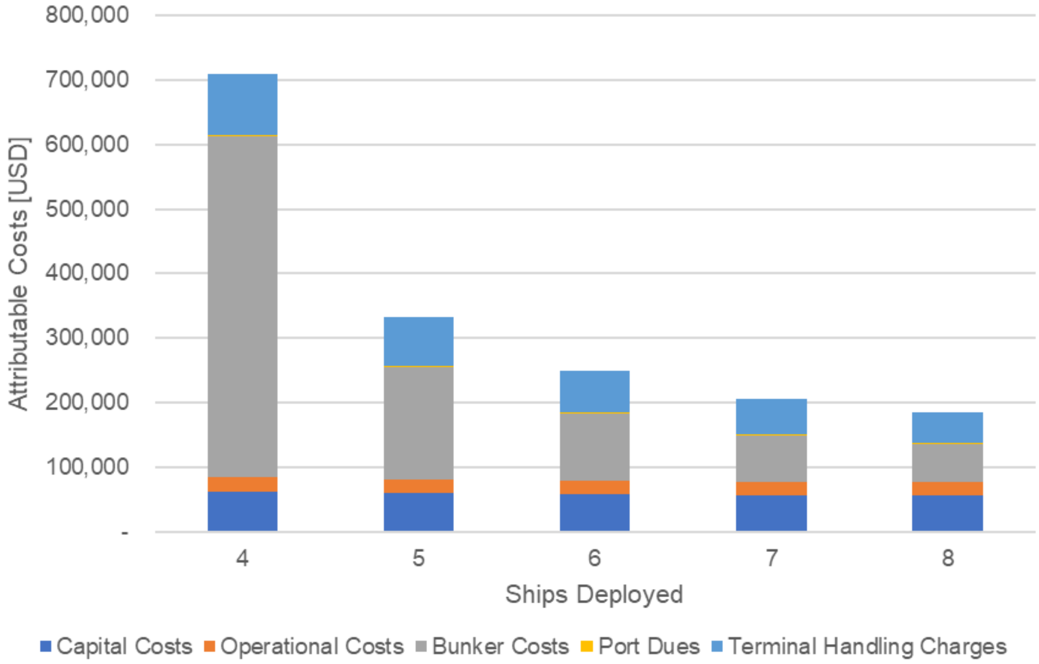
The results of the hypothetical scenario where an annual cargo of 200,000 TEU is estimated are presented in the table below, which shows the transportation cost while retaining the competitive 2.5-day service time. For presentation purposes, the table shows the scenarios where 4 and 5 ships are deployed, however, this analysis is expanded to the scenarios where 8 ships are deployed and is discussed afterwards.

Table 33: *Results Summary for 200,000 TEU Hypothetical Scenario*

	Scenario	4 Ships Deployed Per Ship	4 Ships Deployed Total	5 Ships Deployed Per Ship	5 Ships Deployed Total	n Ships Deployed
Voyage Details	**Service Time**	2.5 days		2.5 days		…
	Service Frequency	Once per 5 days	Once per 1.25 days	Once per 5 days	Once per day	…
	TEU per Round-Trip	715		572		…
	TEU per Single-Leg	358		286		…
	Ship Size [TEU]	550		450		…
	Sailing Speed [Knots]	29.5		20.5		…
Attributable Costs [USD]	**Capital Costs**	62,336	249,343	59,963	299,816	…
	Operational Costs	21,656	86,622	21,049	105,244	…
	Bunker Costs	528,444	2,113,776	173,409	867,047	…
	Port Dues	1,553	6,211	1,438	7,192	…
	Terminal Handling Charges	96,005	384,019	76,803	384,019	…
	Total Transport Costs	**709,993**	**2,839,971**	**332,664**	**1,663,318**	**…**
	Transport Cost per TEU	**496.85**		**290.99**		**…**

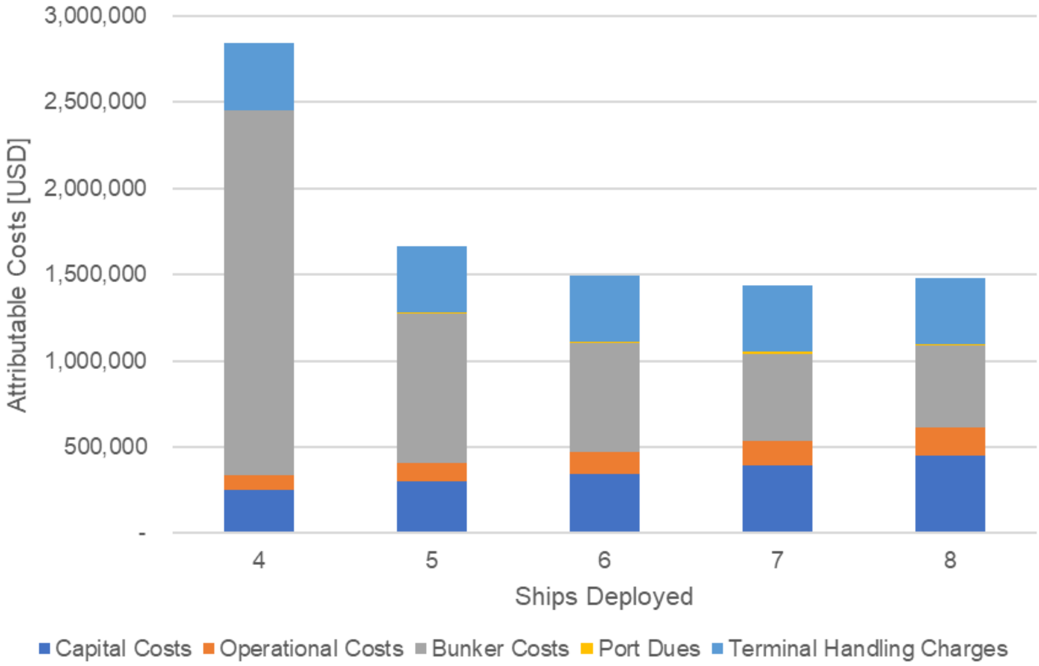
As presented in the table above, it is observable that the deployment of 4 ships would already be inviable as the ships in the service would have to sail at a service speed of 29.5 knots – which is significantly above the typical sailing speeds of a container vessel. Overall, however, it is again observable that deploying more vessels under this case would effectively reduce the transport costs, which is similar to that as shown in the previous scenario. Moreover, the same relationship also holds valid where there is a reduction in total transportation costs only to a certain extent as more ships are deployed. The cost structures for this 200,000 TEU hypothetical scenario are further explained and discussed under the following figures.

***Figure 27**: Cost per Ship Deployed for 200,000 TEU Hypothetical Scenario*



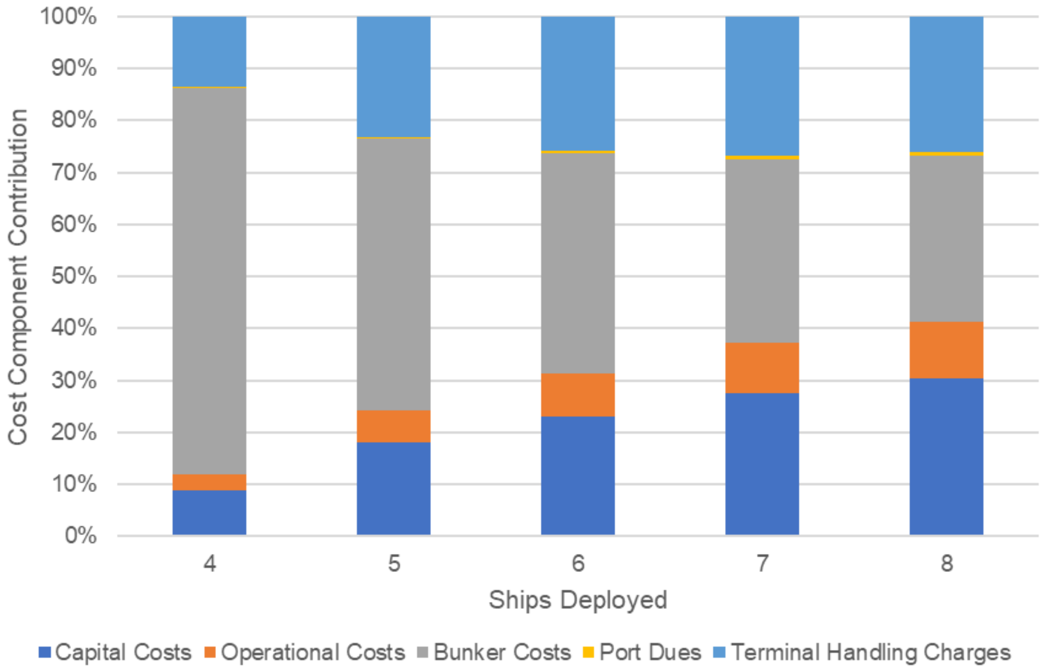
Again, it is conceivable that the same relationship on the concept of multiple ship deployment holds, where it is presented that the costs per ship would in fact decrease as more ships are deployed. Moreover, similar to the previous case, the total transport costs for the entire service would also decrease as more ships are deployed, however, this is only to a certain extent as presented in the figure below.

***Figure 28:** Total Transport Costs for 200,000 TEU Hypothetical Scenario*



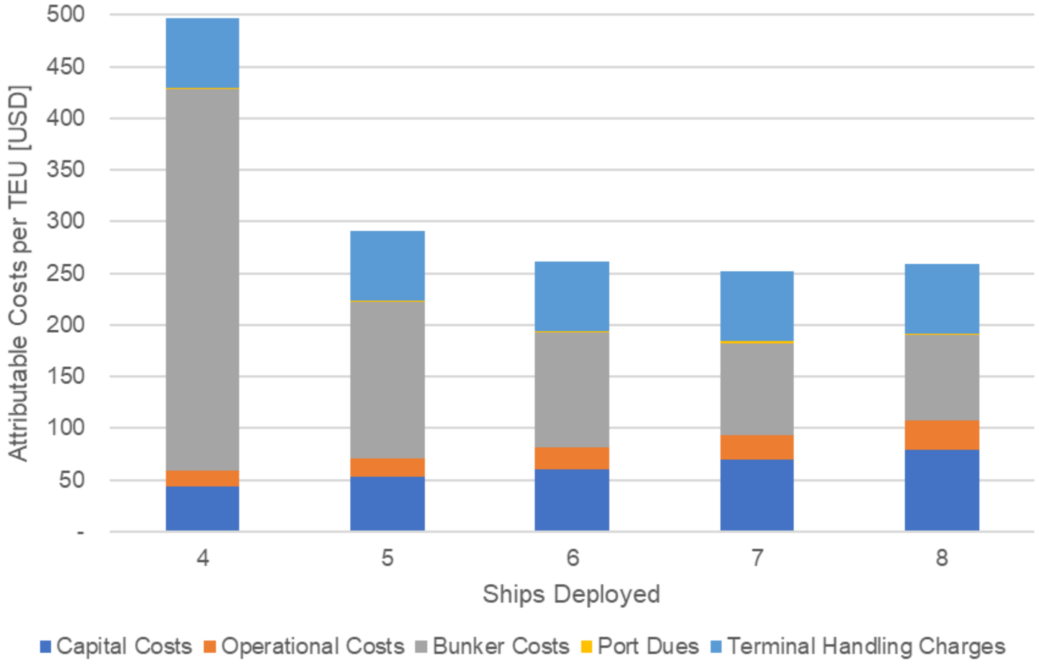
Under the observation of this figure, it is again observable that the total costs for the service would tend decrease as more vessels are deployed into the service, however, this tendency only holds up to the point where 7 vessels are deployed, and there is an increase in total costs when 8 vessels are deployed. The proportionality of these cost components is shown below, which also extend to the transportation costs per TEU.

Figure 29: *Cost Proportionality for 200,000 TEU Hypothetical Scenario*



It is again observable that as a result from deploying more ships into the service, the contribution of capital and operational costs with respect to the total costs tend to increase, however, the bunker costs decrease as a result from slowing down the ship service speed and hence reducing fuel consumption.

Figure 30: *Transportation Cost per TEU for 200,000 TEU Hypothetical Scenario*



A first important highlight to make is that the cost per TEU results in the case where 4 ships are deployed are the highest among all the tested scenarios, and – as further illustrated from the results table – would not be practically viable as the ships would have to sail at a service speed of 29.5 knots. As shown in the figure above, it is observable that the optimum result, quantitatively, would be yielded in the case where 7 ships are deployed into the service, which results to a cost per TEU of USD 251.29. Despite this argument, there are several other considerations that may be taken into account when determining the most suitable service option – other than by a numerically or quantitative manner. Other practical reasons such as the service convenience to the port and frequency could be considered and set as a decision criteria.

Deploying more ships into the service would in turn lead to more frequent calls into a port by the entire service, despite a similar round-trip time per ship. Therefore, in this case, deploying 7 ships to the 5-day round-trip service per ship would mean that a ship would call into each serviced port once every 17 hours (0.71 days). In practice, this would not be very practical as there may be cases where two ships are being serviced at the same port or terminal at the same time. Therefore, under the reasons for service practicality, deploying 7 ships would not be the best decision, despite it yielding the lowest cost per TEU.

Under these qualitative arguments and carried out calculations, therefore, it would perhaps be the optimal solution for this proposed scenario to deploy 5 ships into the service, which results in a transport cost per TEU of USD 290.99. With 5 ships being deployed to the service, there would be a ship calling at each port once every day, which is in fact necessary to accommodate for the large amount of expected annual volume, hence also providing to be very responsive to customer demand. Overall, this resulting cost is still deemed as competitive to the existing transport services by keeping a short service time and also adjusting for readiness and response to customer demand.

5.5 Comparison of the Proposed Services

Under the methodology carried out in this analysis, an outcome can be drawn that a service time of 2.5 days between Jakarta and Surabaya by sea would be the most optimal solution to the research problem. Incorporating the same service times, the analysis also carried out different specific scenarios that undermine the proposition of the direct shipping liner service. The results of these scenarios, despite following the same optimisation algorithm and methodology, yields several interesting and different manners of results as shown in the table below.

