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Operational shadow pricing in back haul container shipping

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ABSTRACT

Minimum acceptable rates for back haul cargo are difficult for carriers to establish in practice. They depend on complex factors such as availability of empty containers in the vicinity, cost of repositioning empties and container on-hiring decisions. A shadow pricing and "shadow credit" approach is proposed and applied to an inland network. Such a model can help carriers undertake yield management at the operational level to improve financial performance in a post-conference era. Results also suggest a positive relationship between variability in the imbalance situation of laden containers in a particular trade and volatility of short-term back haul freight rates.

1. Introduction

The back haul market for freight is an often neglected aspect of the container shipping business (Miller, 2010). The emergence of global markets, improved service of non-conference carriers, and deregulation have contributed to the restructuring of the liner shipping industry and led to a de-emphasis of traditional conferences (Federal Maritime Commission, 2001). At each IPI (inland point intermodal) location, which refers to a non-port that can be served by carriers on a through bill of lading, ocean carriers may compete fiercely in the spot market for export cargo from the hinterland, to minimize unused capacity on the return leg of the ocean journey. In a competitive market, although individual carriers may be price-takers, each indirectly exercises market influence by having the right to decline cargo that pay below the respective carrier's marginal cost.

A round trip in liner shipping can generally be divided into a head haul and a back haul, whereby the head haul is usually the demand intensive direction (Løfstedt et al., 2010). Vessel utilization is typically only around 50–70% in the Asia–Europe back haul trade lane (i.e. Europe to Asia) (Søndergaard et al., 2012). Likewise, half of containers entering the United States (US) are repositioned empty to foreign markets (Rodrigue et al., 2013). In other words, back haul trades are likely to have supply in excess of demand and thus face a surplus of empty containers. Negative trade imbalances tend to increase the rates for inbound flows and depress them for outbound flows, since the higher inbound rates are "subsidizing" the repositioning of empty containers (Rodrigue et al., 2013). Besides trade imbalance, dynamic operations and uncertainties are the other important factors that cause empty container movements (Song and Dong, 2015).

In the US, more than 80% of cargo move under service contracts (Federal Maritime Commission, 2001). Contracts are commonly used for long hauls in thin back haul markets (Hubbard, 2001). Shippers are more likely to engage in spot pricing agreements when the cost of transactions is low, when there are several alternative sources of the commodity to be shipped, when multipurpose vessels can carry it, or when many shippers and carriers operate on a single trade (Pirrong, 1993).

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Unlike in the airline industry, revenue management techniques used in the shipping industry are somewhat less well-established (Zurheide and Fischer, 2012). Even where they exist, the focus of tactical yield management is on slot allocation, i.e. rates are generally assumed fixed and capacity is allocated among particular trades (e.g. Karimi et al., 2005). However, in reality, in the short/immediate time frame, contracted rates may be fixed, but spot rates are still variable. Carriers can theoretically strive towards filling vessel capacity as much as possible in the short/immediate term by adjusting spot prices accordingly (as long as price is above marginal cost). Hummels et al. (2009)'s research suggests that the shipping industry exercises some market power, which helps to explain some portions of the variation in shipping prices. These can depend on cargo type, shippers' urgency and any quasi-rents that carriers can capture from shippers. Fig. 1 shows the degree of flexibility of rates and capacity as the shipping cut-off (or cargo tender) date is approached in the planning horizon.

At the strategic and tactical levels, the principal determinants of marginal costs and mark-ups in maritime shipping are distance, scale economies and policy barriers (Bertho et al., 2014). A low back haul rate is often cross-subsidized by charging a higher price on the head haul leg, and thus repositioning costs can be viewed as a recurring necessary cost.

