Replacement or Dual Hub Port? A Study on the Port Relationship in the Yangtze River Delta and Pearl River Delta Regions

Gordon Kee, Yuhao Wu, Jianfa Shen and Ting Jin

Shanghai-Hong Kong Development Institute

滬港發展聯合研究所

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About the Authors

Gordon Kee is a research associate of Research Centre for Urban and Regional Development, the Hong Kong Institute of Asia-Pacific Studies (HKIAPS), The Chinese University of Hong Kong.

Yuhao Wu is a research assistant of the Shanghai-Hong Kong Development Institute, The Chinese University of Hong Kong.

Jianfa Shen is the Associate Director of the Shanghai-Hong Kong Development Institute. He is also the Director of Research Centre for Urban and Regional Development, HKIAPS, Professor and Chairman of the Department of Geography and Resource Management, The Chinese University of Hong Kong.

Ting Jin is a M. Phil. graduate of the Department of Geography and Resource Management, The Chinese University of Hong Kong.

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替代還是雙樞紐港？長三角及珠三角內部的港口關係研究

Abstract

Through quantitative analysis of four ports and their host cities, this study asserts that Shanghai and Ningbo ports in the Yangtze River Delta region, and Shenzhen and Hong Kong ports in the Pearl River Delta region are not in absolute competition and that the development of one port is not at the expense of another. It is more appropriate to consider the inter-port relationship as a dual hub port system that two ports are in relative competition and mutual beneficial at specific levels. Port development and city (and regional) development are intertwined although urban (and regional) economy is not the single contributing factor to modern port development in these four host cities. The result of analysis shows that neighbouring port and GDP are the most important factors influencing the container throughput and cargo throughput of a port, with either a positive or negative correlation. Therefore, besides the internal improvement of the port, necessary strategic cooperation with the neighbouring port and good economic, trading and physical connections with the city and hinterland can benefit the growth of container and cargo throughput. Co-existence of two major ports in a region in China is possible.

通過對中國沿海四個主要港口及其所在城市的量化分析，本研究指出位於長三角的上海港與寧波港，以及位於珠三角的深圳港和香港港口並非處於絕對競爭的局面。它們之間的發展並不需要犧牲對方的利益。它們的關係可以看為雙樞紐港系統，包含了特定層面的相對競爭和相互利益。就本文所研究的四個城市而言，雖然城市（及區域）經濟並不是現代港口發展的最重要因素，但港口發展與城市（及區域）發展的交織關係無庸置疑。分析結果指出鄰近港口和本地生產總值是影響港口貨櫃和貨物吞吐量的最重要因素，不論是正面影響還是負面影響。因此，除了優化港口內部條件，通過與鄰近港口的戰略性合作及與城市和腹地更好的經貿和交通連繫，將有助貨櫃和貨物吞吐量的增長。在中國，一個區域內兩個主要港口共存是可行的。

1. Introduction

The intensifying trading activities between China and the rest of the world in the global economic platform have led to the rapid growth of maritime freight transport in China in the past 30 years. Numerous modern ports along the Chinese coastline and rivers have emerged. They have different functions and courses of development. While some have hub-and-spoke relationship, some are in competition as they serve an expanding and overlapped hinterland. Ups and downs, replacement, and different degrees of cooperation and integration among ports are not uncommon.

Port system is one approach to study the inter-port relationship. Port system – its functions, roles, evolution and relationship with other ports – is also a major research theme in transport geography. Port concentration and deconcentration, port regionalization, and the application of technology are three major research topics. While the traditional path dependency approach has been applied to explain the port system's concentration and deconcentration processes, frequent global trading and the emergence of intermodal transport, supply chain and logistics in recent decades have complicated the evolution process and offered some new conceptual approaches of explanation (Hayuth, 1988; Kuby & Reid, 1992; McCalla, 1999). The maritime and information technology application has also become popular.

These conceptual approaches, however, may be inadequate to explain the cases in China with the development of port clusters. Although ports in the same range or region are closer substitutes due to the intensifying effect of containerization on port competition (OECD & ITF, 2009), the co-existences of Shanghai port and Ningbo-Zhoushan port in the Yangtze River Delta (YRD) region and Shenzhen port and Hong Kong port in the Pearl River Delta (PRD) region are the popular cases of study offering an alternative answer. These examples show that inter-range and inter-port relationships among Chinese ports can be more than competition and replacement. While some studies have identified a major feature of dual port system among these ports, studies have also found that institutional factors have a major impact on the port concentration-deconcentration and regionalization processes (Slack & Wang, 2002).

It is well known that the development and rise of ports in the south range (Hong Kong and Shenzhen ports) took place earlier than those in the central range (Shanghai and Ningbo-Zhoushan ports) in the period of economic opening in China. An inter-range port study has asserted that the rise of central range ports is at the expense of the south range ports (Comtois & Dong, 2007). At the inter-port level, Li and Oh (2010) identified the comparative advantages of Shanghai port and Ningbo-Zhoushan port such as water depth, charges and range of service that made these two ports successful. Features of competition among ports in PRD and major causes of the structural change of the PRD port system, as well as the institutional factors such as interaction among governments have also been studied in detail (Wang, 2006; Wang & Slack, 2000).

Despite of the rich results of previous studies, there are still research gaps and research questions to be addressed, which will be discussed in the next section. After this introduction, previous studies on the port competition and the evolution of port system will be reviewed in section two. Research gaps and research questions will be presented in the same section. This is followed by the introduction of research methodology and limitation in section three. Section four will introduce the economic and port development of the four host cities in question. Section five to seven will present the findings of statistical analysis, interpretation of results and discussion. A brief conclusion will complete the paper.

2. A theoretical discussion on the evolution of port system

Port system is ever evolving, reflecting the changes of a port's status, function and positioning. There are many factors causing such changes, including its physical conditions, the relationship with hinterland, the complicating development of technology, global trade and the industry per se, as well as the relationship with neighbouring ports. Down to the level of cargo and container throughput, the influencing factors include the transportation distance between a seaport and its hinterland, operation costs, reputation, and reliability of the seaport (Yap, Lam, & Notteboom, 2006), as well as supply from shippers and demand from consumers (Li & Oh, 2010).

A number of theoretical models depicted the concentration-deconcentration process resulting from containerization. By summarizing the experiences of major British and United States ports, port development has been divided into different stages. In Bird's "Anyport" model (Bird, 1963, 1971), there are three major steps of setting up, expansion and specialization of a port. After the stage of rising, the final stage would see the obsolete of the original port and concentration of port activities in new sites. Likewise, Hayuth (1988) proposed a five-stage model of port system. He recognized that technological improvements and economies of scale contributed to the establishment of load centres, forming a port hierarchy system. Ports competed with each other at the same level. Diseconomies of scale and lack of expansion space of a port would give rise to the emergence of secondary ports nearby, and could result in port deconcentration. In general, it is a result of path dependency. While large agglomerations, efficiency and economies of scale are believed to be the factors fostering port concentration, constraints such as congestion, lack of space for expansion, restriction of water depth, diseconomies of scale and distance from shipping lanes could trigger the deconcentration process of a port system (Kuby & Reid, 1992; McCalla, 1999).

The formation and transformation of port-hinterland relationship is another research focus with much concern. A basic understanding is that port is a gateway connecting the developing hinterland and the developed market overseas (Hilling, 1977; Taaffe, Morrill, & Gould, 1963). The rise of transshipment and offshore hubs and the role of freight distribution centres in shaping load centre development are changing the port-hinterland relationship. Notteboom and Rodrigue (2005) introduced the concept of the port regionalization and acknowledged the formation of a regional load centre network, where gateway ports integrated with its inland freight distribution centres and terminals. They extended the concept of regionalization by introducing the foreland-based regionalization where intermediate hubs captured a maritime hinterland in their recent study (Rodrigue & Notteboom, 2010). Similarly, the study of port-city relationships has proved that there was once very close and intertwined relationship in the development of ports and cities. However, the relationship is changing in the modern world as a consequence of maritime technological change

and the growing trends towards multimodalism in international transport (Hoyle, 1996, p.2).

The full application of information technology (IT) and the rapid development of supply chains and logistics networks have also changed the game of port competition. The implementation of standards based technologies such as barcodes and radio frequency identification (RFID) could facilitate information flow amongst organizations in the supply chain and improve business performance (GS1 Australia, 2013), including port. This brings advantages to port in competition as the competition nowadays is based more upon the coordination of ports with other international multimodal transport modes and other elements in the supply chain (Jacobs & Hall, 2007; Robinson, 2002; Rodrigue & Notteboom, 2009).

In short, generally speaking, ports in the same range have been considered as closer substitutes due to the intensifying effect of containerization on port competition (OECD & ITF, 2009). However, the complicating circumstances, both the advancement of the industry per se and the external environment, make inter-port relationship more than simple competition. In fact, rapid rise of ports in Asia in recent decades allows the exploration of additional mechanisms and factors causing port system evolution. For example, Song (2002) showed that Hong Kong used to be the world's busiest container port in the 1990s, but it faced fierce competition from Singapore and Shenzhen. That was because Singapore strived to be a major port in Southeast Asia. The Chinese government had loosed its restrictions on foreign shipping lines' access to China ports that makes Shenzhen ports more favourable for foreign shipping companies. This is a matter of aggressive local and national strategy that can be considered a part of state developmentalism. From the general perspective, the fierce competition was reinforced by serving the overlapping hinterland and resulted in the replacement of Kaohsiung port by Hong Kong port, for example (Yap, Lam, & Notteboom, 2006). Similarly, the rapid rise of Shenzhen port and Ningbo-Zhoushan port in the past decade once led to the following questions in the society: Are these two ports replacing Hong Kong port and Shanghai port respectively? Are Hong Kong port and Shanghai port entering the stage of deconcentration?