Table 34: *Comparison of Proposed Services*

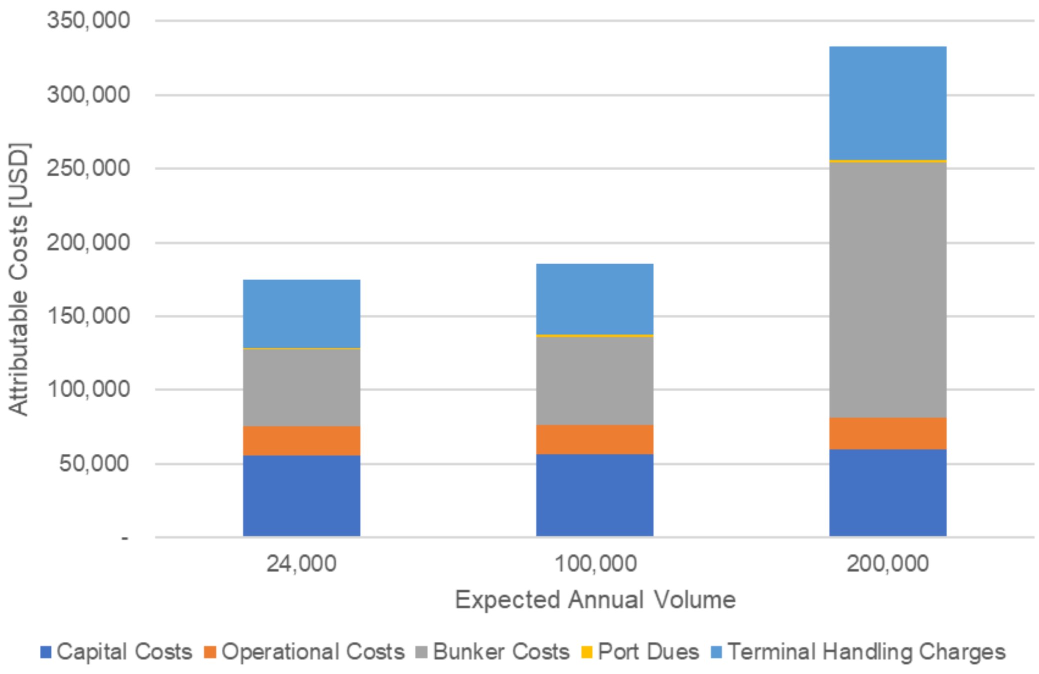
	Scenario	**24,000 TEU Annual Volume**	**100,000 TEU Annual Volume Per Ship**	**Total**	**200,000 TEU Annual Volume Per Ship**	**Total**
Voyage Details	**Service Time**	2.5 days	2.5 days		2.5 days	
	Ships Deployed	1	4		5	
	Service Frequency	Once per 5 days	Once per 5 days	Once per 1.25 days	Once per day	Once per day
	TEU per Round-Trip	343	358		572	
	TEU per Single-Leg	172	179		286	
	Ship Size [TEU]	250	300		450	
	Sailing Speed [Knots]	14	14.5		20.5	
Attributable Costs [USD]	**Capital Costs**	55,206	56,397	225,587	59,963	299,816
	Operational Costs	19,832	20,137	80,547	21,049	105,244
	Bunker Costs	52,731	59,281	237,122	173,409	867,047
	Port Dues	749	1,332	5,327	1,438	7,192
	Terminal Handling Charges	46,055	48,070	192,278	76,803	384,019
	Total Transport Costs	**174,574**	**185,215**	**740,861**	**1,663,318**	**1,663,318**
	Transport Cost per TEU	**254.48**	**259.22**		**290.99**	

The first scenario attempts at proposing a direct shipping line service that captures the entire existing annual predicted sea transport volume of 24,000 TEU, with the hopes that a more frequent and regular service would bring an added-value to the condition that currently stands. Under this scenario, the results show that for a 2.5-day service time between Jakarta and Surabaya, one ship with a carrying capacity of 250 TEU would yield to be the optimum solution that results in a transport cost per TEU of USD 254.48.

On the other hand, the additional hypothetical scenario proposes a service between Jakarta and Surabaya by looking at the case where an expected annual sea transport volume of 100,000 TEU and 200,000 TEU is set. To meet the set target service time under these settings, multiple ships are required due to the limitations and constraints under the existing port and terminal infrastructure conditions. The service to accommodate an annual volume of 100,000 TEU requires the deployment of 4 ships with carrying capacities of 300 TEU, resulting in a total transport cost per TEU of USD 259.22. In the case where there is an expected annual volume of 200,000 TEU, the quantitative optimal would result in the deployment of 7 ships at a transport cost of USD 251.92 per TEU, however, in practice this would be impractical due to a too frequent service schedule which results in a very fast ship turnover time at each terminal. As a result, the most viable solution requires the deployment of 5 ships of 450 TEU and results in a transport cost per TEU of USD 290.99 which serves on a daily schedule.

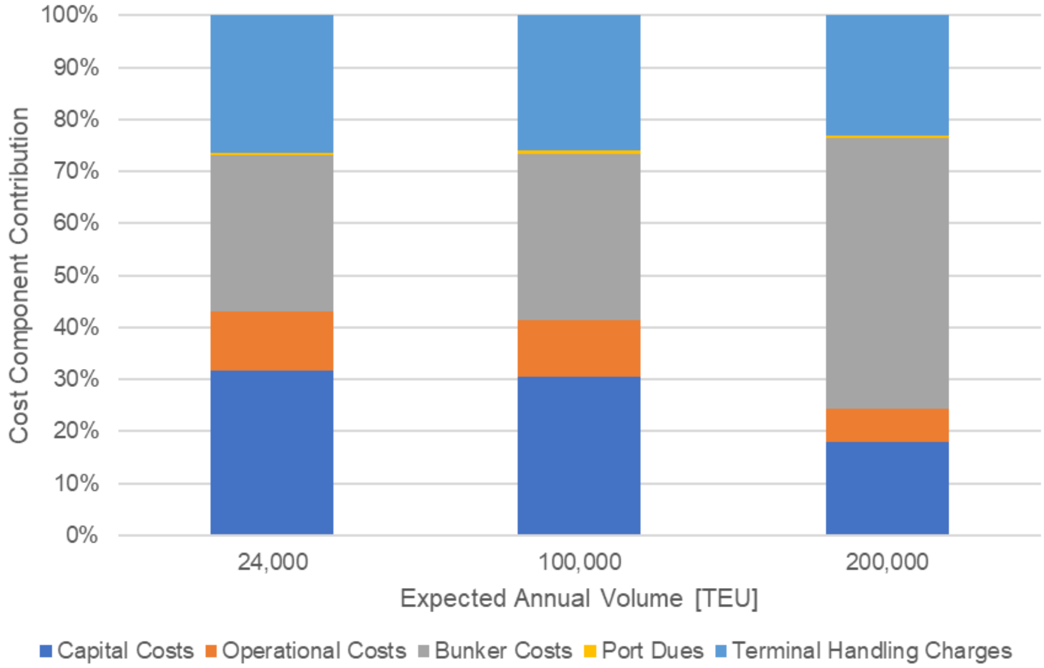
When comparing the costs incurred per ship, it is observable that the total transport costs per ship under these scenarios – as well as its corresponding components – experiences an increase as a larger vessel would be required to accommodate the service. This is also backed by the fact that a larger ship would spend more time in the terminals to handle cargo, hence the need to sail at a faster speed and increasing the required bunker costs, which in turn experience the greatest change. There is, however, not much difference in the capital and operational costs per ship for the two scenarios, as in the hypothetical scenario, as the increasing need in ship size is not that significant.

Figure 31: *Cost per Ship Deployed - Existing vs. Hypothetical Scenarios*



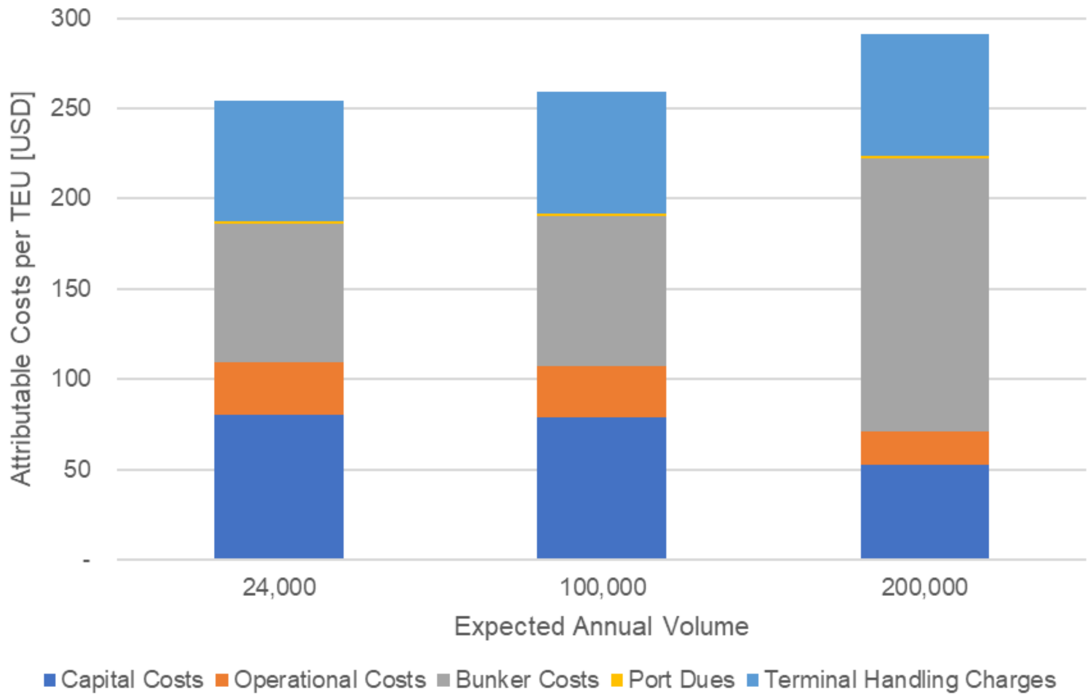
An interesting remark to note in the comparison of these components is that the total cost per ship between the scenario of 24,000 TEU and 100,000 TEU are somewhat very similar, and this is caused by the similarities found in the details for each deployed voyage. As a result, the cost structure between these two scenarios follow a similar manner. Moreover, the capital and operational costs per ship incurred by all three scenarios do not vary significantly as all three cases deploy ships of similar size. Overall, however, a large deviation can be seen in the bunker costs in the case where an annual volume of 200,000 TEU is estimated as a result from a faster optimum service speed of the deployed vessels to accommodate for a longer cargo handling time at the terminals. The costs incurred per ship and the proportionality of the attributable costs is shown in the following figures.

Figure 32: *Cost Component Proportionality – Existing vs. Hypothetical Scenarios*



As expected, it is shown that bunker costs are the most variable cost component and experiences the greatest change when larger volumes are expected, despite the fact that more ships are deployed. The proportion of capital and operational costs, on the other hand show a decrease as larger volumes are expected as these costs are split among greater amount of cargo, given the fixed ship sizes for the proposed hypothetical services. The same relationship also holds with regards to the terminal handling charges, as the costs are split among a greater amount of cargo under the same cargo volume that is shipped on each service. This cost proportionality can further be scaled down to the unit cost level of cost per TEU, and the illustration of this is shown in the figure below.

Figure 33: *Transportation Cost per TEU - Existing vs. Hypothetical Scenario*



In summary, based on the calculations and discussions, the results set are carried out based on a service time to ship cargo between Jakarta and Surabaya of 2.5 days. In the attempt to capture the entire exiting annual sea transport flow of 24,000 TEU by a proposed scheduled service, the results yield that a single vessel would be sufficient to accommodate this demand at a transport cost per TEU of USD 254.48. Under this proposition, however, the consequence of only a single ship being deployed into the service would imply that the ship would only call at each port once every five days. Despite this drawback, these costs appear to still benefit and bring an added value to the existing condition, where as compared to trucking services which charge customers at significantly higher prices and uncertain lead times, the proposed shipping service would guarantee a 2.5-day lead time at a lower overall transport cost.

When comparing this to the option of rail transportation, freight train services are comparatively still priced at lower prices even with a significantly shorter lead time, however, they are limited to capacity as they can only carry about 40 TEU per trip. As a result, the benefit from the possibility of large scale shipping by sea transport would therefore become the added benefit and advantage of the proposed service.

When scaling the expected annual volume to hypothetical estimations of up to 200,000 TEU, the tests conclude that the bottleneck of the proposed services lie in the limited cargo handling capacity of the terminals and restrictions on the respective ports, hence the need to deploy multiple smaller vessels to the proposed services while maintaining the same service times. In turn, the deployment of multiple ships would bring a consequential benefit to the entire service, where there would be more frequent calls into the ports to load and discharge cargo. Despite this added advantage, however, the costs incurred per ship should be optimised with respect to the total costs for the entire service, as it is derived that up to a certain extent, deploying an extra ship would in fact increase the total transport costs.

Overall, the results show that an increase in total costs per TEU is expected with a larger anticipated cargo volume under the same service time set. On this matter, it is derived that a predicted annual cargo volume of 100,000 TEU between Jakarta and Surabaya would yield to a cost per TEU of USD 259.22, and a larger expected volume of 200,00 would result to a cost per TEU of USD 290.99. These higher costs, however, would still be competitive as compared to the existing trucking services and can be further counterbalanced by the fact that under these conditions, service flexibility is encouraged by a daily schedule – hence making the service more responsive to customer demand.

Despite all the calculations carried out under the hypothetical scenario, under the existing conditions, the deployment of 4 or more ships as proposed in the hypothetical scenarios would be possible, however, this would disrupt other ships serviced by the terminals due the limited berths and relatively fast turnaround time per ship. Therefore, the propositions under the hypothetical scenarios, in practice, are not yet deemed as feasible, as the infrastructure would have to be further developed by, say, the provision dedicated berths at the terminals that would only exclusively accommodate the proposed service between Jakarta and Surabaya.

In summary, the results presented by this study show that the proposed service route between Jakarta and Surabaya by looking at the existing transport volume has a high potential to add value to the current transportation network. The total costs per TEU, – despite the arguments under the different hypothetical scenarios of the expected annual volumes – are deemed to be competitive when setting a service time between the two ports at a guaranteed 2.5 days. Furthermore, the resulting costs already incorporate a time value benefit and are significantly cheaper than the prices charged by existing trucking services, which in practice performs under uncertain lead times.

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Chapter 6 – Conclusions and Recommendations

In summary, this thesis has looked at a proposition of a direct and exclusive shipping liner service between the Port of Tanjung Priok in Jakarta and the Port of Tanjung Perak in Surabaya by looking at its probable feasibility to the existing transport and infrastructure conditions. Under the data collection from the respective sources, it is highlighted that the current existing cargo volume flow between Jakarta and Surabaya amounts to around an estimated 1,720,000 TEU per year, which in practice is beyond the capabilities of the existing conditions such as ship size and port restrictions, terminal handling capacities and other factors that are accounted for. Therefore, the aim of this study is to attempt at entirely capturing the existing sea transport volume between Jakarta and Surabaya, which is estimated to be around 24,000 TEU per year. Under this scenario, it is carried out that a direct shipping line service of 2.5 days would yield to be the most optimal at a cost of USD 254.48 per TEU, which in turn is concluded to be a competitive service when compared to the other alternative existing means of transport.

As highlighted in this study, sea transport services between Jakarta and Surabaya are very limited and infrequent due to a high customer reliance towards existing truck services, which are very flexible and guarantees a relatively short lead time. Therefore, the expected added value of the study carried out in this thesis is to attempt to propose an exclusive frequent direct shipping liner service between Jakarta and Surabaya, with the hopes of tackling the existing problems faced by other alternative means of transport while maintaining competitive service times and transport costs.

In the attempt to propose a viable service, the initial input variables that make up the study are collected from various sources and are processed in a proposed optimisation methodology. The results are then tested under different comparable scenarios that are set by different dimension settings of service times, vessel deployment, service frequency and expected cargo volume. The results show that there is in fact a very high added value potential in deploying the service, where the attributable costs are deemed to be very competitive in comparison to the existing means of transport in terms of cost, service time and other added benefits.

