Transportation Research Part E 99 (2017) 115–133

Contents lists available at ScienceDirect

Transportation Research Part E

journal homepage: www.elsevier.com/locate/tre

Modelling port subsidy policies considering pricing decisions of feeder carriers

Chenrui Qu [a], Grace W.Y. Wang [b], Qingcheng Zeng [a,*]

[a] School of Transportation Management, Dalian Maritime University, 1 Linghai Road, Dalian 116026, PR China
[b] Department of Maritime Administration, Texas A&M University, Galveston, USA

ARTICLE INFO

Article history:
Received 19 August 2016
Received in revised form 11 January 2017
Accepted 11 January 2017
Available online 3 February 2017

Keywords:
Feeder carriers
Port subsidy
Pricing of liner shipping
Mainline-feeder liner shipping system

ABSTRACT

Feeder transportation is a key element of a port-oriented intermodal transportation system. In this paper, a pricing model is developed to investigate port subsidies to various players, i.e., mainline companies, feeder carriers, and shippers. The results show that port subsidies change the market equilibrium. Subsidies to mainline carriers increase the profit of the entire mainline-feeder liner shipping system. Subsidies to shippers decrease the equilibrium freight rates and stimulate the shipping demand, while subsidies to feeder carriers reduce operational costs and increase profitability. The results serve as policy recommendations to achieve various long-term goals in port development.

1. Introduction

Large-scale mainline-feeder shipping networks have been formed to improve the accessibility of international transportation networks by integrating the transcontinental shipping network, feeder lines and domestic inland-river networks. Hub ports with transshipment, collection, and distribution serve as the key nodes in container shipping networks. With the development of larger-sized vessels, port competition has evolved to the entire port supply chain and port-oriented intermodal transportation systems (Bichou and Gray, 2004). Multiple participants—such as feeder transportation, feeder and hub port operations, and mainline transportation—are involved in a port-oriented intermodal transportation system, and it is critical for a hub port to compete with cargo from the overlapping hinterlands via feeder ports (Chang et al., 2008). In practice, various port subsidies are implemented to enhance feeder volumes and to improve port competitiveness. For example, Fuzhou Port issues differential handling charges, pilotage dues and towage dues to various international ship lines and provides subsidies to liner companies opening new international routes. Dalian Port provides subsidies to feeder lines in Bohai Bay to maintain growing container volumes from feeder ports such as Jinzhou, Qinhuangdao and Longkou ports. Zhuhai Port provides subsidies to carriers operating domestic short-sea routes. The subsidies help improve the throughput of the ports. However, intensified competition and possible cooperation among multiple participants in the port-oriented transportation system make it extremely difficult to fairly assess the effectiveness of port subsidies.

The pricing decisions of multiple participants in the liner shipping industry are complex issues to study (Lee et al., 2012). While the decision-making process of a shipper's port selection is complicated, feeder carriers provide shippers' connections with hub ports and mainline carriers. Port charges and service quality affect a shipper's port choices and further influence a port's market share and revenue (Nir et al., 2003). Therefore, to evaluate the performance of different port subsidies and to

* Corresponding author.
E-mail addresses: quchenrui@dlmu.edu.cn (C. Qu), wangw@tamug.edu (G.W.Y. Wang), qzeng@dlmu.edu.cn (Q. Zeng).

http://dx.doi.org/10.1016/j.tre.2017.01.004
1366-5545/

address possible issues in liner shipping pricing strategies, we model the pricing decisions and behavior of mainline and feeder carriers. First, a pricing model considering the competition of feeder carriers, the selection behavior of shippers, and the competition of hub ports is developed. Second, port subsidy models are proposed to analyze the performance of different subsidy policies. Third, policy suggestions for port operators and liner carriers are proposed.

In this paper, we model a performance-based system to evaluate port subsidy policies. With numerical examples and cases of current practices, the main contributions of this paper are (i) to compare two practical port subsidies, which is significantly important for ports to improve their competitiveness but not aptly addressed in the literature and (ii) to develop a pricing model to illustrate the pricing decision behavior of mainline and feeder carriers. This model considers the competition of feeder carriers, the port selection behavior of shippers, and the co-operative/coexistence relation of hub ports.

The remainder of this paper is organized as follows. Section 2 provides a brief review of the related literature. A pricing model considering the competition of feeder carriers is developed in Section 3, and port subsidy models are developed in Section 4. Numerical examples are provided in Section 5 to verify the effectiveness of the developed models. Conclusions are given in Section 6.

