# CONTAINER PORT COMPETITION AND COMPLEMENTARITY IN SUPPLY CHAIN SYSTEMS: EVIDENCE FROM PEARL RIVER DELTA

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## ABSTRACT

Container shipping plays an important role for many supply chain systems through its ability to add spatial value to the cargo. Embedded within the container shipping system are competitive elements as well as complementary aspects in inter-container port relationships. The paper aims to examine these relationships through a thorough investigation of the calling patterns of container shipping services in order to understand the dynamics of competition and complementarity which exist among container ports. Specifically, empirical evidence will be sought from China's Pearl River Delta where the analysis will identify the routes and markets where competition or complementarity exists, participants involved, and the extensity and intensity of such relationships between the container ports of Hong Kong and Shenzhen. The investigation shows that apart from container port competition, inter-port complementarity also accounted for a significant share of changes to shipping capacity affected. The paper hopes to draw policy and decision makers' attention to the benefits offered from inter-container port complementarity in order to advance the competitive position of container ports, particularly in the Pearl River Delta.

Keywords: port complementarity, port competition, supply chain, container shipping, Pearl River Delta.

# 1. INTRODUCTION

A container port has a decisive role in influencing the comparative and competitive advantages of its user hinterlands. The port can also influence the entire region's viability and propensity for economic growth because the bulk of international trade, in terms of both tonnage and value, continues to be seaborne. Container shipping also plays an important role for many supply chain systems through its ability to add spatial value to the cargo. Embedded within the container shipping system are competitive elements as well as complementary aspects in inter-container port relationships. This is the focus of the paper which presents a new perspective in studying ports in supply chain systems. The paper aims to examine the inter-container port relationships through a thorough investigation into the calling patterns of container shipping services in order to understand the dynamics of competition and complementarity which exist among container ports. Numerous studies have been devoted to this important research area. A body of literature has examined container port competitiveness and competition by various approaches. The method of analysing annualised slot capacity (ASC) is one of the approaches used. As illustrated in Yap *et al.* (2006) and Lam and Yap (2008), the method can generate insightful information to reveal port competition dynamics. In this paper, we also work on the approach of analysing ASC to further develop this line of research. Specifically, empirical evidence will be sought from China's Pearl River Delta (PRD) where the analysis will identify the routes and markets where competition or complementarity exist, participants involved, and the extensity and intensity of such relationships between the container ports of Hong Kong and Shenzhen.

# 2. LITERATURE REVIEW

Various studies dedicated to analysing the impact of port competitiveness and competition in the container port industry involved approaches using routing strategy (Mourao *et al.*, 2002; Zeng and Yang, 2002), multimodal models (Luo and Grigalunas, 2003), transportation networks (Robinson, 1998 and 2002), logit models (Veldman and Bückmann, 2003), port productivity and efficiency (Sachish, 1996; De and Ghosh, 2002; Sanchez *et al*., 2003), modelling of costs (Baird, 2002; Lam and Yap, 2006), marginal cost pricing (Haralambides *et al.*, 2002), contestability (Notteboom, 2002), game theory (Yang, 1999; Flor and Defilipi, 2003), cluster analysis (De Langen, 2002), cointegration tests and error correction models (Fung, 2001; Yap and Lam, 2006), indifference analysis (Yap and Lam, 2004), and consideration for carrier and shipper requirements (Malchow and Kanafani, 2001; Tiwari *et al*., 2003). The method of analysing annualised slot capacity was used in two previous studies on container port competition in East Asia (Yap *et al.*, 2006) and Southeast Asia (Lam and Yap, 2008) respectively, as well as a paper assessing ports' connectivity (Lam, 2010).

Studying ports as elements in the supply chain is a relatively new and growing research area. The literature, especially for the earlier years, involved largely in the exploration and conceptualisation stage. Research approaches included value-driven chain systems (Robinson, 2002), case study (Carbone and Martino, 2003); market review (De Souza *et al.*, 2003); port development (Paixao and Marlow, 2003); survey of port performance measurement (Bichou and Gray, 2004; Song and Panayides, 2008) and discrete choice modelling (Magala and Sammons, 2008). Slot capacity analysis employed in this study is a new method in researching ports in supply chain systems.

Some previous studies have been done to evaluate inter-port relationships in the Pearl River Delta. These included the works of Robinson (1998), Comtois (1999), Zeng and Yang (2002), Cullinane *et al.* (2004), Song and Yeo (2004), Lee *et al.* (2006), Yap and Lam (2006) and Yap *et al.* (2006) among others. However, these studies focused on the competition aspect of such relationships and tangible elements that could be quantified. Those that are difficult to quantify but remain relevant are generally ignored or represented by subjective proxies. Further studies can be employed to uncover the dynamics of port competition and complementarity in the Pearl River Delta. Hence, our research intends to identify specific arenas of such relationships between the two major ports, Hong Kong and Shenzhen, and establish the intensity and extensity of competition or complementarity that exist. Furthermore, the research will also attempt to determine the competitiveness of these ports in relation to each other.

# 3. RESEARCH METHODOLOGY

The research method used is analysing annualised slot capacity (ASC). Simply put, slot capacity means vessel capacity. Such data can be computed in many ways to generate different useful information. In order to understand the dynamics of inter-port relationships, the point of interest is to know the ASC connected to ports. Computation of ASC for *k* services calling at a port can be obtained with formula (1):

$$\sum_{i=1}^{k} ASC_i = \sum_{i=1}^{k} V_i F_i \quad \ldots (1)$$

where *V* denotes average vessel capacity and *F* denotes the frequency of call in a year. As a single service could be deployed in multiple ports, summation of annualised slot capacity that called at the ports under investigation would exceed 100.0%. Similarly, summation of annualised slot capacity deployed on various trade routes connected to each port would also go beyond 100.0%. In this paper, ASC from year 1995 to year 2006 is computed and analysed. ASC connected to the ports is categorised by various trade routes, shipping lines/alliances, and whether the shipping services made exclusive or parallel calls at the ports.

Specifically, the method employs a bottom-up approach which involved tabulating and analysing over 3,000 container shipping services that called at the two ports on an annual basis over a 12-year period. Computation of this dataset took two years to complete.

The method of analysing annualised slot capacity can reveal the connectivity of the ports in a systematic and quantifiable manner. This is useful for assessing the competitiveness of the ports as well as the developments of inter-port relationships. Specifically, the data allows examination of changes in port calls by shipping services. Port complementarity is defined as services that are initiated or removed from both ports at the same time. As for competition, this can occur when services are removed from one port to call at the other or those that now include the other port in order to handle cargo directly. Hence, the method allows analysis into the networks of the target ports without the need for the access to sensitive data which is difficult, if not impossible, to collect. The data availability of this method greatly facilitates future studies which research on topics of a similar nature.

## 4. OVERVIEW OF MAJOR CONTAINER PORTS IN PRD

Major ports located in the Pearl River Delta include Hong Kong, Shenzhen and Guangzhou. Ranked as the third and fourth busiest container ports worldwide behind Singapore and Shanghai, Hong Kong and Shenzhen respectively handled 20.9 million and 18.3 million TEUs in 2009. Hong Kong and Shenzhen accounted for 81.3% of the total container throughput handled in the Pearl River Delta (Informa UK Ltd, 2008). With the majority of the region's container traffic handled by Hong Kong and Shenzhen, this paper shall focus on inter-container port dynamics between the two ports.