In general, the main varying costs that contribute to the difference in the costs of all the scenarios tested are the capital costs, operational costs as well as voyage bunker costs. In general, it is derived that the capital and operational costs vary depending on ship size, where a proportional relationship is found where larger costs are incurred as a result from deploying a larger ship. Bunker costs, on the other hand, are highly dependable on the ship sailing speed and fuel consumption where a faster service speed would result in significantly higher bunker costs, which, in turn compensates for a faster sailing time at sea. Moreover, it is further shown that the option to choose a larger ship would require a faster sailing speed in order to keep up with the target service times, as a result from more containers being handled in the terminals which take up the available service time.

The option to deploy multiple vessels instead of one would lead to smaller sized ships being deployed, hence reducing the total transport costs per ship. In general, these lower costs per ship result from a reduction in capital and operational costs which are a function of ship size, as well as the fact that smaller ships require less cargo handling time, hence allowing a slower service speed which significantly cuts down bunker costs. Despite so, a concern that needs to be accounted for when deciding to do so is that deploying an additional ship may, in fact, lead to an increase in the total costs for the entire service. Therefore, the decision to deploy multiple ships can severely impact the total costs and hence should be optimised depending on the expected cargo demand, existing infrastructure limitations and other factors that may need to be considered.

Overall, there is a large potential benefit in the proposition of this service as the resulting total transport costs – despite the different scenarios set – are significantly lower than the costs incurred by the existing means of transport. Moreover, collective data from existing reports also show that there is in fact demand for cargo transport between Jakarta and Surabaya, which is significantly above the hypothetical scenario figures of 100,000 TEU and 200,000 TEU, however, the realisation of such a service should be supported by large investments and developments by the existing port and terminal infrastructure, as this appears to be the bottleneck of the optimisation. The resulting calculations show a variety of interesting results in the form of cost interrelationships and trends, which are summarised and concluded in this chapter.

6.1 Implementation to the Maritime Toll Road Initiative

As it stands, the government of Indonesia has proposed the Maritime Toll Road initiative, which aims to provide effective and efficient connectivity between the western and eastern parts of Indonesia. It is evident that there is an imbalance in economy as there is a distinct diversion in terms of development between the two regions. Therefore, as two of the largest ports in Indonesia, The Port of Tanjung Priok in Jakarta has the role to serve more developed areas on the western parts of Indonesia, whereas on the other hand the Port of Tanjung Perak in Surabaya holds a similar role to assist in the connectivity in less developed areas on the east. There are already a number of services that are operational under this government initiative, however, the current issue now is that there is currently no direct and exclusive sea transport connectivity between these two ports. This is seen as an issue because shipping services between Jakarta and Surabaya are relatively infrequent with a relatively longer lead time as compared to other means of transport, and it is often the case where services between the two ports are part of a loop service. As a result, there is a heavy customer reliance towards road transport, which offer relatively shorter lead times, even at significantly high prices, and the mindset held by most shippers tend to prioritise service flexibility over transport costs.

The aim of this thesis is to counter this paradigm and propose a feasibility study of a direct shipping route between the two cities, in the hopes of improving connectivity in terms of lower shipping costs and the corresponding lead times. The results carried out in this research has determined that sea transport could, in fact, become a potential alternative to the heavy customer reliance towards road transport between Jakarta and Surabaya when looking at the cost to time benefits. The results show that the option of short-sea shipping would result to a transport cost per TEU with a relatively competitive guaranteed lead time, in contrast to existing trucking services which are costlier and may face the issue of uncertain lead times due to road congestion and other existing problems.

Time and costs benefit are also apparent, where the proposed shipping line service between Jakarta and Surabaya would, in fact, be lower than that of trucking services while still keeping a competitive service time. As a result, this added value could be considered as an advantage as compared to trucking services, where both shipping companies as well as shippers and cargo owners could benefit from the objective of minimising transport costs and customer demands for frequent and fast service levels.

6.2 Recommendations for Future Work

The research methodology of this thesis presents the resulting outcomes in the form of transport costs, which could be a starting point when analysing the expenditures incurred by the provider which is to deploy the proposed service. This study, therefore, only looks at the feasibility of such a proposed service in terms of the value added to the existing condition of the logistics network in terms of costs. To further look at how such a service may benefit the ship operator, the results delivered from this thesis could further be analysed in the form of revenues, where further research and discussion can propose an optimum freight rate to maximise revenue. Advanced optimisation methodologies such as pricing strategies and revenue management can assist in these future studies to look at the benefits it may give to the ship operator as well as shippers and cargo owners that may be of interest in using the proposed services.

Still from the perspective of the ship operator and expenditures, the cost components proposed under the methodology presented in this research could further be analysed in detail. With regards to the capital and operational costs, this study analyses these costs by scaling down and regression analysis from the cost figures presented by Veldman (2012). In practice, this method of obtaining capital and operational costs may not be accurate, and a more detailed view on this matter could be presented by looking at the existing conditions in Indonesia. These would therefore include the factors such as newbuild or second-hand ship prices in Indonesia, working conditions, minimum employee wages and so on. Bunkering costs under this study also consider that the deployed ships in service fully run on MFO, and the fuel consumption from auxiliary engines for non-propulsive activity is assumed to be absorbed by the main engine. For a further detailed analysis, these components could be further looked at in detail in order to result in a more accurate and realistic outcome.

On the matter of cargo handling, further segregation and cost analysis can be evaluated by looking at the different types of containers that may be on-board the vessel (e.g. include the charges for 40' containers, refrigerated containers, etc.). Moreover, the choice of terminals in the respective ports would have an impact on terminal handling charges, port dues, berth waiting times and cargo handling times, hence causing a domino effect and would require further optimisation of the ship service speed. In this study, the two terminals selected for the analysis, namely the Koja Container Terminal and the Surabaya Container Terminal, is assumed to work under perfect working conditions and the respective berth waiting times follow the average reported waiting times. In practice, waiting times can be very uncertain, hence a dynamic analysis could be conducted by looking at alternative options of the available terminals at the respective ports.

Moreover, as this study only looks at seaway-to-seaway costs, further analysis can be carried out to look at door-to-door costs, which would therefore incorporate the additional mode of trucking between the terminal to the end customer. An attempt to do such a study has been done by Hakim (2018), which in conjunction with this work is a joint thesis effort, however, the outcome results presented assume that operations resume under perfect conditions. This, therefore, could further be optimised to look at how the resulting costs are under existing conditions and limitations.

The scope of this study is also limited to analysis the transport costs between the Port of Tanjung Priok in Jakarta and the Port of Tanjung Perak in Surabaya with respect to the proposed Maritime Toll Road Initiative by the Indonesian government. This route, however, is only one of the few services that interconnect maritime transport between the shortlisted hubs. As the government initiative plans to provide direct connectivity between these hubs, further analysis following a similar methodology could therefore be used when observing the transport costs between these ports.

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Appendix A: Ship Data List

No.	Type	Name	TEU	GT	LOA	Speed	Cons	Age
1	MPP	Meratus Sangatta	170	2,532	88.00	11.5	6.5	22
2	MPP	Tanto Fajar III	221	3,988	97.80	12.5	12.5	26
3	MPP	Multi Express	256	2,826	91.28	12.5	7.3	29
4	MPP	Territory Trader	256	2,826	91.22	12.5	6.5	27
5	MPP	Multi Spirit	256	2,826	91.22	13.0	7.5	28
6	MPP	Tanto Fajar I	270	3,972	97.80	13.1	12.7	26
7	MPP	Mataram Express	300	3,790	97.08	12.0	13.0	33
8	MPP	Tanto Hawari	300	3,777	97.08	14.3	9.5	33
9	MPP	Tanto Harmoni	300	3,843	97.06	12.0	9.0	33
10	MPP	Red Rover	312	4,459	104.87	14.0	16.9	20
11	Container	Tanto Berkat	319	5,203	119.32	14.6	14.0	27
12	MPP	Tanto Handal	320	3,814	98.35	12.0	13.0	33
13	MPP	Mentaya River	326	4,238	101.30	13.0	13.0	37
14	MPP	Ayer Mas	326	3,283	94.95	13.0	7.0	32
15	MPP	Freedom	330	4,303	105.35	13.5	12.0	25
16	Container	Tanto Aman	338	3,994	107.00	14.5	14.8	24
17	MPP	Tanto Sepakat	339	4,460	105.95	13.5	12.0	35
18	MPP	Sinar Papua	343	4,532	110.27	13.5	12.5	37
19	MPP	Reliance	373	4,489	100.70	14.5	14.0	22
20	MPP	Red Resource	380	4,489	100.70	14.5	14.0	23
21	Container	Tanto Subur II	385	4,811	112.96	14.2	14.7	25
22	Container	Tanto Subur I	385	4,811	112.96	14.2	14.7	25
23	Container	Sendang Mas	406	4,225	112.23	22.3	88.0	14
24	MPP	Mentari Perdana	408	4,180	108.00	15.0	16.0	21
25	Container	CTP Bravo	420	4,914	112.50	14.0	13.4	22
26	Container	Bahar Mas	436	5,450	113.63	14.5	16.0	38
27	MPP	Mentari Sentosa	444	4,980	101.10	14.0	16.5	24
28	Container	Armada Sentani	451	5,087	112.63	15.0	21.0	36
29	Container	Armada Segara	453	5,320	120.60	13.7	18.5	27
30	Container	Armada Serasi	453	5,320	120.60	13.7	18.5	27
31	MPP	Meratus Ultima 2	455	4,883	107.00	13.6	15.0	27
32	MPP	Meratus Ultima 1	455	4,882	107.00	14.0	15.0	26
33	Container	Tanto Surya	480	8,168	130.00	15.0	18.0	33
34	MPP	Meratus Project 1	512	4,410	99.95	17.0	17.3	19
35	MPP	Red Rock	514	4,410	99.95	17.0	17.3	18
36	MPP	Mitra Progress III	518	4,400	100.40	15.4	16.0	19
37	Container	Tanto Lestari	569	6,969	124.02	15.0	19.5	29
38	Container	Tanto Sinergi	584	5,938	126.47	15.0	18.0	36
39	Container	CTP Java	585	7,167	134.10	15.0	18.0	24
40	Container	Tanto Raya	588	6,875	120.84	15.6	26.3	20
41	Container	Meratus Dili	600	5,553	118.16	16.5	23.0	21
42	Container	Meratus Ambon	604	7,197	123.50	12.0	13.0	26
43	Container	Meratus Banjar 1	605	6,249	129.80	16.5	18.0	22
44	MPP	Meratus Pekanbaru	618	5,272	117.00	15.0	20.0	10
45	MPP	Meratus Palembang	618	5,612	117.00	15.0	20.0	11
46	MPP	Tanto Bagus	626	7,091	126.42	16.0	20.7	16
47	Container	Meratus Tangguh 1	637	6,245	115.02	14.5	19.0	22
48	Container	Tanto Permai	662	8,652	144.02	18.0	33.0	24
49	Container	Tanto Express	662	8,652	144.02	18.0	33.0	24
50	MPP	Tanto Sakti II	664	5,500	125.30	16.5	22.0	15
51	Container	Mentari Persada	674	7,330	128.00	17.5	29.5	25
52	Container	Armada Permata	714	9,048	129.10	15.0	23.0	24

No.	Type	Name	TEU	GT	LOA	Speed	Cons	Age
53	MPP	Hijau Terang	724	7,420	131.20	17.0	30.0	22
54	Container	Tanto Tangguh	736	9,380	144.83	17.0	26.5	20
55	Container	Tanto Terang	736	9,380	144.83	16.5	26.5	20
56	Container	CTP Honour	739	6,114	126.50	16.5	22.0	22
57	Container	Tanto Damai	740	6,114	126.64	16.5	21.0	22
58	Container	CTP Innovation	740	6,114	126.50	16.5	22.0	22
59	Container	Verizon	758	11,788	145.68	17.3	28.6	23
60	Container	Meratus Kupang	802	8,203	128.01	16.5	27.5	21
61	Container	Meratus Kalabahi	802	8,203	128.86	16.5	27.5	20
62	Container	Meratus Kelimutu	802	8,203	128.86	16.5	27.5	20
63	Container	Hijau Sejuk	802	8,203	128.84	16.5	27.5	20
64	Container	Hijau Segar	812	7,959	133.18	17.5	26.0	19
65	Container	CTP Eagle	818	11,788	145.68	17.3	31.0	24
66	Container	Tanto Tenang	834	9,030	136.00	18.5	33.0	19
67	Container	Tanto Star	846	9,907	147.50	15.0	23.5	36
68	Container	Meratus Manado	848	9,357	144.83	17.0	32.0	21
69	Container	Hijau Jelita	850	8,890	135.80	16.5	28.0	21
70	Container	CTP Golden	972	11,810	145.68	17.3	31.0	21
71	Container	Meratus Gorontalo	1,005	13,444	161.85	17.5	36.0	19
72	Container	Oriental Gold	1,005	13,310	161.85	18.1	36.0	22
73	Container	Tanto Bersinar	1,005	13,300	161.85	18.5	43.2	19
74	Container	CTP Delta	1,012	9,601	149.63	17.5	30.5	25
75	Container	Armada Papua	1,016	9,603	149.64	17.5	29.0	25
76	Container	Armada Purnama	1,016	9,590	149.60	17.3	30.5	23
77	Container	Meratus Medan 1	1,028	13,156	162.00	18.1	38.5	22
78	Container	Strait Mas	1,048	13,941	163.66	20.5	36.0	24
79	Container	Selat Mas	1,048	13,941	163.66	20.5	36.0	23
80	Container	Tanto Jaya	1,060	12,471	147.00	17.0	40.0	20
81	Container	CTP Fortune	1,064	14,855	162.00	19.0	38.0	20
82	Container	Meratus Makassar	1,104	11,964	149.50	19.0	38.0	23
83	Container	Meratus Malino	1,104	11,964	149.50	19.0	38.0	23
84	Container	Meratus Mamiri	1,104	11,964	149.60	19.0	39.0	23
85	Container	Hijau Samudra	1,121	15,184	166.67	17.0	33.0	23
86	Container	Luzon	1,122	12,029	157.13	19.0	44.0	22
87	Container	Meratus Minahasa	1,139	10,546	149.00	18.5	44.0	19
88	Container	Oriental Emerald	1,157	13,448	159.53	18.0	39.0	21
89	Container	Oriental Silver	1,157	13,448	159.53	18.0	39.0	21
90	Container	Sinar Batam	1,157	13,448	159.53	18.0	39.0	20
91	Container	Tanto Bersatu	1,256	16,869	184.51	19.1	43.0	25
92	Container	Meratus Medan 2	1,308	17,156	186.03	18.5	44.8	27
93	Container	Meratus Medan 3	1,404	16,731	174.78	19.0	41.0	28
94	Container	Tanto Bersama	1,404	16,731	174.78	19.1	41.0	27
95	Container	Oriental Galaxy	1,510	17,613	182.83	19.0	44.0	22
96	Container	Tanto Pratama	1,510	17,613	182.82	20.8	44.0	23
97	Container	Tanto Setia	1,525	17,651	182.84	19.0	44.0	25
98	Container	Meratus Medan 5	1,560	16,750	183.21	19.1	45.0	19
99	Container	Spring Mas	1,560	16,705	183.20	18.5	49.0	21
100	Container	Happy Bee	1,570	17,518	171.99	20.5	60.2	12
101	Container	Cala Paguro	1,577	17,518	171.99	19.7	60.2	11
102	Container	Cala Pinguino	1,577	17,518	171.99	20.5	60.2	11
103	Container	Lucky Merry	1,708	17,294	171.99	19.7	60.2	11
104	Container	Oriental Ruby	1,743	18,037	176.57	19.2	44.0	29
105	Container	Oriental Jade	1,743	18,037	176.57	19.0	50.5	28

