



Impact of rail transport services on port competition based on a spatial duopoly model



Qi Zhang, Wenyuan Wang^{*}, Yun Peng, Zijian Guo

State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology, No. 2 Linggong Road, Ganjingzi District, Dalian, Liaoning 116023, China

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ABSTRACT

Rail transport plays an important role in port-based freight flows. In the context of port competition, the change of inland transport modes would directly influence pricing strategies and profits of ports. Therefore, this paper provides a method to analyze how the introduction of rail transport services affect port competition. Firstly, a two-stage game model is constructed based on a Hotelling model, which consists of two ports and one rail operator. Then, this paper demonstrates how the existence of pure strategy equilibrium prices of ports depends on the value of marginal profits of rail transport services. After comparing the results of different situations, our analysis shows there is a negative effect on ports' service prices and profits when the rail transport services are introduced in the port. As shown in the numerical example, the profits of ports would be reduced by about 10% (when rail transport services are only provided to one port) and 20% (provided to both ports) respectively. From the perspective of government, there exists an incentive to support the development of rail transport due to the promotion of social welfare. In addition, the rail operator is also likely to expand rail services in order to improve profits. Finally, the effect of economies of scale of rail transport is extendedly analyzed and three policies are proposed to weaken the loss of ports' profits, including implementing refunding scheme, setting price floor on port service price and providing government subsidy. The findings in this paper could provide support for the decision making towards comprehensive transportation management in coastal zone.

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1. Introduction

The competition between ports is gradually fierce with globalization of trade. As a significant node of supply chains, a port connects its hinterland to the rest of the world. In order to improve port's competitiveness, one straightforward method is to expand areas of its hinterland and capture more cargoes. In the view of shippers, inland transport costs play a crucial role in choosing a port to visit. Under this context, regionalization phase of development of port has been proposed by Notteboom and Rodrigue (2005), who emphasize that it is imperative for inland distribution segments of the supply chain in terms of reducing inland

transport costs, improving its efficiency and capturing more areas of hinterland. Especially in the “multi-port gateway region” proposed by Notteboom (2010), where several ports serve an overlapping hinterland, it is important for each port to have advantages in intermodal connections and suitable logistics structures (Monios and Wilmsmeier, 2013). Traditional ports and port systems are under the pressure to find new solutions to cope with competition. Monios and Wilmsmeier (2012) state that “A trend may be observed, beginning with the port's core business of container throughput, and developing towards hinterland actions and investments (either physical or operational/strategic) with an aim of supporting this core business”. Thus, inland transport (especially rail transport) has become the next competitive field from the viewpoint of port operators.

As an important freight transport mode, rail transport provides some significant advantages. In comparison with road transport, rail transport is more sustainable and reliable.

^{*} Corresponding author.

E-mail addresses: zhangqidlut@163.com (Q. Zhang), wangwenyuan@dlut.edu.cn (W. Wang), yun_peng@yahoo.com (Y. Peng), zjguo@dlut.edu.cn (Z. Guo).

Although delays are unavoidable especially for long-distance transport, rail transport is less impacted by unforeseen events and delays such as extreme weathers. Another advantage, which makes shippers have incentives to choose rail transport, is the price competitiveness in long-distance transport. Nevertheless, rail transport also suffers from some limitations, such as high capital investment in railways and dedicated wagons. Even so, rail transport has been recommended to be used in hinterland transport in many countries, due to its irreplaceable role in sustainable and efficient transport. For example, in EU, the rail market shares in Bremen port and Hamburg are more than 40% in 2013. Although the highest number of rail market share in Chinese ports is less than 10%, rail operators have planned to cooperate with ports to provide more rail freight transport services. Meanwhile, governments and organizations have published plans (e.g. China, GuoBanFa No. 69 [2013]; European Commission, COM (2011) 144; India, Sagarmila National Perspective Plan 2016, etc.) to encourage the use of rail transport services. Although the improvement of rail-based inland transport is of great convenience for hinterland transport of goods, it inevitably increases port competition due to the growing area of overlapping hinterland (Li et al., 2015).

If the rail transport services are introduced in the overlapping hinterland of ports, the users' hinterland transport cost would decrease. However, under this situation, the ports will have to make decisions whether to change their service prices, which may make many variations among the ports' market share and profits. The original equilibrium state between ports would become unstable. Specifically if the ports simultaneously choose to reduce their prices, the competition among the ports would become more severe and may damage the social welfare. Therefore, the following questions could arise: If rail transport is introduced in the overlapping hinterland of ports, how should ports respond in setting their prices? What is the effect on the user surplus¹ and social welfare²? In response, for the sake of sustainable development of regional transport industry, how could regional government formulate policies to make a trade-off between the changing of port profit and user surplus? This paper thus explores these topics to analyze the impact of rail transport services on port competition.