With reference to figure 1, the ports of Hong Kong and Shenzhen are located on the east bank of the PRD. Containers are handled mainly at seven places with Kwai Tsing Container Terminals and River Trade Terminals belonging to Hong Kong, and Yantian, Chiwan, Shekou, Mawan and Dachanwan belonging to Shenzhen.

Several container terminal operators were found to be located in a number of facilities in both ports. For example, Modern Terminals Limited has presence in Kwai Tsing, Shekou, Chiwan and Mawan whereas Hutchison Port Holdings is simultaneously present in Kwai Tsing, River Trade Terminals and Yantian. The proximity of these terminals suggests the presence of a high level of inter- as well as intra-container port dynamics where container terminal operators in both ports sought to position themselves as important links for supply chains that connect between Southern China and major markets in other parts of Asia, North America, Europe, Australasia and even Africa. Being located near the export-oriented manufacturing base in the Guangdong Province, inter-port dynamics in this region are centred on attracting containerised exports from Southern China to be channelled through their respective facilities.

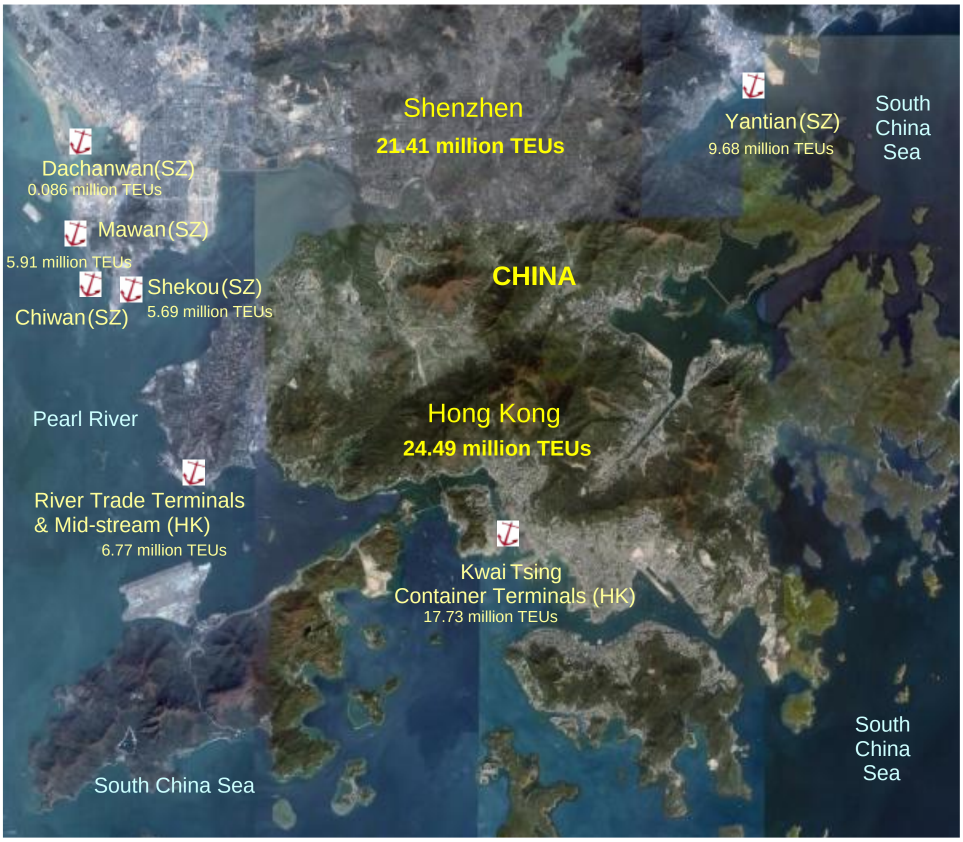


Figure 1: Geographical Location of Major Container Ports in the Pearl River Delta and their container throughput in 2008

Source: Compiled from Informa UK Ltd (2008) and SZ (2009).

# 5. ANALYSIS ON HONG KONG AND SHENZHEN

## 5.1 Developments of total ASC

Based on the computation and analysis method introduced above, we find that in 2006, the container ports of Hong Kong and Shenzhen were connected to 13 trade routes which saw 113.6 million TEUs of ASC deployed by 90 shipping lines in 314 shipping services. With reference to figure 2, this was almost triple the amount of capacity that called in 1995. As a whole, the annual average rate of growth experienced for ASC that called at the two ports was 17.1% in the period of our analysis.

Empirical evidence shows that while Hong Kong was able to attract 100% of the capacity at the beginning, its share began to decline from 1999 as more shipping lines chose to call direct at Shenzhen. As explained in section 3 previously, total ASC connected to the two ports can exceed 100%. Referring to figure 2, in 1995, Hong Kong attracted 100% of ASC while 5.3% also called at Shenzhen. It means that all the shipping services connected to the ports under study (Hong Kong and Shenzhen) called at Hong Kong, while 5.3% called at

Shenzhen. In other words, the bulk of ASC was exclusive to Hong Kong. Parallel calls to both ports increased over the years. Since 1999, Shenzhen started to receive exclusive calls and their share continued to increase.

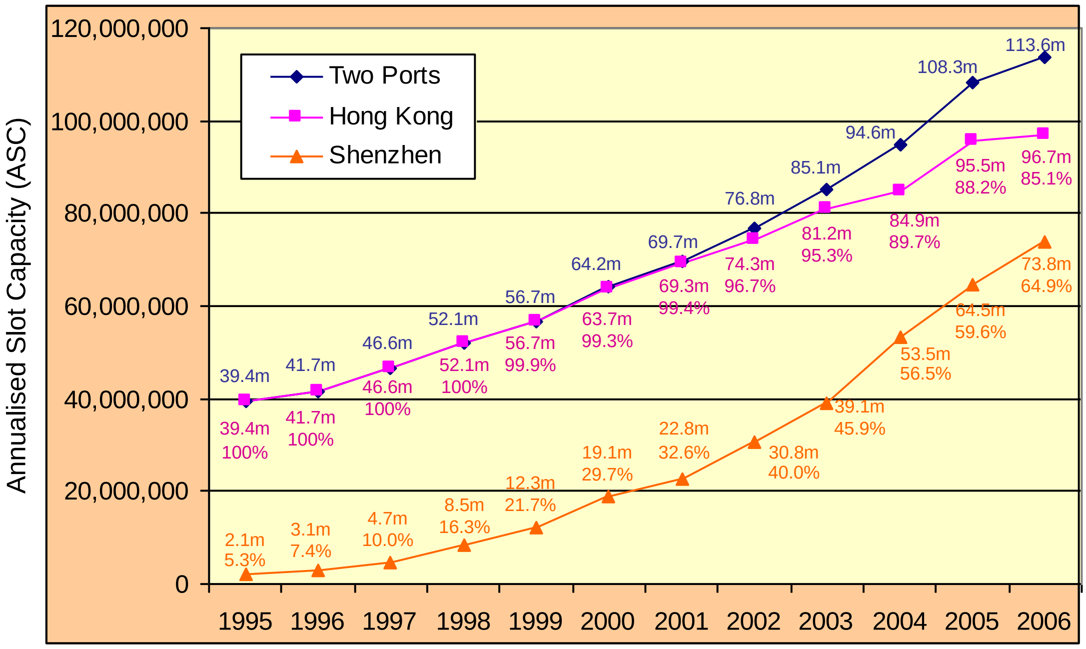


Figure 2: Development of Total ASC Which Called at Hong Kong and Shenzhen (in TEUs)

Source: Authors' computation.