However, we can see clearly that all the four ports are the busiest container ports in the world with increasing volume of cargo and container throughput. Therefore, there is no wonder that their co-existence leads to the emergence of unique dual-port centres in the Asian context (Wang, 1998) and dual hub port systems (J. J. Wang & Olivier, 2007; C. Wang & Ducruet, 2012). In addition, institutional factors have shown a major impact on the port concentration-deconcentration and regionalization processes in Asian ports. Slack and Wang's study (2002) suggested that institutional factors were amongst the most important factors explaining the deconcentration of the ports in Hong Kong, Singapore and Shanghai. The intention of the Chinese government to transform Shenzhen into an international hub for maritime logistics is another example (Wang & Slack, 2000).

Despite of the rich theoretical and empirical studies on the Chinese ports, there are a few research gaps. First, we are yet to confirm the argument that neigbouring port is the factor that has attributed the most to a port's development, particularly from a quantitative perspective, i.e., identifying the crucial quantified variables that have the biggest influences on port development. In fact, most of the previous studies are descriptive statistical studies with a few exceptions (Comtois & Dong, 2007 and Li & Oh, 2010), probably due to the early stages of such studies on Chinese ports and the lack of sufficient sample size for modelling and analysis. This study tries to examine the feasibility of this quantitative approach in modeling inter-port relationship, by applying the statistical data of the four ports in question after a quarter of century of operation. Second, the emergence and rapid development of supply chain, intermodal transport and logistics in China, as well as the intricating port-city relationship make the conditions of port-competition and port system evolution more complicated. It is necessary to place the study of Shanghai port, Ningbo-Zhoushan port, Shenzhen port and Hong Kong port on a new interface. Third, it is also necessary to expand the understanding of competition among ports by introducing the concepts of absolute competition and relative competition (Shen, 2010), i.e., competition that can lead to negative or neutral results respectively. Both methods of statistical analysis and qualitative study are necessary to offer a comprehensive view on this matter. The authors raised three research questions in this study.

1. Are Shanghai and Ningbo ports, and Shenzhen and Hong Kong ports in competition or in cooperation? Furthermore, are these two pairs of ports in absolute competition, relative competition, complementary relationship, or even cooperation?

2. What is the relationship between ports and cities? Cities are flourishing in China, especially in the coastal areas (Shen & Kee, 2017). Besides the host cities of the four ports in question, cities in different physical and economic sizes nearby are developing rapidly. Urban economy is now the key economic engine in China. The economic size of cities is increasing, trading is expanding, logistics industry is growing, and transport and communication infrastructure are improving. These nearby cities are making better physical and intangible connections to these four cities as well. Such changes alter the port-hinterland relationship directly and significantly. It is necessary to examine the port-city relationship under the new circumstances in China and identify the influences of these city factors on port development.

3. What factors contribute the most to the growth of cargo and container throughput in these ports? The development of the neighbouring port, the port per se and the economic activities of the hosting city and hinterland can be the most crucial factors. By identifying the most important factors, it is possible for the stakeholders and the society to work on these factors and the port system to create further synergy of development.

3. Methodology and limitation

Cargo throughput and container throughput are the best and direct indicators and were used in this study to represent the performance of a port. This study used six exogenous variables to explain the changes of cargo and container throughput at the ports of Shanghai, Ningbo, Shenzhen and Hong Kong from year 1990 to 2014. 1990 was chosen when the Chinese ports began to take off. 2014 was the latest year when data were available at the time of the study. The six variables are nominal Gross Domestic Product (GDP), foreign direct investment (FDI), per capita disposable income, total import and export value, transportation investment, and gross industrial output (GIO). This study did not use real GDP figures as they were not available for mainland cities during the

observation period. A detailed description for each variable is included at the Appendix I.

These variables were chosen for the following three reasons. First, it is believed that they influence the cargo and container throughput, not the other way round. Second, only data for these variables are available for all the four cities. Finally, the application of both city level and regional level variables allows the authors to understand the relationship between the port and city economy, as well as the relationship between the port and regional economy as previous studies shown clearly that YRD is the hinterland of Shanghai and Ningbo ports and PRD (and Guangdong) is the hinterland of Shenzhen and Hong Kong ports. These data come from official annual statistical yearbooks of respective mainland cities, and the Census and Statistics Department in Hong Kong. Due to the availability of data and the development trajectories of the four ports, the observation period starts in 1990.

We believe that the dynamics of port cargo throughput is a one-way relationship (external factors affect throughput). Therefore, the authors built multivariate time series regression (MTSR) models, instead of vector auto-regressive models, for our targeted cities. Given the small sample size (n = 25), using panel analysis would give a better model fit statistically. However, panel analysis could not describe the contrast between adjacent ports. For example, given Shanghai and Ningbo are neighbour cities, how the change of container throughput in Shanghai affects the change of that in Ningbo? Therefore, to fulfill our research goals, the authors decided using MTSR instead.

By transforming all data with natural logarithm, the data were less skewed. All potential explanatory variables were included in the initial model for each city. STATA was applied to conduct a stepwise model selection from the initial model, with $p = 0.05$ as the selection criteria. STATA was used for our analysis because it has decent features to help diagnose the validity of the statistical model. The use of $p = 0.05$ is a common practice. The authors then selected the final model based on the significance of variables. After building the final model, the authors conducted several diagnosis tests to examine if the assumptions of MTSR are met, including normality, no serial correlation and homoscedasticity. Our models have the following drawbacks. First, a large sample size ($n \geq 30$) is required for a

statistically valid MTSR model. If the sample size is too small, the assumptions of MTSR may not be all valid. Due to the limitation of data availability, our sample size is small (n=25). As a result, there could be some uncertainties for the coefficients that we estimated. However, we believe that such problem will not affect the analytical outcome significantly. Second, when the authors select the most significant explanatory variables, stepwise procedure alone is insufficient. The authors have to select the variables manually as well so that only meaningful variables are selected.

The four ports studied in this paper are Shanghai, Ningbo, Shenzhen and Hong Kong (Map 1). Shenzhen and Hong Kong are two cities in the PRD region in South China. While Shenzhen is a prefecture-level city of Guangdong province and one of the five special economic zones in China, Hong Kong is one of the two special administrative regions in China, implementing the "one country two systems" from 1997. Shenzhen started its modern socio-economic development in the 1980s and is now one of the richest cities in China. The Shenzhen port commenced its operation in the early 1990s and its container throughput has skyrocketed. Hong Kong port started its operation in the 1950s, rose in the 1980s and reached its golden time in the 1990s. Although the container throughput was growing in the 2000s, the speed was already slowing down along with the slow-growing Hong Kong economy. The port is now experiencing some functional changes and port-hinterland relationship transformation. Shanghai and Ningbo are two cities in the YRD region in eastern China. Shanghai is the municipality under the direct administration of the central government and Ningbo is a prefecture-level city of Zhejiang province. YRD kicked off its modern economic development in the 1990s and the two ports have been experiencing unprecedented pace of growth since the 2000s, especially the Shanghai port. Among all, the institutional factor is of extreme importance as the central government strives to build an international shipping centre in Shanghai. The momentum of Ningbo port's development has been strengthened after Ningbo port merged with its neighbouring port – Zhoushan port in 2006. Although Ningbo port dominates in the container throughput, Zhoushan's cargo throughput is on par with Ningbo's. Therefore, the integration can help mitigate vicious competition and create synergy by building one brand name and coordinating the

division of labour. In this paper, however, we studied the Ningbo port only, excluding Zhoushan port, to make data comparable before and after 2006.

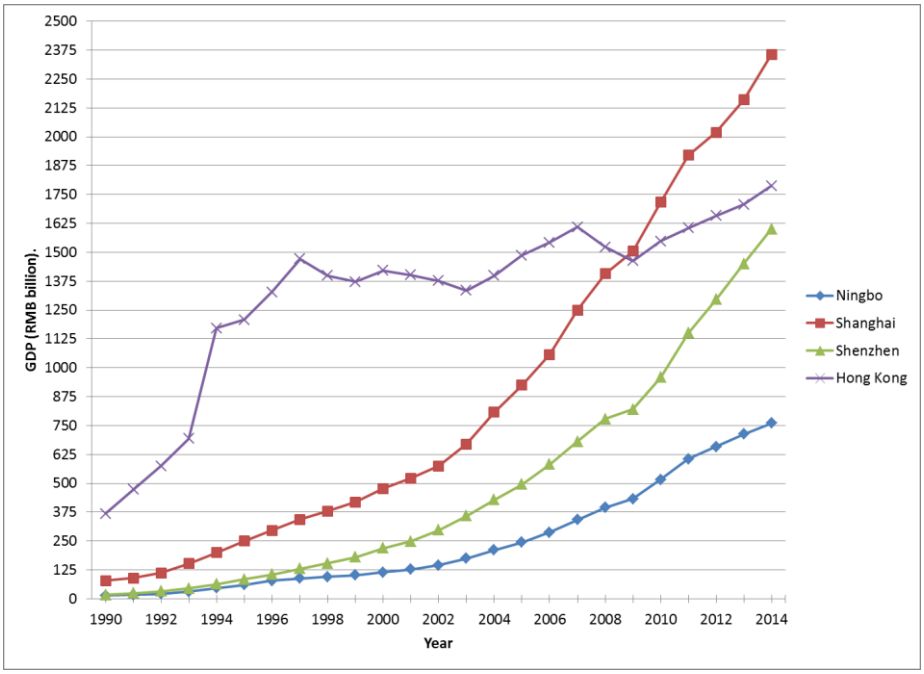
Map 1 Location of Shanghai, Ningbo, Shenzhen and Hong Kong ports

4. Economic and port development

Benefited from the economic opening since the late 1970s and the pursuit of the path of export-oriented economy of the country, all four cities have demonstrated robust economic growth during the observation period although the mechanism of growth in Hong Kong is different from other three mainland Chinese cities. While Hong Kong has transformed successfully from a manufacturing-based economy to a service-based economy in the past three decades, Shanghai, Ningbo and Shenzhen have been experiencing a leap forward in the stage of industrialization, including significant growth in the secondary sectors, manufacturing in particular, and service sectors.

