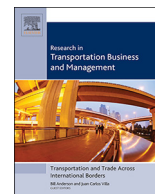




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A game theoretical approach to the effects of port objective orientation and service differentiation on port authorities' willingness to cooperate

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ABSTRACT

This paper analyzes the effects of the objective orientation of port authorities and the level of service differentiation on the capacity, service price, profits and welfare among competing or cooperating ports. We also examine feasible combinations of these two factors (private objective level and service differentiation) to promote port co-operation. We apply the model starting from a mixed duopoly where a landlord port (a port authority with mixed public and private objectives) competes with a profit-seeking port (a port authority with a fully private objective) with differentiated services. The results show that both the private objective level of the port authority and the service differentiation level have a significant influence on various port competition and co-operation settings. Certain combinations of these factors prove to be useful in view of co-operation among port authorities which previously competed. The paper not only contributes to existing literature on port competition/co-operation and the use of game theory in a port setting. It also provides valuable inputs to port devolution and co-operation discussions at the policy level.

1. Introduction

The growth of international trade and the relocation of main centers of production and consumption have resulted in growing port demand. Global and regional maritime and hinterland networks have been developed to accommodate the rise in trade flows. The improved global connectivity resulted in increased port competition as ports are vying for large contestable markets both in the hinterland and in coastal regions. However, the changing business environment has also led to various forms of co-operation in the port industry (Song, 2003). Ports may opt for mergers and acquisitions and the creation of formal or informal alliances with other ports in view strengthening their respective competitive positions (Cetin & Cerit, 2010; Donselaar & Kolkman, 2010). Port integration and alliances can serve as a means to effectively compete with rival ports and to somewhat counterbalance the market power of port users, especially the large container shipping alliances (Slack, Comtois, & McCalla, 2002), by means of sharing common resource/infrastructure, eliminating inefficient activities (Lim, 2008), enjoying economies of scale, and enhancing operations (Ryoo, 2011).

An abundant literature exists on port competition and co-operation

as will be demonstrated in the next section. This paper contributes to existing literature on port competition/co-operation and the use of game theory in a port setting by analyzing the effects of the objective orientation of port authorities and the level of service differentiation on the capacity, service price, profits and welfare among ports who either compete or co-operate. More in particular, we also examine feasible combinations of these two factors (private objective level and the level of service differentiation) to promote port co-operation. We apply the model starting from a mixed duopoly where a landlord port (a port authority or PA with mixed public and private objectives) competes with a profit-seeking port (i.e. PA with a fully private objective) with differentiated services.

This paper fills a gap by studying the effects of the level of service differentiation and port authority objectives (port ownership structure) under different port competition and co-operation settings. As such, this paper can serve as a more methodological reference to policy-makers in view of understanding the consequences of the differentiation of port services and the privatization/devolution of ports. It also provides methodological insights into the economic motivation for port co-operation.

The paper is organized as follows. In the next section, we present a

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literature review in view of positioning the present study in extant literature and explain the main concepts and constructs used. The third part defines the research objective and focus in greater detail. In the fourth section, the model of mixed duopoly with differentiated service is defined. Next, we investigate the effects of port authority objectives and the level of service differentiation on four possible port competition scenarios and a co-operation scenario. In the sixth section, the profits/payoffs of the four scenarios are compared to that of the co-operation option. The final section gives policy implications and concludes the paper.

2. Revisiting port competition and co-operation literature

Port competition studies can be grouped in three categories. The first category contains qualitative conceptual and empirical approaches to port competition using concepts from strategic management and economic geography literature (e.g. Cullinane, Ji, & Wang, 2005; Cullinane, Teng, & Wang, 2005; Notteboom & Yap, 2012; Slack, 1985; Song, 2002). The second group consists of empirically-based quantitative approaches to the measurement of port efficiency and competition through frontal analysis, time series analysis, logit models (e.g. Veldman & Bückmann, 2003) or other statistical methods such as Stochastic Frontier Models (see e.g. the Bayesian Stochastic Frontier Model applied in Notteboom, Coeck, & Van Den Broeck, 2000) or Data Envelopment Analysis (DEA) (see e.g. Cullinane, Ji, & Wang, 2005; Cullinane, Teng, & Wang, 2005). The third group of port competition studies applies game theory to examine competition between and within seaports. This category can be further subdivided in two subgroups:

- Studies on intra-port competition between terminals: for instance, Kaselimi, Notteboom, and De Borger (2011) studied the competition between a dedicated container terminal and multi-user terminals by using the Hotelling model, while Saeed and Larsen (2010) studied intra-port competition among three container terminals located in a port in Pakistan through a two-stage game model and also analyze the coalition of terminals;
- Studies on inter-port competition: for instance, Yap and Lam (2006) examined the relationship between various ports in East Asia using the co-integration test based on historical data. Anderson et al. (2008) examined port competition between Busan and Shanghai by employing a game-theoretical response model to check the interaction on capacity investment. De Borger, Proost, and Van Dender (2008) analyzed the interaction of pricing and capacity investment between two competing ports with congestion in the hinterland. Luo, Liu, and Gao (2012) developed a two-stage game theory model to test the impact of a new port on pricing and capacity investment. Ishii, Lee, Tezuka, and Chang (2013) examined port competition between Busan and Kobe to determine the pricing behaviors of two ports at each period of their capacity investment. Zhuang, Luo, and Fu (2014) concluded that port competition may lead to port specialization by applying a duopoly model on two ports handling two types of cargoes.

