A STUDY ON TRANSSHIPMENT THROUGHPUT OF HONG KONG PORT

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A Study on Transshipment throughput of Hong Kong Port

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CERTIFICATE OF ORIGINALITY

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Dingtong Yang (Name of student)

Abstract

Transshipment throughput has been growing fast in the last decade. This thesis analyses on the transshipment and direct shipment with the focus of Hong Kong Port. Impacts from other related ports, namely the Port of Shenzhen and the Port of Shanghai, are tested. During the past ten years, transshipment of Hong Kong Port has been growing to reach more than 70% of total throughput from less than 40%. Specifically, I have looked at the changing pattern of Hong Kong Port from a gateway port to a transshipment hub. I name this phenomenon as a "Transshipment Reformation of Hong Kong". I attempt to explain this reformation by reviewing global economic environment changes, analyzing regional port competitions and modeling throughput prediction.

Empirical analysis reveals the changing pattern of Hong Kong port versus the effect of rapid growth of Shenzhen port. The transshipment data of Hong Kong in the past 13 years also presents an increasing trend and a feature of non-stationarity. Based on these features, I have conducted a series of econometrics studies on this transshipment data. I qualify and quantify the external impact of one port on another port, and the internal impact of direct shipment and transshipment on each other. I attempt to investigate direct shipment and transshipment separately as they were presenting heterogeneity over the past decade. The separate analysis shows that they are affected by same external factors to different extents. I have also constructed several models to predict transshipment throughput. This study contributes to the literature on port research, abbreviates the gap on understanding transshipment and assists the policy makers and managers in generating strategic development plans of port management.

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1. Introduction

1.1. World Container Port Development

This section covers briefly current situation of container port development. In the year 2013, world container port throughput achieved a 5.6% growth, reaching a total throughput of 651.1 million TEU (twenty-foot equivalent unit). Developing countries contributed 71% of the world total throughput in 2013 (UNCTAD, 2014), which shows the increased potential and market power of developing countries. Also, in the past 15 years, with the development of Asian countries, the world port throughput rank has changed dramatically compared with fifteen years ago.

Table 1.1 and Figure 1.1 show the total container throughput changing from the year 2001 to 2014 (Port rank based on throughput of 2014). Table 1.1 and Figure 1.1 indicate that the world container ports have achieved considerable growth in throughput volume. During the past 13 years, container ports from developing countries, especially China, have gained milestone achievements on port throughput. Shanghai and Shenzhen are two typical examples. For China, infrastructure enhancement, economic growth and international trade expansion are major reasons for her leading position in world port throughput. Shanghai and Ningbo (two major ports in the Yangtze River Delta), Shenzhen, and Guangzhou (two major ports in the Pearl River Delta) together occupied more than half of the container throughput of China. Yangtze River Delta and Pearl River Delta are two major economically well-developed regions in China, and both are centers for agriculture and manufacturing. In 2013, mainland China occupies 26.7% percent of world container throughput (651.1 million TEU), which is also 37.3% of total container throughput of developing countries (466.1 million TEU) (World Bank, 2014).

The major reasons for rapid growth (an average growth rate of 10.14% from the year 2010 to 2013, calculation based on data from the World Bank) are the dramatic increase in China's international trade and the enhancement of logistics infrastructures.

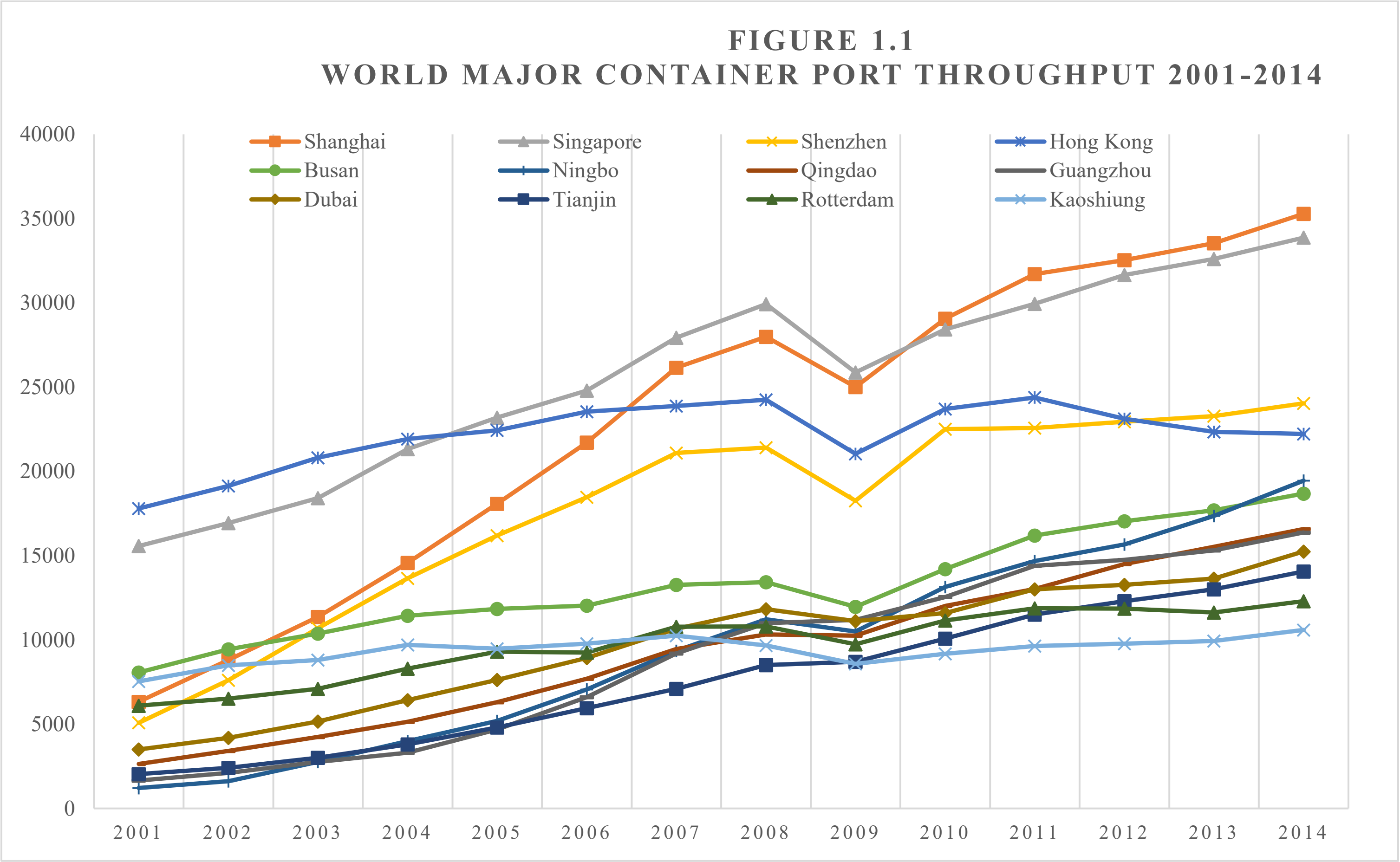
Compared with developing economies, developed countries have been performing differently, in the following two aspects. First, generally, developed economies do not achieve high increases in port throughput. The major increase of port throughput observed in developed countries is due to the trade with developing countries. Second, in addition, developing countries could provide lower-cost labors, with decent infrastructure, the port industry can develop quicker than developed economies. On the world rank list, Singapore, Busan and Kaohsiung are three cases from developed economies but developed along different paths. In the rest of this session, I will analyze briefly about these three ports. For the situation of Hong Kong, I will present discussion in Section 1.3.

Singapore and Busan are two Asian ports which have maintained their competitiveness during the past decade. The geographical location, infrastructure, and reliable port service enable Singapore's growth to the world largest transshipment container hub.

Table 1.1. World Major Container Throughput ('000 TEU) 2001-2014

2014 Rank	Container Port	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	Shanghai	6,330	8,810	11,370	14,570	18,084	21,710	26,150	27,980	25,002	29,069	31,700	32,529	33,541	35,285
2	Singapore	15,570	16,940	18,410	21,330	23,190	24,792	27,932	29,918	25,866	28,431	29,937	31,649	32,600	33,869
3	Shenzhen	5,080	7,610	10,700	13,650	16,200	18,469	21,099	21,414	18,250	22,510	22,570	22,940	23,279	24,037
4	Hong Kong	17,800	19,140	20,820	21,930	22,430	23,538	23,881	24,248	21,040	23,699	24,384	23,117	22,352	22,226
5	Busan	8,070	9,450	10,370	11,430	11,840	12,030	13,270	13,425	11,955	14,194	16,185	17,046	17,686	18,683
6	Ningbo	1,215	1,611	2,770	4,000	5,190	7,068	9,360	11,226	10,503	13,144	14,686	15,670	17,351	19,450
7	Qingdao	2,640	3,410	4,240	5,140	6,310	7,702	9,462	10,320	10,260	12,012	13,020	14,503	15,520	16,580
8	Guangzhou	1,657	2,113	2,760	3,310	4,680	6,600	9,200	11,001	11,190	12,550	14,400	14,743	15,309	16,378
9	Dubai	3,500	4,190	5,150	6,430	7,620	8,923	10,653	11,827	11,124	11,600	13,000	13,270	13,641	15,249
10	Tianjin	2,039	2,412	3,010	3,810	4,810	5,950	7,103	8,500	8,700	10,080	11,500	12,300	13,000	14,061
11	Rotterdam	6,100	6,520	7,100	8,300	9,300	9,251	10,790	10,800	9,743	11,146	11,877	11,866	11,621	12,300
12	Kaohsiung	7,540	8,490	8,810	9,710	9,470	9,775	10,257	9,676	8,581	9,181	9,640	9,780	9,937	10,593

Data Sources:
Review of Maritime Transport, UNCTD, 2003-2014
Ministry of Transport of the P.R.China
Summary Statistics on Port Traffic of Hong Kong, 2015
Port of Kaohsiung Statistics



Data Sources:
Review of Maritime Transport, UNCTD, 2003-2014
Ministry of Transport of the P.R. China
Summary Statistics on Port Traffic of Hong Kong, 2015
Port of Kaohsiung Statistics

Besides, the hub-and-spoke network widely adapted by shipping lines in 2000's has also contributed to Singapore's prosperity. The connectivity provided by this network links a group of small-scale seaports (feeder ports) of Southeast Asia effectively and efficiently. Singapore has successfully doubled its container throughput from the year 2001 to 2014, and more than 80% of its throughput is transshipment. Cargoes are shipped by barges or small ships to Singapore and then transshipped to oceanic vessels. In addition, with its reliable infrastructure and service quality, Singapore has competitive advantages over another two Malacca Strait transshipment hubs, namely Port Klang (65% was transshipment in 2014) and Port Tanjung Pelepas. The shipping lines are also willing to call Singapore port.

Port Busan has also managed to double its throughput from 2001 to 2014. In the year 2014, Busan Port handled 18.6 million of TEU. From the year 2010, China and South Korea have been working on the trade enhancement between the two Countries. Several joint venture factories were founded in China by Korea investment, e.g. KIA, Samsung, and LG. In 2014, a Free Trade Agreement between the two countries was signed. The products produced in China are shipped back to Korea and then to international destinations, which consequently requires additional shipping services from China to Korea. Furthermore, because Busan is on the route of trans-pacific between China and North America, the majority of the cargos transshipped in Busan come from China and U.S.A.

Kaohsiung, another well-developed port, maintained its container throughput volumes but was not able to achieve significant growth. One major reason is that its hinterland, Taiwan, has not been able to maintain its economic prosperity. Besides, regional ports, Hong Kong and Shenzhen, have jointly taken throughput volumes of Kaohsiung.

Terminal operational efficiency is one factor that affects port efficiency and operation rate. In year 2013, Asia ports generally achieved higher productivity than European ports and American ports (JOC, 2014). JOC (2014) also calculated the port productivity, which is defined as “the average of gross moves per hour for each call recorded each year.” “Gross moves” is defined as the total container moves divided by the number of hours the vessel at berth. According to this definition, they ranked the port productivity for 2013 and 2012, as shown in Table 1.2.