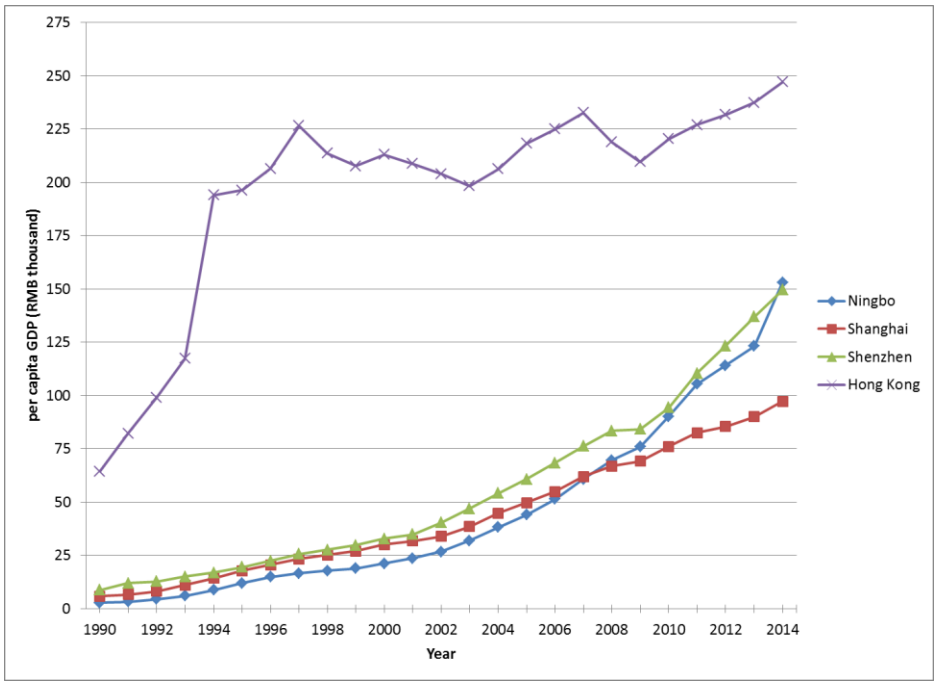
GDP has been widely applied in the past three decades to evaluate the economic development of cities in China. Figure 1 indicates the growth of the nominal GDP of Hong Kong, Shanghai, Shenzhen and Ningbo from 1990 to 2014. Undoubtedly, Hong Kong had been leading four cities in GDP until the end of 2008, when Shanghai surpassed Hong Kong in GDP in 2009. All three mainland Chinese cities have been experiencing rapid growth in GDP indeed, only at different rates. On the contrary, Hong Kong's GDP growth has slowed down. The economic scale of Shenzhen is approaching the one of Hong Kong and it is expected that Shenzhen will also surpass Hong Kong in GDP in a few years' time. Nevertheless, Hong Kong is still leading in per capita GDP, at close to RMB 250,000 in 2014 (Figure 2). All other three cities show steady growth of per capita GDP, especially Ningbo and Shenzhen which experienced even higher rate of growth after 2009. Both cities' per capita GDP were around RMB 150,000 in 2014.

Figure 1 Nominal GDP in Hong Kong, Shenzhen, Shanghai and Ningbo, 1990-2014



Sources: Census of Statistics Department (n.d.), Ningbo Municipal Statistics Bureau (2015), Shanghai Municipal Statistics Bureau (2015), and Shenzhen Municipal Statistics Bureau (2015)

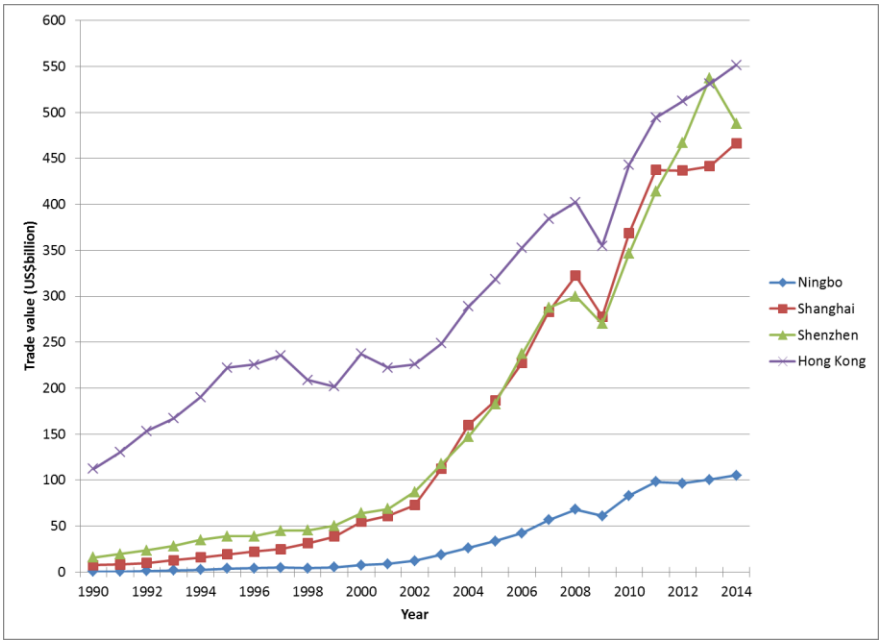
Figure 2 Per capita GDP in Hong Kong, Shenzhen, Shanghai and Ningbo, 1990 to 2014



Sources: Census of Statistics Department (n.d.), Ningbo Municipal Statistics Bureau (2015), Shanghai Municipal Statistics Bureau (2015), and Shenzhen Municipal Statistics Bureau (2015)

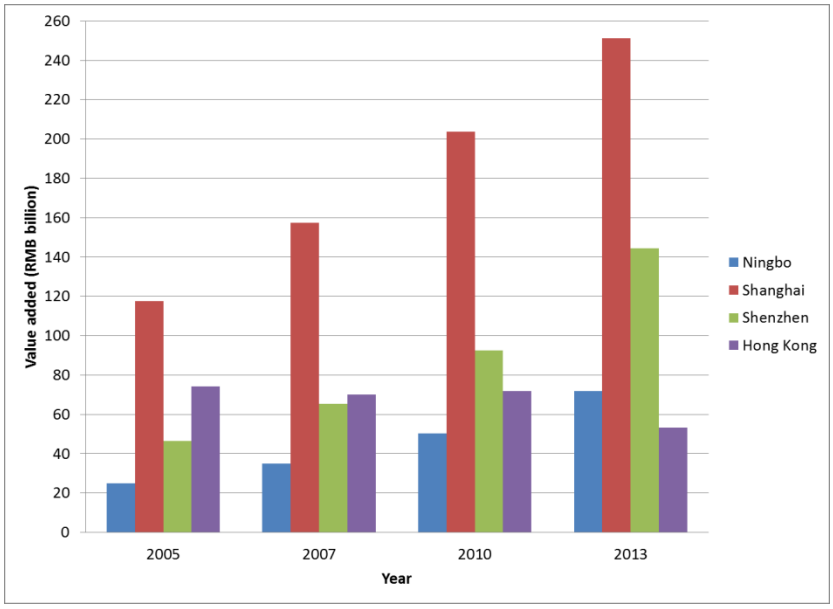
Total import and export value is an indicator that has close relationship with the port development (Figure 3). Although Hong Kong is still leading in the trading volume, the gaps with Shanghai and Shenzhen are narrowing down, as both cities have been expanding their trading activities at a high speed since the early 2000s. Another similar indicator is the value added of the logistics industry (Figure 4). Logistics industry works closely with ports and they have close relationship. For the three mainland cities in question, they have been experiencing rapid increase in the value added of the logistics industry since 2005. While the value added of Shanghai rose 113% from 2005 to 2013, the value added of Ningbo and Shenzhen expanded in folds during the same period; and the value added of both cities surpassed that of Hong Kong in 2013. The skyrocketing logistics industry contributes to the rapid rise of container and cargo throughput of ports in these three cities to certain extent. On the contrary, the performance of logistics industry in Hong Kong is stagnated, even dropped from the peak in the first decade of the twenty-first century, similar to the performance of Hong Kong port. Hong Kong is outstripped substantially by Shanghai and Shenzhen in the value added of the logistics industry.