Port co-operation has also received attention in maritime economics literature (although less than the port competition theme). Scholars have studied port co-operation using economic models, game theory and operations research (Notteboom & Yang, 2017). Quite a few port co-operation studies focus on vertical co-operation such as upstream/downstream co-operation, horizontal co-operation among different ports (i.e. port authorities or terminals), and mixed co-operation (Notteboom & Rodrigue, 2005). Song (2002, 2003) applied the ‘co-opetition’ concept to ports, where competition and co-operation co-exist. Donselaar and Kolkman (2010) discussed the effect of port authority co-operation on social welfare and the promotion of co-operation at a national level. Wang, Ng, Lam, and Fu (2012) applied a game

theoretical model to examine the effects of service differentiation on port integration/co-operation in the Pearl River Delta (China) starting from the current situation of competition. Song, Cheon, and Pire (2015) applied co-opetition theory to analyze the motivation for co-operation between ports in Flanders (i.e. Antwerp, Zeebrugge, Ghent, and Ostend) and found that port size is not a significant factor for co-operation. The port co-operation studies using game theory are mainly focused on port capacity management, as the latter affects the marginal cost in the presence of economies of scale and serves as a possible rationale for port co-operation. For example, Wan, Basso, and Zhang (2016) investigated the incentives and welfare implications of collaboration among local governments in landside port accessibility investments.

A number of the mentioned studies include the **level of service differentiation** among the ports and terminals as a factor in port competition and co-operation dynamics. Service differentiation among ports can result from differences in service quality or service type or even the connection to their overlapping but not identical hinterlands. The concept of service differentiation is documented extensively in micro-economic theory. From a neoclassical perspective, it can be argued that two ports in the same multi-port gateway region are perfect substitutes for a port user if that user is willing to substitute one port for another at a constant rate (Notteboom, 2009). The most commonly used method to analyze service differentiation is by checking the cross-price elasticity between ports. This approach has been used in a number of port pricing studies (Haralambides, Verbeke, Musso, & Benacchio, 2001). Notteboom (2009) proposed an alternative approach to determine the service differentiation level by analyzing the revealed preference of container port users (i.e. shipping lines) in terms of the demand profile (measured by port scale and growth, and the port's foreland and hinterland orientation), the supply profile (assessed by the room for expansion, port location and nautical access) and the market profile (given by the market structure of the terminal operating business, cargo control and distribution activity in port).

Port governance is another factor which can affect competition and co-operation among ports. The governance of ports has changed dramatically since the 1980s, as the private operation of port facilities is increasingly common, particularly following port devolution programs across the world (Brooks & Cullinane, 2006; Brooks, Cullinane, & Pallis, 2017; Ng & Pallis, 2010). Cullinane and Song (2002) analyzed how privatization affects a port's financial and operational performance and how port authorities (PAs) handle this. Heaver, Meersman, and Van de Voorde (2001) investigated the challenges facing PAs in inter- and intra-port competition with the increasing influence of shipping alliances, and Donselaar and Kolkman (2010) summarized the costs and benefits of co-operation between PAs. While these papers give general suggestions with respect to the role of PAs in port competition and port co-operation, none of these papers develops a clear numerical relationship among the different factors relevant to PAs.

When considering the role of PAs in port competition and co-operation, it is important to consider the **objectives of the PAs**. Two basic categories of PA objectives can be distinguished: the private objective (profit-driven) and public objective (social welfare). In practice, PAs might pursue various combinations of private and public objectives. PA objectives will shape the functions of PAs, which, in turn, directly determine the role of PAs in competition and co-operation settings. World Bank (2007) defined a port authority as a “state, municipal, public or private body, which is largely responsible for the tasks...”. PAs typically are key actors in port competition, co-operation, or potential transitions, and they are heavily influenced by the port governance and ownership structure. Although the situation differs from port to port, the World Bank (2007) makes a distinction between four possible situations of port ownership structure: service port (predominantly public), tool port (intermediate zone), landlord port (mixed public-private orientation), and fully privatized port. The typical example of a fully private port is the port of Felixstowe whose daily operations and infrastructure have been privatized since the 1990s and are wholly

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