Table 1.2 World Port Productivity

Port	Country	2013 Productivity	2012 Productivity
Tianjin	China	130	86
Qingdao	China	126	96
Ningbo	China	120	88
Jebel Ali	U.A.E.	119	81
Khor al Fakkan	U.A.E.	119	74
Yokohama	Japan	108	85
Yantian	China	106	78
Xiamen	China	106	76
Busan	Korea	105	80
Nansha	China	104	73

Note: U.A.E. United Arab Emirates

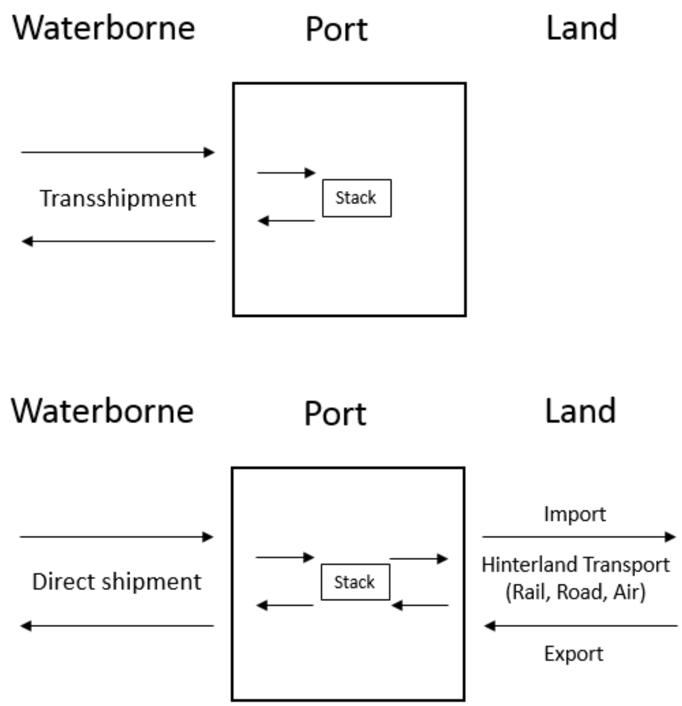
Data Source: JOC, World Port Productivity Rankings

Table 1.2 shows that the productivity increase of ports from 2012 to 2013 is significant. Ports in the Far East and the Middle East achieved the highest productivity, especially those in China. Even the busiest ports America and Europe are not on the top of the list. For American ports, the one with the highest productivity is Port Balboa (Productivity at 91st) (JOC, 2014), which is not even on the Top 10 list. Bremerhaven and Rotterdam are the top two ports with the highest productivity (86th) (JOC, 2014) in the European continent.

1.2. Transshipment in Asia and the world

Transshipment is an important component of international shipping logistics. Transshipment and direct shipment (origin and destination trade, or O/D trade) construct the total port throughput. By definition (Hong Kong Census and Statistical Department, 2002), direct shipment refers to the shipment of cargos from the origin port to destination port directly, and the cargos will not reach any other ports. Before or after direct shipment cargos arrive at the origin or destination port, they will be transported by tracks or trains. For transshipment cargos, they will be "transferred" during the shipping process, unloading to the yard, staying for several days (typically one to three days) and loading to another vessel. Figure 1.2 illustrates direct shipment and transshipment.

Figure 1.2. Transshipment and Direct shipment



Source: Author's own drawing

Table 1.3. Direct shipment vs. Transshipment

	Direct Shipment	Transshipment
Vessels	One vessel	Change of vessel
Yard Stay	Short, 1-3 days	Longer 4-5 days
Land side cost	High, additional Terminal handling Fees	Low, handling and yards fees
Multi-modal transportation	Will transported by other models	Will transported by another vessel

Source: A Summary of Rodrigue (2013), the definition of Transshipment.

Basically, benefits of transshipment include achievement of economies of scale along the route, reduction of empty slots on vessels, and cost-saving for both consignors and shippers.

Genco and Pitto (2000) [also Ducruet and Notteboom (2012)] classified seaborne transshipment into three types, namely

1. hub-and-spoke network transshipment,

2. interlining transshipment, and

3. relay transshipment.

Hub-and-spoke type of transshipment is the most common kind of transshipment, which is about 85% of global total transshipment (Drewry, 2010). This kind of transshipment hub is a part of the hub-and-spoke system. One example is the port of Singapore as the international transshipment hub on the Far East-Europe routes. Containers are collected by feeders from multiple ports, shipped to Singapore and finally loaded on mega vessels to Europe. Shipping lines use this kind of transshipment to minimize the number of empty slots of vessels and achieve economies of scale on board. Another example of interlining transshipment hub is Lisbon (Portugal) which connects the Far East-Europe routes and Europe-North America routes. Containers could be unloaded to Lisbon and loaded to another ship while changed the shipping routes. For relay transshipment, containers are transferred from large vessels to a relay port and loaded to another deep-sea vessel. One major difference between the hub-and-spoke type of transshipment and relay transshipment is the size of connecting vessels. For hub-and-spoke transshipment, containers are transferring through a process of the deep-sea vessel to barge/small ship, or vice versa. On the contrary, for relay transshipment container will be transferred from one deep-sea vessel to another vessel. The purpose of relay transshipment is achieving economies of scale.

During the modern shipping era, transshipment ports started to develop during the 1970s to 1980s (Notteboom, 2014). Singapore, Busan, Kaohsiung and Hong Kong were the first group of ports to provide transshipment service in the Far East. Rodrigue (2013) proposed the following requirements for a port to be a transshipment hub. First, from a location perspective, the hub should be on the major ship route(s), and the hub could connect feeder and deep-sea routes. Basically, ports located near the bottleneck of a route will likely develop as a transshipment hub. Famous examples include Lisbon near the Strait of Gibraltar, Port Said on Suez Canal, Singapore on the Strait of Malacca and Balboa on the Panama Canal. Second, the hub (for example, Hong Kong and Singapore) has the well-developed infrastructure, such as greater depth (>13.5 meters) for Post-Panamax vessels, sufficient yard area and high-capacity equipment. Last, the terminal operators should have high operation efficiency and low handling cost. Rodrigue (2013) pointed out that transshipment cost at the $100 per box was considered to be an acceptable level, and 35-40 moves per hour per crane was a desirable level of productivity. At the beginning, transshipment services are provided by large ports, which had a mix of direct throughput and transshipment throughput. From the 1990s, pure transshipment ports started to develop, namely Salalah (Omen), Tanjung Pelepas (Malaysia) and Gioia Tauro (Italy). Notteboom (2014) defined pure transshipment hub as its transshipment throughput exceeded 75% of total throughput. Figure 1.3 shows the transshipment percentage of major East-Asia ports (Multiple Sources: Busan port authority, 2014; JOC report of Shanghai and Shenzhen, 2014; Hong Kong Census and Statistical Department).

Figure 1.3. Container transshipment percentage of major Asian ports

Source: Author's interpretation of throughput data of individual ports (2014)

Among major Asian transshipment ports, Singapore has the largest container transshipment volume in the year 2014, followed by Hong Kong, Shanghai (which also has a high volume of direct shipment) and Busan. Together these three ports formed a “transshipment belt” for Asia. These transshipment ports serve two major shipping routes, namely Far East-Europe route and Trans-Pacific route.

From the international container transshipment perspective, in the year 2012, transshipment of containers reached 174.6 million TEU, which is about 28% of the world total port throughput (Notteboom, 2014). Far East and South East Asia became the top two leaders of transshipment throughput in 2012, with 48.9 (28% of total transshipment) and 44.1 (25.3% of total transshipment) million TEU, respectively. The high trade and transshipment volume indicate the economic development of the Far East and South East Asia countries.

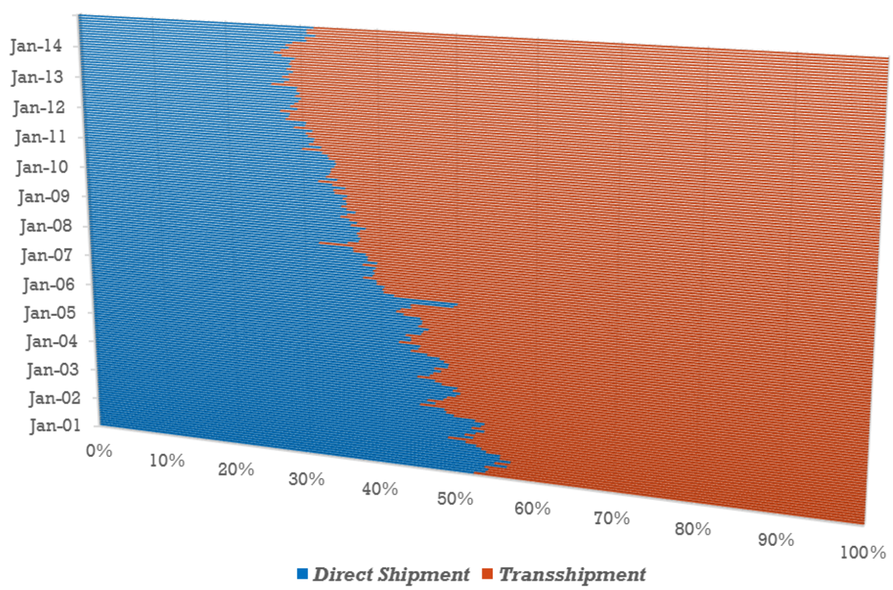
For the future development of world cargo transshipment, Far East and South East Asia will still be the busy transshipment region. One region with bright transshipment opportunities is the Caribbean area. The expansion project of Panama Canal will open new routes for Post-Panamax vessels. Besides, the potential competitor of Panama Canal, Nicaragua Canal, is under construction. The completion of Nicaragua Canal will reshape the trade of North America, especially the trade between the west coast and east coast.

1.3. Port throughput of Hong Kong

Hong Kong port, as an important connecting point between Northeast Asia and Southeast Asia, has been maintaining her leading position in the world container ports for years. For the port of Hong Kong, currently the situation becomes even more complicated and interesting. Hong Kong used to be the leading port of the world. During recent 12 years, the throughput of Hong Kong experienced dramatic changes in its volume allocation.

Hong Kong has been a direct shipment dominant port (a gateway port with 76% direct shipment and 24% transshipment in the year 1998). However, the transshipment volume occupies more than 70% of the total throughput (Figure 1.4). Hong Kong is gradually transforming to a transshipment hub in the past ten years. Based on the definition in Section 1.2, a port could be called a pure transshipment hub, when the volume of transshipment exceeds 75% of its total throughput volume. Hong Kong's transshipment percentage reached 70.27% at the end of 2014, which is almost the boundary of being a pure transshipment port. With this increasing rate, Hong Kong could become the largest transshipment port in East Asia.

Figure 1.4. Direct shipment and Transshipment of Hong Kong

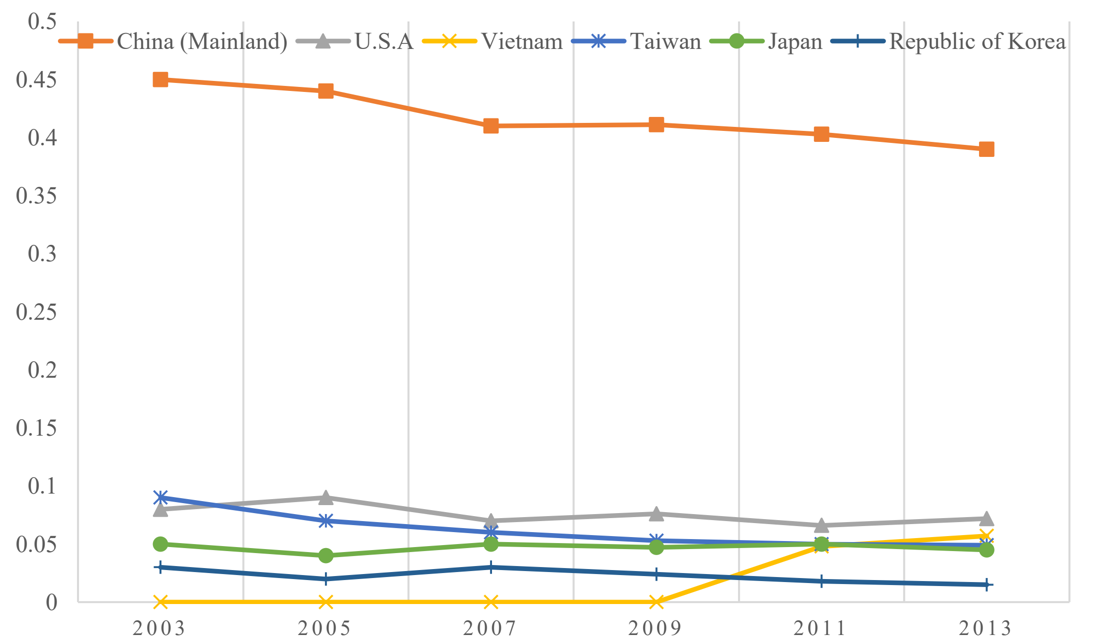


Data Source: Author's interpretation of Hong Kong Throughput data (2014)

The Census and Statistics Department of Hong Kong releases a report on cargo transshipment every two years since 2004. By summarizing the reports from 2004 to 2014, observations are summarized as follows.