This phenomenon was attributed to two major developments. First, the lack of investment in major container-handling facilities between the completion of Container Terminal 8 in 1994 and Container Terminal 9 in 2003 led to container terminals in Hong Kong becoming congested and expensive. For example, terminal handling charges levied on a container by the Intra-Asian Discussion Agreement for Hong Kong rose from HK$600 in July 1992 to HK$1,200 in January 1995 and reached HK$1,800 by June 1998 (Drewry Shipping Consultants Ltd, 2003). Capacity utilisation for container terminals at the port also reached 95.8% in 2001 (Ocean Shipping Consultants Ltd, 2003). Second, presence of internationally-renown terminal operators in Shenzhen contributed to improved confidence of port users and persuaded an increasing number of shipping lines to route an increasing number of their services to call. These developments resulted in the share of capacity received by Hong Kong falling to 85.1% by 2006. Nonetheless, the port continued to receive the bulk of capacity that called in the region with many of the services making parallel calls at Shenzhen in the same schedule. This development also contributed significantly towards boosting the share of capacity received by Shenzhen from 5.3% in 1995 to 64.9% in 2006. In other words, Shenzhen was able to close the gap rapidly with Hong Kong in terms of ASC received as reflected in figure 3.

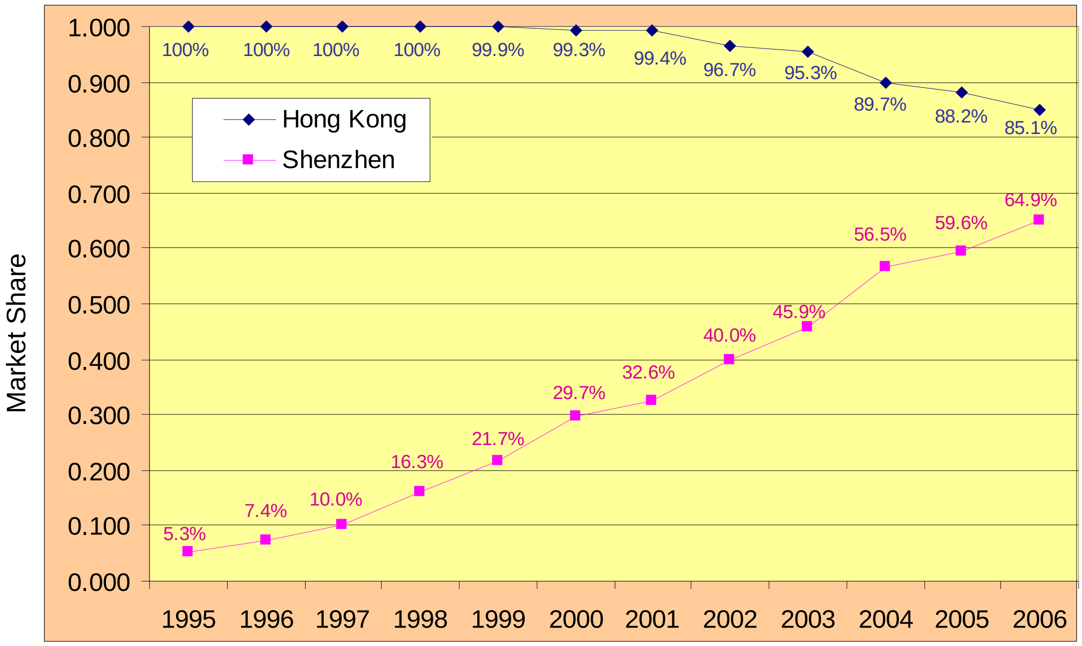


Figure 3: Development in Share of ASC Connected to the Selected Ports

Source: Authors' computation.

### 5.2 Trade route analysis

As shown in table 1, Hong Kong and Shenzhen are key nodes in the supply chains of east-west trades. As of 2006, two-thirds of their ASC were generated from east-west trades. The largest of these was the Transpacific trade which saw 38.3 million TEUs of ASC deployed with a share of 33.7%. This was followed by the Europe-Far East trade route with 27.8 million TEUs of capacity deployed. The third largest east-west trade route was the Mediterranean-Far East trade which saw 13.7 million TEUs of capacity deployed. This was slightly lower than the largest north-south trade, which was the Southeast Asia-Far East route with 14.2 million TEUs of ASC deployed.

Further insights can be gained by examining the individual trade routes. The Transpacific trade was the most important route served by the Hong Kong and Shenzhen. As shown in figure 4, while Hong Kong received 100% of the capacity that called at both container ports from 1995 to 2002, the share began to decline thereafter and reached a record low of 78.3% in 2006. In contrast, Shenzhen saw its share of capacity received for the trade grow from 8.5% in 1995 to 93.0% in 2006. In fact, the port received more container shipping capacity for the trade than Hong Kong by end 2006.

Table 1: ASC Deployed on Major Trade Routes Connected to Hong Kong and Shenzhen in 2006

| **Trade Routes** | **Rank** | **ASC (TEUs)** | **% Share** |
|---|---|---|---|
| **East-West** | | | |
| Transpacific | 1 | 38,312,000 | 33.7 |
| Europe-Far East | 2 | 27,759,000 | 24.4 |
| Mediterranean-Far East | 4 | 13,671,000 | 12.0 |
| Others | - | 3,248,000 | 4.3 |
| **East-West Total** | | **76,040,000** | **66.9** |
| **North-South** | | | |
| Southeast Asia-Far East | 3 | 14,194,000 | 12.5 |
| Far East-Middle East | 5 | 9,258,000 | 8.1 |
| Far East-South America | 7 | 3,702,000 | 3.3 |
| Far East-Australasia | 9 | 2,963,000 | 2.6 |
| Far East-Indian Subcontinent | 10 | 2,188,000 | 1.9 |
| Others | - | 1,691,000 | 1.5 |
| **North-South Total** | | **33,995,000** | **29.9** |
| **Intra-Regional** | | | |
| Intra-Far East | 6 | 5,837,000 | 5.1 |
| **Intra-Regional Total** | | **5,837,000** | **5.1** |
| **Grand Total** | | **113,637,000** | **100.0** |

Source: Authors' computation.

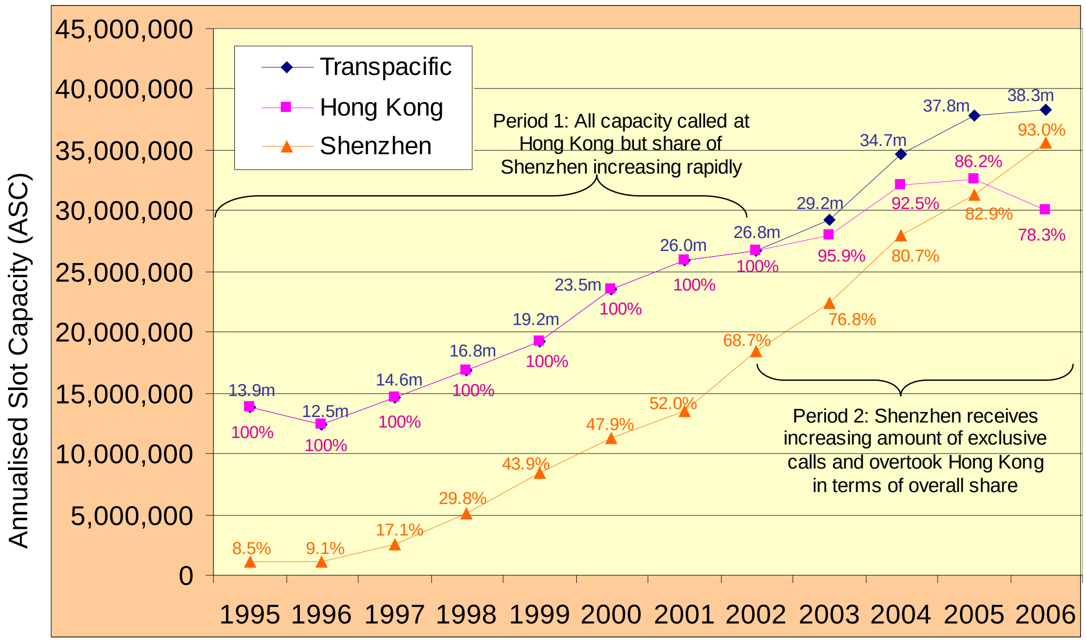


Figure 4: Development of ASC Deployed on the Transpacific Trade Route Connected to Hong Kong and Shenzhen

Source: Authors' computation.

