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Modeling the cost sensitivity of intermodal inland waterway terminals: A scenario based approach

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ABSTRACT

Cost characteristics of differently sized inland waterway terminals (IWTs) have not received much scientific attention. This observation is remarkable given the importance of costs in transportation decision-making. Classification of differently sized IWTs and their cost structure will lead to more insight into the container cost per terminal. Therefore, the goal of our research was to determine both the characteristics of the cost structure associated with different inland waterway (IWW) container terminal types and the sensitivity of the system to cost/TEU changes in input and operational conditions. We show that terminals with a higher container throughput encounter fewer costs, and can therefore charge a lower price. Assumed delays of 2 h per day on the waterside cause a 4.7–6.6% cost increase per container, mainly caused by extra labor costs. It is also assumed that the changing climate will influence terminal operations and results in extreme water levels (lasting two weeks occurring four times a year) causing a cost increase of 1.0–3.4%. Subsidies can cause cost reductions of 0.3–10.4% depending on the exact form, with the smaller terminals benefiting more because their investment costs are higher relative to operational costs. A subsidy can lower costs by up to 10.4%, but it is questionable whether small and medium terminals will have a lower cost price than the market price, showing that it is important for small and medium terminals to quickly grow in size.

1. Introduction

In Europe, inland waterway (IWW) transport is especially important for hinterland transport of containers to and from main deep-sea ports (e.g. Zhang et al., 2009). In IWW transport, the terminals are important in terms of costs, operations, and quality. Investment in and exploitation of inland waterway terminals (IWTs) in relation to occupancy rates and operational characteristics of IWTs and the resulting consequences to the service quality offered by the terminals is unclear. It is often argued that intermodal transport costs increase considerably in the intermodal terminal (Bowersox et al., 1986). However, not much is known regarding the exact cost characteristics of differently sized IWTs or their sensitivity to changes in operational conditions. Furthermore, given that IWTs are capital-intensive, it is important for them to optimally fill their capacity in order to realize low costs per TEU/container (in this paper every container is considered equal to one twenty-feet

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equivalent unit (TEU)). This challenge is complicated by the operating characteristics of the IWT such as operating hours, number of shifts needed, number and type of barges handled, arrival and departure schedules of barges, pre- and end-haulage distance from/to terminal customers, number and type of terminal customers, the impact of regulations, the service package offered by the terminal, the balance in the different handling operations, as well as by the balance in import versus export containers and their resulting impact on cost. Therefore, we analyzed, in detail, IWW terminal investment costs (such as land, cranes and quays) to determine the resulting handling cost for different types of IWTs, their sensitivity to operational and cost input changes, and, if possible, their relationship to paid prices for terminal handling. This detailed modeling approach contributes to suggestions for cost reductions and quality improvements at the IWTs in order to increase the performance and attractiveness of the IWT and of intermodal IWW transport. Given this background, the problem definition of this paper is as follows: What does the cost structure of different IWW container terminal types look like, how sensitive are the types to cost/TEU changes in inputs and operational conditions, and what does that mean for the strategy of IWTs?

In Section 2, the different IWTs types and their respective characteristics are given and then used to develop the base case for the analysis. Section 3 focuses on the investment in and exploitation of IWTs. The scientific state of the art in intermodal terminal research is discussed and analyzed. Theories about investment and exploitation of terminals are presented and related to the cost analysis in Section 4. This section also deals with investment and exploitation models for the respective terminal types, and it analyses and compares the sensitivity to and results of the respective scenarios. Section 5 presents the conclusions of the paper and discusses policy implications.

2. Intermodal IWW transport and terminals in Europe

Inland waterway transport is an important hinterland transport mode for large container ports in Europe (and also increasingly in China). In Europe however, the length of the major inland waterway system is limited (see Fig. 1). The majority of the freight transported by inland waterways consist of dry and liquid bulk (Wiegmans, 2005). Container transport represents a small (approximately 5%) but fast growing segment that is especially focusing on hinterland transport to and from major deep sea ports.

2.1. Inland waterway terminal types

There are many types of intermodal terminals throughout Europe along inland waterways with different regional markets, ownership structures, strategies, and characteristics (Witte et al., 2014). Therefore, it is important to distinguish between different types of IWTs. IWTs are often (1) located within or near an urban area in order to link to large production and consumption bases and to enable minimization of the pre- and end-haulage, (2) they are typically land intensive, (3) they often have a relatively limited number of large users and a large number of smaller users, (4) the 'captive area' of the terminal is ideally limited to 25–50 km, and (5) the focus of most terminals is on large maritime container ports such as Antwerp, Hamburg, Bremen, and Rotterdam. Several different classification systems for IWTs exist, but the classification we use in this paper is related to handled volume (in TEUs). From the joint perspective of volume and capacity, we identify the following five characteristic types of IWTs: XXL-terminals, XL-terminals, L-terminals, M-terminals, and S-terminals (see Table 1 for an overview).

The main advantage of this classification system is that it is 'neutral' in the way the different terminal types are distinguished. Therefore, we use this classification to distinguish between the different terminal types in our research. More specifically, we combine distinct volume classes of the respective terminals with operating characteristics (see Appendix A for a complete overview of the respective terminal cases).

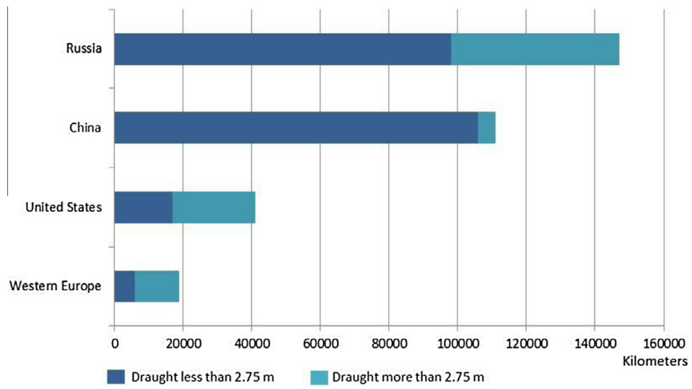

Fig. 1. Length of the major inland waterway systems in kilometers, 2000. *Source:* adapted from World Bank (2000).