1. Cargos from mainland China is the largest percentage share of transshipment cargo throughput in Hong Kong and the percentage share (39% in the year 2013) has been gradually decreasing over the past 10 years. U.S.A. (7.2%), Vietnam (5.7%), Taiwan (4.9%) and Japan (4.5%) are the other four largest cargo transshipment partners of Hong Kong. The top five trading partners add up to more than 60% of the total transshipment cargo throughput. Dating back to the year 2003, the top five transshipment cargo throughput countries were Mainland China (45%), Taiwan (9%), U.S.A. (8%), Japan (5%), and Republic of Korea (3%). The cargo transshipment percentage change by place is shown in Figure 1.5.

FIGURE 1.5 MAJOR CARGO TRANSSHIPMENT PARTNERS OF HONG KONG (PERCENTAGE OF TOTAL TRANSSHIPMENT OF HONG KONG)



Data Source: Hong Kong Shipping Statistics (2001-2013)

Figure 1.5 indicates that as the largest cargo destination/origin of transshipment of Hong Kong. The volume allocation of transshipment remains stable. Korea used to be one of top-five transshipment partners of Hong Kong, but now Vietnam replaced Korea. One reason is that Vietnam is experiencing a “model industrialization”. Considerable manufacturing companies started to relocate their manufacturing plants in Vietnam as Vietnam provides land and labor with cost effectiveness. The total trade value of Vietnam in 2014 was 27.23 billion USD, which increased 14.1% compared with 2013. U.S.A. is the largest trading partner of Vietnam. The major commodities traded are cell-phones, textile, and shoes. Then it is not hard to understand why the transshipment volume between Vietnam and Hong Kong keeps increasing because Hong Kong provides reliable liner services to North America. Korea is enhancing the cooperation with mainland China, but the port of Shanghai remains a better choice for trading. Taiwan is facing a situation of the lukewarm economic environment. For Hong Kong, cargos from the majority origins/destinations are increasing every year. Table 1.3 briefly summarizes the transshipment cargo change of some countries in the year 2003, 2008 and 2013.

Table 1.4 Transshipment Cargo ('000 Tones)

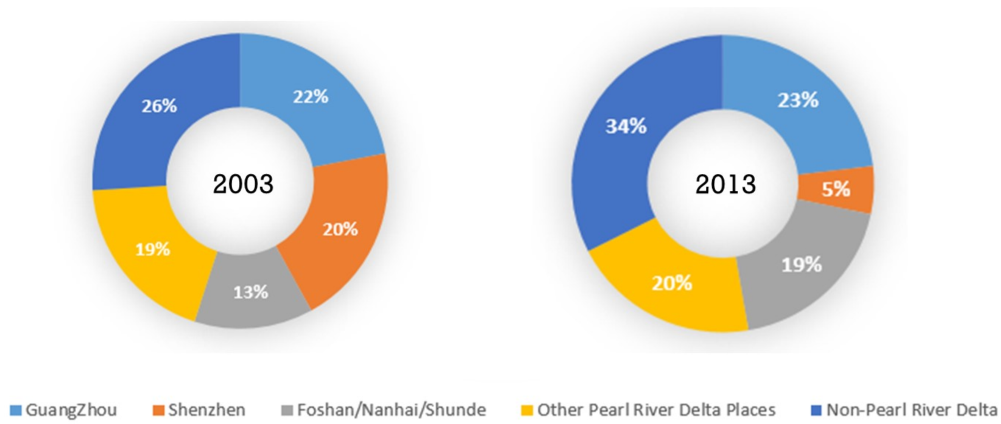
Country/Territory	2003	2008	2013	Rate of Change (2003-2013)*
China (Mainland)	41,269	56,773	61,144	4.0%
U.S.A.	6,845	9,608	11,310	5.1%
Japan	4,113	6,660	7,104	5.6%
Indonesia	2,141	2,468	2,777	2.6%
Vietnam	-	4,031	8,996	17.4%
Taiwan	8,136	8,428	7,611	-0.7%
Others	28,202	52,120	57,771	7.4%
Total	90,706	140,088	156,713	5.6%

Note: The rate of change for Vietnam is from 2008 to 2013.

Source: Hong Kong Shipping Statistics (2001-2013)

2. For all cargo movements between Hong Kong and mainland China, cargo movements between Hong Kong and the Pearl River Delta are major components, which occupy 67.5% in the year 2013. One interesting finding is the changing of movements between Hong Kong and Shenzhen. By the end of the year 2005, cargo movements between Shenzhen and Hong Kong contributed 21% of the total cargo movements between mainland China and Hong Kong. However, this number dropped to only 5.2% as Shenzhen has become an international trade port. In addition, the percentage share of entire Pearl River Delta decreased, which is the result of the rising of Shenzhen port. Figure 1.6 and 1.7 compare the transshipment allocation of Year 2003 and Year 2013.

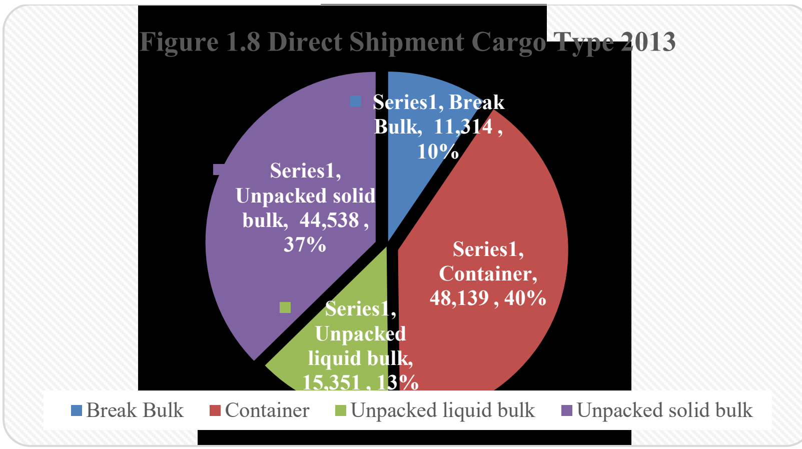
Figure 1.6 &1.7. Mainland transshipment Partners (2003, 2013)

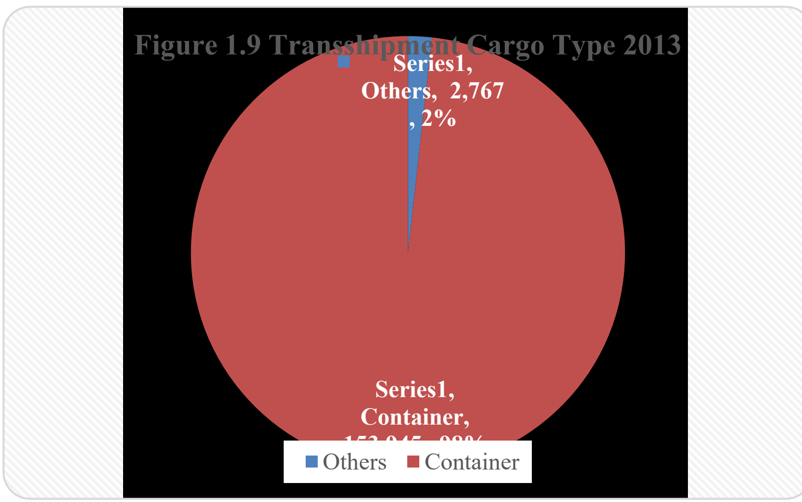


Source: Hong Kong Shipping Statistics (2001-2013)

3. With respect to major transshipment cargo type in Hong Kong in 2013, 98.2% are containerized cargos, which were almost the entire transshipment. However, for direct shipment cargos, containerized cargos are 40.3% out of the total, whereas unpacked solid bulk cargos are 37.3%, liquid bulk cargos are 12.9%, and break bulk cargos are the last 9.5%. This figure shows that Hong Kong port's major business for transshipment is in container transportation. The cargo types vary for direct shipment. This result indicates the importance of containerized cargos in the seaborne trade of Hong Kong.

Table 1.4 shows the commodity types of Hong Kong port's transshipment. As indicated by the last paragraph, transshipment cargos in Hong Kong are almost all containerized. The commodity percentages are relatively stable. Manufactured goods are 35.5% of the total transshipment cargos, which is the largest component of transshipment commodities. The second largest component is a crude material category (24.7%) while the third one is chemical products (16.1%).





Source: Hong Kong Shipping Statistics (2001-2013)

Table 1.5 Transshipment Commodity ('000 Tones)

Commodity	2008	2013
Food, beverage, tobacco	13,185 (9.4%)	21,400 (13.7%)
Crude materials, inedible (except fuels)	32,706 (23.3%)	38,773 (24.7%)
Mineral fuels, lubricants, oils, fats and waxes	894 (0.6%)	1,000 (0.6%)
Chemicals and related products	22,559 (16.1%)	25,169 (16.9%)
Machinery and transport equipment	15,138 (10.8%)	14,719 (10.2%)
Manufactured Goods	55,546 (39.7%)	55,611 (35.5%)
Others	60 (0.1%)	40 (0.1%)
Total	140,087	156,712

4. Current policy related to the throughput of Hong Kong

Currently, the throughput of Hong Kong is also effected by both the policy of Mainland and Hong Kong. Cullinane et al (2004) summarized the policy initiated after 1997 as two major components. One is the cabotage restriction, and the other one is the additional charges to vessels engaged in coastal services.

Cabotage restriction reserved the market of coastal shipping routes solely for vessels flagged under Mainland China. The cabotage restriction in fact enhanced Hong Kong's position as a transshipment hub. Foreign flagged ships would involve in transport of cargo between Hong Kong and Mainland ports.

Since 2013, China has been attempting to ease the cabotage restriction to several ports. In September 2013, Yangshan deepwarter port in Shanghai received government approval to be an exemption from cabotage. Since April 2015, another five ports have been open up for foreign ships, namely, Tianjin Port, Jiangyin Port in Fuzhou, Haicang Port in

Xiamen, Mawan, Chiwan port in Shenzhen, and Nansha Port in Guangzhou. The changing in cabotage restrictions would potentially reduce Hong Kong's competitiveness in cargo transshipment.

In summary, containerized cargos are almost the entire volume of transshipment throughput of Hong Kong. For direct shipment cargos, containers are only 40.3%. Forty percent of transshipment cargos of Hong Kong Port are related to Mainland China, U.S.A. is the second largest origin/destination. Vietnam in the past six years becomes transshipment origin/destination with the most growth rate, indicating the economic advancement in the country and the trade activity increase between Hong Kong and South Asia. In addition, Pearl River Delta region is the largest trade partner of Hong Kong's transshipment in Mainland China. However, in the year 2013, Shenzhen shipped far less its cargos to Hong Kong than in the year 2003. The expansion of Shenzhen port enables direct shipment of its goods to international destination. In general, transshipment volume of Hong Kong port is growing stably and become a dominant component of port throughput.

The future of the port of Hong Kong remains veiled. Logistics industry, as one of the cornerstones for Hong Kong's major income, encounters pressure and challenges from other Asia ports. The following chapters of this thesis will cover detailed studies of port throughput of Hong Kong, and attempts to propound suggestions for the industry.