Figure 3 Total import and export value in Hong Kong, Shenzhen, Shanghai and Ningbo, 1990-2014



Sources: Census of Statistics Department (n.d.), Ningbo Municipal Statistics Bureau (2015), Shanghai Municipal Statistics Bureau (2015), and Shenzhen Municipal Statistics Bureau (2015)

Figure 4 Value added by logistics industry of Hong Kong, Shenzhen, Shanghai and Ningbo, 2005-2013



Sources: Census and Statistics Department (n.d.), Chinanews.com (2011), Luk (n.d.), Ningbo Transportation Management Authority (2014), Ocn.com (2009), Shanghai Municipal Government (2012), Shenzhen Municipal Statistical Bureau (2014), and Tianjian Municipal Government (2015).

We can understand inter-port and port-city relationships as follows. The flourishing and large scale export-oriented manufacturing activities in the PRD and YRD regions not only increased the GDP of these four cities but also expanded the demands for the port services. Similar development path is also found in the emerging consumer markets and logistics industry in recent years. Due to the historical reason and the early development advantage, and as a key source of FDI and the *sanlaiyibu* manufacturing model, Hong Kong port benefited significantly by playing as once the only gateway hub port in China, re-exporting goods from the PRD hinterland to global markets and re-exporting raw materials to the PRD hinterland. This role earned Hong Kong the busiest container port in the world from 1992 to 1997, and from 1999 to 2004. The situation turned to negative since then due to fierce competition of other ports and the economic restructuring of the hinterland. First, Hong Kong port's global ranking was surpassed by Singapore and Shanghai in 2005 and 2007 respectively. This trend keeps going. Second, since

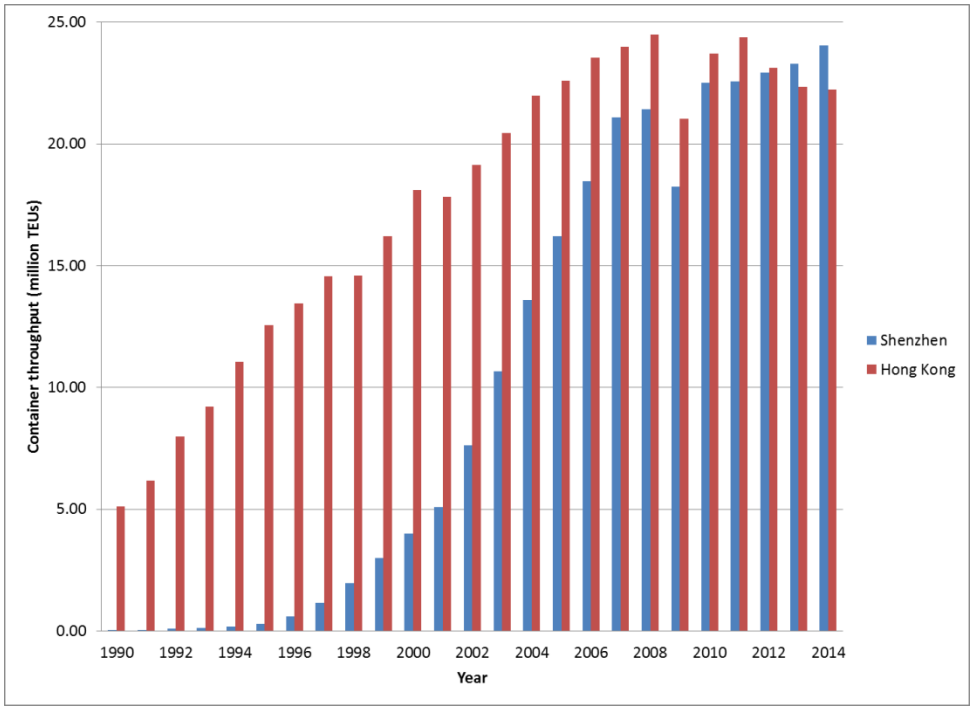
2012, the absolute volume of container throughput handled by Hong Kong has declined.[1]

The steady increase of the volume of goods export (that created the demands for port services), the aggressive development strategies of the local governments, and the active participation of private port operators (especially those from Hong Kong) facilitated the rapid development and modernization of Shanghai, Ningbo and Shenzhen ports. In addition, the higher level and larger scale of economic, industrial and port development in Shanghai, Ningbo and Shenzhen have generated attractiveness (as a pulling effect) to their hinterland for using these cities' port and maritime services that have further expanded the demand and supply of port businesses. Unlike Shanghai, Ningbo and Shenzhen that have flourishing manufacturing industries and large hinterland favouring the development of shipment-based port services, the service-based economy in Hong Kong could hardly provide enough domestic demands (goods) for port services. To compensate for the decreasing volume of shipment-based goods, Hong Kong's port operators strive to establish the foreland relationship with such as Southeast Asian ports and promote transshipment services in recent years (Shen & Kee, 2017).

Shenzhen port enjoys very rapid development generally. Since Yantian and Shekou ports in Shenzhen were built and operated in 1994, the rapid expansion in the first decade of the twenty-first century provided the port a solid foundation of development and helped the port to take over Hong Kong's No. 3 position in 2013. The aggressive development strategies, favourable geographical and spatial conditions, huge investment and modern operation and management by the private port operators from Hong Kong are the crucial factors. Figure 5 compares the total container throughput in Shenzhen and Hong Kong.

[1] The estimated figure in 2015 further dropped from 22.23 million TEUs in 2014 to 20.08 million TEUs. The year-on-year change is -9.7%, which is the largest drop since 2009 (HKPDC, 2015).

Figure 5 Container throughput in Hong Kong and Shenzhen, 1990-2014



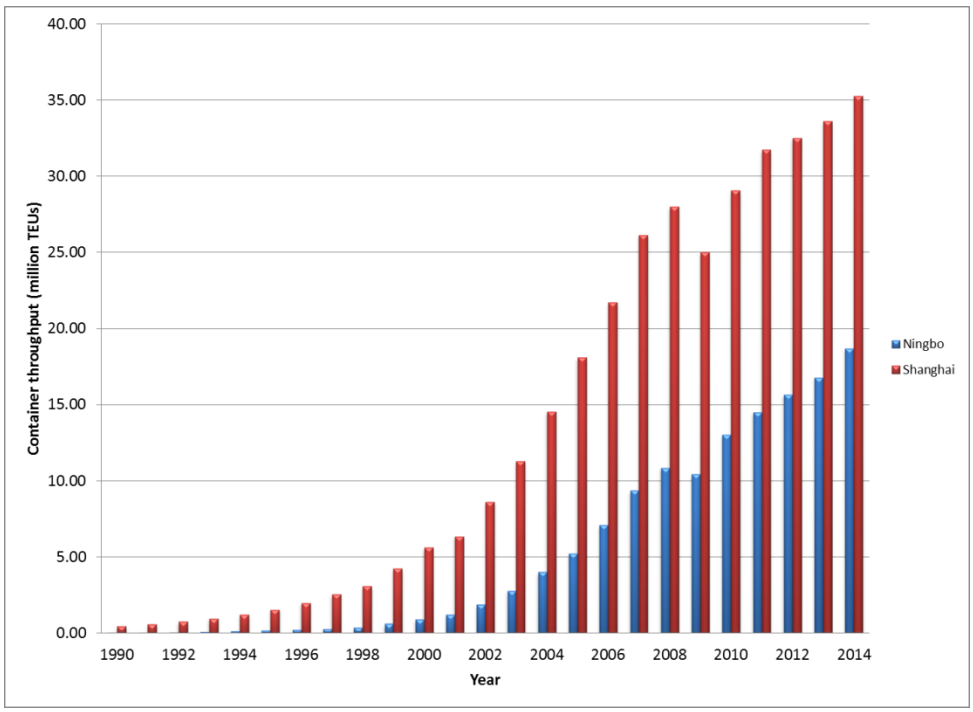
Sources: Census of Statistics Department (n.d.), Ningbo Municipal Statistics Bureau (2015), Shanghai Municipal Statistics Bureau (2015), and Shenzhen Municipal Statistics Bureau (2015)

Different from the development trajectory of Shenzhen port, both Shanghai port and Ningbo port have a long history of development and have experienced many ups and downs (Cao, 1995). Their relationship is always a major study case in China. Shanghai port started to catch up with the rising economy in the 1990s and has regained its global status. Excellent geographical location and huge hinterland – surrounding provinces and along the Yangtze River are Shanghai's existing advantages. Besides the improvement of the existing port zones that have only limited capacity, the most critical move was to build the Yangshan deep-water port on the outlying Yangshan islands that has operated since December 2005. This deep-water port multiplied Shanghai port's capacity instantly and the upgraded Shanghai port undergoes an exponential growth in container throughput (Figure 6). Yangshan port is also the first bonded port area in China (An, 2006). Shanghai has been the leading port in terms of total container throughput in the world since 2010.