2. Literature review

Port competition has grown increasingly fierce with the development of larger-sized vessels. Factors such as port location (Malchow and Kanafani, 2004), port efficiency (Tongzon, 2009; Low et al., 2009; Hung et al., 2010; Tang et al., 2011), demand uncertainty (Ishii et al., 2013), and distinctive shipping service schedules (Yap and Notteboom, 2011) have been identified as influencing port attractiveness. However, with the increasing importance of the global supply chain, ports have become the key nodes in intermodal transportation network systems (Notteboom, 2010).

In terms of supply chain and intermodal transportation, a port-oriented transport chain has gradually become an essential part of the literature. The competition and cooperation among players in the transportation chain are regarded as a strategic issue by Lee and Song (2016), and the port competition is a part of the rivalry between two alternative transportation chains (Bae et al., 2013). From the perspective of transport chain, Song et al. (2016) carried out research on inter-port competition, and develop a non-cooperative game model to find the optimal port pricing level and the port-of-call decision of carriers. It also can be shown that an integration policy should be adopted to increase the supply chain profit. In terms of accessibility, ports often rely on efficient hinterland logistics systems and well-developed sea connections between main and secondary ports (Yap and Lam, 2006; Podevins, 2007; Yeo et al., 2008; Bae et al., 2013; Tovar et al., 2015), and regional ports always compete for transshipment container cargos to maintain the dominant status. The port-of-call decisions of carriers have a significant impact on the regional transshipment market structure. A research study of Bae et al. (2013) provided insight into regional hub port competition for transshipment cargos based on a vertical-structure market including regional ports and shipping lines. The results showed that shipping lines tended to choose the port with cheaper price and larger capacity as transshipment port-of-call. Yap and Notteboom (2011) also studied the effects of shipping lines' service schedule on the port competition with a practical approach. Moreover, the transshipment port connecting mainline and feeder line network may significantly improve the accessibility to local markets. Many articles have addressed the design of mainline and feeder line shipping networks (Hsu and Hsieh, 2007; Ducruet and Notteboom, 2012; Gelareh et al., 2013; Polat et al., 2014; Plum et al., 2014; Zheng et al., 2015) and traffic distribution (Ham et al., 2005; Wang et al., 2015a). A port system comprising one hub port and several feeder ports is commonly observed (Wang and Slack, 2000). Ducruet et al. (2010) analyzed the changing role of hub ports in the shipping network evolution. Wang and Cullinane (2014) noted that the spatial configuration of East Asian ports has featured the long-term coexistence of a hub-and-spoke structure and a round-trip point-to-point structure. Notteboom (2010) compared two types of port systems. While container imports/exports have slightly higher transport costs in a hub configuration than in a multi-porting structure that requires a sequence of port calls, the hub configuration is more attractive for shipping lines.

Furthermore, Lee and Song (2016) pointed out that there was a close relationship between pricing and competition issue, and container shipping involves several players with private profit-maximizing objectives. Multiple participants in a transportation system have pricing power to influence one another, which increase the complexity of container shipping. Shippers always negotiate the price contracts with carriers, which has a significant impact on transport chain efficiency (Fransoo and Lee, 2013). Larger shippers focus on delivery time, while small-sized shippers pay more attention to freight charges (Steven and Corsi, 2012). Wang et al. (2014) discussed the competition among various carriers using game theory to set the optimum price to maximize profits. Many studies have focused on liner shipping carrier alliances (e.g., see Rimmer, 1998; Midoro and Pitto, 2000; Song and Panayides, 2002; Bergantino and Veenstra, 2002; Notteboom and Merckx, 2006; Parola et al., 2006; Shi and Voss, 2008; Agarwal and Ergun, 2010; Lu et al., 2010; Panayides and Wiedmer, 2011). Ishii et al. (2013) studied port competition under uncertain demand with a non-cooperative game model and found the Nash equilibrium of port charges. As port charges have a direct effect on the competitive status between two ports, a port should adopt a cut-price strategy in cases of high demand elasticity. Similar subsidy schemes are helpful in many aspects. For example, forwarders with different transport demand solved the empty equipment repositioning problem with a subsidy contract (Xu et al., 2015). Lee and Flynn (2011) pointed out that cross-subsidy mechanism contributed to the container terminal expansion. Moreover, subsidy scheme would also incent cargo volume in many ways, such as tax rebate, duty free, and export credit (Arslan and Van, 1993).