2. Literature Review and Research Objectives

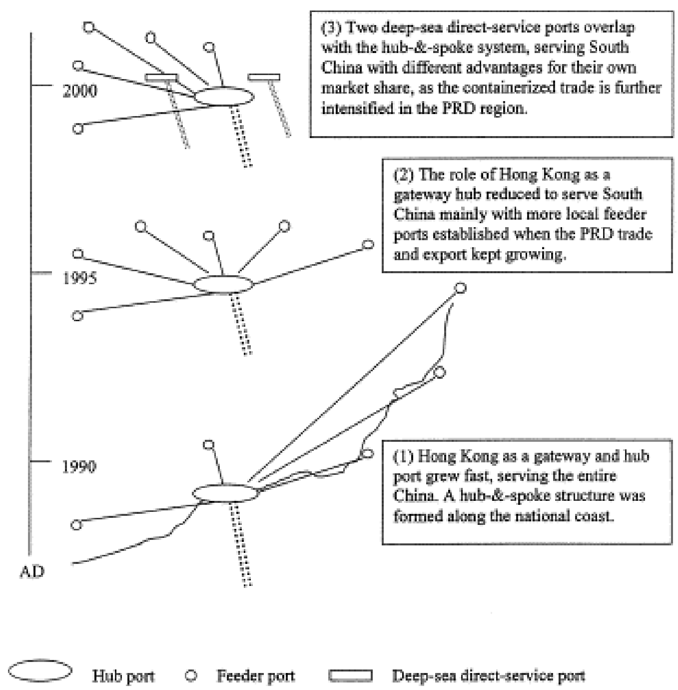
2.1. The development of Pearl River Delta (PRD) and Hong Kong port

Since 1997, intensive research has been conducted regarding the port development of Hong Kong and the regional development of PRD. Since PRD regional development affects the trade volume and value significantly. Also, the container port system changed since the development of the east coast Chinese ports.

For the development of Hong Kong port as a regional container loading center, Wang (1998) examined the role of Hong Kong by Hayuth's five-stage load–center model. This paper analyzed the case of Hong Kong port's growth with the economic development of hinterland. The paper was one of the earliest to discuss the possible outcome of Shenzhen's regional development in sea transportation. The paper also discussed the possible outcome of Hong Kong port's growth at a low rate.

Wang and Slack (2000) conducted a study on container port system changing in PRD. They are among the first scholars to study the port role-changing of Hong Kong port [similar ideas appeared in Wang (1997)]. The paper studied the port throughput data of seaborne transshipment in Hong Kong (with foreign countries and mainland provinces) and compared the data from Shenzhen port. Considering multiple factors including cost, political factors, globalization and multi-modal connectivity, the paper concluded the role-changing of Hong Kong port from an international gateway port and relay hub to a regional service port for the PRD region [shown by Figure 2.1, Wang and Slack (2000)]. The paper also indicated the growth of Shenzhen port would bring competitions between the two adjacent ports.

Figure 2.1 Role-declining of Hong Kong port



Source: Wang and Slack (2000)

Based on the possible competition in the port system in PRD region, Song (2002) conducted a research examine the result of the competition and cooperation. The paper predicted the possible declining in cargo throughput of Hong Kong since it acted as an export of mainland China. Terminal operators (or other individual shipping companies) in Hong Kong invested in newly developing Shenzhen port to maintain market share. Examples are the Hutchison Port Holdings Group (HIT) and Modern Terminal Limited (MTL) both invested in Shenzhen port, one in Yantian and another one in Chiwan respectively. Similar research for the case of HIT, Airriess (2001) conducted a study focusing on the investment of HIT in mainland China. He mentioned the investment behavior of HIT would lead to a decrease in sea cargos share of Hong Kong port.

Song (2003) also proposed a new concept regarding the regional port relationship of Hong Kong and Shenzhen, namely “co-opetition” concept. Under this concept, he proposed the cooperation of Shenzhen port and Hong Kong port, which is a result of Hong Kong’s terminal operator investing in Shenzhen ports. The co-opetition strategy needs a balance between players. The competition structure is affected by terminal operators across ports since they had the co-ownership of both ports.

Following the approach of port system evolution, the PRD ports are experiencing a process of port regionalization, a theory developed by Notteboom and Rodrigue (2005). They considered multiple factors from the ports, logistic partners, and government, and describe a step of regional ports become a system (from scattered ports to interconnected ports, centralization and decentralization and finally regional port system). They also mentioned the inland transport cost affecting the regionalization result.

A similar study regarding regionalization of ports includes Liu, Wang, and Yip (2013). In their paper, they developed the concepts of port regionalization further by evidence of Pearl River Delta, which includes the regionalization of Shenzhen and Hong Kong port. The paper propounded the concept of spatial port network and divergent evolution of port regionalization. They concluded a hinterland dominant role of Shenzhen port and predicted Hong Kong to be an international transshipment hub.

Loo and Hook (2002) summarized factors shaping the port development of Hong Kong. They provided a historical review of Hong Kong's development since the 1990s. Containerization, railway transportation local policy and regional development were considered. They also proposed practical suggestions for Hong Kong to maintain its leading position.

The literature on this port area suggests the tight connection between PRD and Hong Kong's port development. First, PRD is treated as an entire region for analysis. As shown by transshipment data from Chapter 1, Hong Kong's outward transshipment highly relies on the output of Pan-PRD region. Hong Kong has an advantage of barge transportation of containers from the river side. Second, using the regionalization hypothesis, this thesis focuses on the stage which the Hong Kong and Shenzhen ports have been, whether they are "competing" or "co-operating". Last but not least, for individual terminal operators, such as HIT and MTL, their investments in the counterpart of Hong Kong port will assist to shape the regional port competition and collaboration.

2.2. Inter-port competition

In Section 2.1, the regional port system in PRD is changed to a duo-poly port serving the entire hinterland. Therefore, the competition between Hong Kong Port and Shenzhen Port cannot be neglected.

Starting from early 2000, research had been conducted on the development of Shenzhen port affecting the growth of Hong Kong. Wang and Slack (2000) indicated the competition from a regional development view while Song (2002) and Song (2003) analyzed the competition at the individual company level. Yap, Lam, and Notteboom (2006) summarized factors affecting port competitiveness in the East Asia.

Besides the literature appeared in Section 2.1, one of the recent studies from Bae et al. (2013) modeled a duo-poly port competition, using Port Tanjung Pelepas and Port Singapore as an example. They applied a non-cooperative two-stage game to analyze sea port competition in a vertical structure. The model shows that shipping lines tend to call port with a lower price and higher capacity. In addition, congestion cost affects the shipping lines choice significantly. Without congestion effect, a port with higher transshipment level is preferred. The result is also consistent with analysis from Basso and Zhang (2006), who analyzed the congestible facility in a vertical structure.

Another empirical work for Southeast Asia port competition was conducted by Lam and Yap (2008). The paper calculated the annualized slot capacity (ASC) at a certain port for Port Klang, Port Tanjung Pelepas and Port Singapore. The study also considered each single liner services provided by the three ports. The conclusion was drawn based on the ASC analysis. A similar study for Pearl River Delta ports was conducted by Lam and Yap (2011). By calculating ASC, they described the competition between Shenzhen and Hong Kong. The result suggested that Shenzhen and Hong Kong were competing on several liner services while complementing on other liner services.

Busan and Shanghai had been used by Anderson et al. (2008) to analyze competition between container hubs. The paper proposed a game situation which Shanghai and

Busan need to decide whether to invest in additional infrastructure development. By using real-time data, the paper tested the situation under three difference cases when investing. The paper also presented optimal solutions for both ports to invest or not invest in certain infrastructures.

Their analysis also suggested several aspects which affect port competitions. The infrastructure investment [Limao and Venables (2001), Haralambides (2002), Clark, Dollar and Micco (2004)] highly influences the transport efficiency and port performance. Regional development, which includes regional port competition, will affect port performance (Cullinane, Teng and Wang, 2005). Congestion and port pricing are also important. Liner services and shipping companies will assist to shape the competition between ports.

2.3. Port throughput, Transshipment throughput studies and methods

Gooijer and Klein (1989) attempted to apply a vector ARMA model on a multiple time series. Their research was to forecast the steel traffic flow of the port of Antwerp. In their paper, they studied other factors such as other commodity flows which are leading factors to influence the flow of steel. They were confident that the model could have an effective prediction power for the short run. In addition, the multivariate VARMA model had a substantial improvement over some other univariate models.

Fung (2002) forecast the throughput of Hong Kong port using an error correction model (ECM). The model considered a structural error correction model (SECM) within multiple factors including the service quantity of Singapore port, Singapore's port tariff, Hong Kong's port tariff and midstream tariff. In his SECM, he summarized the impact of one factor (shock) to another. Also, a structural auto-regressive model was specified to compare with the SECM. The result indicates a better prediction power of SECM than SVAR and other linear models developed in previous studies. However, the situation is now different from 12 years ago, since Shenzhen has become a major player in this region, and, therefore, impact from Shenzhen should be examined in following.

Seabrooke et al. (2003) forecast the cargo throughput of Hong Kong. In their paper, they generated a linear regression model over multiple commodities, including the factors of population, GDP, and consumption. The model reflected a good prediction power with a decent adjusted-R^2 (Adj-R^2 =0.76). They addressed some other factors such as competition and China's entry to WTO and concluded that the growth of cargo throughput of Hong Kong would continue.

Another study of Hui, Seabrooke and Wong (2004) employed an error correction model (ECM) to forecast the cargo throughput of Hong Kong. Continuously, the model cast a positive sign for the cargo growth of Hong Kong. However, they predicted the transshipment traffic of Hong Kong would be attributed to ports in both Mainland China and Taiwan. This prediction failed and was against the data in the following ten years, which suggests a review on the previous model.

Apart from the above linear analysis of throughput of a port, some non-linear method has also been deployed.

Mostafa (2004) forecast Suez Canal's flow with an ARIMA model, and a neural network model (NN) model. His research indicated that NN tended to capture additional complex relationships. He found that in traffic flow studies, NN had a lower absolute error than ARIMA, and generally NN outperformed random walk models.

Lam et al. (2004) applied NN model basing on the data from 1983 to 2000 to predict the cargo traffic flow in the following ten years. Startling, their NN model generated an R2 = 0.95, which is much higher than a linear regression model.

Goulielmos and Kaselimi (2011) studied the traffic flow of Port of Piraeus by using the Hurst Exponential (H). In their research, H indicted valuable information related to long-term memory. By applying this H method to predict transshipment in Piraeus, they obtained a prediction error 0.19.

Vis and Koster (2003) reviewed the terminal operation process of a transshipment port. This study was not directly related to the topic of transshipment analysis. However, it explained the equipment and material handling processes for a transshipment terminal. More importantly, the paper provided more research questions on transshipment studies, including pickup and delivery of containers, efficiency improvement, and simulation of terminal equipment operation. This paper could be used for reviewing of various terminal operation aspects and digging research questions in transshipment.

With respect to transshipment studies, Schulze (2009) tested the seasonality fluctuation of Hamburg Port's transshipment volume. In this paper, he attempted to explain the seasonal factor affecting transshipment was a stochastic one or deterministic one. He applied a Beaulieu and Miron (1993) version of HEGY unit root test for testing multiple unit roots at the monthly seasonal frequencies. As a conclusion, they found that Hamburg Port transshipment data has a stochastic trend and deterministic seasonality.

Another paper written by Schulze and Prinz (2009), propounded a seasonal autoregressive integrated moving average (SARIMA) model for German's total transshipment volume. By analyzing the ACF and PACF and HEGY test, they concluded an SARIMA (0, 1, 0) (2, 1, 0) model. They also compared the forecast error of SARIMA and Holt-Winters exponential smoothing and concluded that SARIMA model had a better prediction power.

Since port data are always demonstrating a seasonality movement empirically. The following two papers are about HEGY unit root test and SARIMA model. HEGY seasonal unit root test was proposed by Hylleberg, Engle, Granger and Yoo (1990). Beaulieu and Miron (1993) applied the test to a variety of monthly U.S. aggregate data. As a result, they found that in some circumstances, the application of HEGY test should be careful since HEGY approach required a univariate series to be seasonally integrated. They suggested researchers should check the presence of unit root rather than mechanically imposing them to all seasonal frequencies as an assumption.

For analyzing seasonal unit root test, Rodrigues and Osborn (1999) performed a Monte Carlo simulation to test the prediction power of four seasonal unit root tests, namely Dickey, Hasza and Fuller (DHF), HEGY, Osborn, Chui, Smith and Birchenhall (OCSB), and Dickey and Fuller (DF) test. They found that the above four tests always present contradictable results, and researchers should select proper methods under particular circumstances. In general, DHF and OCSB had salient prediction accuracy, but additional restrictions.