Although Ningbo port's geographical location is not as excellent as the Shanghai port, Ningbo has caught up rapidly since 2000. The integration with

Zhoushan port in 2006 helped boost up the cargo throughput in a sizable volume. Moreover, the completion of Hangzhou Bay Sea-crossing Bridge in 2008 reduced the traveling distance between port of Ningbo and coastal area in Hangzhou Bay. Hence, the bridge facilitated the transportation of cargo and container between the two areas (Peng, 2011). From a non-top 10 container port in 2005, Ningbo-Zhoushan port rose quickly and suppressed Hong Kong to become the fourth busiest container port in the world in 2015, at an estimated volume of container throughput of 20.62 million TEUs.[2]

Figure 6 Container throughput in Shanghai and Ningbo, 1990-2014

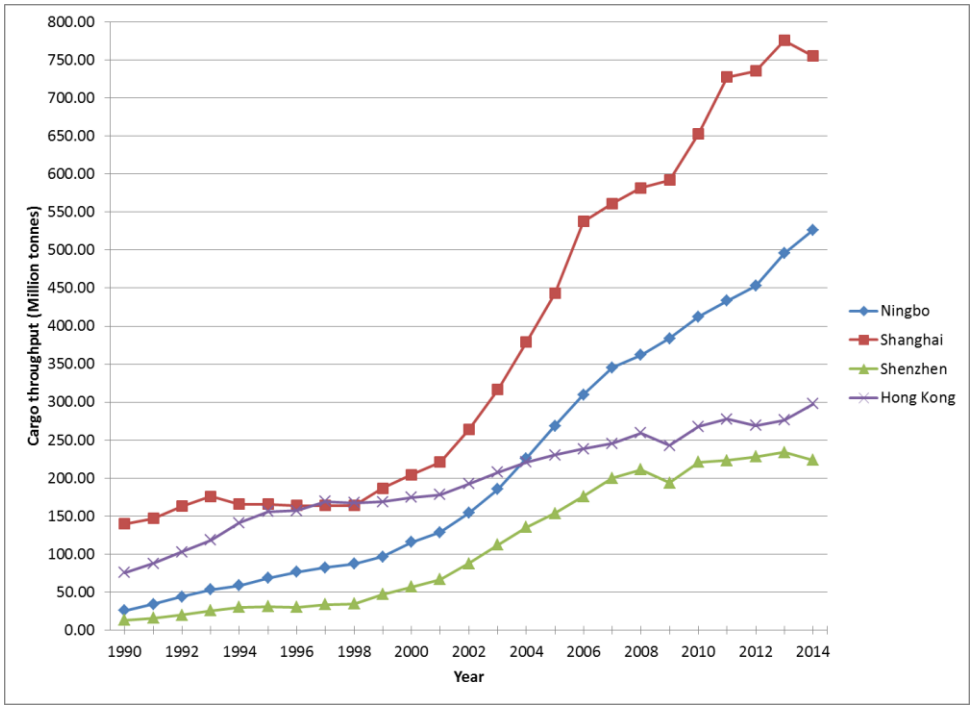


Sources: Census of Statistics Department (n.d.), Ningbo Municipal Statistics Bureau (2015), Shanghai Municipal Statistics Bureau (2015), and Shenzhen Municipal Statistics Bureau (2015)

[2] *See* the news "Ningbo-Zhoushan port box throughput up 6.1% in 2015", http://www.simic.net.cn/news_show.php?lan=en&id=176220

Figure 7 shows the total cargo throughput of all four cities from 1990 to 2014. It reveals another picture of inter-port relationship. Shanghai port has the most and the greatest rate of change in cargo throughput between 2002 and 2014. Ningbo port had slightly more than 0.5 billion tonnes of cargo throughput only in 2014, which was far below that of Shanghai, similar to the situation in container throughput. However, officially, Zhoushan port contributed another 0.3 billion tonnes and this made the figure of Ningbo-Zhoushan port at 0.89 billion tonnes. This result outpaced the performance of Shanghai (0.76 billion tonnes) and places two ports in stronger competition in terms of statistical figure. Similarly, there has been fierce competition between Shenzhen and Hong Kong, in terms of the total cargo throughput, as their throughput only differs by 50 million tonnes or less from 2006 onwards. Both ports are very close in cargo throughput and container throughput.

Figure 7 Total cargo throughput in Hong Kong, Shenzhen, Shanghai and Ningbo, 1990-2014



Sources: Census of Statistics Department (n.d.), Ningbo Municipal Statistics Bureau (2015), Shanghai Municipal Statistics Bureau (2015), and Shenzhen Municipal Statistics Bureau (2015)

Therefore, it is not hard to find the subtle changes of the roles and functions of these four ports. Hong Kong port has been changing from the only international hub in China to one of a few international hubs in China although it still has some advantages owing to its mode of operation and Hong Kong's well-established customs, legal, financial and other systems. It is still a third generation port with not only transport service but also incorporated advanced professional services and logistics functions that can help the smooth distribution of goods and data processing. However, this cannot stop Hong Kong being overtaken by Shanghai port which is evolving from a domestic hub to an international hub. Shanghai is already the top container port in the world and Shanghai aims to become a real international maritime centre with businesses more than cargo break-and-bulk or pick-and-pack. This goal is supported by the expanding financial, maritime and related professional services industries in Shanghai. Similarly, Ningbo and Shenzhen evolved from a feeder port of Shanghai and Hong Kong respectively to a major hub with increasing number of international shipping routes and expanding capacity. Their annual cargo and container throughput reveal clearly that they can be a strong challenger to Shanghai port and Hong Kong port respectively. Nevertheless, it is also possible to create a win-win situation and avoid vicious competition if two ports can carry out proper cooperation and division of labour. Institutional arrangement, if not administrative intervention, is not something strange in China indeed. The integration between Ningbo and Zhoushan ports, and among the three Guangxi ports are the examples.

5. Statistical analysis

Based on our hypothesis that urban and regional economy (represented by the indicators of GDP, per capita disposable income/GDP, GIO, import and export, FDI and transportation investment), as well as the performance of the neighbouring port have a strong relationship with container/cargo throughput of a port, regression analyses are conducted to assess their relationships. Appendix I shows all variables used in the analyses.

Shanghai port

Tables 1 to 4 are the analytical result of Shanghai port. Table 2 presents that the container throughput in Shanghai is mostly associated with the container throughput in Ningbo, GDP in Shanghai, GDP in YRD region, and the total import and export in YRD region. For 1% increase of container throughput in Ningbo, the ceteris paribus expected throughput in Shanghai increases 0.31%. The 1% increase of the total of import and export in YRD, the ceteris paribus expected throughput in Shanghai increases 0.12%. The coefficients of the GDP in Shanghai and the YRD are opposite in signs. The ceteris paribus throughput in Shanghai is predicted to increases by 2.85%, with 1% increase in Shanghai GDP. These positive impacts are expected. In contrast, when the GDP in YRD region increases 1%, the ceteris paribus throughput in Shanghai is expected to decrease by 0.82%. This means that the economic growth in YRD will not result in growth in container throughput in Shanghai if other things are equal. As the container throughput is increasing with Shanghai's GDP, the GDP increase in YRD region would not bring additional growth in Shanghai's container throughput.

On the other hand, the cargo throughput in Shanghai is mostly influenced by the cargo throughput in Ningbo, the total import and export in Shanghai, GDP in Shanghai and GDP in YRD region (Table 4). For 1% increase of the cargo throughput in Ningbo, the ceteris paribus cargo throughput in Shanghai is expected to increase by 0.47%. Interestingly, the ceteris paribus cargo throughput in Shanghai is forecasted to decrease by 3.57%, with 1% increase of GDP in Shanghai. As Shanghai's cargo throughput is increasing with the cargo throughput in Ningbo, the GDP increase in Shanghai would not bring additional growth in Shanghai's cargo throughput. This means that the GDP growth in Shanghai will result in growth in container throughput, but not cargo throughput in Shanghai.

Table 1 Model testing of container throughput in Shanghai

Source	SS	df	MS
Model	51.8222	4	12.9555
Residual	0.0252	20	0.0013
Total	51.8473	24	2.1603

F-statistic = 10295.74; Prob > F = 0; R^2 = 0.9995; Adj R^2 = 0.9994; Root MSE = 0.0355

Table 2 Model coefficients of container throughput in Shanghai (shcontainer)

Variable	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
nbcontainer	0.3057	0.0758	4.03	0.001	0.1475	0.4638
yrdtrade	0.1176	0.0294	4.00	0.001	0.0563	0.1788
shgdp	2.8498	0.3629	7.85	0.000	2.0927	3.6069
yrdgdp	-0.8186	0.1023	-8.00	0.000	-1.0320	-0.6051
cons	-1.2646	0.5987	-2.11	0.047	-2.5134	-0.0158

Table 3 Model testing of cargo throughput in Shanghai

Source	SS	df	MS
Model	9.7540	4	2.4385
Residual	0.0533	20	0.0027
Total	9.8073	24	0.4086

F-statistic = 915.53; Prob > F = 0; R^2 = 0.9946; Adj R^2 = 0.9935; Root MSE = 0.0516

Table 4 Model coefficients of cargo throughput in Shanghai (shcargo)

Variable	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
nbcargo	0.4720	0.1635	2.89	0.009	0.1309	0.8131
shgdp	-3.5662	0.2714	-13.14	0.000	-4.1324	-3.0001
shtrade	0.6753	0.0818	8.26	0.000	0.5048	0.8459
yrdgdp	0.8754	0.0827	10.59	0.000	0.7029	1.0479
cons	5.4475	0.2925	18.62	0.000	4.8374	6.0577

Ningbo port

Tables 5 to 8 are the analytical result of Ningbo port. The container throughput in Ningbo is mostly associated with container throughput in Shanghai, per capita disposable income in Ningbo, GDP in Ningbo and GDP in YRD (Table 6). Parallel growth between container throughput in Shanghai and Ningbo is found. The ceteris paribus container throughput in Ningbo is forecasted to increase by 1.38%, for 1% increase of container throughput in Shanghai. Meanwhile, the expected ceteris paribus container throughput in Ningbo is negatively correlated with the GDP in Ningbo (coef = -2.61). This means that the GDP growth in Ningbo will not result in container throughput in Ningbo. In contrast, when the GDP in YRD region increases 1%, the ceteris paribus container throughput in Ningbo is predicted to increase by 0.78%. As the container throughput is increasing with YRD's GDP, the GDP increase in Ningbo would not bring additional growth in Ningbo's container throughput.