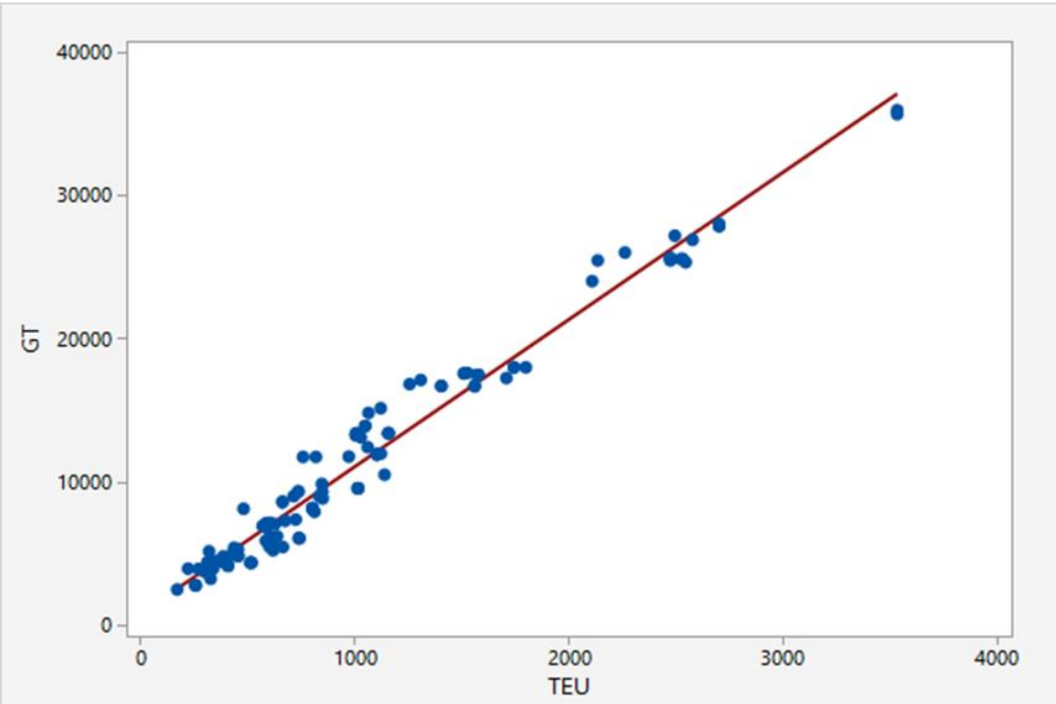
No.	Type	Name	TEU	GT	LOA	Speed	Cons	Age
106	Container	Oriental Mutiara	1,799	18,037	176.59	19.5	53.0	29
107	Container	Meratus Jayapura	2,109	24,053	205.75	20.0	53.0	21
108	Container	Sungai Mas	2,135	25,497	193.90	20.0	66.0	19
109	Container	Oriental Diamond	2,262	26,047	195.60	22.5	85.0	17
110	Container	Meratus Jayakarta	2,474	25,674	207.39	22.0	78.2	13
111	Container	Meratus Jayawijaya	2,474	25,500	207.40	22.0	78.2	13
112	Container	SPIL Nisaka	2,474	25,630	207.40	22.0	74.0	16
113	Container	Tanto Nusantara	2,495	27,227	199.95	22.5	79.8	15
114	Container	SPIL Ningsih	2,524	25,600	208.30	22.1	83.0	15
115	Container	SPIL Niken	2,532	25,600	208.30	22.1	83.0	15
116	Container	SPIL Nita	2,546	25,371	207.40	22.0	78.2	16
117	Container	SPIL Nirmala	2,578	26,936	211.85	22.0	82.0	10
118	Container	Meratus Tomini	2,702	28,050	215.29	21.7	88.0	11
119	Container	Segara Mas	2,702	27,915	215.50	21.7	88.0	12
120	Container	Sendang Mas	2,702	27,915	215.50	22.3	88.0	13
121	Container	Situ Mas	2,702	27,915	215.50	21.8	88.0	13
122	Container	SPIL Citra	3,534	35,981	230.92	23.5	120.0	9
123	Container	SPIL Caya	3,534	35,700	230.92	23.5	122.0	9

Appendix B: Model Ship Data – Initial Parameters

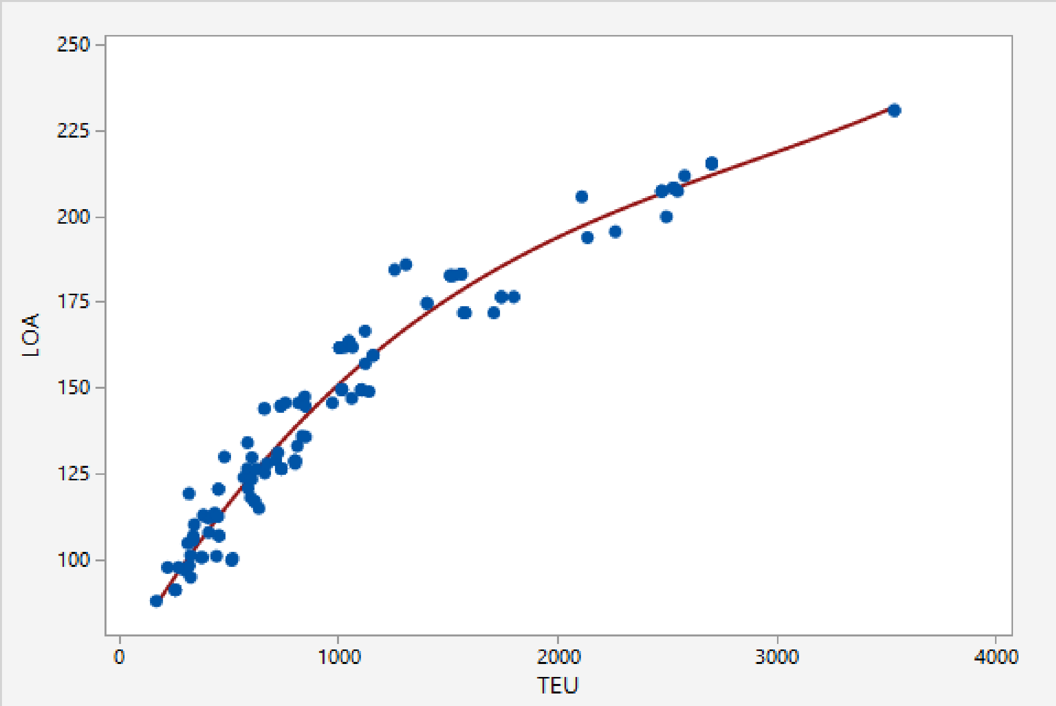
B1: *Model Ship Initial Parameters*

TEU	K Value	GT	LOA	Annual Cap. Costs	Annual Op. Costs
100	0.0049217	1,870	79.95	3,613,910	1,324,174
150	0.0049822	2,383	84.97	3,697,484	1,345,549
200	0.0050427	2,896	89.84	3,780,986	1,366,906
250	0.0051032	3,410	94.56	3,864,416	1,388,244
300	0.0051637	3,923	99.14	3,947,775	1,409,565
350	0.0052242	4,436	103.56	4,031,063	1,430,867
400	0.0052847	4,949	107.84	4,114,279	1,452,150
450	0.0053452	5,463	111.97	4,197,423	1,473,415
500	0.0054057	5,976	115.95	4,280,496	1,494,662
550	0.0054662	6,489	119.79	4,363,498	1,515,891
600	0.0055267	7,003	123.47	4,446,428	1,537,101
650	0.0055872	7,516	127.01	4,529,286	1,558,293
700	0.0056477	8,029	130.39	4,612,073	1,579,467
750	0.0057082	8,543	133.63	4,694,788	1,600,623
800	0.0057687	9,056	136.73	4,777,432	1,621,760
850	0.0058292	9,569	139.67	4,860,004	1,642,879
900	0.0058897	10,083	142.46	4,942,505	1,663,979
950	0.0059502	10,596	145.11	5,024,934	1,685,061
1000	0.0060107	11,109	147.61	5,107,292	1,706,125

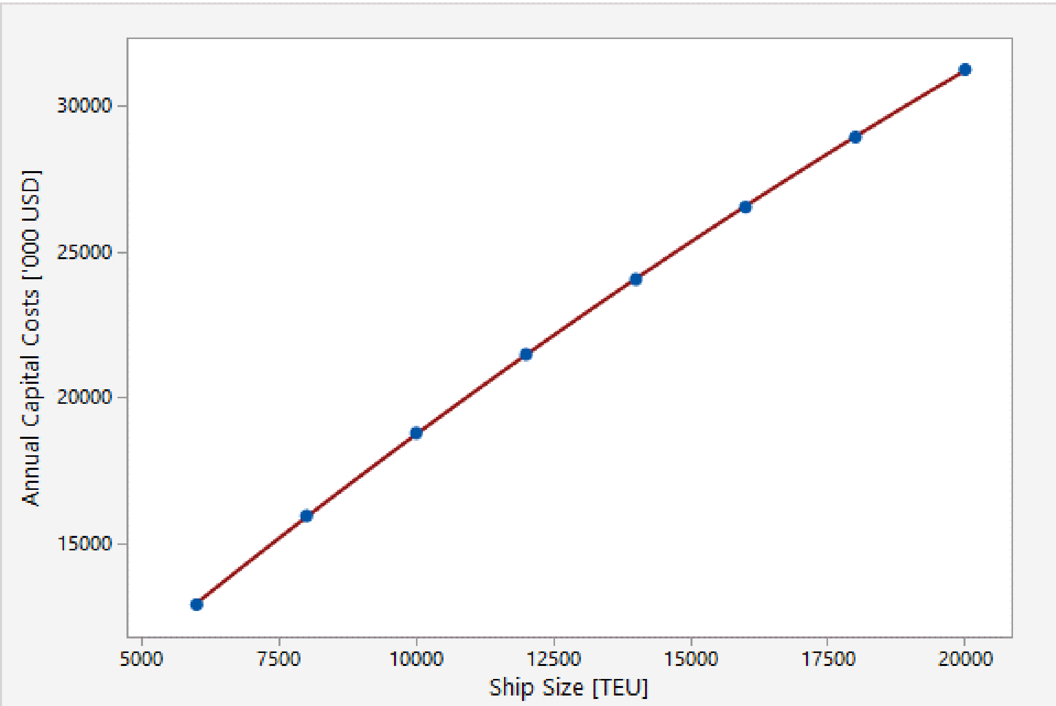
B2: *Regression Model - GT vs. TEU*



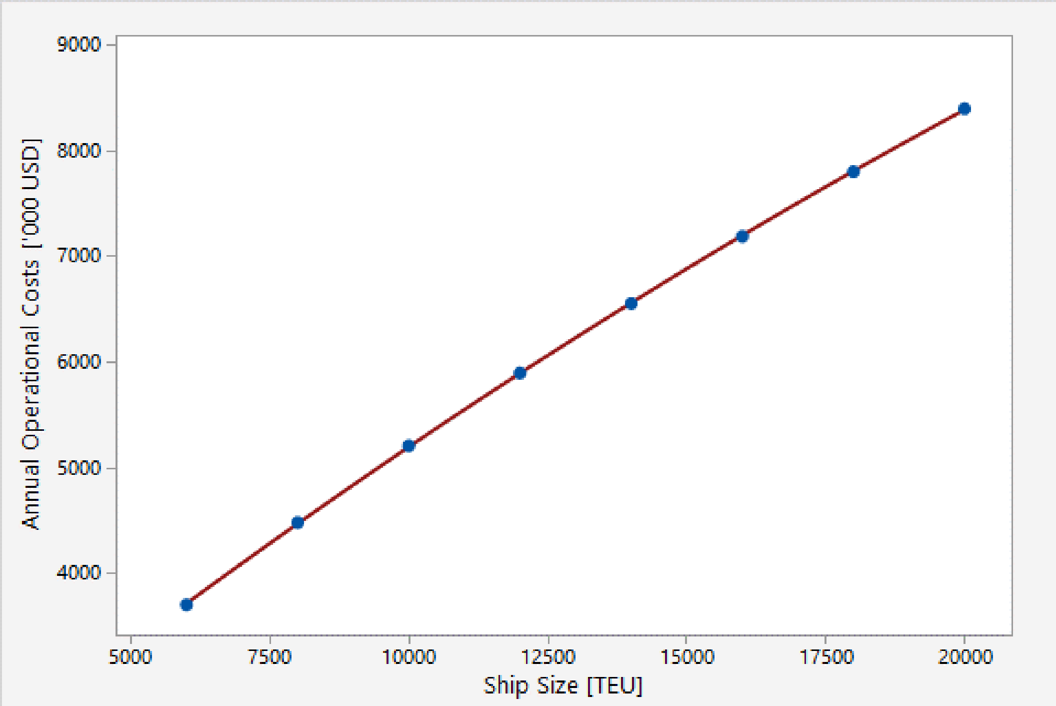
B3: *Regression Model - Ship LOA vs. TEU*



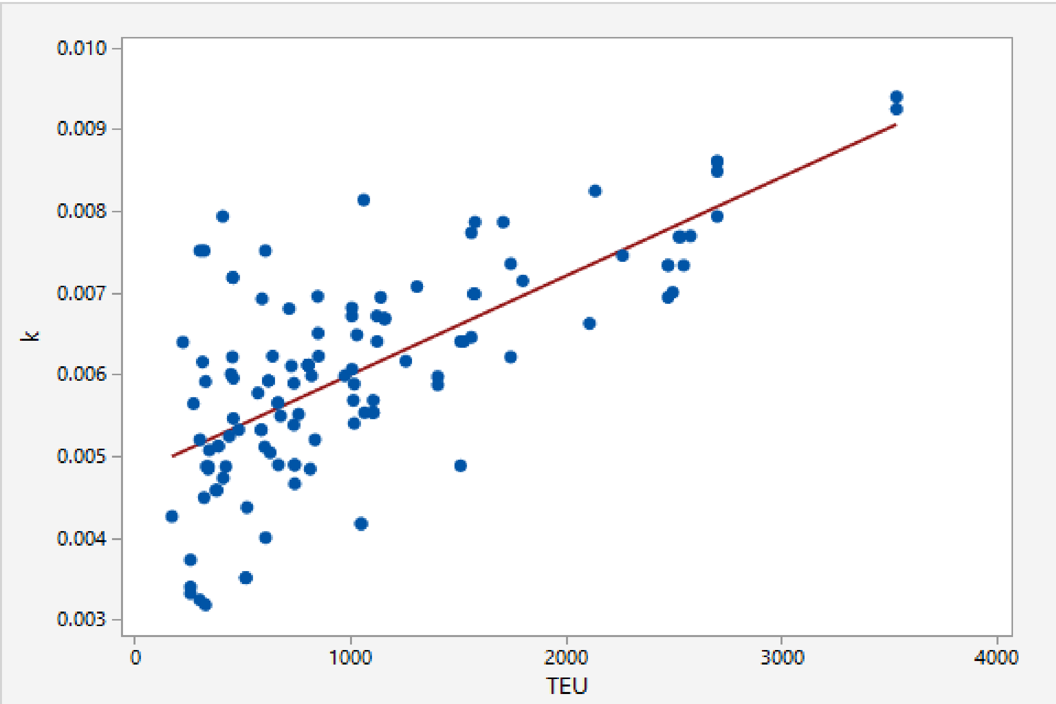
B4: *Annual Capital Costs vs. Ship Size (Based on Veldman, 2012)*