To sum up, the literature of port throughput research provides a solid background for forecasting. The models deployed by previous research are powerful in prediction. However, few papers have focused on transshipment. With the sustainable transshipment volume, it is motivated to study factors affecting Hong Kong's transshipment changes.

2.4. Research Objectives

Hong Kong is now experiencing the dramatic change in transshipment. This phenomenon becomes interesting to both industry and academia. This study decomposes direct shipment and transshipment of Hong Kong and two separate time series and attempts to answer several research questions. First, what are the possible impact factors for transshipment and direct shipment? Are they the same? Second, what is the possible impact from Shenzhen port on Hong Kong port, are they competing with each other? Third, what would be the possible connection between direct shipment and transshipment for Hong Kong. Econometric methods will assist to release some connection between direct shipment and transshipment.

Based on econometric tests, some regional analysis of PRD regional will help addressing the questions.

At the end of this thesis, several suggestions will be propound to the industry.

3. Econometric models

In this thesis, in order to test the feature of Hong Kong’s transshipment and direct shipment, I will test the statistical properties of these two time series. In addition, I will also test the effect from two major mainland ports, Shenzhen and Shanghai. In year 2014, the summation of total throughput of Shanghai and Shenzhen accounts for almost half of the total throughput of China. The throughput of these two ports also represents the trade volume of Yangtze River Delta and Pearl River Delta. By analyzing these two time series, I am able to capture the effects of mainland China's port throughput growth on Hong Kong's.

Meanwhile, this thesis attempts to determine the inner connection among throughput of multiple ports. Hence, other common factors, such as GDP, the number of berth, population and wages are excluded. Based on the above discussion, data of throughput, direct shipment and transshipment are collected.

The source of the Hong Kong shipping data is the Census and Statistics Department of Hong Kong. The data of Hong Kong is retrieved from Hong Kong Shipping Statistics. The time range is from January 2001 to December 2014. In total, 168 observations are obtained. Throughput data of Shanghai and Shenzhen is retrieved from National Bureau of Statistics of China. Descriptive statistics is summarized in Table 3.1.

Table 3.1. Descriptive Statistics

Variable	*Abbreviation*	*Observations*	*Mean*	*Std. Dev*	*Min*	*Max*
			Unit: 000 TEU			
Total THP Hong Kong	*TOHK*	168	1,537.28	204.57	902	1,911
Direct Shipment Hong Kong	*DRHK*	168	596.96	105.14	309	875
Transshipment Hong Kong	*TRHK*	168	940.31	219.97	427	1,317
Total THP Shenzhen	*TOSZ*	168	1,465.22	532.36	307	2,294
Total THP Shanghai	*TOSH*	168	1,910.11	800.88	405	3,100

Note: THP stands for throughput

3.1. Co-integration, long-run and short-run relations

3.1.1. Unit-root Test

Traditionally, the Augmented Dickey-Fuller (ADF) test is the first step to understand the basic feature of these four time-series. The ADF test will consider the following three models:

$$\Delta y_t = c_0 + c_1 t + \gamma y_{t-1} + \sum_{j=1}^{p} \phi_j \Delta y_{t-j} + \epsilon_t$$

(3.1)

$$\Delta y_t = c_0 + \gamma y_{t-1} + \sum_{j=1}^{p} \phi_j \Delta y_{t-j} + \epsilon_t$$

(3.2)

$$\Delta y_t = \gamma y_{t-1} + \sum_{j=1}^{p} \phi_j \Delta y_{t-j} + \epsilon_t \qquad (3.3)$$

The test is to test the following null hypothesis:

H_0: $\gamma = 0$, H_1: $\gamma < 0$` (3.4)

The ADF test can follow the following steps:

Step 3.1, Follow Model (3.1) to test H_0, if H_0 is rejected, then y_1 is not an I (1) process. If H_0 is not rejected , then move to Step 3.2;

Step 3.2, Restrict Y=0 and test C_1. If C_1 is not significant, then move to Step 3.3, otherwise y_1 is a I (1) process with trend;

Step 3.3, Test H_0 with Model 3.2, if H_0 is rejected, then y_1 is not an I (1) process. If H_0 is not rejected, then move to Step 3.4;

Step 4, Restrict Y_0=0 and test c_0, if c_0 is not significant, then Step 3.5, Otherwise y (1) is an I (1) process with constant.

Step 3.5, Test H_0 with Model 3.3, If H_0 is rejected, then y_1 is not an I (1) process. If H_0 is not rejected, then y_1 is an I (1) process;

In addition to the above steps, the first difference of time series should be tested. When the first difference of time series is proved to be stationary, the non-stationarity and I (1) are concluded.

Table 3.2.Unit-root Test

Series	*Model*	C_0	C_1	Γ	*Lags*	*ADF*
DRHK	*3.1*	*161.3712*	*-0.5755*	*-0.2009*	*11*	*-1.872*
		(0.047)	*(0.005)*	*(0.063)*		*(-3.444)*
	3.2	*-43.4509*		*0.0564*		*0.956*
		(0.236)		*(0.341)*		*(-2.887)*
	3.3			*-0.0133*		*-1.792*
				(0.075)		*(-1.950)*
TRHK	*3.1*	*136.0065*	*0.4609*	*-0.1631*	*11*	*-1.379*
		(0.046)	*(0.408)*	*(0.170)*		*(-3.444)*
	3.2	*87.1951*		*-0.06906*		*-2.035*
		(0.009)		*(0.044)*		*(-2.887)*
	3.3			*0.01873*		*2.538*
				(0.012)		*(-1.950)*
TOSZ	*3.1*	*178.0562*	*-0.008529*	*-0.08313*	*11*	*-1.167*
		(0.001)	*(0.991)*	*(0.245)*		*(-3.444)*
	3.2	*178.3524*		*-0.0838*		*-3.034*
		(0.000)		*(0.003)*		*(-2.887)*
TOSH	*3.1*	*161.0354*	*-0.1936*	*-0.02828*	*11*	*-0.362*
		(0.001)	*(0.885)*	*(0.718)*		*(-2.887)*
	3.2	*164.9255*		*-0.03928*		*-2.207*
		(0.000)		*(0.029)*		*(-2.887)*
	3.3			*0.03079*		*3.906*
				(0.000)		*(-1.950)*

Note: () denotes …what are statistical significant?

In addition, Table 3.3 presents the Dickey-Fuller test results for the first difference of the four time series.

Table 3.3 indicates that the Null hypothesis cannot be rejected for all cases, but the first differences of four time series yields out the test statistics to be rejected by the 5%

significant level. Therefore, it can be observed that all four time series are integrated of order one, i.e. I(1) processes. Specifically, DRHK is a non-stationary time series with a trend. The significant level of coefficient suggests the trend is also significant. And the negative sign indicates the declining trend of the series. On the other hand, both TRHK and TOSH are I(1) processes with a constant term. And TOSZ is a non-stationary time series without a constant. Hence, it is reasonable to apply co-integration test to the time series.

Table 3.3 ADF Test for the first difference

Series	C_0	Γ	*Lag*	*ADF*	*5% Critical value*
D.DRHK	*-8.8541*	*-7.2044*		*-11.530*	
D.TRHK	*21.7039*	*-5.0131*	*10*	*-7.456*	*-2.887*
D.TOSZ	*88.55942*	*-5.656*		*-8.930*	
D.TOSH	*51.8628*	*-4.933*		*-8.203*	

3.1.2. Granger-causality Test

Granger-causality test can be applied to test whether one variable X is a "cause" of another variable Y, or vice versa. The result of Granger test partially explains the influence from one variable to another. By applying Granger-causality test in this study, the thesis captures the relations among the time series. However, granger test does not release the economic reasons behind the “causality” effect. To be more cautious, this study treated the result as a lead-lag correlation effect among these time series.

Granger-causality test can be used on stationary time series or two co-integrated time series after Vector Error Correction Model (VECM). Because these four time series are I (1) processes, this test can be performed by two methods. One is by direct first difference, the other by seasonal difference. First difference will imply the Granger effect between "monthly increases", which means whether the monthly increase of a time series will have effect on another. In contrast, seasonal difference will offer explanation for seasonal increases effects. The first difference Granger test result is presented in Table 3.4. When the probability of F-test is larger than 5%, the Null hypothesis cannot be rejected.

Null Hypothesis: X does not Granger-cause Y (3.5)

against

Alternative Hypothesis: X is the Granger-cause of Y (3.6)

Table 3.4. First difference Granger-causality Test

Null Hypothesis X-Y (X DOES NOT Granger- Cause Y)	*Chi-square Statistics*	*Probability*
D.DRHK-D.TRHK	*4.7499*	*0.191*
*D.TRHK-D.DRHK**	*13.801*	*0.003*
*D.DRHK-D.TOSZ**	*8.0235*	*0.018*
*D.TOSZ-D.DRHK**	*7.3708*	*0.025*
D.DRHK-D.TOSH	*3.6748*	*0.299*
D.TOSH-D.DRHK	*4.7007*	*0.195*
D.TRHK-D.TOSZ	*1.2374*	*0.539*
*D.TOSZ-D.TRHK**	*7.4229*	*0.024*

D.TRHK-D.TOSH	*2.1150*	*0.549*
D.TOSH-D.TRHK	*5.7715*	*0.123*

* indicates X Granger-cause Y at the 5% confidence level.

By comparing each pair of time series on Granger-Causality, Table 3.4 indicates some interesting behaviors of them. First, D.DRHK does not has a lead-lag relation with D.TRHK, but D.TRHK has a lead-lag correlation with D.DRHK. This can be interpreted as "a change in transshipment of Hong Kong will first happen then a change in direct shipment of Hong Kong would follow the effect". This intuitively explains the throughput percentage share changes along the past ten years. Similar effect is also indicated by the pair of D.TRHK and D.TOSZ, which means "a change in total throughput of Shenzhen has a lead-lag correlation with change in transshipment of Hong Kong". The third relation therefore is not hard to understand. Changes in direct shipment of Hong Kong and changes in total throughput of Shenzhen will influence each other.

The Granger-causality Tests support the view that both TRHK and TOSZ are useful in forecasting DRHK. At the meantime, TOSZ is useful for predicting TRHK.

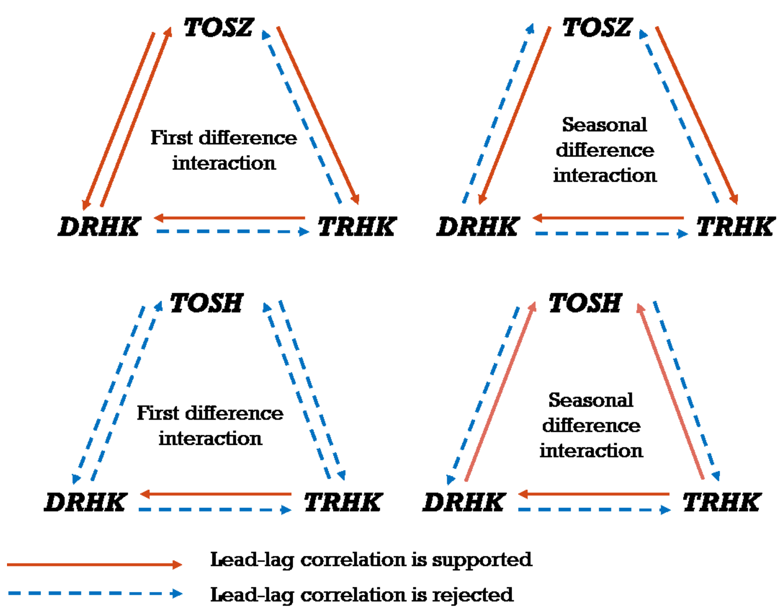
Table 3.5. Seasonal difference Granger-causality Test

Null Hypothesis *X-Y (X DOES NOT Granger- Cause Y)*	*Chi-square Statistics*	*Probability*
SD.DRHK-SD.TRHK	*4.1149*	*0.128*
*SD.TRHK-SD.DRHK**	*19.951*	*0.000*
SD.DRHK-SD.TOSZ	*0.0845*	*0.959*
*SD.TOSZ-SD.DRHK**	*6.0297*	*0.049*

*SD.DRHK-SD.TOSH**	*11.003*	*0.012*
SD.TOSH-SD.DRHK	*2.9831*	*0.394*
SD.TRHK-SD.TOSZ	*2.6717*	*0.263*
*SD.TOSZ-SD.TRHK^*	*5.8173*	*0.055*
*SD.TRHK-SD.TOSH**	*21.9190*	*0.000*
SD.TOSH-SD.TRHK	*5.0887*	*0.165*

* indicates X Granger-cause Y at the 5% confidence level.