From the perspective of methodologies, we firstly review the studies on the impact of hinterland transport on ports. Many methods have been used to study the impact or relationship between different objects, for example development history review and empirical method (Yannopoulos et al., 2015; Maheshwari et al., 2016), regression analysis (Valipour and Eslamian, 2014; Valipour, 2015a, b), data mining method (Valipour, 2016) and so on. The previous studies on this topic mainly use empirical method and numerical cost analysis method. King et al. (2014) use empirical method to examine how the price of hinterland transport affects freight activity with regard to regional competitiveness and economic development. Meersman et al. (2016) take a micro-research approach to analyze how road pricing affects the cost functions in the logistics chain and how it impacts on the competitiveness of ports. By analyzing the difference between combined transport and road transport, Frémont and Franc (2010) argue that the combined

transport (including rail-road transport) is the only way forward to guarantee further growth of maritime traffic follows in North European seaports. Lättilä et al. (2013) numerically study the impact of usages of rail transport and dry port on transportation costs and environment by using the case of Finnish ports. However, most studies only consider the prices of ports as fixed numbers, rather than pay attentions to the probable changes of prices caused by the ports' competition.

For the studies on competition between ports and related factors, researchers usually applied two kinds of methods, including empirical analysis and game theory. These methods have unique characteristics and different advantages. For empirical analysis, there is a rich body of literature involving data sets and in-depth case studies, of which the research process is to provide empirical evidences to support their conclusions (Ng et al., 2014; Ng and Ducruet, 2015). Tian et al. (2015) propose a transformation method to examine the relationship and relative competitiveness between Shenzhen Port and Hong Kong Port. Veenstra and Notteboom (2011) analyze the level of cargo concentration and the degree of inequality in operations of the container ports to address the dynamics in Yangtze River port system. What is worth mentioning is the contributions of Castillo-Manzano et al. (2013). They attempt to explain the dynamism of inbound and outbound port hinterland traffic in Spain under a competition context by using pool balanced dynamic models. And they suggest that there is no correlation between capturing traffic and good intermodal transport condition of port. Although the empirical results is different with the opinions of some other researchers (e.g. Li et al., 2015), the result is persuasive and valuable for the further research. It also implies that more in-depth analysis is still needed on some topics to proof and complement the existing studies, such as the impacts of rail transport on the prices and profits of ports and so on. The above-mentioned studies provide us with informative details about port competition by narrative analysis and empirical data, however these methods could not theoretically analyze the mechanism of the stakeholders' actions under port competition.

For game theory, as one of the practical analysis tools, it has been widely and effectively used to address the questions about port competition under various contexts. With respect to the spatial differentiation, we respectively review the literature on the non-spatial game model and Hotelling model used to research the port competition.

On the one hand, the non-spatial game models have been widely applied in the relevant studies. De Borger et al. (2008) analyze the interaction between the pricing behavior of the ports and optimal investment policies in port and hinterland capacity. Luo et al. (2012) develop a two-stage duopoly model that comprises the pricing and capacity decisions of two heterogeneous players (new and existing port) serving an increasing market. Ishii et al. (2013) construct a non-cooperative game theoretic model where each port selects port charges in the timing of port capacity investment. Xu et al. (2015) study the revenue distribution of ports in the cooperative game and analyze the effect of quantity demands on prices of ports. Song et al. (2016) formulate a game model for a two-ports-one-ocean carrier system from a transport chain perspective to examine ports' relative competitiveness. Sheng et al. (2017) develop a game model to investigate the economic and environmental effect of different maritime emission regulations considering the competitions between ports and shipping companies. Matsushima and Takauchi (2014) investigate the effect of port privatization on the port competition. Wan and Zhang (2013) study the container port competition for transshipment cargo in

¹ User surplus is the total utility which identifies the difference between the willingness to pay and the disutility freight rate including transport charge and port price. Obviously the users are better off when the user surplus is higher. This indicator has been used in many literature, such as Chen and Liu (2016), Wan et al. (2016) and Matsushima and Takauchi (2014) and so on.

² Social welfare is understood as the sum of the stakeholders' payoffs, which includes the ports' and rail operator's profits and user surplus in this paper. This term is used to measure the wellbeing of studied society.

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