Freight Calculation Model: A Case Study of Coal Distribution

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Abstract. Coal has been known as one of energy alternatives that has been used as energy source for several power plants in Indonesia. During its transportation from coal sites to power plant locations is required the eligible shipping line services that are able to provide the best freight rate. Therefore, this study aims to obtain the standardized formulations for determining the ocean freight especially for coal distribution based on the theoritical concept. The freight calculation model considers three alternative transport modes commonly used in coal distribution: tug-barge, vessel and self-propelled barge. The result shows there are two cost components very dominant in determining the value of freight with the proportion reaching 90% or even more, namely: time charter hire and fuel cost. Moreover, there are three main factors that have significant impacts on the freight calculation, which are waiting time at ports, time charter rate and fuel oil price.

1. Introduction

One of the main problems in an effort to maintain the availability of national electricity supply is to preserve a continuous supply of primary energy. One of energy sources that has dominantly been used for maintaining the electricity supply in Indonesia is coal. However, there are limitations and challenges on coal distribution during its transportation from coal sites to power plant locations. They are including the spreading out of power plant locations from coal supply site, the variety of the number of coal required for each power plant, the difference of coal characteristics on every coal site, and so on [1].

In order to face these problems, it is required the eligible shipping line services that are able to provide the best freight rate in a certain route. In addition, there are three modes that can be used to serve the coal distribution in Indonesia, which are tug-barge, vessel and self-propelled barge (SPB).

Therefore, this study aims to obtain the standardized formulations for determining the freight rate based on the theoritical concept. The freight rate produced is the required freight rate (RFR), meaning the tariff that is able to cover all expenses incurred in the process of sea transport without adding a profit. The result shows the determination of required freight rate for coal distribution by using three alternative transport modes, namely tug-barge, vessel and self-propelled barge.

2. Literature Review

2.1. Dry-bulk shipping

Transport (in all modes) is the essential link between supplier and receiver, and the aim is to receive the goods in good condition, when and where they are needed with an affordable price. Since most of coal distributions are shipped by sea transportation mode, then understanding the type of ships commonly used, how they are operated and how the freight rate is determined are indispensable.

In general, types of ship can be classified into three groups: cargo ships, offshore mobile structures, and non-cargo ships. Furthermore, the group of cargo ships can be divided into four sectors, namely general cargo, bulk cargo, oil and chemicals and liquid gas. A dry bulk carrier is a ship specially designed to transport dry unpackaged bulk cargo, such as grains, coal, ore, etc in its cargo holds. Dry bulk carriers usually have several holds that are covered by hatches and equipment for loading and unloading of the cargo. In large part the design of dry bulk carriers depends on the density (stowage factor) of the cargo that will be transported [2].

2.2. Shipping costs
In general, the shipping costs can be classified into two main categories. First is the cost of operating the ship, and the second is costs of maintaining and financing the ship. These classifications can be broken down as follows [2]:
- Cost of operating the ship
  o Operating costs, which constitute the expenses involved in the dayto-day running of the ship - essentially those costs such as crew, stores, running repair, insurance and administration.
  o Vogaye costs are variable costs associated with a specific voyage and include such as items as fuel cost, port charges and canal dues
  o Cargo handling costs represent the expense of loading, stowing and discharging cargo.
- Cost of maintaining and financing the ship
  o Capital Costs, are the costs to finance the ship and depend on the way the ship has been financed. They may take the form of dividends to equity, which are discretionary, or interest and capital payments on debt finance, which are not.
  o Periodic Maintenance Costs are incurred when the ship is dry-docked for major repairs, usually at the time of its special survey. In older ships this may involve considerable expenditure, and it is not generally treated as a part of operating expenses.

3. Methodology
The keys to survival in the shipping market in which ship owners have to work with are the revenue received from operating the ship and cost of running and maintaining the ship. Revenue received from operating the ship is a multiplication of the freight (price) by volume of cargo transported. Although ship owners do not generally control the freight they receive per ton of cargo, there is a way to estimate whether the ship can generate positive cash flow or not. This can be done by calculating the Required Freight Rate (RFR).

