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Port integration method in multi-port regions (MPRs) based on the maximal social welfare of the external transport system

Liquan Guo[a], Dong Yang[b], Zhongzhen Yang[a,*]

[a] Transportation Management College, Dalian Maritime University, Dalian, PR China
[b] Department of Logistics and Maritime Studies, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong

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ABSTRACT

The port integration problem in a multi-port region (MPR) is studied from the perspective of maximizing the social welfare of the external transport system in a closed region in which the ports are regarded as external transport hubs. First, the economic principle of maximizing the social welfare of the external transport system is analyzed, and a method to calculate the total internal transport cost of the external transport system is proposed. Second, the optimal scale of the port group in an MPR is determined by comparing the total internal costs for different scales of the port group. An integration method with multi-period investment and asset idling is also proposed that takes into account excess port resources in MPRs. Finally, main gateway ports in Northeast China are selected for an empirical study. Based on the findings, suggestions regarding port resource integration and cooperative operation in MPRs are presented.

1. Introduction

For the past twenty years, Chinese port cities have invested substantially in expanding their local ports with the "promoting the local economy through port" strategy (Monios and Wilmsmeier, 2012; Zheng and Negenborn, 2014). By the end of 2015, five port clusters were formed along the 18,000 km coastline from north to south along the coast of Mainland China (Tongzon and Yang, 2016; Guo and Yang, 2017). Among these clusters, seven container ports rank in the top ten in the world in terms of total throughput. Currently, in China, it is common that grouping seaports are within the same gateway region, this region is thus called Multi-Port Regions (MPR) by Notteboom (2010), and Chinese coastal regions are all multi-port regions now. To expand their hinterland scope, the ports must strengthen their investment effort with the aim of improving the level of service and expand their capacity to attract more cargo accordingly (Song and Geenhuizen, 2014; Figueiredo et al., 2015). Nevertheless, with the slowdown in growth of hinterland's freight demand, excess port capacity,[1] wasted shoreline resources, and the idleness of port assets[2] are becoming an increasingly serious problem (Zheng and Yang, 2016). For example, nearly 50% of port assets are idle in some of the 40 ports in the Liaoning Province of China (PortNews, 2012).

With overcapacity and wasted resources becoming increasingly severe, the integration of port resources and cooperative operation have become important issues in the field of Chinese port operation and management (Yang et al., 2014; Notteboom and

* Corresponding author at: Transportation Management College, Dalian Maritime University, Linghai Road 1, Dalian, Liaoning, PR China.
E-mail addresses: guoliquan@dlmu.edu.cn (L. Guo), dong.yang@polyu.edu.hk (D. Yang), yangzz@dlmu.edu.cn (Z. Yang).

[1] According to Dekker (2005), port capacity is positively correlated with port assets, and higher port capacity indicates the volumes of port assets are also high. In our study, both of the port capacity and assets are utilized to serve the all categories of sea transport cargoes (including bulk cargo, general cargo, and container cargo et al.).

[2] The idleness of port assets means the port capacity is not fully utilized (i.e. port capacity utilization does not reach 100%), the port capacity utilization describes the port actual throughput relative to its specified capacity.

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Yang, 2017). Certain local governments have already started to employ administrative intervention or state-owned asset reorganization strategies to integrate the ports so they can achieve a common level of development (Wang et al., 2015). For example, in 2007, Fangchenggang Port, Beihai Port and Qinzhou Port in Guangxi Province restructured their assets to form the Beibu Gulf Port Group; this port group now plans infrastructure construction projects and provides pricing guidance. In 2015, The Ningbo-Zhoushan Port Group was formed with the complete transfer of Zhoushan Port's equity to Ningbo Port. Consequently, the Ningbo-Zhoushan Port Group has become the largest port in the world, handling more than 880 million tons of cargo. Administrative intervention and state-owned asset reorganization aims to accelerate the port resource integration process and avoid homogeneous competition. Note that the current measures can only integrate the administrative system and realize the sharing of technology and resources. These measures can barely optimize the size and number of ports in present MPRs to meet hinterland freight demand and are insufficient to solve port resource waste and reconstruction problems. Therefore, local governments and the newly founded port corporations are seeking methods to further promote port integration.