Meanwhile, the cargo throughput in Ningbo is mostly influenced by the cargo throughput in Shanghai, FDI in Ningbo, GDP in YRD, and total import and export at YRD (Table 8). For 1% increase of cargo throughput in Shanghai, the ceteris paribus cargo throughput in Ningbo is forecasted to increase by 0.18%. When the FDI in Ningbo, GDP in YRD region and the import and export in YRD region increase 1%, the predicted ceteris paribus cargo throughput in Ningbo goes up by 0.09%, 0.06% and 0.11%, respectively.

Table 5 Model testing of container throughput in Ningbo

Source	SS	df	MS
Model	116.3615	4	29.0904
Residual	0.0801	20	0.0040
Total	116.4416	24	4.8517

F-statistic = 7262.57; Prob > F = 0; R^2 = 0.9993; Adj R^2 = 0.9992; Root MSE = 0.0633

Table 6 Model coefficients of container throughput in Ningbo (nbcontainer)

Variable	Coef.	Std. Err.	T	P>t	[95% Conf. Interval]	
shcontainer	1.3779	0.0593	23.25	0.000	1.2542	1.5015
nbincome	0.7789	0.2911	2.68	0.015	0.1718	1.3861
nbgdp	-2.6064	0.5476	-4.76	0.000	-3.7486	-1.4642
yrdgdp	0.7828	0.1281	6.11	0.000	0.5156	1.0501
cons	-7.0570	0.7185	-9.82	0.000	-8.5558	-5.5581

Table 7 Model testing of cargo throughput in Ningbo

Source	SS	df	MS
Model	20.6108	4	5.1527
Residual	0.0351	20	0.0018
Total	20.6459	24	0.8602

F-statistic = 4180.41; Prob > F = 0; R^2 = 0.9983; Adj R^2 = 0.9980; Root MSE = 0.0419

Table 8 Model coefficients of cargo throughput in Ningbo (nbcargo)

Variable	Coef.	Robust Std. Err.	t	P>t	[95% Conf. Interval]	
shcargo	0.1824	0.0505	3.61	0.002	0.0770	0.2878
nbfdi	0.0879	0.0282	3.12	0.005	0.0291	0.1466
yrdgdp	0.0584	0.0146	4.00	0.001	0.0280	0.0889
yrdtrade	0.1084	0.0168	6.46	0.000	0.0734	0.1434
cons	0.8672	0.3767	2.30	0.032	0.0814	1.6529

Shenzhen port

Tables 9 to 12 are the analytical result of Shenzhen port. The container throughput in Shenzhen is mostly associated with the container throughput in Hong Kong, GIO in Guangdong, per capita disposable income in Shenzhen, transportation investment in Shenzhen, and GDP in Shenzhen (Table 10). For 1% increase of container throughput in Hong Kong, the ceteris paribus container throughput in Shenzhen rises by 3.13%. For 1% increase GDP in Shenzhen, the ceteris paribus container throughput in Shenzhen increases by 4.33%. However, the container throughput is negatively correlated with the GIO in Guangdong province. For 1% increase of GIO in Guangdong, the ceteris paribus container throughput in Shenzhen drops by 3.88%. As the container throughput is increasing with Shenzhen's GDP, the GIO increase in Guangdong would not bring additional growth in Shenzhen's container throughput.

In the meantime, the cargo throughput in Shenzhen is mostly associated with the cargo throughput in Hong Kong, the total import and export in Shenzhen, GDP in Guangzhou and the GIO in Shenzhen (Table 12). For 1% decrease of cargo throughput in Hong Kong, the expected ceteris paribus cargo throughput in Shenzhen increases by 0.74%. It shows some substitution between two ports. The cargo throughput in Shenzhen is also negatively correlated with the GDP in Guangdong (coef = -0.82). However, when the GIO in Shenzhen increases 1%, the ceteris paribus cargo throughput in Shenzhen is predicted to go up by 1.17%. As the cargo throughput is increasing with Shenzhen's GIO, the GDP increase in Guangdong would not bring additional growth in Shenzhen's cargo throughput.

Table 9 Model testing of container throughput in Shenzhen

Source	SS	df	MS
Model	123.9464	5	24.7893
Residual	0.6267	19	0.0330
Total	124.5731	24	5.1905

F-statistic = 751.56; Prob > F = 0; R^2 = 0.995; Adj R^2 = 0.9936; Root MSE = 0.1816

Table 10 Model coefficients of container throughput in Shenzhen (szcontainer)

Variable	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
hkcontainer	3.1255	0.3099	10.08	0.000	2.4768	3.7742
gdgio	-3.8785	0.6545	-5.93	0.000	-5.2483	-2.5087
szincome	-0.9161	0.2696	-3.40	0.003	-1.4804	-0.3518
sztrans_invest	0.4079	0.1779	2.29	0.033	0.0356	0.7803
szgdp	4.3269	0.5136	8.42	0.000	3.2519	5.4018
cons	-17.4562	0.9549	-18.28	0.000	-19.4549	-15.4575

Table 11 Model testing of cargo throughput in Shenzhen

Source	SS	df	MS
Model	23.2673	4	5.8168
Residual	0.0709	20	0.0035
Total	23.3382	24	0.9724

F-statistic = 1774.44; Prob > F = 0; R^2 = 0.9961; Adj R^2 = 0.9955; Root MSE = 0.0661

Table 12 Model coefficients of cargo throughput in Shenzhen (szcargo)

Variable	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
hkcargo	-0.7372	0.2785	-2.65	0.015	-1.3182	-0.1561
sztrade	0.4156	0.0902	4.61	0.000	0.2274	0.6037
gdgdp	-0.8224	0.1297	-6.34	0.000	-1.0929	-0.5518
szgio	1.1687	0.1064	10.98	0.000	0.9467	1.3907
cons	10.5270	1.3608	7.74	0.000	7.6884	13.3655

Hong Kong port

Tables 13 to 16 are the analytical result of Hong Kong port. Since the data of per capita disposable income for Hong Kong is not available, per capita GDP was used as a proxy variable. Table 14 shows that the container throughput in Hong Kong is mostly associated with the container throughput in Shenzhen, GIO in Guangdong, and the GDP in Hong Kong and Guangdong. With 1% increase of GDP in Hong Kong, the ceteris paribus container throughput in Hong Kong increases by 0.33%. With 1% increase of GIO in Guangdong, the ceteris paribus container throughput in Hong Kong increases by 0.68%. On the contrary, with 1% increase of GDP in Guangdong, the ceteris paribus container throughput in Hong Kong decrease by 0.77%. The container throughput in Hong Kong is positively affected by GIO but not GDP in Guangdong.

On the other hand, the cargo throughput in Hong Kong is mostly associated with the cargo throughput in Shenzhen, the total import and export in Hong Kong, and the GDP in Hong Kong. From table 16, for 1% increase in Shenzhen cargo throughput, the total import and export in Hong Kong, and the GDP in Hong Kong, the ceteris paribus cargo throughput in Hong Kong goes up by 0.17%, 0.18% and 0.36%, respectively.

Table 13 Model testing of container throughput in Hong Kong

Source	SS	df	MS
Model	4.8076	4	1.2019
Residual	0.0357	20	0.0018
Total	4.8432	24	0.2018

F-statistic = 674.1; Prob > F = 0; R^2 = 0.9926; Adj R^2 = 0.9912; Root MSE = 0.0422

Table 14 Model coefficients of container throughput in Hong Kong (hkcontainer)

Variable	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
szcontainer	0.1449	0.0145	10.01	0.000	0.1147	0.1751
gdgio	0.6827	0.1853	3.69	0.001	0.2963	1.0691
hkgdp	0.3271	0.0441	7.42	0.000	0.2351	0.4191
gdgdp	-0.7676	0.2014	-3.81	0.001	-1.1878	-0.3475
cons	3.6964	0.9813	3.77	0.001	1.6495	5.7434

Table 15 Model testing of cargo throughput in Hong Kong

Source	SS	df	MS
Model	3.3156	3	1.1052
Residual	0.0136	21	0.0006
Total	3.3291	24	0.1387

F-statistic = 1710.39; Prob > F = 0; R^2 = 0.9959; Adj R^2 = 0.9953; Root MSE = 0.0254

Table 16 Model coefficients of cargo throughput in Hong Kong (hkcargo)

Variable	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
szcargo	0.1672	0.0158	10.61	0.000	0.1344	0.1999
hktrade	0.1825	0.0372	4.90	0.000	0.1051	0.2600
hkgdp	0.3559	0.0215	16.53	0.000	0.3111	0.4007
cons	0.9437	0.1512	6.24	0.000	0.6293	1.2581