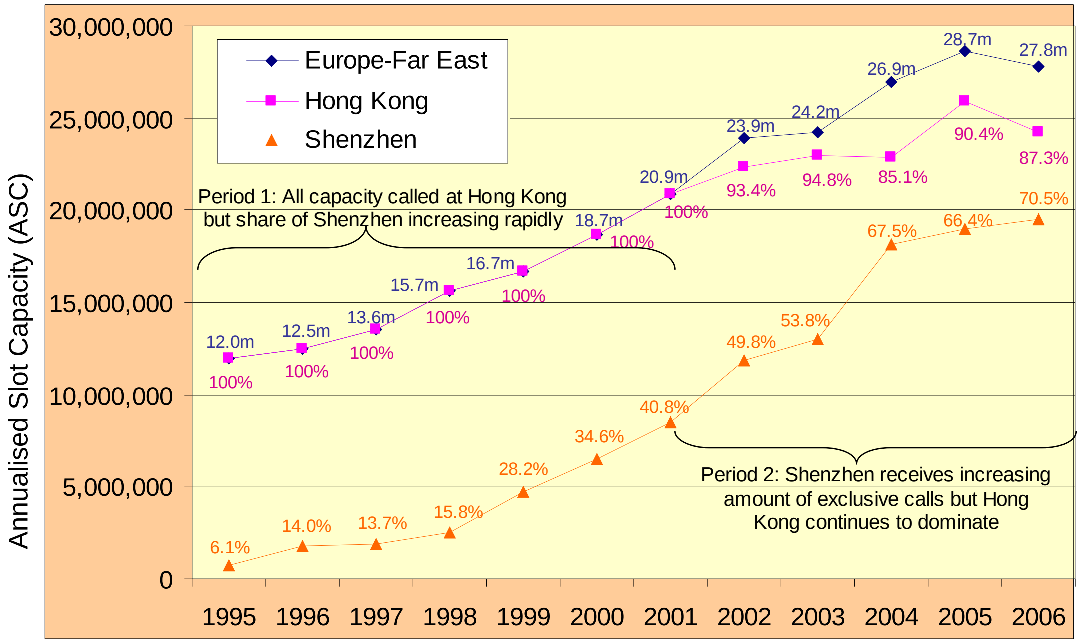


Figure 5: Development of ASC Deployed on the Europe-Far East Trade Route Connected to Hong Kong and Shenzhen

Source: Authors' computation.

With regards to the second largest trade route, the Europe-Far East trade, we can see from figure 5 that Shenzhen received increasing volume of exclusive calls. Shenzhen's share of ASC has particularly grown rapidly from 2003 to 2004, in contrast with Hong Kong's decline for the same period. Nevertheless, Hong Kong still attracted higher ASC and continued to have more exclusive calls as compared to Shenzhen.

With reference to figure 6, Hong Kong continued to maintain a dominant position over Shenzhen in the Southeast Asia-Far East trade receiving 100% of the capacity that called while Shenzhen was able to attract only 11.9% of the capacity. While parallel calls to both ports increased, Hong Kong continued to receive the majority of exclusive calls. Services deployed on this trade route were operated by shipping lines intending to capitalise on direct traffic carried between the two regions and transhipment opportunities generated by the central location of Hong Kong with respect to Japan and Taiwan in East Asia, and Vietnam, Indonesia and the Philippines in Southeast Asia. Unlike the main trades which saw several major carriers and shipping alliances involved, the profile of operators on this trade was dominated by intra-Asian operators that are mostly based in Taiwan or Korea.

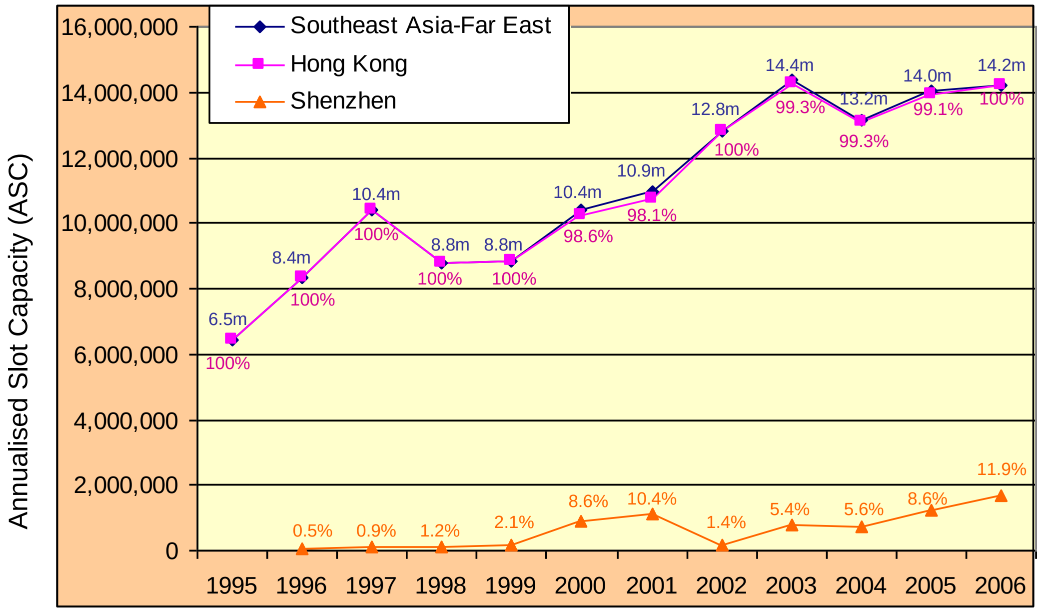


Figure 6: Development of ASC Deployed on the Southeast Asia-Far East Trade Route Connected to Hong Kong and Shenzhen

Source: Authors' computation.