At the operational level, marginal costs are more complicated and have two components: the direct cost and the indirect cost (Koopmans, 1949). Direct costs are incurred when equipment is tied up at any time during loading, loaded movements and discharging. Indirect cost arises whenever there is a "departure from perfect balance in the program and a continual movement of empty equipment is required from points of equipment surplus to points where there is a deficit." At the operational level, one challenge for carriers is thus in quoting rates that are greater than or equal to the short run marginal cost (SRMC) of accepting the export freight. In other words, it is a matter of establishing a "charging floor" consisting of the direct handling costs, but also charging as close as possible to the "charging ceiling" for each type of commodity, without ever exceeding it (Jansson and Schneerson, 1987). However, in a non-conference setting, each carrier would have different SRMC curves, due to different cost bases, trade strategies and states of container imbalance. Since the share of empty containers in hinterland transport ranges from 40% to 50% of all containers transported (Song and Dong, 2015), one of the largest components of marginal costs comes from the cost of regional repositioning of containers from IPIs with surplus containers, to where there are shortages.

The discussion on marginal costs thus leads to the concept of shadow pricing. The use of the term "shadow price" in the context of shipping can probably be traced to Goss (1967), who described "shadow price" as the freight rate at which the net present value of using a ship becomes zero, taking into considering the investment cost of the ship, the opportunity cost of capital and port dwell time. However, in optimization problems, shadow price takes on a different meaning, in that the shadow price of a constraint is the "rate of change of the maximized objective with respect to a unit relaxation of the constraint" (Layard and Glaister, 1994). This shadow price concept has been used in the broader context of transportation and transport economics. For example, Satar and Peoples (2010) analyzed the US coal industry and the divergence between transportation prices charged to shippers and the shadow prices. Clyde and Reitzes (1998) studied the effect of conference sizes on shadow value and marginal cost of capacity. Bell et al. (2011) described how the dual variable for a maximum rate of container movements at a port provides a shadow price, or surcharge, for loading or unloading a container at a congested port. Talley (1994) presented a shadow price methodology in evaluating a hypothetical non-profit port with respect to its optimum economic throughput and proposed that the Lagrangian multiplier could be a single overall performance indicator of the port.

Repositioning has a close link with yield management concepts. As Gardoń et al. (2013) explained, "margin" refers to revenue subtracting costs, whereas "yield" is the "margin after the addition of the so-called flow adjustment linked to the empty containers evacuation". Optimizing profitability at the operational level is challenging and requires not just good forecasts of revenue, but also of marginal costs. Marginal costs are difficult to determine due to the indirect cost components (Koopmans, 1949). Nonetheless, the operational planning level is characterized by a highly dynamic environment and the time factor plays an important role at this level (Braekers et al., 2011). Thus any optimization model at this level should not be too complex and should be solvable rapidly in almost real-time. Within a deregulated and highly competitive market, there is a propensity for carriers to enter in a price war (Bowman, 2013) and undercut not just competitors' rates, but also the carrier's own marginal costs. It would be of interest to pricing managers to understand how low a carrier should be prepared to quote to pursue the finite amount of freight in the back haul market.

The motivation for this paper stemmed from a study at an Asia-based shipping line (Carrier X) that was seeking ways to improve its profitability in the US-export market. As a small/mid-sized carrier, Carrier X does not currently adopt a sophis-

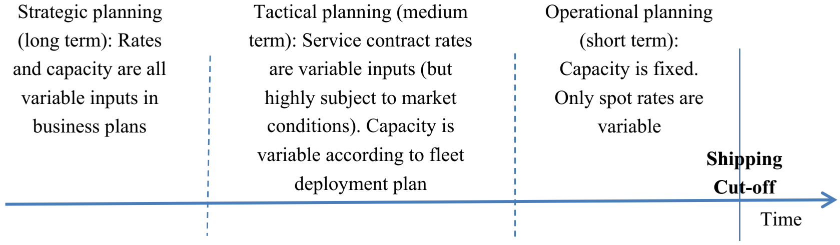

Fig. 1. Carrier's ability to vary rates and capacity with time.