6. Interpretation of results

First, there is a very clear result that Shanghai and Ningbo ports, and Shenzhen and Hong Kong ports are not in competition, absolute competition in particular. Absolute competition refers to the situation of win or loss (Shen, 2010, p.135), i.e., one port grows at the expense of another port. From both the statistical figures and the analytical result, no sign of absolute competition can be found. There are upward trends for both cargo throughput and container throughput of all four ports with two exceptions. The first exception is the drop in 2009 of all four ports due to the external factor of global financial crisis. The figures bounced back immediately in 2010. The second exception is the gentle decline of Hong Kong's container throughput since 2012, which will be discussed later. The analysis also shows that when the container (cargo) throughput at one city increases, so does the other city, with the only exception of the negative influence of Hong Kong's cargo throughput on Shenzhen's cargo throughput. The degree of influence varies. For example, the container throughput in Shanghai has a higher influence on the container throughput in Ningbo (coef = 1.38, with t-statistic = 23.25) than Ningbo on Shanghai (coef = 0.31, with t-statistic = 4.03). That is possibly due to the different size of economic activity, i.e., the economic activities of Shanghai are more robust than that of Ningbo. Hence, Shanghai has a greater spillover to Ningbo. In comparison, the container throughput in Hong Kong and Shenzhen has equivalent influence on one another (both with t-statistic roughly equal to 10).

From the statistical figures and the analytical result, it may be valid to argue that Shanghai and Ningbo ports, and Shenzhen and Hong Kong ports have a relative competition relationship, if not also a complementary relationship, as the overall port businesses in the PRD and YRD regions are still growing. The relative competition means that these ports are often compared in terms of throughput and ranking. The development of Ningbo port in the period of 1990-2014 did not harm Shanghai port and vice versa. They have their own comparative advantages and attractiveness.[3] It is the same in the Shenzhen and Hong Kong port relationship. On the contrary, their co-existence and development has created a dual port system (Wang, 1998). By the same token, although the container

[3] See the study of Li and Oh, 2010.

throughput of Shanghai and Ningbo ports (central range ports) has surpassed the one of Hong Kong and Shenzhen ports (south range ports), it is not 100% correct to argue that the development of central range ports is at the expense of south range ports (Comtois & Dong, 2007). They are in relative competition only. However, it is impossible to verify if there is any cooperation among ports from purely statistical figures and analysis. Nevertheless, according to other studies, news and reports, we may understand that they have some tactic relationships. Definitely, the merger of Ningbo and Zhoushan ports is an outstanding example of cooperation. Shanghai port and Ningbo port are in cooperation at corporate level.[4] The argument of complementary relationship is valid at port operator level indeed. For example, Hutchison Port Holdings Trust (HPHT) is a key operator in Hong Kong, Shenzhen Yantian, Shanghai and Ningbo. Modern Terminals Limited (MTL) is also a key operator in Hong Kong and Shenzhen Dachan Bay. Although these four ports operate independently, these port operators make use of them for their complementary benefit and strategic development of the port business, forming the dual hub port system in PRD and YRD respectively.

Concerning the latest declining trend of container throughput in Hong Kong, explanations can be given at three levels. Globally, the economic recession resulted in the loss of momentum of further growth in trading in Hong Kong although Asia – China in particular – is the only place with growth. Up till now, Europe and the United States – the two regions suffered hardly in the recession – are still the traditional markets of Hong Kong trading, logistics and port industries. Regionally, the growth rate of container throughput in the south range (both Hong Kong and Shenzhen) ports is declining and is smaller than the one of central range. Bold industrial re-structuring and massive factory removal have led to the drop of direct source of goods in the hinterland. Locally, the rapid improvement of transport networks in Shenzhen, the improvement of port facilities and services (such as the number of berths, more open space, the introduction of major shippers and shipping routes) are the pulling factors, while the higher handling charges in Hong Kong, the less advantage in water depth, the slow progress of new port and berth development, and so on are the pushing factors

[4] See “Shanghai gang he Ningbo gang jiang zhankai shizhixing hezuo” (Shanghai port and Ningbo port to launch substantive cooperation), http://sh.people.com.cn/GB/134952/150425/150539/9025438.html; “Shanghai gang shishi ‘Changjiang zhanlve jiedu” (Interpreting the Yangtze River Policy of the Shanghai port), http://info.hktdc.com/shippers/vol31_6/vol31_6_chi_logistic.htm.

that have made both consigners and international shippers to use Hong Kong port less frequently. This is also a reason why the foreland transshipment is developing rapidly in Hong Kong as an alternative. This is a phenomenon of port deconcentration and it is appropriate to argue that Shenzhen port is replacing Hong Kong port in terms of local factors. While in terms of the type of throughput, the analytical results show that Hong Kong has a positive influence on Shenzhen's container throughput but a negative one on Shenzhen's cargo throughput. This means that there is no direct competition in container throughput between Hong Kong and Shenzhen. However, cargo has become light and is not growing as fast as container throughput. The drop of cargo throughput in Shenzhen but rise in Hong Kong in 2014 (Figure 7) may be an early sign that the two ports will face direct competition in cargo throughput in the coming years.

Second, GDP is an important factor. GDP is the factor that contributes the most to the growth of cargo and container throughput in six out of the eight equations above. The two exceptions are that Shanghai's cargo throughput contributes the most to the growth of Ningbo's cargo throughput and Shenzhen's GIO contributes the most to the growth of Shenzhen's cargo throughput. There are two major features. The first feature is that the influence of GDP on cargo and container throughput in Shanghai, Ningbo and Shenzhen (coef. ranged from -3.57 to 4.33) is much greater than the one on Hong Kong (coef. = -0.77 and 0.36). This is probably due to the difference in economic structure and the stage of economic development between Hong Kong and these three mainland Chinese cities. As well known, Hong Kong is a service economy. Service sectors contribute over 90% of GDP. Manufacturing activities have become insignificant. In addition, the logistics sector only contributed 3.23% of Hong Kong's GDP in 2013.[5] The two major sources of Hong Kong's cargoes and containers are mainland China and foreland transshipment goods, which do not make much contribution to Hong Kong's GDP. Indeed, all factors in the equations of Hong Kong cargo throughput and container throughput have only small coefficients (ranged from -0.77 to 0.68), reflecting that Hong Kong port is already at a stage of development different from other three ports. While there are diversified influencing factors, the throughput volume may hit the peak capacity so that the elasticity of influence of those economic factors on throughput volume is low and dropping.

[5] http://www.censtatd.gov.hk/hkstat/sub/sp80.jsp?tableID=188&ID=0&productType=8

The second feature is that GDP has both positive and negative influences. For instance, the GDP in Shanghai is positively associated with its container throughput (coef = 2.85), but the GDP in YRD region has a negative association with the cargo throughput in Shanghai (coef = -0.82). Similarly, the GDP in Hong Kong is positively associated with its container throughput (coef = 0.33), but the GDP in Guangdong province has a negative association with the container throughput in Hong Kong (coef = -0.77). Likewise, while Shanghai's GDP has a big positive impact on Shanghai's container throughput (coef = 2.85), it also has a big negative impact on Shanghai's cargo throughput (coef = -3.57). Shenzhen's GDP makes an even bigger positive contribution to Shenzhen's container throughput (coef = 4.33), but it makes no significant contribution to Shenzhen's cargo throughput (not in the equation). Ningbo's GDP has a big negative impact on Ningbo's container throughput (coef = 2.61) but it has no significant impact on Ningbo's cargo throughput (not in the equation). In general, local GDP has a stronger influence on the throughput than the regional GDP, implying that port operation has a closer relationship with the urban economic development.

However, we cannot offer a reasonable explanation on the opposite influence of GDP on container throughput and cargo throughput in Shanghai, which may be due to the model limitation, as well as other non-quantifiable factors. It is the same case for the opposite results of the negative influence of Hong Kong cargo throughput on Shenzhen cargo throughput (Table 12) and the positive influence of Shenzhen cargo throughput on Hong Kong cargo throughput (Table 16).

7. Discussion

As mentioned in the methodology section, our research suffers from the limitation of data. As a result, the estimated coefficients could be biased. However, with the possible best statistical model built, the authors expect to provide some new insights on the port dynamics.

From the above analysis, this paper brings out two important messages. First, Shanghai port and Ningbo port are not in absolute competition in the observation period. Two ports made good use of existing advantages and favourable institutional factors to develop and made necessary division of labour.

Shenzhen port and Hong Kong port are also not in absolute competition in the observation period. They have once benefited from the favourable regional and global economic environment and are both suffering from the transformation of the hinterland in the past few years. However, global economy is now encountering difficulties that leads to the uncertainty of the growth of global trade and may result in the over capacity of port services. Regionally, other ports in the YRD and PRD regions are also upgrading themselves and increasing their capacities that may threaten the operation of the four ports in question. Therefore, skillful measures at different levels are needed to handle the inter-port relationship properly in the coming years.

