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# Network design approach for hub ports-shipping companies competition and cooperation

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ABSTRACT

In the maritime industry, the stakeholders comprising the port authorities, shipping companies, and port operators often compete and collaborate within an ecological system. This paper investigates the competition and cooperation strategies amongst three parties: two major container hub ports and the shipping companies. This research develops a game theoretic network design model which considers three scenarios: (i) perfect competition between the hub ports, (ii) perfect cooperation between the hub ports, and (iii) cooperation between the shipping companies and the hub ports as a whole. The scenarios are tested using empirical data from two leading Asian hub ports: Singapore and Hong Kong. An interval branch and bound is designed to solve the models.

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## 1. Introduction

The maritime sector is one of the most globalized industry (Rodrigue et al., 2009). In 2006, seaborne trade accounted for 89.6% of global trade by volume and 70.1% by value. Cargo is transported as either: (i) container, (ii) bulk, or (iii) general cargo. Among these, the share of container cargo is significantly greater than the rest. The current global port/shipping network consists of a network of hub ports which link the East–West services to each other or to the North–South services (http://halshs.archives-ouvertes.fr/docs/00/50/59/49/PDF/Paper_Maersk_Fremont_3.pdf). Fig. 1 shows the container traffic for the top twenty ports from 1985 to 2005 where the share of the containers handled by Asian ports in the top twenty ports increased from 45% to 73% (Containerization International Yearbook, 2009). However, only a small number of ports in the world capture the most market share (in terms of cargo handling), which are hub ports of their own regions. Campbell (1994) defines a hub as a node that services many origin–destination pairs as a transformation and trade-off node. Such hub ports are connected to other major (usually hubs themselves) ports around the world.

Table 1 shows that of the world's ten busiest container ports, eight are situated in East Asia. Recently, with the advent of the larger containerships, hub ports have come into greater demand for reasons of economies of scale during transport (Imai et al., 2009) and the need for better containership capacity management. Baird (2006) reports that containerization, designing and building bigger ships and traffic growth will give rise to more hub ports. In addition, within Asia, Southeast Asia and East Asia, hub ports are important as at least 30% of the world's container traffic passes through Southeast Asia (Lam and Yap, 2008).

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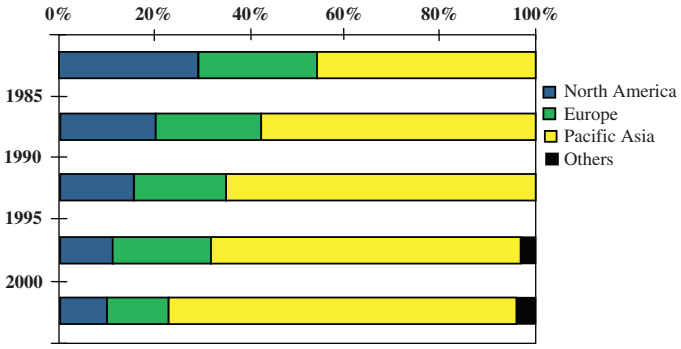


**Fig. 1.** Total container traffic of the 20 most important ports (1985–2005). *Source*: Containerization International Yearbook (2009).

**Table 1**
Containerized traffic for top 10 container ports in thousand TEU (Twenty-foot Equivalent Units). *Source*: http://en.wikipedia.org/wiki/List_of_busiest_container_ports.

| Port | 2009 | 2008 | 2007 | 2006 | 2005 |
|---|---|---|---|---|---|
| Singapore | 25,866 | 29,918 | 27,932 | 24,792 | 23,192 |
| Shanghai | 25,002 | 27,980 | 26,150 | 21,710 | 18,084 |
| Hong Kong | 20,983 | 24,248 | 23,881 | 23,539 | 22,427 |
| Shenzhen | 18,250 | 21,414 | 21,099 | 18,469 | 16,197 |
| Busan | 11,954 | 13,425 | 13,270 | 12,039 | 11,843 |
| Guangzhou | 11,190 | 11,001 | 9200 | 6600 | 4685 |
| Dubai | 11,124 | 11,827 | 10,653 | 8923 | 7619 |
| Ningbo | 10,502 | 11,226 | 9349 | 7068 | 5208 |
| Qingdao | 10,260 | 10,320 | 9462 | 7702 | 6307 |
| Rotterdam | 9743 | 10,784 | 10,791 | 9655 | 9287 |

Rodrigue et al. (2009) classify these hub ports into three categories:

(i) *Hub and spoke*: A hub port that connects regional ports (feeder lines) to other hub ports (global network).
(ii) *Relay*: These hub ports are interchange points for transoceanic shipping lanes. The location of these ports makes them a bottleneck (such as the Straits of Malacca for Singapore).
(iii) *Interlining*: While serving a different set of port calls, these intermediate hubs are interfaces between several pendulum routes along the same maritime range.

Hub ports try to increase their market share, as measured by a market share index based on the number of TEUs handled. Thus, hub ports have to enhance their competitiveness not only to remain a hub port for their current customers but also to attract new shipping companies to increase market share. For example, Maersk, the biggest shipping line with 15% of the global maritime market, changed its transshipment base from Singapore to the Port of Tanjung Pelepas (PTP) in Malaysia (Chang et al., 2008).

### 1.1. Motivation

Given that East Asia is strategic for maritime trade, shipping companies need to choose reliable hub ports. Hence, hub ports and shipping companies need to know how to connect to each other. Ports usually adjust their Terminal Handling Charges (THCs) to attract shipping companies while shipping companies look for a long-term commitment from the regional ports as their main transshipment points. These form the motivation for our research. Our work focuses on the competition and cooperation of the hub ports of Singapore and Hong Kong seeking to capture market share from the leading shipping companies.

Both ports are involved in transshipment. In 2009, 49% of Singapore's exports were due to re-exports (transshipment) while 53% of Hong Kong's cargo throughput was transshipped (McKinnon, 2011). Both ports compete to capture the transshipment market share on routes which can use Singapore and Hong Kong as substitution ports, particularly for the lucrative transpacific route. The current research develops a model for competition–cooperation among the hub ports and shipping companies. To the best of our knowledge, only two pieces of work sit closest to this area of this research. Anderson et al. (2008) used a game theoretic approach to analyze the competition between two hub ports of Busan (South Korea) and Shanghai (China). They analyzed the effect of creating new capacity to gain market share and realized that hub ports must consider the strategies of competition, failing to do may cause a surplus of port capacity and lead to lower port prices. Yeo

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