Required Freight Rate (RFR) is the tariff that is able to cover all expenses incurred in the process of sea transport without adding a profit. Meanwhile, freight is the rate (selling price) charged by the ship owner to the tenant in which there is included ship owner's profit. Thus, the relationship between RFR and freight can be written in the following formula [3]:

$$Freight = RFR + Profit \qquad (1)$$

To calculate the amount of RFR, firstly we determine all the costs, which are the ship owner's responsibility for the economic life of vessels by considering the increasing of each cost in a year. Afterwards, calculating the present value of all costs incurred during the economic life of vessels with the discount rate, which is applied by the method of Weighted Average Cost of Capital (WACC).

The purpose of calculating the total costs incurred is to calculate the cost burden uniformly over the economic life of vessels, then the method can be used to homogenize those expenses is the annuity method. This annuity calculation can be done by using the equivalence principle commonly used in theory of engineering economy [4]. The formula for calculating the value of an annuity on the present value can be formulated as follows:

$$A = P \left[\frac{i\,(1+i)^n}{(1+i)^n - 1} \right] \qquad (2)$$

Where:
A = Annual equivalent value
P = Present equivalent value
i = interest rate (in this case is WACC)
n = economic life of vessels

By knowing the value of an annuity represents the annual fixed costs of vessel, which are including capital cost and periodic maintenance cost. Thus, if it is divided uniformly by the economic life of vessels, then it will be a basic calculation to determine the time charter hire.

Furthermore, total costs can be generated by adding the annual fixed costs and variable costs. Meanwhile, components of variable costs are voyage cost and cargo handling cost. The RFR can be known as unit cost, which can be calculated by dividing the total costs with the amount of cargo transported over one year. Thus, we obtain the unit cost of transporting the goods per unit of weight (USD/ton). In general, the cost calculation of unit cost can be formulated as follows [5]:

$$Unit\ cost = \frac{(LC + OPEX + CH)}{PS} \tag{3}$$

The unit cost of transporting a ton of cargo on a voyage is defined as the sum of the capital cost of the ship (LC), the cost of operating the ship (OPEX) and the cost of handling the cargo (CH), divided by the parcel size (PS), which for bulk vessel is the tonnage of cargo carried.

4. Result and Discussion

4.1. Transport modes alternatives
There are three alternatives of transport modes commonly used today for coal distribution in Indonesia, which are barge, vessel and Self-Propelled Barge (SPB).
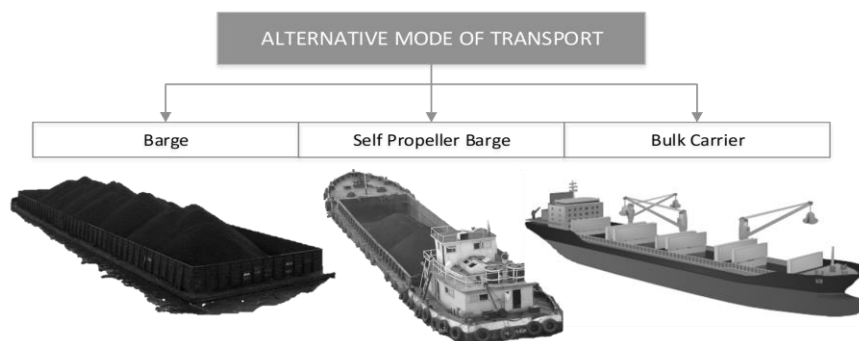
Figure 1. Transport modes alternatives

Before determining the required freight rate, we have to compute the total costs of coal distribution. Firstly we identify the specifications of each transport mode commonly used. Table 1 presents the specification of transport modes used on the freight calculation model.

Table 1. Transport modes specification

No.	Transport mode	Type	Payload (Ton)	Crew	Main engine	Auxiliary engine	No.	Transport mode	Type	Payload (Ton)	Crew	Main engine	Auxiliary engine
1	Barge	BG 365'	12,500	10	3,000	300	6	Vessel	Panamax	65,000	24	15,400	2,400
2	Barge	BG 330'	9,500	10	2,400	300	7	Vessel	Handymax	45,000	22	11,500	1,800
3	Barge	BG 300'	7,400	10	2,000	200	8	Vessel	Small Handy	20,000	20	6,700	1,100
4	Barge	BG 270'	5,000	10	1,600	200	9	SPB	SPB 10.000	10,000	20	3,300	500
5	Barge	BG 230'	3,000	10	1,200	200	10	SPB	SPB 12.000	12,000	20	3,900	600

4.2. Time charter hire

The components of cost calculated on the time charter hire consists of two components namely capital cost and operating cost. In this case, the component costs repair and maintenance costs are also included in the operating cost component. By applying the formula on the Equation 2, thus we obtain the value of time charter hire for each type of transport mode as follows:

Table 2. Time charter hire

No.	Transport mode	Type	Payload (Ton)	Economic life	Ship's Price[a]	TCH[b]	No.	Transport mode	Type	Payload (Ton)	Economic life	Ship's Price[a]	TCH[b]
1	Barge	BG 365'	12,500	15	37,000	733	6	Vessel	Panamax	65,000	25	320,000	5,419
2	Barge	BG 330'	9,500	15	32,000	648	7	Vessel	Handymax	45,000	25	250,000	4,278
3	Barge	BG 300'	7,400	15	29,000	596	8	Vessel	Small Handy	20,000	25	145,000	2,584
4	Barge	BG 270'	5,000	15	25,000	528	9	SPB	SPB 10.000	10,000	15	105,000	1,983
5	Barge	BG 230'	3,000	15	21,000	460	10	SPB	SPB 12.000	12,000	15	126,000	2,339

[a] Ship's price in million-rupiah per unit

[b] Time charter hire (TCH) in million-rupiah per month

4.3. Freight calculation

In order to calculate the required freight rate (RFR) for coal distribution in Indonesia, we select one of dedicated routes as an example to describe how the model calculation works by considering three types of transport modes.

Distance by barge or SPB = 587 Nm
Distance by vessel = 527 Nm
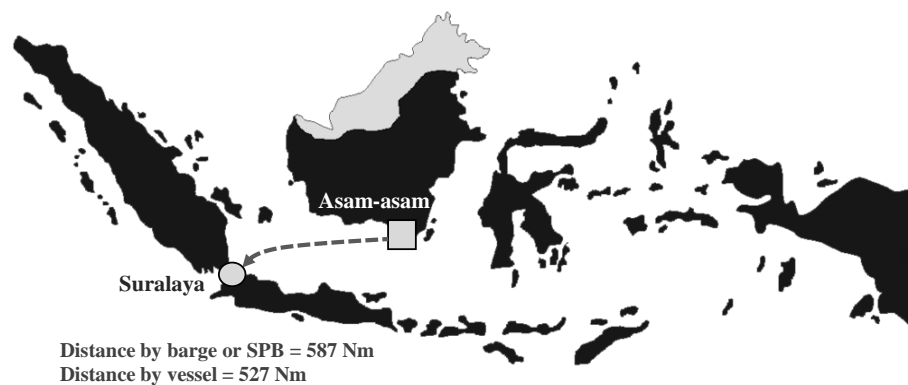
Figure 2. Coal distribution from Asam-asam to Suralaya

Asam-asam, one of the biggest coal suppliers in Kalimantan island, is selected as a coal site. On the other side, one of Asam-asam's consumers is Suralaya Power Plant in Banten – Java island. From Asam-asam to Suralaya has a distance of 527 Nm by vessel and 587 Nm by barge or SPB. Hence, in this calculation, Panamax vessel is selected to be analyse on this spesific route.

**Table 3.** Operational analysis by using Panamax from Asam-asam to Suralaya

Tranport mode operations			Transport mode consumptions		
Sea time	(hour/R.trip)	111.26	Fuel consumption		
Port time			Main engine	(KL/R. Trip)	203.20
Port of loading	(hour/call)	102.00	Auxiliary engine	(KL/R. Trip)	84.21
Port of discharging	(hour/call)	332.84	Total fuel cons.	(KL/R. Trip)	287.41
Total port time	(hour/call)	434.84	Fresh water cons.	(ton/trip)	109.22
Total time	(hour/R.trip)	546.09			
	(day/R.trip)	22.75			

Table 4. Freight calculation by using Panamax from Asam-asam to Suralaya

Total shipping cost		
Time charter rate	(Mln-Rp/month)	5,419.00
Fixed costs	(Mln-Rp/R.trip)	4,110.10
Fuel costs	(Mln-Rp/R.trip)	1,414.36
Port charges	(Mln-Rp/R.trip)	220.38
Port of loading	(Mln-Rp/R.trip)	110.19
Port of discharging	(Mln-Rp/R.trip)	110.19
Towing fee	(Mln-Rp/R.trip)	10.00
Fresh water cost	(Mln-Rp/R.trip)	8.74
Total cost	**(Mln-Rp/R.trip)**	**5,763.58**
Unit cost (RFR)	Rp/ton	88,670.40

Waiting time for both at Asam-asam and at Suralaya are six hours. Meanwhile, waiting time at Asam-asam and at Suralaya are three days and four days, simultenously. By applying the formula on Equation 3, as the result, the required freight rate on this route is IDR 88,670.4 per ton by using Panamax vessel, which has capacity of 65,000 ton.