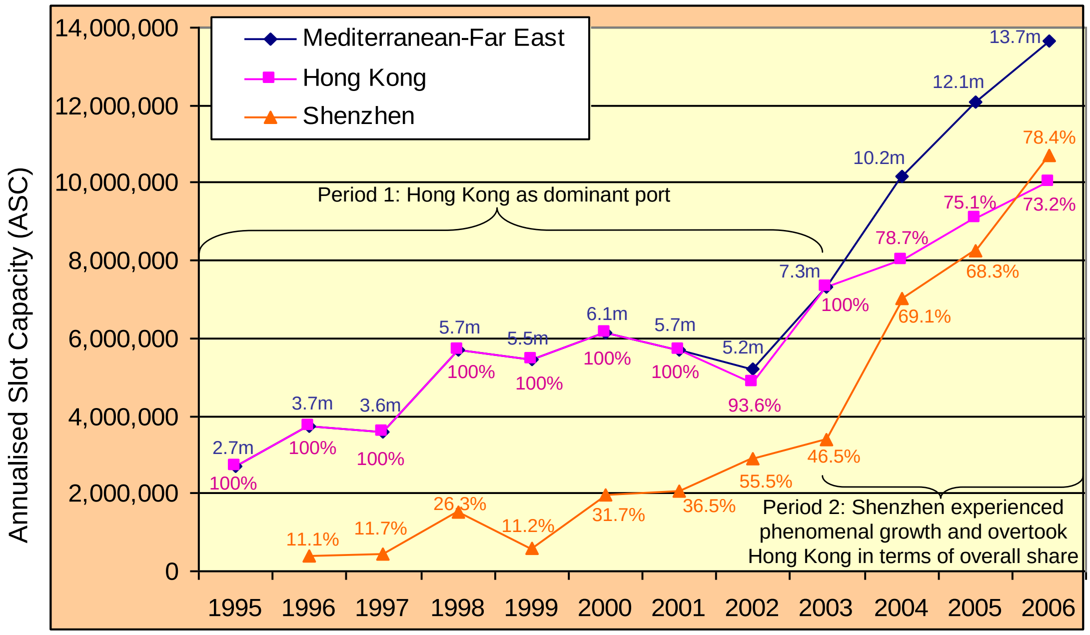


Figure 7: Development of ASC Deployed on the Mediterranean-Far East Trade Route Connected to Hong Kong and Shenzhen

Source: Authors' computation.

The Mediterranean-Far East trade is ranked the fourth largest trade route after the above three trades discussed. Unlike the Europe-Far East trade which saw Hong Kong receiving

100% of the vessel capacity that called until 2001, the Mediterranean-Far East trade saw the comparative situation lasting longer until 2003, after which, the gap between ASC received by Hong Kong and those that called at Shenzhen rapidly narrowed to the extent that Shenzhen (with share of 78.4%) was able to overtake Hong Kong (73.2%) as the largest container port connected to the trade in the Pearl River Delta by 2006 (refer to figure 7).

As a whole, shipping services that called at both container ports, i.e. parallel calls from the largest segment of ASC connected to the region by 2006. In addition, we find that the share of capacity received by Shenzhen for the Transpacific and Mediterranean-Far East trade routes exceeded those that called at Hong Kong. Specifically, the container port of Shenzhen received more capacity than Hong Kong for two of the three major east-west trades. This is an important achievement for Shenzhen considering the fact that two-thirds of capacity that called at the region was generated from such trades with the largest (i.e. Transpacific trade) accounting for a share of 33.7%.

**5.3 Further analysis on inter-port relationships in supply chain systems**

The basis for Shenzhen's strong performance was laid down in the period between 1996 and 2001 which saw many container shipping lines beginning to include the port in their service schedule in addition to Hong Kong. This is a positive development for Shenzhen because its supply chain capability has increased. As an element in the supply chain, it is important for a port and its service providers to offer cost-efficient services and sustainable value to port users. Shippers in the supply chain can benefit from improved connectivity and a larger choice of shipping lines to choose from. Economies of scale and scope generated from higher traffic volumes could also lead to lower cost per TEU handled for both shippers and shipping lines. All together, Shenzhen was increasingly a favourable port of call serving more and more supply chains. However, Hong Kong would see the same development to be unfavourable because container traffic that could have been handled through its terminals was diverted to Shenzhen. As a result, most of the changes in capacity affected prior to 2001 were of a competitive nature, mainly with Shenzhen benefiting at the expense of Hong Kong.

The period after 2001 saw most of the services initiated or removed from the region affecting both Hong Kong and Shenzhen in a complementary manner, as we classify the ASC accordingly. Specifically, most of the container shipping services which began to call in the region chose to call at both container ports. Similarly, services that were withdrawn also affected both ports in the same manner although the degree of impact could vary because capacity supplied would be affected by the frequency of call (i.e. single versus double call). In the case of the Europe-Far East trade, changes in shipping capacity which could be attributed to inter-container port complementarity reached 87.4% in 2006. Comparative figures for the Transpacific and Far East-Middle East trade routes were 75.7% and 65.8% respectively. Hence, inter-container port dynamics between the two container ports appeared to have moved from being competitive to becoming more complementary in nature.

However, comparison of container shipping statistics for the two ports revealed Hong Kong to remain the focus in service schedules operated by major container shipping lines. With reference to table 2, most of the major container shipping entities tended to deploy more capacity and services to call at Hong Kong instead of Shenzhen. Exceptions were the Grand Alliance, MSC and CMA-CGM.

Table 2: Calling Pattern for Major Carriers at Hong Kong and Shenzhen*

| | HKG (TEUs) | Svcs | % of HKG | SEZ (TEUs) | Svcs | % of SEZ | Calling at | Total (TEUs) | Svcs |
|---|---|---|---|---|---|---|---|---|---|
| CHKY Alliance | 14,223,000 | 24 | 14.7 | 9,693,000 | 20 | 13.1 | YNT | 15,261,000 | 27 |
| Maersk | 11,591,000 | 20 | 12.0 | 10,284,000 | 15 | 13.9 | YNT | 13,750,000 | 23 |
| New World Alliance | 8,030,000 | 11 | 8.3 | 7,154,000 | 11 | 9.7 | YNT CHW | 9,671,000 | 12 |
| Grand Alliance | 7,250,000 | 8 | 7.5 | 7,446,000 | 9 | 10.1 | YNT SHK | 8,750,000 | 9 |
| MSC | 4,318,000 | 7 | 4.5 | 7,590,000 | 9 | 10.3 | CHW | 7,590,000 | 9 |
| Evergreen | 6,710,000 | 14 | 6.9 | 4,761,000 | 10 | 6.5 | YNT SHK | 6,710,000 | 14 |
| CMA-CGM | 2,917,000 | 7 | 3.0 | 5,255,000 | 9 | 7.1 | YNT CHW | 5,366,000 | 11 |
| CSCL | 3,019,000 | 8 | 3.1 | 3,538,000 | 4 | 4.8 | YNT CHW | 3,944,000 | 8 |
| Wan Hai | 3,577,000 | 16 | 3.7 | 953,000 | 4 | 1.3 | SHK | 3,577,000 | 16 |
| CMA-CGM and CSCL | 2,565,000 | 5 | 2.7 | 2,311,000 | 5 | 3.1 | YNT CHW | 2,565,000 | 5 |
| Evergreen and others | 2,514,000 | 10 | 2.6 | 755,000 | 2 | 1.0 | YNT SHK | 2,514,000 | 10 |
| **Total** | **96,720,000** | | | **73,775,000** | | | | **113,637,000** | |

Source: Authors' computation. * HKG denotes Hong Kong, SEZ denotes Shenzhen, YNT denotes Yantian, CHW denotes Chiwan, SHK denotes Shekou and Svcs denotes services.

