ABSTRACT
A generalized cost analysis for neopanamax vessels

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EXTENDED ABSTRACT

The value of the Panama Canal routes to ship operators comes from the role of the Canal as a time and distance saver for voyages between Atlantic and Pacific regions. From this point of view, the competitiveness of routes that use the Panama Canal against alternative routes has been based on total transportation expenses for different type of vessels, including fuel, capital/charter costs, and operational costs.
This paper will expand the competitive analysis from the vessel operator's point of view to the shipper's standpoint. With the opening of the Third Set of Locks in 2016, now there is an opportunity to analyze the economies of scale for the new neopanamax vessels. Shippers mainly care about total landed cost (TLC), which is the total cost of a product from an origin to the final destination. In addition of the transportations expenses, this includes inventory holding cost, "in-transit" time reliability and frequency of services.
This paper will derive inventory related costs in the case of containerships. By analyzing other factors besides transportation costs, such as inventory cost, reliability and frequency, a better understanding of their effects on the competitiveness of the Panama Canal routes can be obtained.

METHODOLOGY

In general, the competitiveness of a route is related to how well the route serves the purpose of moving cargo from an origin A to a destination B. The analysis of two competing routes can be done from two different perspectives: from the standpoint of the vessel operator or from the point of view of the shipper. For the container vessel operator, the goal is to minimize the total cost of transportation between point A and B. On the other hand, the shipper cares about the total landed cost (TLC), which is the total cost of a product from the origin to the final destination, which includes other factors such as: inventory carrying costs, handling costs, and reliability.
There are three important components that need to added to the traditional transportation cost analysis:

a. **Value of time (VOT)**
While the cargo is being transported, the owner/consignee needs additional working capital to finance goods in transit. This type of inventory is called "pipeline stock". This cost will be proportional to the value of the cargo and transit time.
The cost of working capital because of the idle inventory during transit time can be estimated as follows:

$$VOT_{rc} = i \cdot TT_r \cdot V_c \qquad (2)$$

where VOT is the value of time for route r and commodity c, i represents daily interest rate for commercial loans, V is the cargo value for a commodity c in US$ per TEU and TT is the total time (days) of route r. The VOT depends crucially on the type of commodity.

b. **Value of Reliability (VOR)**

Congestion in transportation systems cause an increase in safety stock at regional distribution centers to avoid costly stockouts. This increase in safety stock will require additional working capital to finance goods at regional distribution centers.
The reliability of a transportation route is greatly affected by uncertainties in transit time. Variations on "in-transit" time will affect the pipeline stock as well as safety stock. Hence the VOR can be decomposed in two parts:

$$VOR = VOR_{ps} + VOR_{ss} \quad (6)$$

The first term of the former equation represents the extra cost the shipper bears because of the idle cargo while being transported (pipeline stock). The second term of the equation represents the extra cost the shippers must bear for higher safety stock at its warehouse, for avoiding sale shortages.
The cost of a delay in transit time will be

$$VOR_{ps} = i_{LT} \cdot V_c \cdot dev_{1-\alpha} \quad (12)$$

where i_{LT} is the interest during lead time and *dev* is the deviations in transit time as a function of the mean of the Gumbel distribution and the probability of delay 1-α.
The cost of the delay in terms of safety stock will be

$$VOR_{SS} = i \cdot V_c \cdot (SS) \quad (16)$$

where i is the interest and SS is the safety stock. SS is defined as the number of standard deviations of the demand during lead time the firm should have in inventory to account for uncertainties. ($SS = K \cdot \sigma_L$)

c. **Value of frequency (VOF)**
More frequent services will allow shippers to reduce replenishment times and inventory levels at their distribution centers, reducing inventory and handling costs. Changes in frequency affect average cycle stock at destination.

The cost of the changes in frequency can be estimated by:

$$VOF = i_{LT} \cdot \left\lfloor \tfrac{1}{2} + K \cdot cv \cdot \sqrt{freq} \right\rfloor \cdot V_c \quad (18)$$

Where i_{LT} is the interest in lead time, Vc is the value of the cargo, K is the service factor, cv is the variation coefficient (ratio of standard deviation to mean) and freq is the frequency.

GENERAL ASSESSMENT OF PANAMA CANAL COST COMPETITIVENESS

The previous methodology was implemented in an Analytica software platform. The electronic tool is the Panama Canal Integrated Forecast Model or PCIFORM[1].
Most of the Canal's containerized cargo volume is concentrated in the Asia to East Coast US route. For example, a containership service has a weekly frequency, uses heavy fuel oil (HFO), and sails at 17 knots average speed in slow steaming. The utilization rate in full containers is assumed to be 90% in headhaul and 50% en backhaul.

A potential alternative to this service would be a route via Suez Canal. The typical vessel size used in this route would be similar to the neopanamax vessels through the new Panama Canal locks.

[1] The tool was developed under a Panama Canal study by Novix and Drewry in 2011. (Novix and Drewry Shipping Consultants, PCDM Integration with PCRCAM Final General Report, 2012)

Table 1. Vessel size for potential alternate routes

Routes	headhaul/backhaul	vessel size (in TEUs)
Panama Canal route	Asia - ECUSA -Asia Panamax Locks	4000
	Asia - ECUSA -Asia Neopanamax locks	8000
Suez route	Asia - ECUSA - Asia Via Suez Canal	8000

Let's assume we need to move cargo from Shanghai to the United States East Coast (Allentown, PA), with vessel provision costs based on charter rates. Feeding the model with data as of February 2018, we estimate the total transportation cost or freight rates plus the value of time, value of reliability and value of time to obtain the total landed cost for the owner/consignee. This exercise will be done for two types of commodities: high value and low value.

We observe that Panama Canal route cost is lower than the alternate route by about 4%. In terms of total transportation time, using Panama route can save up to 5 days vs. the Suez route.

In addition to the total transportation cost, now we added the costs associated with VOT, VOR and VOF for two types of goods: one of high-value and one of low-value. For the purpose of this example, we evaluate apparel as a high-value commodity per TEU and construction goods/materials as a low-value commodity. In this example, the high-value commodity is 7 times more costly than the low-value commodity.

We observed that the share of the inventory-related costs is higher for the high-value commodities than for the low-value items in a per TEU basis. In the case of apparel, the additional costs amount to about one third of the total landed cost, whereas in the case of the construction goods the additional costs represents only an 8% of total landed cost. There are two findings: a) the additional inventory-related cost increased the competitive gap between the two routes and b) the inventory-related cost did not alter the cost ranking of the routes. In the case of the high-value item, the inventory-related cost made the longest route more costly by an additional 7%. On the other hand, in the case of the low-value item, the inventory related cost increased the gap only by 1%.

CONCLUSIONS

The addition of the shipper's perspective to the traditional transportation cost approach provides a more complete picture of the competitiveness of the Panama Canal routes.

There are two findings: a) the additional inventory-related cost increased the competitive gap between the two routes and b) the inventory-related cost did not alter the cost ranking of the routes. Another interesting finding was that high value cargoes have a larger impact on the competitive gap than low value items.

The implications of the study are significant for the measurement and estimation of the route competitiveness in the maritime industry.