Figure 3.1. shows the lead-lag correlation generated from granger-causality test. Comparing the result from Shanghai and Shenzhen, Shenzhen has more lead-lag correlation with Hong Kong, while Shanghai has only seasonal correlation with Hong Kong.



3.2. Long-run Relation

Dickey-Fuller stationary test indicates that all the throughput time series are non-stationary time series. The non-stationary conclusion is the sufficient condition to construct the long-run and short-run equilibrium for DRHK and TRHK. Based on the co-integration test, a conclusion that co-integration relation exists between TRHK and TOSZ could be drawn. The result from Granger-causality test and co-integration test enable to describe the long-term and short-term relations between transshipment of Hong Kong and throughput of Shenzhen.

Traditionally, port throughput can be described as

$$THP = f(GDP, Port\ Tariff, Berth \dots) \tag{3.7}$$

Our previous analysis indicates that for transshipment throughput of Hong Kong, Shenzhen's trade volume will add prediction power. TOSZ has been further added as one component to the prediction model. Second, for GDP, Hong Kong Statistical Department only releases the data as a quarterly base, for this study, a monthly data set is expected. Therefore, import and export as components of GDP are chosen as independent variable for transshipment description. Then for transshipment of Hong Kong, the model can be developed as

$$TRHK = f(TOSZ, Import, L_{TRHK}, Berth) \tag{3.8}$$

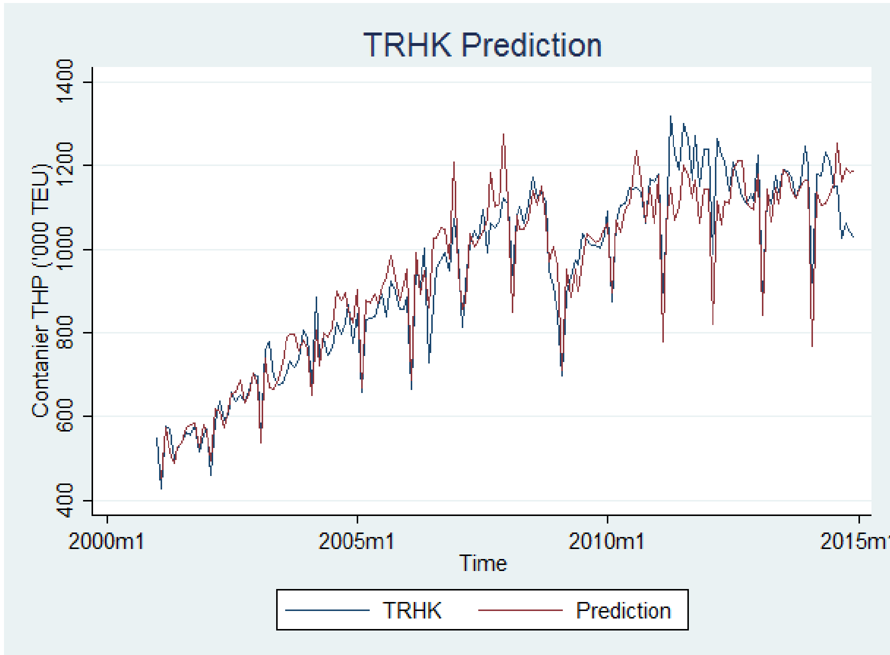
Table 3.6 shows the regression result for transshipment of Hong Kong

Table 3.6. GMM Regression Result for TRHK

	Variable	*Coefficient*	*Std. Err.*	*z-Statistics*	*Prob.*	*Vif (Multicollinarity Test)*	*R2*
Model 3.1	*L.TRHK*	*0.1399*	*0.06870*	*2.04*	*0.042*	*5.99*	*0.9064*
	TOSZ	*0.2064*	*0.0263*	*7.85*	*0.000*	*10.70*	
	Rexpt	*0.0005*	*0.0001*	*4.17*	*0.000*	*6.45*	
	Berth	*4.4036*	*3.6629*	*1.20*	*0.229*	*3.32*	
	constant	*187.9942*	*60.9361*	*3.09*	*0.002*		
Model 3.2	*L.TRHK*	*0.2236*	*0.0621*	*3.60*	*0.000*	*5.37*	*0.8937*
	TOSZ	*0.3134*	*0.0298*	*10.52*	*0.000*	*6.49*	
	Berth	*-2.2064*	*3.9055*	*-0.56*	*0.572*	*2.99*	
	constant	*321.6736*	*66.1367*	*4.86*	*0.000*		
Model 3.3	*L.TRHK*	*0.2194*	*0.0619*	*3.54*	*0.000*	*5.27*	*0.8935*
	TOSZ	*0.3075*	*0.0263*	*11.69*	*0.000*	*5.27*	
	constant	*283.9079*	*25.5181*	*11.13*	*0.000*		

Figure 3.1 shows the prediction against true value of TRHK

Figure 3.1. Observed and predicted time series of TRHK



Granger causality test indicates that transshipment of Hong Kong will affect the direct shipment of Hong Kong. For the GDP part, import and domestic export are chosen. For direct shipment of Hong Kong, similarly, the long-run model can be obtained by:

$$DRHK = f(TRHK, Import, Dexpt, L_{DRHK}, Berth) \tag{3.9}$$

The regression result is shown in Table 3.7.

Table 3.7. GMM Regression Result for DRHK

	Variable	*Coefficient*	*Std. Err.*	*t-Statistics*	*Vif (Multicollinearity Test)*	*Adj-R2*
Model 3.1	*L.DRHK*	*0.4440*	*0.0617*	*7.2***	*1.15*	*0.7136*
	TRHK	*0.1434*	*0.0576*	*2.49**	*8.24*	
	Drpt	*-0.0006*	*0.0001*	*-4.07***	*7.00*	
	Berth	*12.18*	*3.2585*	*3.74***	*2.60*	
	constant	*130.2498*	*70.161*	*1.86(0.065)*		
Model 3.2	*L.DRHK*	*0.4615*	*0.0644*	*7.16***	*1.15*	*0.6861*
	TRHK	*-0.03558*	*0.0388*	*-0.92(0.36)*	*3.42*	
	Drpt	*0.02606*	*0.001933*	*13.48***	*2.60*	
	Berth	*14.8812*	*3.3398*	*4.46***	*2.15*	
	constant	*59.8226*	*71.1769*	*0.84(0.40)*		
Model 3.3	*L.DRHK*	*0.4407*	*0.0603*	*7.31***	*1.00*	*0.6864*
	Dexpt	*0.02692*	*0.001689*	*15.94***	*1.64*	
	Berth	*13.0219*	*2.6518*	*4.91***	*1.64*	
	constant	*61.2230*	*71.1256*	*0.86(0.40)*		

(1). * means the variable is statistically significant at the 5% confidence level;

(2). **means the variable is statistically significant at the 1% confidence level.

The domestic export part does not contribute considerably to the throughput, and the constant term is not statistically significant. Also, the lag of DRHK bears considerable regression power, which finally leads to auto-regression model.

3.3. Short-run equilibrium and co-integration

Besides the long-run relationship, short run equilibrium has also been studied in this thesis. For short-run equilibrium, the first step is establishing the co-integration relation and then forming a vector error correction model.

On the basis of the non-stationary conclusion, Johansen co-integration test will release information on the co-integration relationship among these four time series. Johansen co-integration test is a robust method for multivariate time series.

Table 3.8 shows the result of Johansen co-integration test.

Table 3.8. Johansen Co-integration Test

Hypothesis (No. of Co-integrations)	*Eigenvalue*	*Test Statistics (5% Critical Value)*	*Max-Eigen Statistics (5% Critical Value)*
None		*110.0280 (47.21)*	*60.5041 (27.07)*
At most 1	*0.3054*	49.5239 (29.68)	27.6692 (20.97)
At most 2	*0.1535*	*21.8547 (15.41)*	*21.0035 (14.07)*
*At most 3**	*0.1189*	***0.8512 (3.76)***	***0.8512 (3.76)***
At most 4	*0.0051*		

The Johansen co-integration test indicates that at most 3 co-integration relations among four time series, direct and transshipment throughput of Hong Kong, the total throughput of Shenzhen and Shanghai. The three co-integration relations can be detected by Johansen Co-integration test between each pair of time series. Table 3.9 shows the results of Johansen test.

Table 3.9 Johansen Test for time series pairs

Co-integration Test Pairs	*Test Result*	*5% Critical Value for 1 co-integration*	*1% Critical Value for 1 co-integration*
*DRHK & TRHK**	*1.6681*	*3.76*	*6.65*
*DRHK & TOSZ**	*1.4996*	*3.76*	*6.65*
DRHK &TOSH	*19.1053*	*15.41*	*20.04*
TRHK & TOSZ	*4.2138*	*3.76*	*6.65*
TRHK & TOSH	*13.2212*	*15.41*	*20.04*
*TOSZ & TOSH**	*1.4612*	*3.76*	*6.65*

For the perspective of short-run equilibrium, it is interesting to understand time series change of Hong Kong port. Table 3.9 shows two pairs are statistically significant. Hence only the error correction model for DRHK&TRHK and DRHK&TOSZ pairs have been calculated. In a standard error correction model, the formula is written as follows:

$$\Delta y_t = \alpha\beta' y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + V + \delta t + \epsilon_t \qquad (3.10)$$

Where α is the adjustment coefficient, $I2$ is co-integration equation coefficients, V is a constant term, and Γ is a matrix of short-run coefficients.

Table 3.10 shows the VECM estimation for DRHK&TRHK and DRHK&TOSZ pairs

Table 3.10 VECM result for co-integration pairs

	Pairs		
Coefficients	*DRHK*	*TRHK*	*Constant*
α	*-0.2959*	*-0.3421*	
β	*1*	*0.4157*	*-999.39*
V	*-2.4377#*	*2.1088#*	
Γ	*0.0396#*	*-0.1993*	
	0.4485	*-0.5348*	
	Pairs		
Coefficients	*DRHK*	*TOSZ*	
α	*-0.2959*	*-0.3801*	
β	*1*	*0.1571*	*-853.28*
V	*-7.7815#*	*6.0476#*	
Γ	*-0.2474*	*0.0120#*	
	0.6271	*-0.3764*	

means NOT statistically significant at the 5% confidence level.

The results show that the following two time series are stationary (indicated by coefficient ***β***):

DRHK+0.4157 x TRHK-999.39, and

DRHK+0.1571 x TOSZ -853.28. And both DRHK/TRHK and DRHK/TOSZ pairs are adjusted to the equilibrium in the short run. Adjustment coefficient α , shows that when DRHK is lower than the equilibrium, and TRHK will adjust to the opposite sign of DRHK at a rate of 0.34, indicating the gap between DRHK and TRHK will be enlarged. The result for DRHK and TOSZ also indicates that TOSZ will adjust to opposite sign of DRHK, which means when DRHK falls, TOSZ will increase and the gap will be enlarged. Besides, TRHK (0.34) has a similar rate of adjustment as TOSZ (0.38), which is the same as the result in the long run perspective. TOSZ will affect TRHK at the same period, and no lag exists between TOSZ and TRHK.

3.4. The impact of cabotage on port throughput

Cabotage refers to the restriction that a country reserves the rights of carrying cargos and passengers between cities in its jurisdiction to domestic carriers. It is treated as a strategical protection of domestic carriers. Cabotage is normal in both shipping and aviation industry. Figure 3.2. briefly demonstrates cabotage restriction.