Examination of overall container shipping statistics also showed that while Shenzhen received calls from 153 container shipping services that were operated by 41 shipping lines, the comparative figures for Hong Kong were 290 services and 90 lines. In fact, only 24 services called exclusively at Shenzhen with the rest making simultaneous calls at Hong Kong as well. By comparison, 158 shipping services called exclusively at Hong Kong and these were mostly services that operated within East Asia and between the Far East and Southeast Asia. This also suggests that unlike Shenzhen which derived its container throughput mainly from the vicinity of the east bank of the Pearl River Delta, container traffic handled at the port of Hong Kong came from supply chains covering a wider geographical region which extended beyond the delta to include other parts of China, Taiwan, Vietnam and the Philippines. The connection of Hong Kong to these regions is supported by a strong network of feeder services which are operated by a host of dedicated and common feeder operators, many of which are based in Taiwan (e.g. CNC Line, Evergreen, TS Lines, Wan Hai and Yangming), Korea (e.g. Dongnama, Heung-A, KMTC and Sinokor), or China (e.g. COSCO, CSCL, OOCL, Sinotrans, SYMS and Xiamen Harvest). Hence, unlike Hong Kong which has a well established feeder network, the port of Shenzhen received only 17.2% of ASC that were deployed in feeder services.

This development helps to explain, in part, of why the majority of shipping capacity operating on east-west trades chose to call at both ports. Specifically, these services would call at Shenzhen to handle direct cargo generated from the vicinity of the Pearl River Delta and the same services will also include Hong Kong in order to capitalise on direct cargo as well as the increasing proportion of transhipment cargo generated by hub-and-spoke and interlining operations carried out at the port. In fact, transhipment traffic at Hong Kong almost doubled from 5.9 million TEUs in 2001 to 11.0 million TEUs in 2007 to account for 45.7% of total container throughput handled at the port (Hong Kong Marine Department, 2008). Therefore, while Shenzhen has become a major gateway port mainly serving PRD's export activities in the supply chains, Hong Kong has enhanced its role as a transhipment hub serving larger number of supply chains with various origins and destinations in East Asia.

The other development which contributed significantly to the characteristic of calling jointly at both ports was the phenomenon of capacity constraint faced at Shenzhen. As with Hong Kong, the port of Shenzhen also faced a case of high capacity utilisation for its container terminals which reached 91.9% in 2007. The figure was estimated by using an assumed container-handling capacity of 850,000 TEUs for each of the 27 berths in Shenzhen in 2007 (Seaports Publications Group, 2008). This would put resulting capacity of the port at 23.0 million TEUs, which would be slightly higher than the container throughput of 21.1 million TEUs.

In summary, table 3 reveals many of the inter-container port dynamics recorded for changes in ASC deployed for Hong Kong and Shenzhen to be complementary in nature. The corresponding figures for changes in ASC deployed that were attributed to inter-container port complementarity reached 56.7% for the Transpacific trade and 65.0% for the Europe-Far East trade. However, examination of changes to shipping capacity deployed between the Far East and Southeast Asia found most of it to be competitive in nature affecting mainly those that called at Hong Kong. Shipping lines that plied on the trade tended to call at either of the ports with the majority choosing to call exclusively at Hong Kong. This could be explained by the lower scale of cargo volumes involved and stronger support from intra-Asian operators for Hong Kong. Examination of inter-container port dynamics for the Far East-Mediterranean and Far East-Middle East trades also found them more of competitive in nature with almost equal amount of changes in ASC affecting Hong Kong and Shenzhen. Hence, the analysis of inter-container port dynamics shows that the largest trade routes, which accounted for more than 50% of total ASC that called in the region, tended to exhibit greater inter-port complementarity whereas capacity deployed on the smaller trade routes tended to reveal greater inter-port competition.

Figure 8 conceptualises inter-port relationships in supply chain systems. Expanding international markets and improving landside transportation and logistics can result in hinterlands that increasingly overlap. As a result, inter-port relationships can occur at the range level as supply chain systems have the choice of utilizing the services of various ports located within the range (e.g. supply chain 1 and 2) or even between ranges (e.g. supply chains 3, 4, 5, 6 and 7). Van de Voorde and Winkelmans (2002) defined a port range as a geographically defined area comprising those ports that serve much the same customers. Portrayed at the range level, the number of ports involved in the inter-port dynamics increases from four to eight. Ports X1, X2, Y1 and Y2 now share the same or similar hinterland. Other than being competitors, complementarity can also exist between X1 and Y1 as they compete together with X3 and Y3 against X2 and Y2 to retain supply chain systems 1, 3 and 4 while at the same time, attract supply chain systems 2, 6 and 7 to utilize their services. In practice, Hong Kong and Shenzhen can be considered as X1 and Y1, while Guangzhou and Zhongshan on the west bank of the PRD are X2 and Y2. This approach analyses ports by ranges and by supply chain systems, which generates new insights for research and practice.

Table 3: Summary of Inter-Container Port Dynamics in the Pearl River Delta, 1995-2006 (in TEUs)

| | Transpacific | | |
|---|---|---|---|
| | Complementary | Competitive | Total |
| Hong Kong | 63.2% | 36.8% | 59,966,340 |
| Shenzhen | 51.4% | 48.6% | 73,705,300 |
| **Overall** | **56.7%** | **43.3%** | **133,671,640** |
| | Europe-Far East | | |
| | Complementary | Competitive | Total |
| Hong Kong | 70.0% | 30.0% | 36,263,300 |
| Shenzhen | 60.7% | 39.3% | 41,850,800 |
| **Overall** | **65.0%** | **35.0%** | **78,114,100** |
| | Southeast Asia-Far East | | |
| | Complementary | Competitive | Total |
| Hong Kong | 18.8% | 81.2% | 27,030,220 |
| Shenzhen | 60.1% | 39.9% | 8,453,800 |
| **Overall** | **28.6%** | **71.4%** | **35,484,020** |
| | Mediterranean-Far East | | |
| | Complementary | Competitive | Total |
| Hong Kong | 45.8% | 54.2% | 11,184,860 |
| Shenzhen | 42.5% | 57.5% | 12,047,100 |
| **Overall** | **44.1%** | **55.9%** | **23,231,960** |
| | Far East-Middle East | | |
| | Complementary | Competitive | Total |
| Hong Kong | 47.4% | 52.6% | 11,440,400 |
| Shenzhen | 50.1% | 49.9% | 10,830,000 |
| **Overall** | **48.7%** | **51.3%** | **22,270,400** |

Source: Authors' computation.