If this route is served by tug-barge (330 feet) with the capacity of 9,500 ton and by SPB with the capacity of 10,000 ton, then the RFR produced are 126,555 per ton and 145,662 per ton, respectively. Overall, the other routes could be determined by the similar method by changing on the type of transport modes. The result for other routes by using three type of transport modes can be seen in the Figure 3 as below:
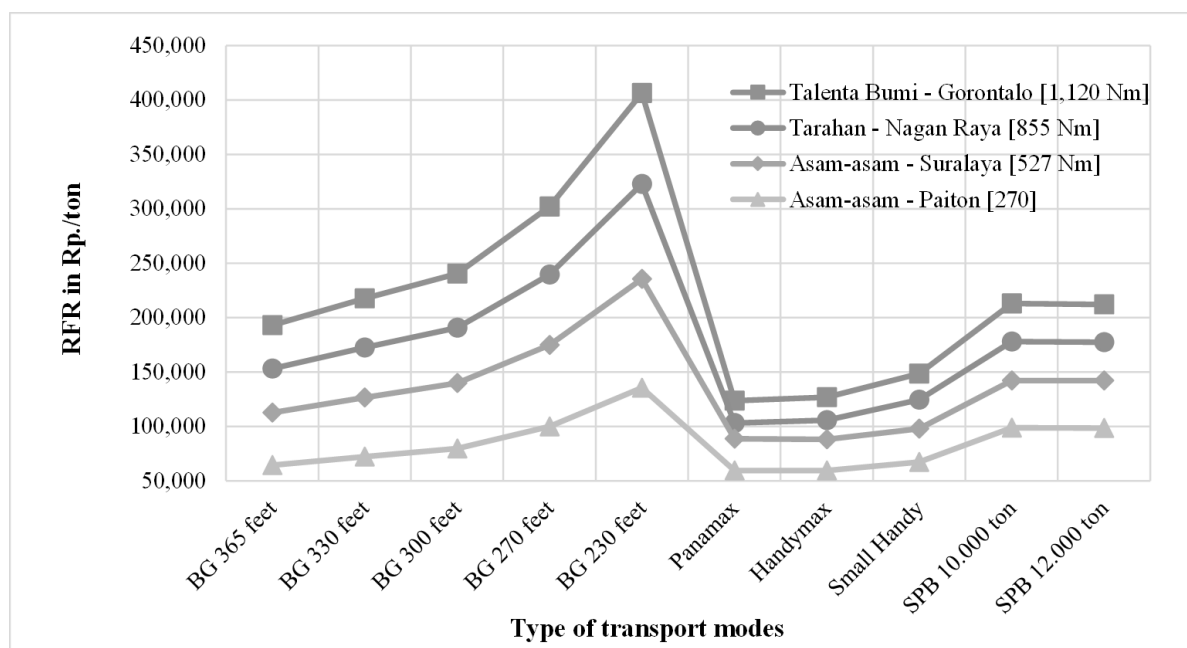
Figure 3. RFR for other routes by using three type of transport modes

From the figure 3 above, it can be concluded that the bigger capacity of transport modes used to transport the coal within the same length of distance, the cheaper unit cost produced. Kindly note that only several ports that could be served by bigger vessels. Thus, the decision for selecting the type of transport modes in the case of coal distribution should be considering about the number of coal distributed, the characteristics of ports and the length of distance between port of loading and port of discharging.

5. Conclusion

Based on the analysis, the type of transport modes used for distributing coal from coal sites to power plants depends on the volume of coal transported, the length of distance and the draught of ports. Meanwhile, selecting the type of transport mode for a certain route affects on the total cost during the coal distribution. Meaning that the bigger vessel used, the cheaper cost incurred.

There are two component costs are very dominant in determining the value of freight with the proportion reaching 90% or even more namely:

- Time charter hire, where the factors that determine the high and low of time charter rate are the type, the age and the capacity of transport modes.
- Fuel costs, where the factors that specify the high and low of fuel costs are engine power, fuel consumption and average speed.

In addition, there are three main factors that have significant impacts on the freight calculation, which are waiting time at ports, time charter rate and fuel oil price.

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