B5: *Annual Operational Costs vs. Ship Size (Based on Veldman, 2012)*



B6: *Regression Model - k vs. TEU*



Appendix C: Model Ship Data – Fuel Consumption

Speed	Ship Size									
	100	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1000**
0	0	0	0	0	0	0	0	0	0	0
1	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
2	0.039	0.040	0.040	0.041	0.041	0.042	0.042	0.043	0.043	0.044
3	0.133	0.135	0.136	0.138	0.139	0.141	0.143	0.144	0.146	0.148
4	0.315	0.319	0.323	0.327	0.330	0.334	0.338	0.342	0.346	0.350
5	0.615	0.623	0.630	0.638	0.645	0.653	0.661	0.668	0.676	0.683
6	1.063	1.076	1.089	1.102	1.115	1.128	1.141	1.155	1.168	1.181
7	1.688	1.709	1.730	1.750	1.771	1.792	1.813	1.833	1.854	1.875
8	2.520	2.551	2.582	2.613	2.644	2.675	2.706	2.737	2.768	2.799
9	3.588	3.632	3.676	3.720	3.764	3.808	3.853	3.897	3.941	3.985
10	4.922	4.982	5.043	5.103	5.164	5.224	5.285	5.345	5.406	5.466
11	6.551	6.631	6.712	6.792	6.873	6.953	7.034	7.114	7.195	7.276
12	8.505	8.609	8.714	8.818	8.923	9.027	9.132	9.237	9.341	9.446
13	10.81	10.95	11.08	11.21	11.34	11.48	11.61	11.74	11.88	12.01
14	13.51	13.67	13.84	14.00	14.17	14.34	14.50	14.67	14.83	15.00
15	16.61	16.81	17.02	17.22	17.43	17.63	17.84	18.04	18.24	18.45
16	20.16	20.41	20.65	20.90	21.15	21.40	21.65	21.89	22.14	22.39
17	24.18	24.48	24.77	25.07	25.37	25.67	25.96	26.26	26.56	26.86
18	28.70	29.06	29.41	29.76	30.11	30.47	30.82	31.17	31.53	31.88
19	33.76	34.17	34.59	35.00	35.42	35.83	36.25	36.66	37.08	37.49
20	39.37	39.86	40.34	40.83	41.31	41.79	42.28	42.76	43.25	43.73

Appendix D: 24,000 TEU Scenario – Single Ship Deployment

D1: *24,000 TEU – 4 Days Round Trip – Single Ship*

Spreadsheet Legend	
Fixed values (do not change)	
Variable values (change as requred)	
Output values	
Optimisation Result	

Input Variables	Value	Unit
Annual Cargo Estimate	24,000	TEU
Target Round-Trip Voyage Time	4	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	275	TEU
Cargo per Single-Leg Voyage	138	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	198	TEU
Ship Size Required (round up B20)	200	TEU
Ship Gross Tonnage	2,896	GT
Ship Length	89.8342	m
Ship *k* Value	0.0050427	constant
Ship Annual Capital Costs	3,780,985.74	USD
Ship Annual Operational Costs	1,366,905.97	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	96	hours
Total Time Spent at Terminals	22.00	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	38.00	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	21	knots
Time at Sea (should not exceed B39)	37.24	hours
TOTAL VOYAGE TIME	95.24	hours
TOTAL VOYAGE TIME	3.97	days

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	275	275	TEU
TIME SPENT AT TERMINAL	11.00	11.00	hours
TERMINAL HANDLING COST	17,658.92	19,266.00	USD
TOTAL TERMINAL TIME	22.00	hours	
TOTAL THC	36,924.92	USD	

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)		
Ship Fuel Consumption	46.70	tonnes/day
Fuel Required	186.80	tonnes
Voyage Bunker Costs	140,688.41	USD
Voyage Capital Costs	43,211.27	USD
Voyage Operational Costs	15,621.78	USD
Terminal Handling Costs	36,924.92	USD
Port Dues	718.28	USD
Total Voyage Costs	237,164.65	USD
COST PER TEU (Round-Trip)	862.42	USD
COST PER TEU (Single-Leg)	431.21	USD

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		14.62	23.23	USD
Berthing Fees		12.02	12.02	USD
Mooring Fees		33.54	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		23.72	18.03	USD
Tug (Primary)		209.93	159.97	USD
Tug (Additional)		13.22	54.08	USD
PORT DUES		336.55	381.73	USD
PORT TIME SPENT		22	14	hours
TOTAL PORT TIME	36.00	hours		
TOTAL PORT DUES	718.28	USD		

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.0021	per GT/ship/hour
	>75,000 GT	0.00076	0.0031	

D2: 24,000 TEU – 5 Days Round Trip – Single Ship

Spreadsheet Legend

Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables	Value	Unit
Annual Cargo Estimate	24,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	343	TEU
Cargo per Single-Leg Voyage	172	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	246	TEU
Ship Size Required (round up B20)	250	TEU
Ship Gross Tonnage	3,410	GT
Ship Length	94.556625	m
Ship *k* Value	0.0051032	constant
Ship Annual Capital Costs	3,864,416.34	USD
Ship Annual Operational Costs	1,388,244.46	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	27.44	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	56.56	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	14	knots
Time at Sea (should not exceed B39)	55.86	hours
TOTAL VOYAGE TIME	**119.30**	**hours**
TOTAL VOYAGE TIME	**4.97**	**days**

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	343	343	TEU
TIME SPENT AT TERMINAL	13.72	13.72	hours
TERMINAL HANDLING COST	22,025.48	24,029.96	USD
TOTAL TERMINAL TIME	**27.44**	**hours**	
TOTAL THC	**46,055.44**	**USD**	

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)		
Ship Fuel Consumption	14.00	tonnes/day
Fuel Required	70.02	tonnes
Voyage Bunker Costs	52,731.97	USD
Voyage Capital Costs	55,205.95	USD
Voyage Operational Costs	19,832.06	USD
Terminal Handling Costs	46,055.44	USD
Port Dues	748.57	USD
Total Voyage Costs	174,574.00	USD
COST PER TEU (Round-Trip)	**508.96**	**USD**
COST PER TEU (Single-Leg)	**254.48**	**USD**

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		17.21	27.35	USD
Berthing Fees		14.15	14.15	USD
Mooring Fees		33.54	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		27.92	21.22	USD
Tug (Primary)		209.93	159.97	USD
Tug (Additional)		15.56	63.67	USD
PORT DUES		347.82	400.76	USD
PORT TIME SPENT		22	14	hours
TOTAL PORT TIME	**36.00**	**hours**		
TOTAL PORT DUES	**748.57**	**USD**		

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

D3: 24,000 TEU – 6 Days Round Trip – Single Ship

Spreadsheet Legend

Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables	Value	Unit
Annual Cargo Estimate	24,000	TEU
Target Round-Trip Voyage Time	6	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	412	TEU
Cargo per Single-Leg Voyage	206	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	295	TEU
Ship Size Required (round up B20)	300	TEU
Ship Gross Tonnage	3,923	GT
Ship Length	99.1308	m
Ship *k* Value	0.0051637	constant
Ship Annual Capital Costs	3,947,775.42	USD
Ship Annual Operational Costs	1,409,564.64	USD

Fuel Price Information

Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)

Target Round-Trip Time	144	hours
Total Time Spent at Terminals	32.96	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	75.04	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	10.5	knots
Time at Sea (should not exceed B39)	74.48	hours
TOTAL VOYAGE TIME	**143.44**	**hours**
TOTAL VOYAGE TIME	**5.98**	**days**

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	412	412	TEU
TIME SPENT AT TERMINAL	16.48	16.48	hours
TERMINAL HANDLING COST	26,456.27	28,863.97	USD
TOTAL TERMINAL TIME	**32.96**	**hours**	
TOTAL THC	**55,320.24**	**USD**	

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

Ship Fuel Consumption	5.98	tonnes/day
Fuel Required	35.87	tonnes
Voyage Bunker Costs	27,012.04	USD
Voyage Capital Costs	67,676.15	USD
Voyage Operational Costs	24,163.97	USD
Terminal Handling Costs	55,320.24	USD
Port Dues	1,331.70	USD
Total Voyage Costs	175,504.10	USD
COST PER TEU (Round-Trip)	**425.98**	**USD**
COST PER TEU (Single-Leg)	**212.99**	**USD**

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		19.81	31.47	USD
Berthing Fees		16.28	16.28	USD
Mooring Fees		33.54	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		32.12	24.42	USD
Tug (Primary)		524.83	397.90	USD
Tug (Additional)		17.91	73.25	USD
PORT DUES		673.98	657.72	USD
PORT TIME SPENT		22	14	hours
TOTAL PORT TIME	**36.00**	**hours**		
TOTAL PORT DUES	**1,331.70**	**USD**		

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

D4: 24,000 TEU – 7 Days Round Trip – Single Ship

Spreadsheet Legend

Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables	Value	Unit
Annual Cargo Estimate	24,000	TEU
Target Round-Trip Voyage Time	7	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	480	TEU
Cargo per Single-Leg Voyage	240	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	343	TEU
Ship Size Required (round up B20)	350	TEU
Ship Gross Tonnage	4,436	GT
Ship Length	103.556725	m
Ship *k* Value	0.0052242	constant
Ship Annual Capital Costs	4,031,062.95	USD
Ship Annual Operational Costs	1,430,866.51	USD

Fuel Price Information

Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)

Target Round-Trip Time	168	hours
Total Time Spent at Terminals	38.40	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	93.60	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	8.5	knots
Time at Sea (should not exceed B39)	92.00	hours

TOTAL VOYAGE TIME	**166.40**	**hours**
TOTAL VOYAGE TIME	**6.93**	**days**

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	480	480	TEU
TIME SPENT AT TERMINAL	19.20	19.20	hours
TERMINAL HANDLING COST	30,822.83	33,627.93	USD

TOTAL TERMINAL TIME	**38.40**	**hours**
TOTAL THC	**64,450.76**	**USD**

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

Ship Fuel Consumption	3.21	tonnes/day
Fuel Required	22.46	tonnes
Voyage Bunker Costs	16,914.22	USD
Voyage Capital Costs	80,621.26	USD
Voyage Operational Costs	28,617.33	USD
Terminal Handling Costs	64,450.76	USD
Port Dues	1,377.73	USD
Total Voyage Costs	191,981.30	USD

COST PER TEU (Round-Trip)	**399.96**	**USD**
COST PER TEU (Single-Leg)	**199.98**	**USD**

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		22.40	35.59	USD
Berthing Fees		18.41	18.41	USD
Mooring Fees		49.28	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		36.33	27.61	USD
Tug (Primary)		524.83	397.90	USD
Tug (Additional)		20.25	82.84	USD
PORT DUES		700.99	676.75	USD
PORT TIME SPENT		22	14	hours

TOTAL PORT TIME	**36.00**	**hours**
TOTAL PORT DUES	**1,377.73**	**USD**

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

D5: *24,000 TEU – 8 Days Round Trip – Single Ship*

Spreadsheet Legend	
Fixed values (do not change)	
Variable values (change as requred)	
Output values	
Optimisation Result	

Input Variables	Value	Unit
Annual Cargo Estimate	24,000	TEU
Target Round-Trip Voyage Time	8	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	549	TEU
Cargo per Single-Leg Voyage	275	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	393	TEU
Ship Size Required (round up B20)	400	TEU
Ship Gross Tonnage	4,949	GT
Ship Length	107.8344	m
Ship *k* Value	0.0052847	constant
Ship Annual Capital Costs	4,114,278.96	USD
Ship Annual Operational Costs	1,452,150.09	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	192	hours
Total Time Spent at Terminals	43.92	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	112.08	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	7	knots
Time at Sea (should not exceed B39)	111.71	hours
TOTAL VOYAGE TIME	191.63	hours
TOTAL VOYAGE TIME	7.98	days

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	549	549	TEU
TIME SPENT AT TERMINAL	21.96	21.96	hours
TERMINAL HANDLING COST	35,253.62	38,461.94	USD

TOTAL TERMINAL TIME	43.92	hours
TOTAL THC	73,715.56	USD

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)		
Ship Fuel Consumption	1.81	tonnes/day
Fuel Required	14.50	tonnes
Voyage Bunker Costs	10,921.49	USD
Voyage Capital Costs	94,040.66	USD
Voyage Operational Costs	33,192.00	USD
Terminal Handling Costs	73,715.56	USD
Port Dues	1,408.03	USD
Total Voyage Costs	213,277.74	USD
COST PER TEU (Round-Trip)	388.48	USD
COST PER TEU (Single-Leg)	194.24	USD

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		24.99	39.71	USD
Berthing Fees		20.54	20.54	USD
Mooring Fees		49.28	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		40.53	30.81	USD
Tug (Primary)		524.83	397.90	USD
Tug (Additional)		22.59	92.42	USD
PORT DUES		712.25	695.78	USD
PORT TIME SPENT		22	14	hours
TOTAL PORT TIME	36.00	hours		
TOTAL PORT DUES	1,408.03	USD		

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

D6: *24,000 TEU – 9 Days Round Trip – Single Ship*

Spreadsheet Legend

Fixed values (do not change)	
Variable values (change as requred)	
Output values	
Optimisation Result	

Input Variables	**Value**	**Unit**
Annual Cargo Estimate	24,000	TEU
Target Round-Trip Voyage Time	9	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	618	TEU
Cargo per Single-Leg Voyage	309	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	**Value**	**Unit**
Ship Load Factor	0.7	constant
Ship Size Suggested	442	TEU
Ship Size Required (round up B20)	450	TEU
Ship Gross Tonnage	5,463	GT
Ship Length	111.963825	m
Ship *k* Value	0.0053452	constant
Ship Annual Capital Costs	4,197,423.43	USD
Ship Annual Operational Costs	1,473,415.36	USD

Fuel Price Information

Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)

Target Round-Trip Time	216	hours
Total Time Spent at Terminals	49.44	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	130.56	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	6	knots
Time at Sea (should not exceed B39)	130.33	hours
TOTAL VOYAGE TIME	**215.77**	**hours**
TOTAL VOYAGE TIME	**8.99**	**days**

TERMINAL HANDLING OPTIMISATION

Information	**TPK - Jakarta**	**TPS - Surabaya**	**Unit**
Terminal Handling	25	25	boxes/hour
Total Containers Handled	618	618	TEU
TIME SPENT AT TERMINAL	24.72	24.72	hours
TERMINAL HANDLING COST	39,684.40	43,295.96	USD

TOTAL TERMINAL TIME	**49.44**	**hours**
TOTAL THC	**82,980.36**	**USD**

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	**TPK - Jakarta**	**TPS - Surabaya**
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	**TPK - Jakarta**	**TPS - Surabaya**
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