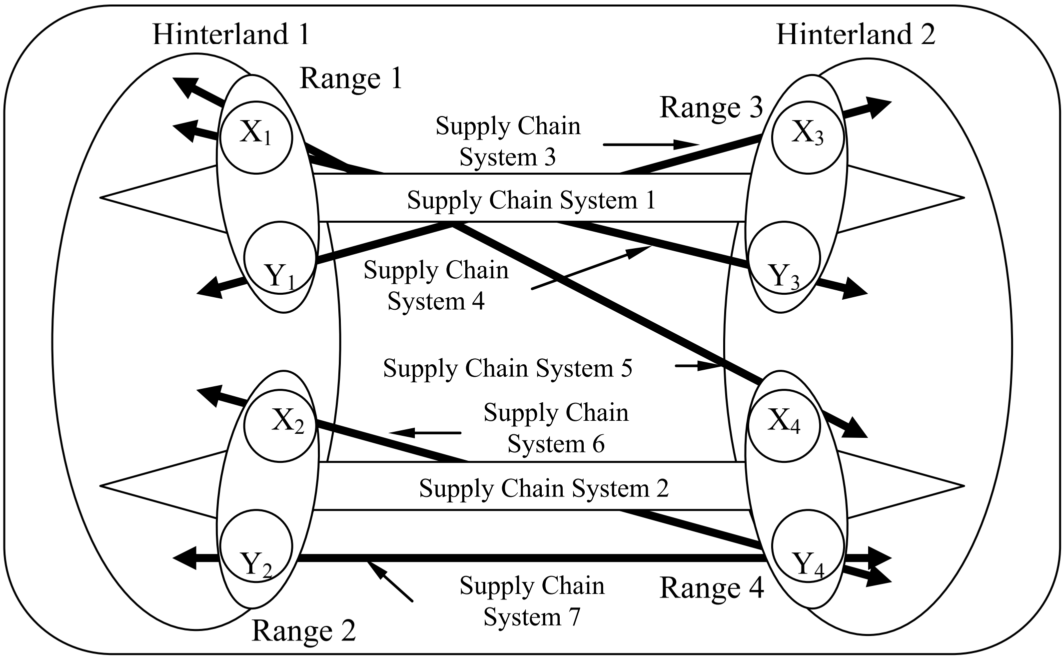


Figure 8: An illustration of inter-port relationships in supply chain systems

Source: Authors

As a whole, container terminal operators and shipping lines that are involved in commercial operations in the Pearl River Delta appeared to be more concerned with capitalising on traffic generated from the region as these entities are simultaneously present in both ports. Similarly for container shipping lines, calls from their services tended to be spread across facilities located in both container ports. For example, table 2 above shows that the largest amount of capacity was contributed by the CHKY Alliance which had 27 services calling at ports in the region. Of these, 18 services called at both Hong Kong and Shenzhen. In all, there were a total of 20 services that called at Shenzhen and these called mainly at Yantian. For Maersk, the carrier had 23 services deployed to call at Hong Kong and Shenzhen and as with the CHKY Alliance, most of the services which called at Shenzhen called at Yantian. Details of the calling pattern for other major container shipping lines with ASC deployed at Hong Kong and Shenzhen are shown in the table.

Taken together, Shenzhen was able to make strong gains on the major east-west trade routes which resulted in the profile of ASC connected to the port being mostly mainline services. In contrast, Hong Kong was able to retain a sizeable feeder network which has supported its premier hub status in the region thus far. Specifically, the development of calling patterns at both container ports suggests that most container shipping lines called at both Shenzhen and Hong Kong in order to pick up direct cargo at the former, and direct cargo albeit with an increasing share of transhipment cargo, which are fed from the region, at the latter. However, Hong Kong runs the risk of losing a significant share of the feeder business should these services follow their mainline counterparts by increasing the number of calls or even relocating to Shenzhen. Thus, policy makers in Hong Kong should pay much attention to maintain and enhance its feeder network in order to retain the port's competitiveness.

## 6. POLICY, MANAGERIAL AND RESEARCH IMPLICATIONS

It was shown that analyses of inter-container port relationships would be incomplete if complementary aspects are not accounted for. The preceding analyses have shown that the decision by container shipping services to call at a port can be influenced by the joint competitive offering of a group of ports instead of one individual entity. The extent of such relationships was found to rival or even exceed the amount of shipping capacity involved in port competition in some cases. As the notion of complementarity advocated suggests that container ports are related to each other through the network of shipping services in a mutually supporting manner, policies and decisions implemented in one port would have resulting implications for other ports which are complemented by the network of services linked to the ports in question. For example, investments undertaken to improve Hong Kong's accessibility, such as upgrading of factor conditions, could boost the demand attractiveness of the port and have resounding impact on other ports which are complemented by the port (e.g. Shenzhen). Transmission of these effects throughout the network further suggests that economic contribution of the port would be underestimated if the assessment was restricted to the locality. Nonetheless, our research has also shown that the symbiotic nature of inter-port relationships are not constant as container shipping lines periodically restructure their networks to pre-empt and accommodate new demands from the market. Therefore, the extensity and intensity of inter-container port complementarity are bound to changes as well.

Consequently, shipping lines and container ports which focus on the competition aspect of the business would be missing out on opportunities that could be capitalised through exploitation of complementary relationships that exist between the ports. In other words, focusing on combating inter-container port competition may become myopic to the win-win relationships that can be forged from inter-container port complementarity where circumstances permit. The above analyses have shown that inter-container port complementarity accounted for a significant share of changes to shipping capacity affected in the Pearl River Delta. Hence, the research hopes to draw policy and decision makers' attention to implications offered from inter-container port complementarity in order to advance the competitive position of their respective ports.

The research has also shown that analyses of relationships between container ports should not be conducted at an aggregated level. With various supply chains served by each port involving different decision makers, regions, routes, cargoes and shipping lines connected to, it is unlikely for a port to be competing with another port on the whole spectrum of variables and sectors. Similarly, it is impossible for complementary relationships between two ports to extend to all their markets served. This was demonstrated explicitly for connectivity by shipping services to Hong Kong and Shenzhen which showed that two container ports could be competing on a particular trade while complementing each other on another route. Hence, the aim is to draw decision makers' and researchers' attention to the need to identify the extensity and intensity of such relationships in order to craft and implement decisions with greater precision.

We have also presented a new method, slot capacity analysis, to study ports as elements in supply chains. The method provides a specific means to quantify the ports' connectivity and inter-port relationships in supply chains. Empirical research in this research theme has been quite limited and mainly employed survey instruments. This paper is the major empirical work in the literature so far to use secondary data for analysis. These fresh research elements can deepen our understanding on inter-port dynamics and facilitate future research in the field.

It is of fundamental importance that policy makers should understand and be aware of the distinctive characteristics of the business, particularly so if the policies are intended for that sector. This premise applies especially to all regulatory bodies including port authorities, competition commissions, industry promotion organisations, government ministries and local municipalities among others. The reason for so being is attributed to the greater extent and wider influence of the economic, political and social effects of their policies and welfare consequences on society as a whole. Our research has revealed the complexities involved in the container shipping and port industry in supply chain systems. For example, a municipal government can coordinate the efforts with the aim to increase the collective competitive advantage of the ports in the range. Hence, greater appreciation of the industry could yield more effective policy responses and better knowledge of the outcomes while at the same time, minimise unintended consequences as a result of greater precision in the application of policy instruments on specific sectors, trade routes, shipping lines, cargoes, shippers and even port entities among other target groups.

# 7. CONCLUSIONS AND FUTURE RESEARCH

The paper has presented a thorough investigation into the calling patterns of container shipping services in order to understand the dynamics of competition and complementarity which exist among container ports. Empirical evidence was drawn from the ports of Hong Kong and Shenzhen. The research findings presented were based primarily on evidences provided by container shipping services that called at the selected ports and container throughput handled at these ports between 1995 and 2006. While the merits of this approach have been discussed, the research is bound by certain restrictions.

A limitation of the research is that it has adopted a broad definition of complementarity where two ports were noted to be complementary if container shipping services were initiated to call jointly at or removed from both ports. However, the strict definition of complementarity would define both ports to be complementary only if initiation of calls by ASC at one port requires ASC to call at the other port as well. Nonetheless, such information is unlikely to be available on public domain as they require insight into the planning faculties of shipping lines. Hence, the recourse of this research was to observe actual ASC deployed and changes to such capacity. Furthermore, it would be useful to account for the network structures of the selected ports and order of port call in order to yield greater clarity on the competitive and complementary relationships embedded within the supply chains. Also, examination of such relationships for Hong Kong and Shenzhen could also include the port of Guangzhou to which significant variations in ASC deployed at both ports could be related. In addition, examination of such relationships for Hong Kong could also account for other ports that are also competing with the port for transhipment traffic and these could include those that are located beyond the Pearl River Delta. Availability of such information will shed greater light on the issue of complementarity and competition between container ports. All these gaps present opportunities for research work that can be done in the future.