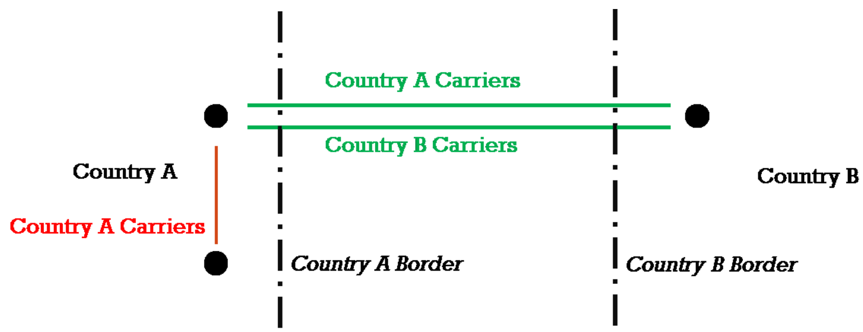


Figure 3.2. Demonstration of Cabotage

However, Hong Kong, as a special administrative region in China, is not treated as a domestic port. Therefore, foreign could possibly choose Hong Kong for transshipment with Mainland ports, since they are forbidden to ship cargos directly between two mainland ports. For years, cabotage restriction is believed to benefit transshipment in Hong Kong (Wee, 2013 and Mooney, 2015).

In September, 2013, Shanghai received exemption from cabotage. Thereafter, foreign carriers could use Shanghai as a transshipment hub with other mainland ports. In 2014, five more ports were entitled exemptions for cabotage, namely, Tianjin port, Jiangyin

Port in Fuzhou, Haicang Port Xiamen, Mawan, Chiwan, and Shekou port in West Shenzhen port; and Nansha port in Guangzhou.

This study attempts to understand the effect of cabotage using regression models. Cabotage (cab) is selected as a dummy variable to decide the influence when the restriction is released.

The variable cab is valued at 1 when cabotage restriction was fully enforced before Sep. 2013; and it is valued 0 when cabotage releasement was applied.

Models are presented as:

$$TRHK = \beta_0 + \beta_1 \times L.TRHK + \beta_2 \times TOSZ + \beta_3 \times cab \quad (Model\ 7)$$

and

$$DRHK = \beta_0 + \beta_1 \times L.DRHK + \beta_2 \times TRHK + \beta_3 \times Dexpt + \ \beta_4 \times cab \ \ (Model\ 8)$$

The regression results are showing as following

Table 3.11. Regression with dummy variable cab

	Variable	*Coefficient*	*Std. Err.*	*t-Statisctis*	*Prob.*	*Adj-R^2*
Model 7	*L.TRHK*	*0.1273*	*0.0598*	*2.30***	*0.023*	*0.9003*
	TOSZ	*0.3045*	*0.0233*	*13.04***	*0.000*	
	constant	*343.6545*	*31.0203*	*11.08***	*0.000*	
	cab	***57.898***	***15.307***	***3.78***	***0.000***	

	Variable	Coefficient	Std. Err.	t-Statisctis	Prob.	Adj-R^2
Model 8	*L.DRHK*	*0.3936*	*0.0631*	*6.24***	*0.000*	*0.6901*
	TRHK	*0.01607*	*0.0305*	*5.04***	*0.000*	
	Drpt	*0.01523*	*0.0025*	*6.00***	*0.000*	
	constant	*95.0404*	*52.7392*	*1.8*	*0.073*	
	cab	***-51.955***	***17.7557***	***-2.93***	***0.400***	

Comparing model 7 and 8, results of adding cabotage as a dummy variable to the regression indicates that when cabotage restriction exists, it has a positive impact on transshipment of Hong Kong. Therefore, it is beneficial to Hong Kong.

However, when the cabotage dummy variable is added to the direct shipment throughput model, the variable becomes insignificant, which means the cabotage rule has no statistical impact on direct shipment.

For model 7, the coefficient indicates that when cabotage restriction existed the transshipment volume of Hong Kong would benefit for an additional 57.8 thousand of TEU. When cabotage is released, this effect is eliminated. In addition, compared with model 3, model 7 has slightly gained additional explanatory power over data. Based on Adjusted-R^2, previous 89% of the total data would been explained, currently, 90% of the total date could be explained.

This result provides a basis to discuss the impact on transshipment from political perspective. Detailed discussion is developed in Chapter 4.2.

4. Implications

4.1. Transshipment versus direct shipment

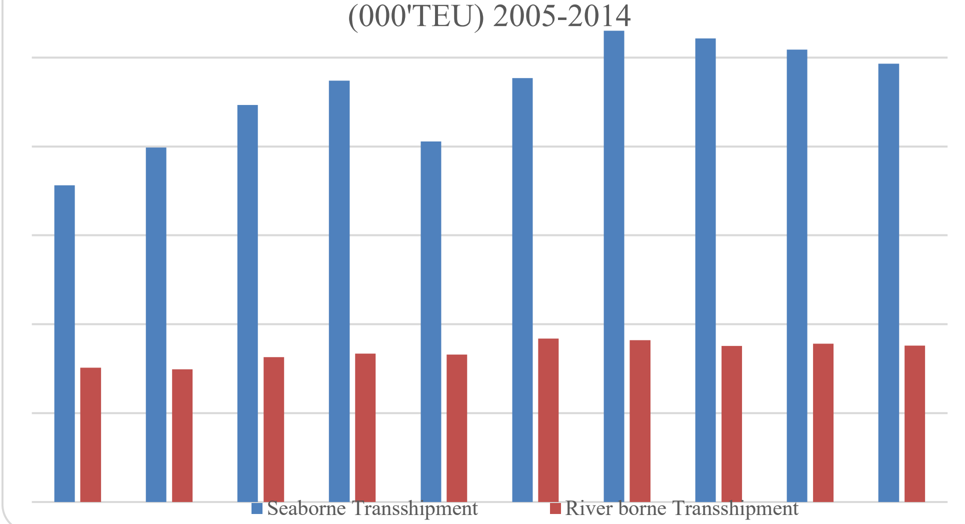
From the econometric analysis in Table 3.4, a change in transshipment of Hong Kong would "Granger-cause" a change in a direct shipment of Hong Kong. In other words, transshipment of Hong Kong adds prediction power to direct shipment of Hong Kong prediction. The Granger effect from transshipment to direct shipment is observed in both month-to-month difference (first difference) and seasonal difference.

When the first difference of direct shipment is regressed by the lagged first difference of transshipment, the coefficient of transshipment becomes negative (-0.28) in Table 3.6, indicating that if transshipment in Hong Kong in one of previous two months increase, then in the following month direct shipment of Hong Kong will decrease. A similar result is observed in seasonal difference, as shown in Table 3.5. For example, compared with the same month of 2013 and 2014, an increase in transshipment in January indicates an increase in direct shipment in March; a decrease in transshipment in February also indicates an increase in direct shipment in March.

From the above analysis in Section 3.1 and 3.2, for the majority of the time periods, for the port of Hong Kong, an increase in transshipment leads to a decrease in direct shipment volume for the next period. Although the Grange causality test does not provide any explanations for the relation it may indicate, the result suggests heterogeneity in nature of transshipment and direct shipment.

For Hong Kong port, the increase of transshipment and decrease of direct shipment are due to the following two reasons. First, Hong Kong is not a city/port with intensive manufacturing activities; therefore, the quantity of local products for export is limited. The export of goods is majorly “re-exported” cargoes from Pearl River Delta. Second, local consumption of foreign goods is also limited by the population size. Local production and consumption can hardly support the increase in direct shipment. Therefore, previously the direct shipment of Hong Kong heavily relied on the re-export of mainland China goods. Port competition and land connectivity are major factors that affect the direct shipment. From the view of a port, these factors are completely exogenous. Currently, enhancing land connectivity and lower the land transportation charges will attract more cargo export from the mainland China.

Figure 4.1. Seaborne and river borne Transshipment (000'TEU) 2005-2014



For transshipment, endogenous factors of a port are more deterministic, because of the following two reasons. First, as reviewed in literature in Section 2.1, the location of a port decides the seaborne transshipment volume to a large extent. During the past decade, the port of Hong Kong has retained its competitiveness in seaborne transshipment, and she has also gained an increase in river borne transshipment. Figure 4.1 shows the container transshipment changes both for seaborne and river borne transshipment. River borne transshipment has increased for 17% over the past ten years (2005-2014, data from Hong Kong Census and Statistical Department). Besides, the river borne transshipment highly relies on barge connection with the hinterland. Recently, Hong Kong is facing a problem of barge service congestion (Fu et al., 2010; Asia cargo news, 2014). The demand for barge service has increased, but the total number of berths for barges has not. On the other hand, an opportunity for Hong Kong to retain its high container throughput volume could also emerge from improved barge service. Session 4.2 will discuss land usage and barge service enhancement in detail.

In summary, direct shipment throughput is affected by exogenous factors, for example, hinterland production level and hinterland land transportation connectivity; and endogenous factors, for example, port handling cost and efficiency. However, for transshipment, endogenous factors contribute a larger proportion than exogenous ones. Location, cost, and efficiency are major independent variables.

4.2. Impact of transshipment from political aspects

In Chapter 3.4, the effect of cabotage is tested. Statistically, when cabotage restriction was applied, Hong Kong would gain an additional monthly average of 57.8 thousand of TEU in transshipment, when cabotage was released, this effect is eliminated.

The major questions may be asked are whether China would continue to release the cabotage and whether the releasement would continue to reduce the transshipment volume of Hong Kong.

First, currently, most of the major ports in Southern China has been exempted from the cabotage (Shanghai, Shenzhen, Guangzhou and Xiamen). These ports became exemptions mainly due to the compliance of free trade zone requirements. And they also served as regional gateway ports, which means they could be competitors of Hong Kong Port. China may still some other ports along the coast for exemptions (small to medium ports), but those ports may not be major competitions of Hong Kong.

In addition, statistically, on average, Hong Kong is experiencing a deduction of 57.8 thousand of TEU in transshipment, which is 5.1% of average monthly total transshipment throughput. When the releasement continues, the effect would be mild.

4.3. A new era of Pearl River Delta ports

Econometric results indicate influence from Shenzhen port's total throughput on Hong Kong's transshipment. Granger causality tests have shown the relations. In the regression model in Table 3.4 and 3.5, Shenzhen's total throughput (TOSZ) is also significant for affecting transshipment throughput (TRHK) of Hong Kong (coefficient is 0.3075). Econometrically, the coefficient can be interpreted as "one TEU of container throughput increase in Shenzhen will result in 0.3 TEU of container transshipment in Hong Kong". In addition, the impact of TOSZ on TRHK can also be explained as a new stage of Pearl River Delta port system.

As discussed in the literature review in Section 2.1, Wang and Slack (2000) described the port system changing from the early 1990s to 2000s. The research presented the stages of PRD ports development: first, Hong Kong was a gateway port serving entire south China, then Hong Kong became a gateway port serving PRD region, and finally Hong Kong and Shenzhen served the region as two gateway ports simultaneously. Further discussion was made by Liu et al. (2013). The PRD ports system enters into a new era today and becomes a regionalized port system.

Shenzhen emerged as a new gateway for Pearl River Delta in the early 2000s. Since then, Shenzhen has been keeping a high speed of throughput growth, and direct shipment possessed 75% of total throughput on average. Shenzhen and Hong Kong, a duo-port system starts to perform their own advantage in serving the PRD hinterland. They are two gateways ports, but within the same hinterland and specialized in their own areas. Currently, the duo-port system can be described as follows: Shenzhen serves majority demand of direct shipment and Hong Kong serves as a transshipment hub. The situation could continue as Shenzhen would keep the growth in direct shipment and Hong Kong in transshipment.

4.2.1. Cost differences

Multiple factors contributed to shaping the new pattern of Pearl River Delta port system have been described by Liu et al. (2013). Cost factor is the first one. At the beginning of this port throughput competition, Shenzhen enjoyed a competitive advantage of lower labor and land cost than Hong Kong, and this competitive advantage has been achieved since the establishment day of Shenzhen port. During these years, the land transportation cost gap between Hong Kong and Shenzhen has been enlarged (BMT, 2014).

Table 4.1. Total Cost Comparisons of Moving a TEU Container: East PRD (Dongguan) to Los Angeles (in US Dollars)

Industry data, Multiple sources, 2015	Via Hong Kong	Via Yantian	Difference
Ocean Freight Rate (Destination Delivery Charges included)	2,457	2,457	-
Fees^	434	434	-
Terminal Handling Charges (THC)	276	125	151
Truck Fees to Terminal	430	220	210
Total	3,597	3,236	361

* TEU refers to a Twenty-feet equivalent container

^ Fees include documentation fees and Bunker adjustment

Sources: Writer's own estimation based on consultation with OOCL and APL, truck companies and the HK shipping Council.