Ship Fuel Consumption	1.15	tonnes/day
Fuel Required	10.39	tonnes
Voyage Bunker Costs	7,825.96	USD
Voyage Capital Costs	107,933.75	USD
Voyage Operational Costs	37,887.82	USD
Terminal Handling Costs	82,980.36	USD
Port Dues	1,483.66	USD
Total Voyage Costs	238,111.55	USD
COST PER TEU (Round-Trip)	**385.29**	**USD**
COST PER TEU (Single-Leg)	**192.65**	**USD**

PORT SERVICE OPTIMISATION

Information	*****Leave Blank*****	**Tg. Priok - Jakarta**	**Tg. Perak - Surabaya**	**Unit**
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		27.58	43.82	USD
Berthing Fees		45.34	45.34	USD
Mooring Fees		49.28	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		44.73	34.00	USD
Tug (Primary)		524.83	397.90	USD
Tug (Additional)		24.93	102.01	USD
PORT DUES		746.19	737.47	USD
PORT TIME SPENT		22	14	hours

TOTAL PORT TIME	**36.00**	**hours**
TOTAL PORT DUES	**1,483.66**	**USD**

PORT DUES INFORMATION

Charges [IDR]	**Ship Size**	**Tg. Priok - Jakarta**	**Tg. Perak - Surabaya**	**Unit**
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	**Ship Size**	**Tg. Priok - Jakarta**	**Tg. Perak - Surabaya**	**Unit**
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

Appendix E: 24,000 TEU Scenario – 5 Days Round Trip – Multiple Ship

E1: 24,000 TEU – 5 Days Round Trip – 1 Ship

Spreadsheet Legend	
Fixed values (do not change)	
Variable values (change as requred)	
Output values	
Optimisation Result	

Input Variables	Value	Unit
Annual Cargo Estimate	24,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	343	TEU
Ships Deployed	1	ships
Cargo per Ship per Round-Trip Voyage	343	TEU
Cargo per Single-Leg Voyage	172	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	246	TEU
Ship Size Required (round up B20)	250	TEU
Ship Gross Tonnage	3,410	GT
Ship Length	94.556625	m
Ship *k* Value	0.0051032	constant
Ship Annual Capital Costs	3,864,416.34	USD
Ship Annual Operational Costs	1,388,244.46	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	27.44	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	56.56	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	14	knots
Time at Sea (should not exceed B39)	55.86	hours
TOTAL VOYAGE TIME	119.30	hours
TOTAL VOYAGE TIME	4.97	days

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	343	343	TEU
TIME SPENT AT TERMINAL	13.72	13.72	hours
TERMINAL HANDLING COST	22,025.48	24,029.96	USD
TOTAL TERMINAL TIME	27.44	hours	
TOTAL THC PER SHIP	46,055.44	USD	
TOTAL THC PER SERVICE	46,055.44	USD	

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	14.00	14.00	tonnes/day
Fuel Required	70.02	70.02	tonnes
Voyage Bunker Costs	52,731.97	52,731.97	USD
Voyage Capital Costs	55,205.95	55,205.95	USD
Voyage Operational Costs	19,832.06	19,832.06	USD
Terminal Handling Costs	46,055.44	46,055.44	USD
Port Dues	748.57	748.57	USD
Total Voyage Costs	174,574.00	174,574.00	USD
COST PER TEU (Round-Trip)	508.96	508.96	USD
COST PER TEU (Single-Leg)	254.48	254.48	USD

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		17.21	27.35	USD
Berthing Fees		14.15	14.15	USD
Mooring Fees		33.54	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		27.92	21.22	USD
Tug (Primary)		209.93	159.97	USD
Tug (Additional)		15.56	63.67	USD
PORT DUES		347.82	400.76	USD
PORT TIME SPENT		22	14	hours
TOTAL PORT TIME	36.00	hours		
PORT DUES PER SHIP	748.57	USD		
TOTAL PORT DUES PER SERVICE	748.57	USD		

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

E2: *24,000 TEU – 5 Days Round Trip – 2 Ships*

Spreadsheet Legend

Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables	Value	Unit
Annual Cargo Estimate	24,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	343	TEU
Ships Deployed	2	ships
Cargo per Ship per Round-Trip Voyage	172	TEU
Cargo per Single-Leg Voyage	86	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	123	TEU
Ship Size Required (round up B20)	150	TEU
Ship Gross Tonnage	2,383	GT
Ship Length	84.963525	m
Ship *k* Value	0.0049822	constant
Ship Annual Capital Costs	3,697,483.60	USD
Ship Annual Operational Costs	1,345,549.18	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	13.76	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	70.24	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	11.5	knots
Time at Sea (should not exceed B39)	68.00	hours
TOTAL VOYAGE TIME	117.76	hours
TOTAL VOYAGE TIME	4.91	days

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	172	172	TEU
TIME SPENT AT TERMINAL	6.88	6.88	hours
TERMINAL HANDLING COST	11,044.85	12,050.01	USD
TOTAL TERMINAL TIME	13.76	hours	
TOTAL THC PER SHIP	23,094.86	USD	
TOTAL THC PER SERVICE	46,189.71	USD	

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	7.58	7.58	tonnes/day
Fuel Required	37.89	75.77	tonnes
Voyage Bunker Costs	28,533.96	57,067.91	USD
Voyage Capital Costs	52,821.19	105,642.39	USD
Voyage Operational Costs	19,222.13	38,444.26	USD
Terminal Handling Costs	23,094.86	46,189.71	USD
Port Dues	687.98	1,375.96	USD
Total Voyage Costs	124,360.12	248,720.24	USD
COST PER TEU (Round-Trip)	723.02	725.13	USD
COST PER TEU (Single-Leg)	361.51	362.57	USD

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		12.03	19.12	USD
Berthing Fees		9.89	9.89	USD
Mooring Fees		33.54	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		19.51	14.83	USD
Tug (Primary)		209.93	159.97	USD
Tug (Additional)		10.88	44.50	USD
PORT DUES		325.28	362.70	USD
PORT TIME SPENT		22	14	hours
TOTAL PORT TIME	36.00	hours		
PORT DUES PER SHIP	687.98	USD		
TOTAL PORT DUES PER SERVICE	1,375.96	USD		

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

E3: 24,000 TEU – 5 Days Round Trip – 3 Ships

Spreadsheet Legend

Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables	Value	Unit
Annual Cargo Estimate	24,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	343	TEU
Ships Deployed	3	ships
Cargo per Ship per Round-Trip Voyage	115	TEU
Cargo per Single-Leg Voyage	58	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	83	TEU
Ship Size Required (round up B20)	100	TEU
Ship Gross Tonnage	1,870	GT
Ship Length	79.9446	m
Ship *k* Value	0.0049217	constant
Ship Annual Capital Costs	3,613,909.94	USD
Ship Annual Operational Costs	1,324,174.09	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	9.20	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	74.80	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	10.5	knots
Time at Sea (should not exceed B39)	74.48	hours
TOTAL VOYAGE TIME	**119.68**	**hours**
TOTAL VOYAGE TIME	**4.99**	**days**

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	115	115	TEU
TIME SPENT AT TERMINAL	4.60	4.60	hours
TERMINAL HANDLING COST	7,384.64	8,056.69	USD

TOTAL TERMINAL TIME	**9.20**	**hours**
TOTAL THC PER SHIP	**15,441.33**	**USD**
TOTAL THC PER SERVICE	**46,323.99**	**USD**

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	5.70	5.70	tonnes/day
Fuel Required	28.49	85.46	tonnes
Voyage Bunker Costs	21,455.09	64,365.27	USD
Voyage Capital Costs	51,627.28	154,881.85	USD
Voyage Operational Costs	18,916.77	56,750.32	USD
Terminal Handling Costs	15,441.33	46,323.99	USD
Port Dues	657.69	1,973.06	USD
Total Voyage Costs	108,098.16	324,294.49	USD
COST PER TEU (Round-Trip)	**939.98**	**945.46**	**USD**
COST PER TEU (Single-Leg)	**469.99**	**472.73**	**USD**

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		9.44	15.00	USD
Berthing Fees		7.76	7.76	USD
Mooring Fees		33.54	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		15.31	11.64	USD
Tug (Primary)		209.93	159.97	USD
Tug (Additional)		8.53	34.91	USD
PORT DUES		314.01	343.67	USD
PORT TIME SPENT		22	14	hours

TOTAL PORT TIME	**36.00**	**hours**
PORT DUES PER SHIP	**657.69**	**USD**
TOTAL PORT DUES PER SERVICE	**1,973.06**	**USD**

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

E4: *24,000 TEU – 5 Days Round Trip – 4 Ships*

Spreadsheet Legend	
Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables	Value	Unit
Annual Cargo Estimate	24,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	343	TEU
Ships Deployed	4	ships
Cargo per Ship per Round-Trip Voyage	86	TEU
Cargo per Single-Leg Voyage	43	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	62	TEU
Ship Size Required (round up B20)	100	TEU
Ship Gross Tonnage	1,870	GT
Ship Length	79.9446	m
Ship *k* Value	0.0049217	constant
Ship Annual Capital Costs	3,613,909.94	USD
Ship Annual Operational Costs	1,324,174.09	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	6.88	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	77.12	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	10.5	knots
Time at Sea (should not exceed B39)	74.48	hours
TOTAL VOYAGE TIME	117.36	hours
TOTAL VOYAGE TIME	4.89	days

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	86	86	TEU
TIME SPENT AT TERMINAL	3.44	3.44	hours
TERMINAL HANDLING COST	5,522.42	6,025.00	USD

TOTAL TERMINAL TIME	6.88	hours
TOTAL THC PER SHIP	11,547.43	USD
TOTAL THC PER SERVICE	46,189.71	USD

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	5.70	5.70	tonnes/day
Fuel Required	28.49	113.95	tonnes
Voyage Bunker Costs	21,455.09	85,820.36	USD
Voyage Capital Costs	51,627.28	206,509.14	USD
Voyage Operational Costs	18,916.77	75,667.09	USD
Terminal Handling Costs	11,547.43	46,189.71	USD
Port Dues	657.69	2,630.74	USD
Total Voyage Costs	104,204.26	416,817.05	USD
COST PER TEU (Round-Trip)	1,211.68	1,215.21	USD
COST PER TEU (Single-Leg)	605.84	607.61	USD

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		9.44	15.00	USD
Berthing Fees		7.76	7.76	USD
Mooring Fees		33.54	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		15.31	11.64	USD
Tug (Primary)		209.93	159.97	USD
Tug (Additional)		8.53	34.91	USD
PORT DUES		314.01	343.67	USD
PORT TIME SPENT		22	14	hours

TOTAL PORT TIME	36.00	hours
PORT DUES PER SHIP	657.69	USD
TOTAL PORT DUES PER SERVICE	2,630.74	USD

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

E5: 24,000 TEU – 5 Days Round Trip – 5 Ships

Spreadsheet Legend

Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables	Value	Unit
Annual Cargo Estimate	24,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	343	TEU
Ships Deployed	5	ships
Cargo per Ship per Round-Trip Voyage	69	TEU
Cargo per Single-Leg Voyage	35	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	50	TEU
Ship Size Required (round up B20)	100	TEU
Ship Gross Tonnage	1,870	GT
Ship Length	79.9446	m
Ship *k* Value	0.0049217	constant
Ship Annual Capital Costs	3,613,909.94	USD
Ship Annual Operational Costs	1,324,174.09	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	5.52	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	78.48	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	10	knots
Time at Sea (should not exceed B39)	78.20	hours
TOTAL VOYAGE TIME	**119.72**	**hours**
TOTAL VOYAGE TIME	**4.99**	**days**

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	69	69	TEU
TIME SPENT AT TERMINAL	2.76	2.76	hours
TERMINAL HANDLING COST	4,430.78	4,834.01	USD

TOTAL TERMINAL TIME	**5.52**	**hours**
TOTAL THC PER SHIP	**9,264.80**	**USD**
TOTAL THC PER SERVICE	**46,323.99**	**USD**

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	4.92	4.92	tonnes/day
Fuel Required	24.61	123.04	tonnes
Voyage Bunker Costs	18,533.71	92,668.57	USD
Voyage Capital Costs	51,627.28	258,136.42	USD
Voyage Operational Costs	18,916.77	94,583.86	USD
Terminal Handling Costs	9,264.80	46,323.99	USD
Port Dues	657.69	3,288.43	USD
Total Voyage Costs	99,000.25	495,001.27	USD
COST PER TEU (Round-Trip)	**1,434.79**	**1,443.15**	**USD**
COST PER TEU (Single-Leg)	**717.39**	**721.58**	**USD**

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		9.44	15.00	USD
Berthing Fees		7.76	7.76	USD
Mooring Fees		33.54	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		15.31	11.64	USD
Tug (Primary)		209.93	159.97	USD
Tug (Additional)		8.53	34.91	USD
PORT DUES		314.01	343.67	USD
PORT TIME SPENT		22	14	hours

TOTAL PORT TIME	**36.00**	**hours**
PORT DUES PER SHIP	**657.69**	**USD**
TOTAL PORT DUES PER SERVICE	**3,288.43**	**USD**

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

Appendix F: 100,000 TEU Scenario – 5 Days Round Trip – Multiple Ship

F1: 100,000 TEU – 5 Days Round Trip – 2 Ships

Spreadsheet Legend

Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables	Value	Unit
Annual Cargo Estimate	100,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	1429	TEU
Ships Deployed	2	ships
Cargo per Ship per Round-Trip Voyage	715	TEU
Cargo per Single-Leg Voyage	358	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	512	TEU
Ship Size Required (round up B20)	550	TEU
Ship Gross Tonnage	6,489	GT
Ship Length	119.777925	m
Ship *k* Value	0.0054662	constant
Ship Annual Capital Costs	4,363,497.78	USD
Ship Annual Operational Costs	1,515,890.99	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	57.20	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	26.80	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	29.5	knots
Time at Sea (should not exceed B39)	26.51	hours
TOTAL VOYAGE TIME	119.71	hours
TOTAL VOYAGE TIME	4.99	days

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	715	715	TEU
TIME SPENT AT TERMINAL	28.60	28.60	hours
TERMINAL HANDLING COST	45,913.18	50,091.60	USD

TOTAL TERMINAL TIME	57.20	hours
TOTAL THC PER SHIP	96,004.78	USD
TOTAL THC PER SERVICE	192,009.56	USD

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	140.33	140.33	tonnes/day
Fuel Required	701.65	1,403.30	tonnes
Voyage Bunker Costs	528,443.89	1,056,887.77	USD
Voyage Capital Costs	62,335.68	124,671.37	USD
Voyage Operational Costs	21,655.59	43,311.17	USD
Terminal Handling Costs	96,004.78	192,009.56	USD
Port Dues	1,552.77	3,105.55	USD
Total Voyage Costs	709,992.71	1,419,985.42	USD
COST PER TEU (Round-Trip)	993.00	993.69	USD
COST PER TEU (Single-Leg)	496.50	496.85	USD

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		32.76	52.06	USD
Berthing Fees		53.86	53.86	USD
Mooring Fees		49.28	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		53.14	40.39	USD
Tug (Primary)		524.83	397.90	USD
Tug (Additional)		29.62	121.18	USD
PORT DUES		772.98	779.79	USD
PORT TIME SPENT		22	14	hours