Second, neighbouring port and GDP are the most influential factors to the throughput of the port as found in this study. Definitely, the efficiency of the port operation is also very important. Therefore, it is reasonable to suggest that the successful development of high value-added port-related activities such as supply chain and logistics industry, as well as other trading-related policies like free trade zones, can provide direct and indirect contribution (via GDP) to port throughput. It is an important issue to develop the port-neighbouring port-city (economic activities) relationship in the context of new business environment. Moreover, from the viewpoint of port governance, stakeholders such as port operators and shippers play strategic and substantial roles in port operation and development. For example, the roles of HPHT and MTL in these four ports that mentioned above. It is also not unfamiliar that major international shippers are now in alliances to maximize their benefit by bargaining with different ports on their extremely strong basis. Therefore, even though they are not examined in this study, they should be well considered in order to reach a comprehensive development strategy for a port.

In the case of Shanghai port and Ningbo port, Shanghai port's recent performance outpaced Ningbo port. But the pace of Ningbo port's development should not be underestimated, Ningbo-Zhoushan port integration is a particular signal that made it a comparable counterpart of Shanghai port. YRD regional integration is in good progress. While transport infrastructure is improving and one hour living circle, three hours transport circle and so on have been established, YRD cities are drawing strategies to integrate with Shanghai and benefit from Shanghai's development and spillover. In fact, different national and

regional plans are fostering the integration of port resources and division of labour among ports in the YRD region. For example, both the YRD Regional Planning and a State Council document emphasize this.[6] Therefore, spatially, the intensifying transport networks in YRD will definitely shorten the travelling distance between two ports. Functionally, the strategy of international maritime centre will work with other national, regional and local plans to redistribute various economic activities in Shanghai, Ningbo and other YRD cities. While Shanghai will definitely strive for maritime professional services like maritime finance, maritime insurance, ship trading and management along the maritime product chain, Ningbo can focus on the physical transport and other auxiliary services that complement with Shanghai. It is highly possible that a mega dual hub port system will emerge with Shanghai and Ningbo-Zhoushan ports as the two cores with both high capacity of physical shipment services and advanced maritime professional services, if not also a bargaining power of the industry at the global level.

In the case of Shenzhen port and Hong Kong port, the condition is more complicated than the one in YRD. Physically, both the direct distance between Kwai Tsing port (Hong Kong) and Yantian port (Shenzhen), and the distance between Kwai Tsing port and Shekou port (Shenzhen) are very short. But the administrative division and the two individual customs systems hinder the direct exchange and free flows of goods, as well as lengthen the travelling time, not mentioning the integration at administrative level. Moreover, Shenzhen is no longer Hong Kong's hinterland and two cities are serving the same hinterland generally. Conceptually, without considering the administrative boundary and political and customs systems, the two ports that already formed a dual port system should seek better integration and division of labour. In fact, if they are integrated, no matter named Shenzhen-Hong Kong port or Hong Kong-Shenzhen port, it would be the busiest container port in the world (46.24 million TEUs vs. Shanghai's 35.29 million TEUs in 2014). The strongest economy of the two cities in China and a comprehensive economic structure are the good foundation to the port development. Hong Kong has a very strong service economy and well-established systems. Shenzhen also has a very strong secondary industry and

[6] See YRD Regional Planning released in 2010 and the State Council's Opinion on Fostering the Development of Modern Service, Advanced Manufacturing, International Financial and International Maritime Centres in Shanghai (國務院關於推進上海加快發展現代服務業和先進製造業建設國際金融中心和國際航運中心的意見) in 2009.

service industry. Both cities are developing hi-tech economy that is expected to raise the productivity. In terms of ideal division of labour, while Hong Kong port can further expand its foreland due to the limitation of its physical condition and Hong Kong's economy, Shenzhen port can enlarge its hinterland. This can provide sufficient cargo and container for both shipment and transshipment of two ports. This can also mitigate the problem of port deconcentration in Hong Kong due to the unfavourable local factors and both ports can face the regional and global challenges together. Nevertheless, cooperation at governmental level is far from enough and breakthrough of the "one country, two systems" at constitutional level is of ultimate importance for the realization of such design although it is hard to achieve at this moment. However, if two ports fail to further cooperate and Shenzhen port chooses to development foreland transshipment, then direct and absolute competition may exist between two ports at government and city level, but not firm level.

8. Conclusion

Ports develop rapidly in China and scatter along the long coastline from north to south. Some of them are now the busiest ports in the world, such as Shanghai port and Ningbo port in YRD, and Shenzhen port and Hong Kong port in PRD. Not only they are in close spatial proximity and have overlapped hinterland, but also they are strong in physical scale and playing similar roles and functions in maritime services. Naturally, their relationship falls under the spotlight of different stakeholders, by asking questions such as "is Shenzhen (Ningbo) port going to replace Hong Kong (Shanghai) port?" Nevertheless, existing theoretical explanations generalized from the development of ports in Europe and North America cannot fully explain the development of ports and the change of inter-port relationship in Asia, China in particular, which have unique context. Previous studies have identified the influence of institutional factors on port development, and the emergence and features of dual hub port system.

This study employed quantitative analysis and intended to explain inter-port and port-city relationship and figure out the most significant variables on container and cargo throughput in Shanghai, Ningbo, Shenzhen and Hong Kong ports, in order to fill the research gap. This study found that the container and

cargo throughput of the four ports in question experienced a rising trend in the observation period in general. Therefore, it is affirmative to say that Shanghai port and Ningbo port, and Shenzhen port and Hong Kong port are not in absolute competition and that the development of one port is not at the expense of another.

Instead, from the analytical result, Shanghai port and Ningbo port, and Shenzhen port and Hong Kong port are in relative competition and complementary relationship, i.e., the increase of container or cargo throughput of one port has a positive correlation with the increase of container or cargo throughput of another, only at different degree. They form two dual hub port systems in YRD and PRD respectively. This study also asserts that port and city are closely related in development. Among all variables, GDP – both urban GDP and regional GDP – is believed to be an important factor on container or cargo throughput. However, the influence is inconsistent in the four ports. Host city's GDP is not necessary to have positive correlation with container or cargo throughput of its port, and regional GDP can have both positive and negative contribution to a port. Trading value and GIO are also common variables.

Continuous and successful development must be the most important matter of the four ports, i.e., not to be replaced by the neigbouring port or other upcoming ports. The proper development of port-neighbouring port-city relationship can be a way out. In this process, the institutional factor exerts a crucial influence. Not only there is the aggressive macro strategy like the international maritime centre goal of Shanghai, but also there are aggressive development plans to strengthen the port capacity on the one hand, and strengthen the connection and shorten the distance to city through building better transport networks on the other hand. Nevertheless, administrative fragmentation is the most crucial institutional barrier to be solved properly and quickly, particularly in the case of Shenzhen port and Hong Kong port.

Appendix Variables used in modeling

Variable name	Description of the variable
hkcontainer	container throughput in Hong Kong (million TEUs)
shcontainer	container throughput in Shanghai (million TEUs)
szcontainer	container throughput in Shenzhen (million TEUs)
nbcontainer	container throughput in Ningbo (million TEUs)
hkcargo	cargo throughput in Hong Kong (million tons)
shcargo	cargo throughput in Shanghai (million tons)
szcargo	cargo throughput in Shenzhen (million tons)
nbcargo	cargo throughput in Ningbo (million tons)
hkgdp	nominal Gross Domestic Product in Hong Kong (RMB billion)
shgdp	nominal Gross Domestic Product in Shanghai (RMB billion)
szgdp	nominal Gross Domestic Product in Shenzhen (RMB billion)
nbgdp	nominal Gross Domestic Product in Ningbo (RMB billion)
gdgdp	nominal Gross Domestic Product in Guangdong (RMB billion)
jsgdp	nominal Gross Domestic Product in Jiangsu (RMB billion)
zjgdp	nominal Gross Domestic Product in Zhejiang (RMB billion)
shtrans_invest	transportation investment in Shanghai (RMB billion)
sztrans_invest	transportation investment in Shenzhen (RMB billion)
shfdi	Foreign Direct Investment in Shanghai (USD million)
szfdi	Foreign Direct Investment in Shenzhen (USD million)
nbfdi	Foreign Direct Investment in Ningbo (USD million)
hktrade	total of import and export in Hong Kong (USD billion)
shtrade	total of import and export in Shanghai (USD billion)
sztrade	total of import and export in Shenzhen (USD billion)
nbtrade	total of import and export in Ningbo (USD billion)
gdtrade	total of import and export in Guangdong (USD billion)
jstrade	total of import and export in Jiangsu (USD billion)

zjtrade	total of import and export in Zhejiang (USD billion)
shgio	Gross industrial output in Shanghai (RMB hundred million)
szgio	Gross industrial output in Shenzhen (RMB hundred million)
nbgio	Gross industrial output in Ningbo (RMB hundred million)
gdgio	Gross industrial output in Guangdong (RMB hundred million)
Jsgio	Gross industrial output in Jiangsu (RMB hundred million)
zjgio	Gross industrial output in Zhejiang (RMB hundred million)
shincome	Per capita disposable income in Shanghai (RMB thousand)
szincome	Per capita disposable income in Shenzhen (RMB thousand)
nbincome	Per capita disposable income in Ningbo (RMB thousand)
yrdgdp	shgdp + jsgdp + zjgdp
yrdgio	shgio + jsgio + zjgio
yrdtrade	shtrade + jstrade + zjtrade
prdgdp	gdgdp + hkgdp
prdtrade	gdtrade + hktrade
hk_pcgdp	per capita GDP in Hong Kong (RMB thousand)

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