With this background in mind, this paper first put forth a method to determine the optimal scale of the port group in MPRs (including the port numbers, size and location of each port), and then to propose an effective method to integrate the gateway ports in a MPR. The work described herein considers the MPR in Northeast China as real investigation case. The novelty of this work lies in that it proposes the method for dividing the hinterland for the ports in different port layouts of MPRs with the utility theory. It presents the method for determining the optimal scale of the port group in MPRs with maximizing the social welfare. Moreover, it designs the multi-period investment and quit mechanism to integrate the present gateway ports in the MPR, so as to construct the port group structure that maximizes the social welfare. This research angle and applied method of this paper are new and can enrich the previous literatures concerning port integration/cooperation problems. It can be applied to many similar problems.

The reminder of this paper is organized as follows. Section 2 presents a literature review on the issue of port integration/cooperation. Section 3 presents the economic principle of maximizing the social welfare. Section 4 proposes the principle of ports' hinterland division and the method to calculate the internal cost of the external transport system. Section 5 determines the optimal scale of port group in a MPR. Section 6 designs multi-period investment and quit integration mechanism. Two main gateway ports in Liaoning Province in Northeast China are selected for an empirical study in Section 7. Section 8 discusses the main issues in our paper and presents the policy/practical implications. Finally, Section 9 concludes the study.

2. Literature review

Port integration/cooperation problems have become an important topic in the study of maritime or shipping economies (Woo et al., 2011; Asgari et al., 2013; Lee and Song, 2017). Many scholars have investigated integration/cooperation problems based on economic models, game theory and operations research (Notteboom and Yang, 2017). According to decision makers in the integration/cooperation process, research related to port integration/cooperation can be divided into two types: 1) cooperation or integration among the stakeholders in one port and 2) cooperation or integration among different ports or port authorities. Regarding cooperation/integration in one port, Saeed and Larsen (2010a) applied the concept of "core theory" in a two-stage cooperative game to analyze the stability of the coalitions which involves three container terminals located in Karachi Port in Pakistan. In the same year, Saeed and Larsen (2010b) also used the game theory to analyze the effect of the type of concession contracts on port user surplus and on profits of terminal operators (or port authorities) within the three terminals. The results reveal that in the long run it is profitable for the Karachi Port to establish a same fixed fee contract with its private terminals. Saurí and Robusté (2012) designed an incentive cooperation mechanism based on principal-agent theory for encouraging a private terminal operator and a stevedore company to reduce tariffs and increase the terminal's productivity. The results suggest that an improvement both in the terminal's productivity and in tariffs is possible through an annual fee. Wang and Pallis (2014) identified the post contractual moral hazard problem in port concession agreements with game theory, and provides a model involving performance-based concession fees to align successfully the Port Authorities' interests with those of the terminal operators. To match theory and practice, the paper reviewed factual information of recent projects in Europe and the US, and the results indicate that the port authority needs to identify clearly the objectives undertaken to avoid transaction failures in a Greenfield concession. It is found that research regarding cooperation/integration in one port has focused primarily on the influence of cooperation among the stakeholders on port efficiency, the benefits to port enterprises, and the other factors; game theory was found to be a popular method for investigating the above problems.

For the second type of port cooperation/integration among different ports or port authorities, Song (2003) proposed a new strategic option known as co-opetition, the combination of competition and co-operation, for the port industry, and explains a case of co-opetition between the container ports in Hong Kong and South China. Panayides and Song (2009) defined and empirically developed measures of seaport integration in global supply chains and inferred implications for maritime logistics. Donselaar and Kolkman (2010) elaborated on the question how cooperation between port authorities can contribute to the societal welfare and what role the national government can play in promoting this cooperation. Wang et al. (2012) investigated the factors and conditions affecting regional port governance in South China (i.e. alliance formation for ports serving partially overlapping hinterlands) by developing a game theory model and calibrated the model on the basis of the Pearl River Delta (PRD) context. Zhuang et al. (2014) applied the game theory approach to study port specialization and government regulations in China. They concluded that if there is a clear market leader, policy intervention may not be necessary. However, if no port has clear market power, then government coordination and intervention may be needed in order to prevent overcapacity and to encourage specialization. Song et al. (2015) investigated the motivations for the ports of Flanders (Antwerp, Zeebrugge, Ghent and Ostend) to choose coopetition (competition and cooperation) as an emerging strategy to react towards the rapidly changing market environment, and consider whether the size of port is a factor having an impact on the cooperative strategy. From a qualitative analysis on the matter, the paper concludes that