The analyses have covered a 12-year period from 1995 to 2006. Although the paper accounted for the situation prior to the formation of shipping alliances to the series of acquisitions that involved major container shipping lines which led to significant changes to shipping service schedules that became apparent only in 2006, future research could examine the impact of the recent economic downturn on relationships between container ports as shipping lines adjust their fleet deployment and service arrangements to counter the effects of the slowdown in container trade. Moreover, slot capacity analysis is a versatile research method that can be useful for analysing other port ranges and clusters in different settings. The paper hopes to stimulate more studies in ports and shipping, particularly related to supply chain dynamics, which are ultimately beneficial to trade and economic development.

## ACKNOWLEDGEMENTS

The comments and suggestions from the anonymous reviewers are acknowledged.

## REFERENCES

Baird, A.J. (2002). The economics of transhipment. In: Grammenos, C.T. (ed.) The Handbook of Maritime Economics and Business, pp. 832–859. LLP, London
Bichou, K. and Gray, R. (2004). A logistics and supply chain management approach to port performance measurement, Maritime Policy and Management, 31(1), 47-67
Carbone, V. and Martino, M. (2003). The changing role of ports in supply chain management: an empirical analysis, Maritime Policy and Management, 30(4), 305-320
Comtois, C. (1999). The integration of China's port system into global container shipping, GeoJournal, 48, 35-42.
Cullinane, K., Wang, T.F. and Cullinane, S. (2004). Container terminal development in mainland China and its impact on the competitiveness of the port of Hong Kong, Transport Reviews, 24(1), 33-56.
De Langen, P.W. (2002). Clustering and performance: the case of maritime clustering in The Netherlands. Maritime Policy and Management, 29, 209–221

De Souza, G.A., Beresford, A.K.C. and Pettit S.J. (2003). Liner shipping companies and terminal operators: internationalization or globalization? Maritime Economics and Logistics, 5(4), 393-412

De, P. and Ghosh, B. (2002). Productivity, efficiency and technological change in Indian ports, International Journal of Maritime Economics, 4(4), 348-368

Drewry Shipping Consultants Ltd (2003). Intra-Asia Container Trades: Dynamism Beyond Bounds, London, Drewry Shipping Consultants Ltd.

Flor, L. and Defilippi, E. (2003). Port infrastructure: an access model for the essential facility. Maritime Economics and Logistics, 5, 116–132

Fung, K.F. (2001). Competition between the ports of Hong Kong and Singapore: a structural vector error correction model to forecast the demand for container handling services, Maritime Policy and Management, 28(1), 3-22

Haralambides, H.E., Cariou, P. and Benacchio, M. (2002). Costs, benefits and pricing of dedicated container terminals. International Journal of Maritime Economics, 4(1), 21–34

Hong Kong Marine Department (2008). Port and Maritime Statistics, Online available at: http://www.mardep.gov.hk/en/publication/pdf/portstat_2_y_b3. pdf.

Informa UK Ltd (2008). On-line available at: http://www.ci-online.co.uk.

Lam, J.S.L. (2010). Patterns of maritime supply chains: slot capacity analysis, Journal of Transport Geography. (in press)

Lam, J.S.L. and Yap, W.Y. (2006). A measurement and comparison of cost competitiveness of container ports in Southeast Asia, Transportation, 33(6), 641-654

Lam, J.S.L. and Yap, W.Y. (2008). Competition for transhipment containers by major ports in Southeast Asia: slot capacity analysis, Maritime Policy and Management, 35(1), 89-101.

Lee, L.H., Chew, E.P. and Lee, L.S. (2006). Multicommodity network flow model for Asia's container ports, Maritime Policy and Management, 33(4), 387-402.

Luo, M. and Grigalunas, T. (2003). A spatial-economic multimodal transportation simulation model for US coastal container ports. Maritime Economics and Logistics, 5, 158–178

Magala, M. and Sammons, A. (2008). A new approach to port choice modelling, Maritime Economics and Logistics, 10(1/2), 9-34

Malchow, M. and Kanafani, A. (2001). A disaggregate analysis of factors influencing port selection, Maritime Policy and Management, 28(3), 265-277

Mourao, M.C., Pato, M.V. and Paixao, A.C. (2002). Ship assignment with hub and spoke constraints, Maritime Policy and Management, 29(2), 135-150

Notteboom, T. (2002). Consolidation and contestability in the European container handling industry, Maritime Policy and Management, 29(3), 257-269

Ocean Shipping Consultants Ltd (2003). World Containerport Outlook to 2015, Chertsey, England, Ocean Shipping Consultants Ltd

Paixao, A.C. and Marlow, P.B. (2003). Fourth generation ports – a question of agility? International Journal of Physical Distribution and Materials Management, 33(4), 355-376

Robinson, R. (1998). Asian hub/feeder nets: the dynamics of restructuring, Maritime Policy and Management, 25(1), 21-40

Robinson, R. (2002). Ports as elements in value-driven chain systems: the new paradigm, Maritime Policy and Management, 29(3), 241-255

Sachish, A. (1996). Productivity functions as a managerial tool in Israeli ports, Maritime Policy and Management, 23(4), 341-369

Sanchez, R. J., Hoffmann, J., Micco, A., Pizzolitto, G.V., Sgut, M. and Wilmsmeier, G. (2003). Port efficiency and international trade: port efficiency as a determinant of maritime transport costs, Maritime Economics and Logistics, 5(2), 199-218

Seaports Publications Group (2008). Advertising Information, 2008-2009 Shenzhen Port Directory, Online available at: http://www.seaportsinfo.com/shenzhenport/shenzhenportdir.pdf.

Shenzhen port net (2009). Online available at: http://www.szport.net/

Song, D.W. and Panayides, P.M. (2008). Global supply chain and port/terminal: integration and competitiveness, Maritime Policy and Management, 35(1), 73–87

Song, D.W. and Yeo, K.T. (2004). A competitive analysis of Chinese container ports using the Analytic Hierarchy Process, Maritime Economics and Logistics, 6(1), 34-52.

Tiwari, P., Itoh, H. and Doi, M. (2003). Shippers' port and carrier selection behaviour in China: a discrete choice analysis. Maritime Economics and Logistics, 5, 23–39

Van de Voorde, E. and Winkelmans, W. (2002). A general introduction to port competition and management. In: Port Competitiveness: An Economic and Legal Analysis of the Factors Determining the Competitiveness of Seaports, edited by M. Huybrechts, H. Meersman, E. van de Voorde, E. van Hooydonk, A. Verbeke and W. Winkelmans. (Antwerp: De Boeck Ltd), pp. 1-16.

Veldman, S. J. and Bückmann, E.H. (2003). A model on container port competition: an application for the West European container hub-ports, Maritime Economics and Logistics, 5(1), 3-22

Yang, Z. (1999). Analysis of container port policy by the reaction of an equilibrium shipping market, Maritime Policy and Management, 26(4), 369-381

Yap, W.Y. and Lam, J.S.L. (2004). An Interpretation of Inter-Container Port Relationships from the Demand Perspective, Maritime Policy and Management, 31(4), 337-355.

Yap, W.Y. and Lam, J.S.L. (2006). Competition dynamics between container ports in East Asia, Transportation Research Part A, 40, 35-51.

Yap, W.Y., Lam, J.S.L. and Notteboom, T. (2006). Developments in container port competition in East Asia, Transport Reviews, 26(2), 167-188

Zeng, Z.B. and Yang, Z. (2002). Dynamic programming of port position and scale in the hierarchised container ports network, Maritime Policy and Management, 29(2), 163-177.