TOTAL PORT TIME	36.00	hours
PORT DUES PER SHIP	1,552.77	USD
TOTAL PORT DUES PER SERVICE	3,105.55	USD

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

F2: *100,000 TEU – 5 Days Round Trip – 3 Ships*

Spreadsheet Legend	
Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables	Value	Unit
Annual Cargo Estimate	100,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	1429	TEU
Ships Deployed	3	ships
Cargo per Ship per Round-Trip Voyage	477	TEU
Cargo per Single-Leg Voyage	239	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	342	TEU
Ship Size Required (round up B20)	350	TEU
Ship Gross Tonnage	4,436	GT
Ship Length	103.556725	m
Ship *k* Value	0.0052242	constant
Ship Annual Capital Costs	4,031,062.95	USD
Ship Annual Operational Costs	1,430,866.51	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	38.16	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	45.84	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	17.5	knots
Time at Sea (should not exceed B39)	44.69	hours
TOTAL VOYAGE TIME	118.85	hours
TOTAL VOYAGE TIME	4.95	days

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	477	477	TEU
TIME SPENT AT TERMINAL	19.08	19.08	hours
TERMINAL HANDLING COST	30,630.19	33,417.75	USD
TOTAL TERMINAL TIME	38.16	hours	
TOTAL THC PER SHIP	64,047.95	USD	
TOTAL THC PER SERVICE	192,143.84	USD	

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	28.00	28.00	tonnes/day
Fuel Required	139.99	419.98	tonnes
Voyage Bunker Costs	105,434.14	316,302.41	USD
Voyage Capital Costs	57,586.61	172,759.84	USD
Voyage Operational Costs	20,440.95	61,322.85	USD
Terminal Handling Costs	64,047.95	192,143.84	USD
Port Dues	1,377.73	4,133.20	USD
Total Voyage Costs	248,887.38	746,662.14	USD
COST PER TEU (Round-Trip)	521.78	522.51	USD
COST PER TEU (Single-Leg)	260.89	261.25	USD

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		22.40	35.59	USD
Berthing Fees		18.41	18.41	USD
Mooring Fees		49.28	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		36.33	27.61	USD
Tug (Primary)		524.83	397.90	USD
Tug (Additional)		20.25	82.84	USD
PORT DUES		700.99	676.75	USD
PORT TIME SPENT		22	14	hours
TOTAL PORT TIME	36.00	hours		
PORT DUES PER SHIP	1,377.73	USD		
TOTAL PORT DUES PER SERVICE	4,133.20	USD		

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

F3: 100,000 TEU – 5 Days Round Trip – 4 Ships

Spreadsheet Legend		
Fixed values (do not change)		
Variable values (change as requred)		
Output values		
Optimisation Result		

Input Variables	Value	Unit
Annual Cargo Estimate	100,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	1429	TEU
Ships Deployed	4	ships
Cargo per Ship per Round-Trip Voyage	358	TEU
Cargo per Single-Leg Voyage	179	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	256	TEU
Ship Size Required (round up B20)	300	TEU
Ship Gross Tonnage	3,923	GT
Ship Length	99.1308	m
Ship *k* Value	0.0051637	constant
Ship Annual Capital Costs	3,947,775.42	USD
Ship Annual Operational Costs	1,409,564.64	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	28.64	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	55.36	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	14.5	knots
Time at Sea (should not exceed B39)	53.93	hours
TOTAL VOYAGE TIME	118.57	hours
TOTAL VOYAGE TIME	4.94	days

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	358	358	TEU
TIME SPENT AT TERMINAL	14.32	14.32	hours
TERMINAL HANDLING COST	22,988.70	25,080.83	USD
TOTAL TERMINAL TIME	28.64	hours	
TOTAL THC PER SHIP	48,069.53	USD	
TOTAL THC PER SERVICE	192,278.11	USD	

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	15.74	15.74	tonnes/day
Fuel Required	78.71	314.84	tonnes
Voyage Bunker Costs	59,280.56	237,122.25	USD
Voyage Capital Costs	56,396.79	225,587.17	USD
Voyage Operational Costs	20,136.64	80,546.55	USD
Terminal Handling Costs	48,069.53	192,278.11	USD
Port Dues	1,331.70	5,326.82	USD
Total Voyage Costs	185,215.22	740,860.90	USD
COST PER TEU (Round-Trip)	517.36	518.45	USD
COST PER TEU (Single-Leg)	258.68	259.22	USD

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		19.81	31.47	USD
Berthing Fees		16.28	16.28	USD
Mooring Fees		33.54	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		32.12	24.42	USD
Tug (Primary)		524.83	397.90	USD
Tug (Additional)		17.91	73.25	USD
PORT DUES		673.98	657.72	USD
PORT TIME SPENT		22	14	hours
TOTAL PORT TIME	36.00	hours		
PORT DUES PER SHIP	1,331.70	USD		
TOTAL PORT DUES PER SERVICE	5,326.82	USD		

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

F4: 100,000 TEU – 5 Days Round Trip – 5 Ships

Spreadsheet Legend	
Fixed values (do not change)	
Variable values (change as requred)	
Output values	
Optimisation Result	

Input Variables	Value	Unit
Annual Cargo Estimate	100,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	1429	TEU
Ships Deployed	5	ships
Cargo per Ship per Round-Trip Voyage	286	TEU
Cargo per Single-Leg Voyage	143	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	205	TEU
Ship Size Required (round up B20)	250	TEU
Ship Gross Tonnage	3,410	GT
Ship Length	94.556625	m
Ship *k* Value	0.0051032	constant
Ship Annual Capital Costs	3,864,416.34	USD
Ship Annual Operational Costs	1,388,244.46	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	22.88	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	61.12	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	13	knots
Time at Sea (should not exceed B39)	60.15	hours
TOTAL VOYAGE TIME	119.03	hours
TOTAL VOYAGE TIME	4.96	days

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	286	286	TEU
TIME SPENT AT TERMINAL	11.44	11.44	hours
TERMINAL HANDLING COST	18,365.27	20,036.64	USD
TOTAL TERMINAL TIME	22.88	hours	
TOTAL THC PER SHIP	38,401.91	USD	
TOTAL THC PER SERVICE	192,009.56	USD	

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	11.21	11.21	tonnes/day
Fuel Required	56.06	280.29	tonnes
Voyage Bunker Costs	42,220.17	211,100.84	USD
Voyage Capital Costs	55,205.95	276,029.74	USD
Voyage Operational Costs	19,832.06	99,160.32	USD
Terminal Handling Costs	38,401.91	192,009.56	USD
Port Dues	748.57	3,742.87	USD
Total Voyage Costs	156,408.67	782,043.33	USD
COST PER TEU (Round-Trip)	546.88	547.27	USD
COST PER TEU (Single-Leg)	273.44	273.63	USD

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		17.21	27.35	USD
Berthing Fees		14.15	14.15	USD
Mooring Fees		33.54	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		27.92	21.22	USD
Tug (Primary)		209.93	159.97	USD
Tug (Additional)		15.56	63.67	USD
PORT DUES		347.82	400.76	USD
PORT TIME SPENT		22	14	hours
TOTAL PORT TIME	36.00	hours		
PORT DUES PER SHIP	748.57	USD		
TOTAL PORT DUES PER SERVICE	3,742.87	USD		

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

Appendix G: 200,000 TEU Scenario – 5 Days Round Trip – Multiple Ship

G1: 200,000 TEU – 5 Days Round Trip – 4 Ships

Spreadsheet Legend

Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables	Value	Unit
Annual Cargo Estimate	200,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	2858	TEU
Ships Deployed	4	ships
Cargo per Ship per Round-Trip Voyage	715	TEU
Cargo per Single-Leg Voyage	358	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	512	TEU
Ship Size Required (round up B20)	550	TEU
Ship Gross Tonnage	6,489	GT
Ship Length	119.777925	m
Ship *k* Value	0.0054662	constant
Ship Annual Capital Costs	4,363,497.78	USD
Ship Annual Operational Costs	1,515,890.99	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	57.20	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	26.80	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	29.5	knots
Time at Sea (should not exceed B39)	26.51	hours
TOTAL VOYAGE TIME	119.71	hours
TOTAL VOYAGE TIME	4.99	days

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	715	715	TEU
TIME SPENT AT TERMINAL	28.60	28.60	hours
TERMINAL HANDLING COST	45,913.18	50,091.60	USD
TOTAL TERMINAL TIME	57.20	hours	
TOTAL THC PER SHIP	96,004.78	USD	
TOTAL THC PER SERVICE	384,019.13	USD	

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	140.33	140.33	tonnes/day
Fuel Required	701.65	2,806.61	tonnes
Voyage Bunker Costs	528,443.89	2,113,775.54	USD
Voyage Capital Costs	62,335.68	249,342.73	USD
Voyage Operational Costs	21,655.59	86,622.34	USD
Terminal Handling Costs	96,004.78	384,019.13	USD
Port Dues	1,552.77	6,211.09	USD
Total Voyage Costs	709,992.71	2,839,970.84	USD
COST PER TEU (Round-Trip)	993.00	993.69	USD
COST PER TEU (Single-Leg)	496.50	496.85	USD

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		32.76	52.06	USD
Berthing Fees		53.86	53.86	USD
Mooring Fees		49.28	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		53.14	40.39	USD
Tug (Primary)		524.83	397.90	USD
Tug (Additional)		29.62	121.18	USD
PORT DUES		772.98	779.79	USD
PORT TIME SPENT		22	14	hours
TOTAL PORT TIME	36.00	hours		
PORT DUES PER SHIP	1,552.77	USD		
TOTAL PORT DUES PER SERVICE	6,211.09	USD		

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

G2: 200,000 TEU – 5 Days Round Trip – 5 Ships

Spreadsheet Legend

Fixed values (do not change)	blue
Variable values (change as requred)	yellow
Output values	green
Optimisation Result	orange

Input Variables	Value	Unit
Annual Cargo Estimate	200,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	2858	TEU
Ships Deployed	5	ships
Cargo per Ship per Round-Trip Voyage	572	TEU
Cargo per Single-Leg Voyage	286	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	409	TEU
Ship Size Required (round up B20)	450	TEU
Ship Gross Tonnage	5,463	GT
Ship Length	111.963825	m
Ship *k* Value	0.0053452	constant
Ship Annual Capital Costs	4,197,423.43	USD
Ship Annual Operational Costs	1,473,415.36	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	45.76	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	38.24	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	20.5	knots
Time at Sea (should not exceed B39)	38.15	hours
TOTAL VOYAGE TIME	**119.91**	**hours**
TOTAL VOYAGE TIME	**5.00**	**days**

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	572	572	TEU
TIME SPENT AT TERMINAL	22.88	22.88	hours
TERMINAL HANDLING COST	36,730.54	40,073.28	USD

TOTAL TERMINAL TIME	**45.76**	**hours**
TOTAL THC PER SHIP	**76,803.83**	**USD**
TOTAL THC PER SERVICE	**384,019.13**	**USD**

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	46.05	46.05	tonnes/day
Fuel Required	230.25	1,151.24	tonnes
Voyage Bunker Costs	173,409.49	867,047.44	USD
Voyage Capital Costs	59,963.19	299,815.96	USD
Voyage Operational Costs	21,048.79	105,243.95	USD
Terminal Handling Costs	76,803.83	384,019.13	USD
Port Dues	1,438.33	7,191.63	USD
Total Voyage Costs	332,663.62	1,663,318.11	USD
COST PER TEU (Round-Trip)	**581.58**	**581.99**	**USD**
COST PER TEU (Single-Leg)	**290.79**	**290.99**	**USD**

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		27.58	43.82	USD
Berthing Fees		22.67	22.67	USD
Mooring Fees		49.28	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		44.73	34.00	USD
Tug (Primary)		524.83	397.90	USD
Tug (Additional)		24.93	102.01	USD
PORT DUES		723.52	714.80	USD
PORT TIME SPENT		22	14	hours

TOTAL PORT TIME	**36.00**	**hours**
PORT DUES PER SHIP	**1,438.33**	**USD**
TOTAL PORT DUES PER SERVICE	**7,191.63**	**USD**

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

G3: *200,000 TEU – 5 Days Round Trip – 6 Ships*

Spreadsheet Legend

Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables	**Value**	**Unit**
Annual Cargo Estimate	200,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	2858	TEU
Ships Deployed	6	ships
Cargo per Ship per Round-Trip Voyage	477	TEU
Cargo per Single-Leg Voyage	239	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	**Value**	**Unit**
Ship Load Factor	0.7	constant
Ship Size Suggested	342	TEU
Ship Size Required (round up B20)	350	TEU
Ship Gross Tonnage	4,436	GT
Ship Length	103.556725	m
Ship *k* Value	0.0052242	constant
Ship Annual Capital Costs	4,031,062.95	USD
Ship Annual Operational Costs	1,430,866.51	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	38.16	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	45.84	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	17.5	knots
Time at Sea (should not exceed B39)	44.69	hours
TOTAL VOYAGE TIME	**118.85**	**hours**
TOTAL VOYAGE TIME	**4.95**	**days**

TERMINAL HANDLING OPTIMISATION

Information	**TPK - Jakarta**	**TPS - Surabaya**	**Unit**
Terminal Handling	25	25	boxes/hour
Total Containers Handled	477	477	TEU
TIME SPENT AT TERMINAL	19.08	19.08	hours
TERMINAL HANDLING COST	30,630.19	33,417.75	USD
TOTAL TERMINAL TIME	**38.16**	**hours**	
TOTAL THC PER SHIP	**64,047.95**	**USD**	
TOTAL THC PER SERVICE	**384,287.67**	**USD**	

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	**TPK - Jakarta**	**TPS - Surabaya**
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	**TPK - Jakarta**	**TPS - Surabaya**
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	28.00	28.00	tonnes/day
Fuel Required	139.99	839.95	tonnes
Voyage Bunker Costs	105,434.14	632,604.83	USD
Voyage Capital Costs	57,586.61	345,519.68	USD
Voyage Operational Costs	20,440.95	122,645.70	USD
Terminal Handling Costs	64,047.95	384,287.67	USD
Port Dues	1,377.73	8,266.41	USD
Total Voyage Costs	248,887.38	1,493,324.29	USD
COST PER TEU (Round-Trip)	**521.78**	**522.51**	**USD**
COST PER TEU (Single-Leg)	**260.89**	**261.25**	**USD**

PORT SERVICE OPTIMISATION

Information	*****Leave Blank*****	**Tg. Priok - Jakarta**	**Tg. Perak - Surabaya**	**Unit**
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		22.40	35.59	USD
Berthing Fees		18.41	18.41	USD
Mooring Fees		49.28	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		36.33	27.61	USD
Tug (Primary)		524.83	397.90	USD
Tug (Additional)		20.25	82.84	USD
PORT DUES		700.99	676.75	USD
PORT TIME SPENT		22	14	hours
TOTAL PORT TIME	**36.00**	**hours**		
PORT DUES PER SHIP	**1,377.73**	**USD**		
TOTAL PORT DUES PER SERVICE	**8,266.41**	**USD**		

PORT DUES INFORMATION

Charges [IDR]	**Ship Size**	**Tg. Priok - Jakarta**	**Tg. Perak - Surabaya**	**Unit**
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	**Ship Size**	**Tg. Priok - Jakarta**	**Tg. Perak - Surabaya**	**Unit**
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

