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The value of specific cargo information for substitutable modes of inland transport

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ABSTRACT

Communication about containers onboard a cargo carrier approaching a harbor with a hinterland operator who is to receive the containers usually reveals the total amount of goods (aggregate number of containers) to be transported inland upon unloading at the arrival dock. This communication is useful for the hinterland operator to plan and deploy its transport capacities. However, further transport of containers on the hinterland involve various transport modes at differing costs. For example, the delivery time requirement of a container dictates the most appropriate mode of inland transport, be it truck, rail, or barge, in decreasing order of speed, flexibility and cost, to move the container to the next destination. In general there may be several types of delivery time requirements and containers of each type is most economically moved inland in a corresponding transport mode. Trucking is usually used for containers that need urgent delivery and train or barge for not so urgent types. In order to efficiently plan the transport capacities for after-arrival conveyance of containers having multi-type delivery time requirements, not only should the aggregate number of containers, but also the number of containers of each type, be made available to the hinterland operator. We consider several information scenarios and in each scenario we solve a single-period capacity planning serving multi-type demands with product substitution. We then compare expected transport costs between information scenarios to evaluate the benefit of specific cargo information in improving the next-step transporting after containers are unloaded at the port of entry.

1. Introduction

As the world trade becomes more globalized, with more production outsourcing and offshoring, ocean transport plays an increasingly important role in facilitating the exchange of goods. As reported by International Chamber of Shipping,[1] ocean transport takes care of 90% of the world trade by volume. However, ocean transport management is not as structured, and well-studied, as air transport. For example, in marine shipping, even bill of lading is sometimes still done manually. While information sharing is generally understood to be beneficial for a transportation system as it can help make transport arrangement more effective and efficient, there is very little information sharing across ocean container transport logistics networks. From an import perspective, we would expect that accurate information about the time when individual containers will need to

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[1] http://www.ics-shipping.org/shipping-facts/shipping-and-world-trade.

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be delivered to the next or final destination, and about the required mode of transport (e.g., truck, rail, or barge), should be very useful not only for efficient inland transport but also for optimizing container storage, preventing excessive moves, and saving yard space. However, to the best of our knowledge (learned in part through collaboration with industry executives), for logistics networks surrounding many ports in the world, this information has not yet been made available to hinterland transport operators.

1.1. Research issues

In this paper we study information sharing in relation to inland transport of ocean containers. The purpose of this study is to evaluate the impact of using specific cargo information to improve the next-step inland transport after containers are unloaded from vessels at a terminal. The problem we study concerns information about containers onboard a cargo vessel approaching the terminal and is related to the communication between liners/shippers and a hinterland operator who is to convey the containers further inland to their next or final destination (e.g., to a "dry port" or a central warehouse). This communication, before the vessel arrives at the port, usually reveals the total amount of goods (total number of containers) to be transported by the hinterland operator. While this information is useful to the hinterland operator, it is not specific enough for its best planning of transport capacities because further conveyance of a container upon unloading may involve different modes of transport at differing costs. For example, a container's delivery time requirement (which we call its *type*) dictates the most appropriate mode of inland transport, be it truck, rail, or barge, to move the container to the next or final destination. In many situations, however, liners/shippers inform the hinterland operator on how many containers of each type to be further transported only *after* the vessel arrives at the port. This does not allow sufficient time for the hinterland operator to efficiently plan and deploy the transport capacities of multiple modes. In order to benefit from cost advantages of barge and rail transport, one needs to have highly utilized trains and barges. Efficient planning means organizing these highly utilized trains and barges, which requires time and information.

Absence of advanced information is not uncommon in practice, often due to lack of interconnected information systems or just any information system. In fact one may sometimes find that even bills of lading are hand-written. Since each type of container is most economically moved on land by transport in a mode corresponding to its type, for efficient inland conveyance, the hinterland operator needs to know not only the aggregate number of containers, but also the number of containers of each specific type (i.e., delivery time requirement), *before* the vessel arrives.

Different modes of inland transport have associated with it different flexibility, transit time, and costs. In comodal transport services involving multiple modes, the fast and flexible trucking option is used to execute shipments under time pressure (Groothedde et al., 2005). Trucking capacity is usually the most flexible to deploy, has the shortest point-to-point transit time, but is also the most costly, in comparison to rail and barge. We say that trucking capacity is of a higher type than rail and barge as it is the more flexible and quicker, and can substitute for, or make up for the shortfall of, rail or barge capacity. On the other hand, because of their inferior flexibility and speed, rail or barge cannot make up for the shortfall of trucking capacity. Similarly, rail capacity is of a higher type than barge.

The questions facing the hinterland operator in charge of further inland transport of containers are:

- How much capacity of each mode should be deployed before the containers arrive at the port?
- How can the deployment decision be facilitated by information sharing regarding specific cargo types?
- How much value does the information sharing create?

Information sharing may be full or partial. In full information sharing, the volume of each cargo type is revealed. In partial information sharing, only the volumes of a subset of types (e.g., the highest type because it is the most urgent and receives the most attention) are revealed. Full information sharing completely eliminates uncertainty and enables a precise match between the number of containers of each individual type and the planned transport capacity of the corresponding type (mode). Under partial or no information sharing, the planning problem is to find optimal capacity decisions to minimize the total expected transport costs, conditional on the information available. Here the planning problem is that of capacity decisions serving multiple demand types with product substitution. Our capacity planning problem is directly related to the single-period multi-product inventory model with downward substitution. Downward substitution decisions are directed by firms to reduce lost sales. This differs from situations where downward substitution decisions are made by customers, as in Ganesh et al. (2008).

Our aim is to estimate the value of information sharing in improving inland transport operations. If this value is significantly higher than the cost of sharing information, the hinterland transport operator should take the initiative to seek *advanced* information from liners/shippers because it is a "user" and a direct beneficiary of this information. We evaluate the benefit of sharing specific cargo information, which enables more efficient next-step conveyance after the unloading of containers from the vessel, through different modes (truck, rail, or barge), to move the container to the next or final destination. The information sharing also helps managing storage capacity at the terminal yard: by better matching the predetermined capacity (supply) of a given mode of transport and the actual requirement (demand) for that mode, we can potentially reduce the storage duration of containers at the yard.