G4: 200,000 TEU – 5 Days Round Trip – 7 Ships

Spreadsheet Legend

Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables

Input Variables	Value	Unit
Annual Cargo Estimate	200,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	2858	TEU
Ships Deployed	7	ships
Cargo per Ship per Round-Trip Voyage	409	TEU
Cargo per Single-Leg Voyage	205	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	293	TEU
Ship Size Required (round up B20)	300	TEU
Ship Gross Tonnage	3,923	GT
Ship Length	99.1308	m
Ship *k* Value	0.0051637	constant
Ship Annual Capital Costs	3,947,775.42	USD
Ship Annual Operational Costs	1,409,564.64	USD

Fuel Price Information

Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)

Target Round-Trip Time	120	hours
Total Time Spent at Terminals	32.72	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	51.28	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	15.5	knots
Time at Sea (should not exceed B39)	50.45	hours
TOTAL VOYAGE TIME	**119.17**	**hours**
TOTAL VOYAGE TIME	**4.97**	**days**

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	409	409	TEU
TIME SPENT AT TERMINAL	16.36	16.36	hours
TERMINAL HANDLING COST	26,263.62	28,653.80	USD

TOTAL TERMINAL TIME	**32.72**	**hours**
TOTAL THC PER SHIP	**54,917.42**	**USD**
TOTAL THC PER SERVICE	**384,421.94**	**USD**

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	19.23	19.23	tonnes/day
Fuel Required	96.14	673.01	tonnes
Voyage Bunker Costs	72,410.81	506,875.67	USD
Voyage Capital Costs	56,396.79	394,777.54	USD
Voyage Operational Costs	20,136.64	140,956.46	USD
Terminal Handling Costs	54,917.42	384,421.94	USD
Port Dues	1,331.70	9,321.93	USD
Total Voyage Costs	205,193.37	1,436,353.56	USD
COST PER TEU (Round-Trip)	**501.70**	**502.57**	**USD**
COST PER TEU (Single-Leg)	**250.85**	**251.29**	**USD**

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		19.81	31.47	USD
Berthing Fees		16.28	16.28	USD
Mooring Fees		33.54	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		32.12	24.42	USD
Tug (Primary)		524.83	397.90	USD
Tug (Additional)		17.91	73.25	USD
PORT DUES		673.98	657.72	USD
PORT TIME SPENT		22	14	hours

TOTAL PORT TIME	**36.00**	**hours**
PORT DUES PER SHIP	**1,331.70**	**USD**
TOTAL PORT DUES PER SERVICE	**9,321.93**	**USD**

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

G5: 200,000 TEU – 5 Days Round Trip – 8 Ships

Spreadsheet Legend

Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables	Value	Unit
Annual Cargo Estimate	200,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	2858	TEU
Ships Deployed	8	ships
Cargo per Ship per Round-Trip Voyage	358	TEU
Cargo per Single-Leg Voyage	179	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	Value	Unit
Ship Load Factor	0.7	constant
Ship Size Suggested	256	TEU
Ship Size Required (round up B20)	300	TEU
Ship Gross Tonnage	3,923	GT
Ship Length	99.1308	m
Ship *k* Value	0.0051637	constant
Ship Annual Capital Costs	3,947,775.42	USD
Ship Annual Operational Costs	1,409,564.64	USD

Fuel Price Information		
Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)		
Target Round-Trip Time	120	hours
Total Time Spent at Terminals	28.64	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	55.36	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	14.5	knots
Time at Sea (should not exceed B39)	53.93	hours
TOTAL VOYAGE TIME	118.57	hours
TOTAL VOYAGE TIME	4.94	days

TERMINAL HANDLING OPTIMISATION

Information	TPK - Jakarta	TPS - Surabaya	Unit
Terminal Handling	25	25	boxes/hour
Total Containers Handled	358	358	TEU
TIME SPENT AT TERMINAL	14.32	14.32	hours
TERMINAL HANDLING COST	22,988.70	25,080.83	USD
TOTAL TERMINAL TIME	28.64	hours	
TOTAL THC PER SHIP	48,069.53	USD	
TOTAL THC PER SERVICE	384,556.22	USD	

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	TPK - Jakarta	TPS - Surabaya
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	TPK - Jakarta	TPS - Surabaya
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	15.74	15.74	tonnes/day
Fuel Required	78.71	629.69	tonnes
Voyage Bunker Costs	59,280.56	474,244.51	USD
Voyage Capital Costs	56,396.79	451,174.33	USD
Voyage Operational Costs	20,136.64	161,093.10	USD
Terminal Handling Costs	48,069.53	384,556.22	USD
Port Dues	1,331.70	10,653.64	USD
Total Voyage Costs	185,215.22	1,481,721.79	USD
COST PER TEU (Round-Trip)	517.36	518.45	USD
COST PER TEU (Single-Leg)	258.68	259.22	USD

PORT SERVICE OPTIMISATION

Information	***Leave Blank***	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		19.81	31.47	USD
Berthing Fees		16.28	16.28	USD
Mooring Fees		33.54	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		32.12	24.42	USD
Tug (Primary)		524.83	397.90	USD
Tug (Additional)		17.91	73.25	USD
PORT DUES		673.98	657.72	USD
PORT TIME SPENT		22	14	hours
TOTAL PORT TIME	36.00	hours		
PORT DUES PER SHIP	1,331.70	USD		
TOTAL PORT DUES PER SERVICE	10,653.64	USD		

PORT DUES INFORMATION

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

Conversion to USD

Charges [IDR]	Ship Size	Tg. Priok - Jakarta	Tg. Perak - Surabaya	Unit
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

Appendix H: 250,000 TEU Scenario – 5 Days Round Trip – Test Scenario

Spreadsheet Legend

Fixed values (do not change)	(blue)
Variable values (change as requred)	(yellow)
Output values	(green)
Optimisation Result	(orange)

Input Variables	**Value**	**Unit**
Annual Cargo Estimate	250,000	TEU
Target Round-Trip Voyage Time	5	days
Operational Days per Year	350	days
Cargo per Round-Trip Voyage	3572	TEU
Ships Deployed	5	ships
Cargo per Ship per Round-Trip Voyage	715	TEU
Cargo per Single-Leg Voyage	358	TEU
Jakarta-Surabaya Round-Trip Distance	782	nautical miles
IDR/USD Exchange Rate	14,459.41	IDR/USD

Ship Requirements	**Value**	**Unit**
Ship Load Factor	0.7	constant
Ship Size Suggested	512	TEU
Ship Size Required (round up B20)	450	TEU
Ship Gross Tonnage	5,463	GT
Ship Length	111.963825	m
Ship *k* Value	0.0053452	constant
Ship Annual Capital Costs	4,197,423.43	USD
Ship Annual Operational Costs	1,473,415.36	USD

Fuel Price Information

Bunker Price	9,900.00	IDR/litre
Bunker Price	10,890,000.00	IDR/tonne
Bunker Price	753.14	USD/tonne

VOYAGE OPTIMISATION (TIME)

Target Round-Trip Time	120	hours
Total Time Spent at Terminals	57.20	hours
Total Time Serviced at Ports	36.00	hours
Voyage Time Should Not Exceed	26.80	hours
Optimise		
Round Trip Distance	782	nautical miles
Ship Speed	29.5	knots
Time at Sea (should not exceed B39)	26.51	hours

TOTAL VOYAGE TIME	**119.71**	**hours**
TOTAL VOYAGE TIME	**4.99**	**days**

TERMINAL HANDLING OPTIMISATION

Information	**TPK - Jakarta**	**TPS - Surabaya**	**Unit**
Terminal Handling	25	25	boxes/hour
Total Containers Handled	715	715	TEU
TIME SPENT AT TERMINAL	28.60	28.60	hours
TERMINAL HANDLING COST	45,913.18	50,091.60	USD

TOTAL TERMINAL TIME	**57.20**	**hours**
TOTAL THC PER SHIP	**96,004.78**	**USD**
TOTAL THC PER SERVICE	**480,023.91**	**USD**

TERMINAL HANDLING CHARGES INFORMATION

Tariffs per TEU [IDR]	**TPK - Jakarta**	**TPS - Surabaya**
Stevedoring	650,000	728,000
Lo-Lo	187,500	180,000
Terminal Haulage	91,000	105,000
TOTAL TARIFF	928,500	1,013,000

Conversion to USD

Tariffs per TEU [USD]	**TPK - Jakarta**	**TPS - Surabaya**
Stevedoring	44.95	50.35
Lo-Lo	12.97	12.45
Terminal Haulage	6.29	7.26
TOTAL TARIFF	64.21	70.06

VOYAGE OPTIMISATION (COSTS)

	Per Ship	Per Service	
Ship Fuel Consumption	137.22	137.22	tonnes/day
Fuel Required	686.12	3,430.60	tonnes
Voyage Bunker Costs	516,746.23	2,583,731.16	USD
Voyage Capital Costs	59,963.19	299,815.96	USD
Voyage Operational Costs	21,048.79	105,243.95	USD
Terminal Handling Costs	96,004.78	480,023.91	USD
Port Dues	1,483.66	7,418.31	USD
Total Voyage Costs	695,246.66	3,476,233.30	USD
COST PER TEU (Round-Trip)	**972.37**	**973.19**	**USD**
COST PER TEU (Single-Leg)	**486.19**	**486.59**	**USD**

PORT SERVICE OPTIMISATION

Information	*****Leave Blank*****	**Tg. Priok - Jakarta**	**Tg. Perak - Surabaya**	**Unit**
Port Waiting Time		16	8	hours
Port Service Time		6	6	hours
Port Charges		27.58	43.82	USD
Berthing Fees		45.34	45.34	USD
Mooring Fees		49.28	83.28	USD
Pilotage (Primary)		29.50	31.12	USD
Pilotage (Additional)		44.73	34.00	USD
Tug (Primary)		524.83	397.90	USD
Tug (Additional)		24.93	102.01	USD
PORT DUES		746.19	737.47	USD
PORT TIME SPENT		22	14	hours

TOTAL PORT TIME	**36.00**	**hours**
PORT DUES PER SHIP	**1,483.66**	**USD**
TOTAL PORT DUES PER SERVICE	**7,418.31**	**USD**

PORT DUES INFORMATION

Charges [IDR]	**Ship Size**	**Tg. Priok - Jakarta**	**Tg. Perak - Surabaya**	**Unit**
Port Charges	All ships	73	116	per GT/visit
Berthing Fees	All ships	60	60	per GT/24 hours
Mooring Fees	0-50 m	128,375	602,100	per ship/movement
	51-100 m	242,500	602,100	
	101-150 m	356,250	602,100	
	151-200 m	470,000	602,100	
	>201 m	583,750	602,100	
Pilotage (Primary)	All ships	213,248	225,000	per ship/movement
Pilotage (Additional)	All ships	59	45	per GT/ship/movement
Tug (Primary)	0-3,500 GT	505,920	385,500	per ship/hour
	3,501-8,000 GT	1,264,800	958,900	
	8,001-14,000 GT	2,002,600	1,518,200	
	14,001-18,000 GT	2,635,000	1,997,700	
	18,001-26,000 GT	4,216,000	2,196,300	
	26,001-40,000 GT	4,216,000	2,196,300	
	40,001-75,000 GT	4,216,000	2,196,300	
	>75,001 GT	5,691,600	4,315,100	
Tug (Additional)	<75,000 GT	8	30	per GT/ship/hour
	>75,000 GT	11	45	

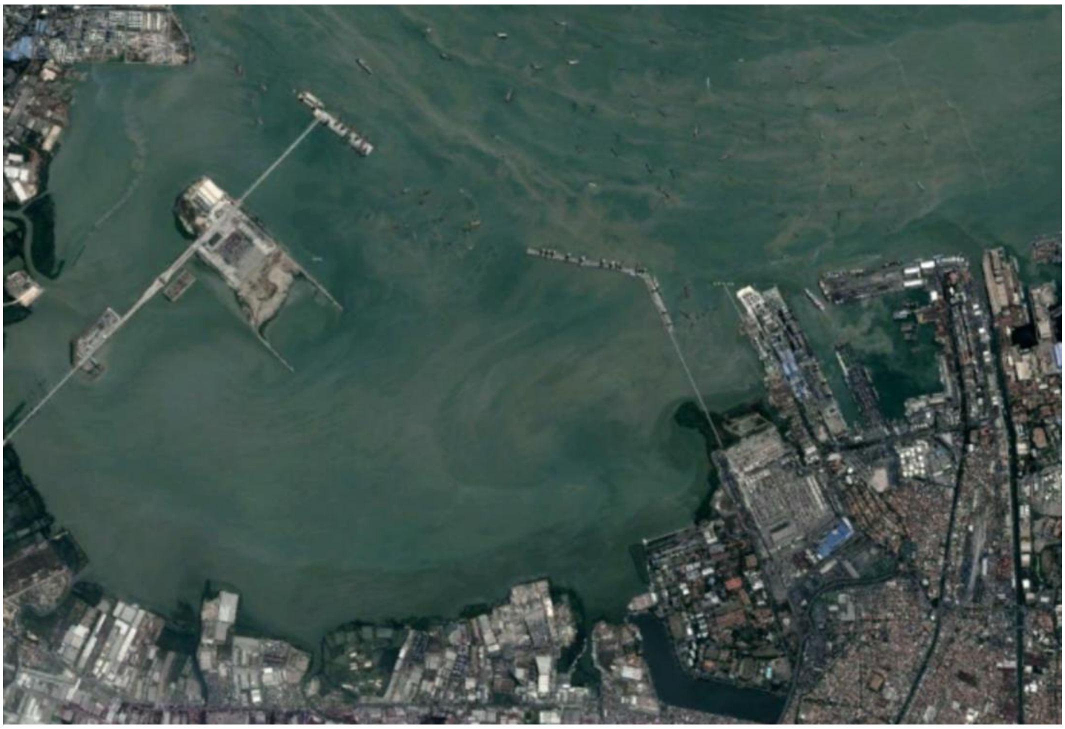
Conversion to USD

Charges [IDR]	**Ship Size**	**Tg. Priok - Jakarta**	**Tg. Perak - Surabaya**	**Unit**
Port Charges	All ships	0.0050	0.0080	per GT/visit
Berthing Fees	All ships	0.0041	0.0041	per GT/24 hours
Mooring Fees	0-50 m	8.88	41.64	per ship/movement
	51-100 m	16.77	41.64	
	101-150 m	24.64	41.64	
	151-200 m	32.50	41.64	
	>201 m	40.37	41.64	
Pilotage (Primary)	All ships	14.75	15.56	per ship/movement
Pilotage (Additional)	All ships	0.0041	0.0031	per GT/ship/movement
Tug (Primary)	0-3,500 GT	34.99	26.66	per ship/hour
	3,501-8,000 GT	87.47	66.32	
	8,001-14,000 GT	138.50	105.00	
	14,001-18,000 GT	182.23	138.16	
	18,001-26,000 GT	291.57	151.89	
	26,001-40,000 GT	291.57	151.89	
	40,001-75,000 GT	291.57	151.89	
	>75,001 GT	393.63	298.43	
Tug (Additional)	<75,000 GT	0.00055	0.00207	per GT/ship/hour
	>75,000 GT	0.00076	0.00311	

Appendix I: Industrial Complex of Ports in Scope of Research

I1: *Port of Tanjung Priok Industrial Area, North Jakarta – Java Sea*
[Source: Google Earth, 2018]

I2: *Port of Tanjung Perak Complex, North Surabaya – Madura Strait*
[Source: Google Earth, 2018]



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