Table 4.1 compares the cost of transferring a TEU container from Dongguan to West Coast of U.S. via Hong Kong and Shenzhen. Compared with Yantian, Hong Kong has two cost disadvantages, namely the Terminal Handling Charges (THC) and Truck transportation cost. Table 4.2 compares the truck cost from Dongguan to Shenzhen/Hong Kong in the year 2006 and 2015.

Table 4.2 Truck cost comparison between 2006 and 2015 (in USD)

From Dongguan	2006		2015	
	To HK	To SZ	To HK	To SZ
Truck cost per FEU	300	120	467	225
Cost difference	180		242	

* Source of 2006 data: GHK(2008) "Study on Hong Kong Port Cargo Forecast 2005/2006".
Note: HK = Hong Kong port; SZ = Shenzhen port
FEU = Forty-foot Equivalent Unit

In 2006, the truck cost to Hong Kong from Dongguan was USD180/FEU higher than the truck cost to Shenzhen. Ten years later, the cost gap has been enlarged to USD242/FEU. The gap of the cost cannot be alleviated and will be even amplified for the future. Both direct shipment and transshipment throughput are affected by the terminal handling cost. In addition, direct shipment is also affected by the cost of land connection. Land side cost issues are partially explained the current Pearl River Delta container throughput distribution: intensive direct shipment in Shenzhen, and a considerable amount of transshipment in Hong Kong.

In the future, econometrically, with other factors fixed, if the land transportation cost difference continues to enlarge, Hong Kong will become less favorable for direct shipment while Shenzhen will continue to collect additional import and export of Pearl River Delta. As the direct shipment occupied capacity of Shenzhen port, capacity constraints and congestion issues lead to that transshipment throughput will be served in Hong Kong. Econometrically, one TEU direct shipment increase in Shenzhen will lead to 0.3075 TEU transshipment increase in Hong Kong. However, the increases in throughput in both Shenzhen and Hong Kong ports are not unlimited. However, the extreme case that Shenzhen handles the entire direct shipment of PRD and Hong Kong handles transshipment will not happen. Multiple other factors, such as land and river connectivity of both ports with the hinterland will largely affect the choice of consignors and shippers.

4.2.2. Two ways of international trade

Apart from the truck cost difference, water transportation cost also affects the transshipment pattern in the Pearl River Delta. For cargoes from a mainland China port in PRD, Hong Kong is treated as an international port. Therefore, two ways of international transshipment will be applied for cargoes from PRD.

The first route of transshipment is transshipping through Shenzhen. Cargoes are first shipped to Shenzhen, and then to international destinations. The name for the first route is an International Trade with a Domestic Transshipment (ITDT). An alternative route of transshipment is transshipping through Hong Kong. Cargoes are first shipped to Hong Kong (river trade terminal), then transferred to Shenzhen and finally loaded on mega vessels to international destinations. This route of transshipment is called International Trade with an International Transshipment (ITIT). ITDT adds cargo throughput to only Shenzhen port. ITIT counts both transshipment volumes to Shenzhen and Hong Kong.

The two routes of transshipment can be compared by, first, procedure; and second, cost. For the procedure, although ITIT has one more station to stay (Hong Kong), it has two fewer documents to report, namely "export cargo list by truck" and "Custom declaration for transshipment." The checking procedure is more complex for ITDT than ITIT. For ITIT, the containers are randomly picked by the customs, and on average the checking rate is 5% to 7%. However, for ITDT, all containers above the second stack will be checked by the custom. The checking rate is around 60%. The checking procedure highly favors ITIT.

Besides, the costs of ITDT and ITIT are also different. Table 4.3 compares the cost for ITDT and ITIT. The total costs for ITDT and ITIT are similar.

Table 4.3. Cost comparison of international trade with different transshipment [RMB per TEU)]

	ITDT		ITIT	
Deport charges (RMB)	Custom clearance charge	180	Custom clearance charge	180
	Export cargo list by truck	20		
	Custom declaration for transshipment	30		
	Seal fee	5		
	Handling fee	25		
	Container checking fee	40		
Transportation fee (RMB)	Transportation fee to Shenzhen	468	Transportation fee to Hong Kong	468
			Terminal Handling cost	155
Port charges (RMB)	Handling fee	245	Handling fee	220
	Hygiene checking cost	40	Hygiene checking cost	40
	Custom clearance charge	65	Custom clearance charge	15
Total cost (RMB)		1,118		1,078

Note:

ITDT = International Trade with a Domestic Transshipment

ITIT= International Trade with an International Transshipment

Source of data: Multiple sources including Port Authority and Shipping Companies.

For the two routes of transshipment, ITIT has simplified checking procedure but will take additional shipment time for container handling in Hong Kong. ITDT applies a complex checking procedure but saves shipment time to Hong Kong. The costs of two routes are comparable. In the real practice, ITIT is the major way for international trade with transshipment (Cosco Group, 2013). The result adds river transshipment volume to Hong Kong. If Hong Kong can further improve the operational efficiency of river terminals, the river side transshipment volume will increase.

4.2.3. Land connectivity

Considerable literature included the connectivity issues of hinterland and port to the analysis [e.g. Wang and Slack (2005), Liu et al. (2013)]. In Hong Kong, four land ports together offer cargo transferring services between Hong Kong and the mainland, namely, Lok Ma Chau (Huanggang) Port, Shenzhen Bay Port, Man Kam To Port, and Sha Tau Kok Port. According to the Census and Statistics Department of Hong Kong, for the year 2009 to 2014, cargoes carried by road are dropping at an average rate of 4%. The number indicates a decaying trend of land transportation of Hong Kong. As discussed in Section 4.2.1, the cost difference between Hong Kong and Shenzhen partially explains the decrease of the direct shipment of Hong Kong. The average truck cost for a single TEU from Dongguan to Shenzhen is about USD242 lower than the truck cost to Hong Kong.

In addition, checking and inspection procedures, to some extent, limited the connection of land traffic. Prior to the year 2002, both Shenzhen and Hong Kong were starting to improve the efficiency of land side ports. Huanggang Port became a 24-hour port in the year 2003, and it is now the busiest land port between Shenzhen and Hong Kong. Currently, Huanggang port has 40 truck inspection lines. Huanggang Port has simplified the checking procedure for trucks exporting goods and transshipped goods from China. Huanggang Port implied a quick checking procedure for outgoing trucks and incoming trucks but inspected in another customs district. However, for trucks entering Shenzhen, the waiting time still varies. On average, a truck completes 2 to 3 round trips per day through Huanggang port in a day (HAFFA, 2014). However, the round trip frequency is reduced to one or less than one trip per day, when Huanggang Port unexpectedly implies some additional checking procedures (e.g. increase the number of opening checking trucks or some disinfection procedure). The waiting time can be prolonged to 10 hours in the port. Congestion and additional waiting time impede the development of truck traffic flow.

In the year 2009, Hong Kong-Zhuhai-Macau Bridge (abbreviated as HZM Bridge) began construction. The HZM Bridge connects West Pearl River Delta with Hong Kong, and will serve as a relief for both passenger and cargoes congestion problem between Shenzhen and Hong Kong. Certainly, the HZM Bridge will enhance the land connection between Hong Kong and the Pearl River Delta hinterland, especially PRD West side. Road charges and checking procedure is critical for real practice and congestion problems.

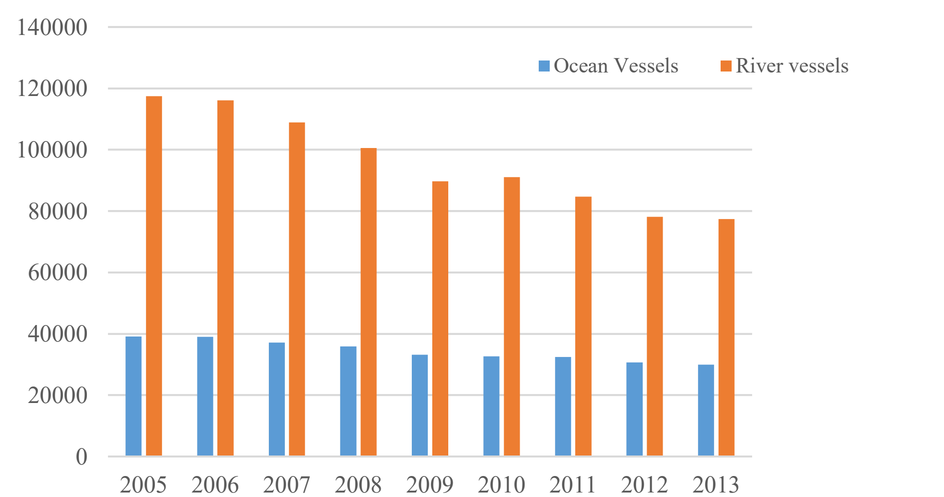
As a result, land side connectivity also limits the truck transportation between Hong Kong and Pearl River Delta, which will reduce the volume of direct shipment.

4.2.4. Water borne connectivity and international transshipment

River traffic connecting Hong Kong and the Pearl River Delta region, in the past ten years, demonstrates a steady trend of increase. Barges are major vessels deployed for river borne transportation. The gap of barge transportation cost between Shenzhen and Hong Kong has been narrowed over the past ten years (Hong Kong Shipping Council, 2013). Enhancing the river transportation becomes an opportunity for Hong Kong to retain its competitiveness.

However, Hong Kong is not able to provide sufficient barge berths for container handling. Current, Modern Terminal Limited has only two barge berths (MTL, 2015) and Hong Kong International Terminals provides 10 to 14 barge berths. During peak hours, some barges are arranged to ocean container berths container handling, which leads to an outcome of low efficiency and congestion problem. In a report from the Legislative Council dated December 2014, the shipping industry stated that during 2014, about 9% of container ship skipped calling Kwai Tsing Terminals, which was believed to be a fact of congestion. Although total throughput of cargoes remained stable, the number of vessels arrived per year in Hong Kong has indicated a down trend from 2005 (Figure 4.2.). According to the Marine Department, the average in-berth-duration for ships in 2011, 2012 and 2013 were 11.5 hours, 11.8 hours and 13.1 hours, respectively. One reason for the prolonged hours was the increase in ship size and capacity. The handling efficiency was also improved.

Figure 4.2. Number of vessels arriving in Hong Kong



Source: Hong Kong Shipping Statistics (2005-2013)

4.2.5. Lead-lag relationship and seasonal effect.

The interaction between Shenzhen port and Hong Kong port is also reflected by their lead-and-lag relationship and seasonal effect.

For transshipment of Hong Kong (TRHK), the throughput of the current month is affected by the throughput of last month and the current total throughput of Shenzhen (TOSZ). Both long run and short run analyses (Table 3.7 and Table 3.10) show that results. However, for direct shipment, although a Granger effect from TOSZ or TRHK exists by the granger causality test, regression result indicates only first lag of DRHK will enforce influence.

4.3. Future of Hong Kong Port

4.3.1. New Terminal and Land usage

Several infrastructure projects will enhance the port connectivity of Hong Kong and the Pearl River Delta. Correspondingly, the projects are aiming at solving the problem of land and water connectivity.

The first infrastructure project is the Hong Kong-Zhuhai-Macau Bridge (HZM Bridge). As discussed above, the HZM Bridge will enhance the connection between Hong Kong and the West Pearl River Delta.

Figure 4.3 is the planning map of the new bridge. Currently, Humen Bridge is the only connection between West and East Pearl River Delta. The congestion is a salient problem for transportation. The average traffic of Humen Bridge was estimated to be 120,000 vehicles per day, which is the designed maximum traffic flow of the bridge. HZM Bridge will largely reduce the flow pressure of Humen Bridge.

The traffic flow of the HZM Bridge is estimated to be around 50,000 vehicles per day in the year 2035 (HKTDC, 2014). However, the critical problem is still the fees charged for the vehicles, especially trucks. As an alternative, Humen Bridge charges 150 RMB for a truck (over 15 tons). For marine transportation cargoes, the demand of using HZM Bridge will not be sensitive (elastic) to the charges of the bridge, since the terminal handling cost of Hong Kong is considerably higher than that of Shenzhen. Shipping time for sea cargoes is always not critical since they are non-perishable. For Kwai Tsing Container Terminals, a significant growth in direct shipment will not be observed. On the other hand, for perishable goods, or air cargoes, the bridge will contribute significantly for time-saving.

Figure 4.3. Hong Kong Macau Zhuhai Bridge and adjacent network`

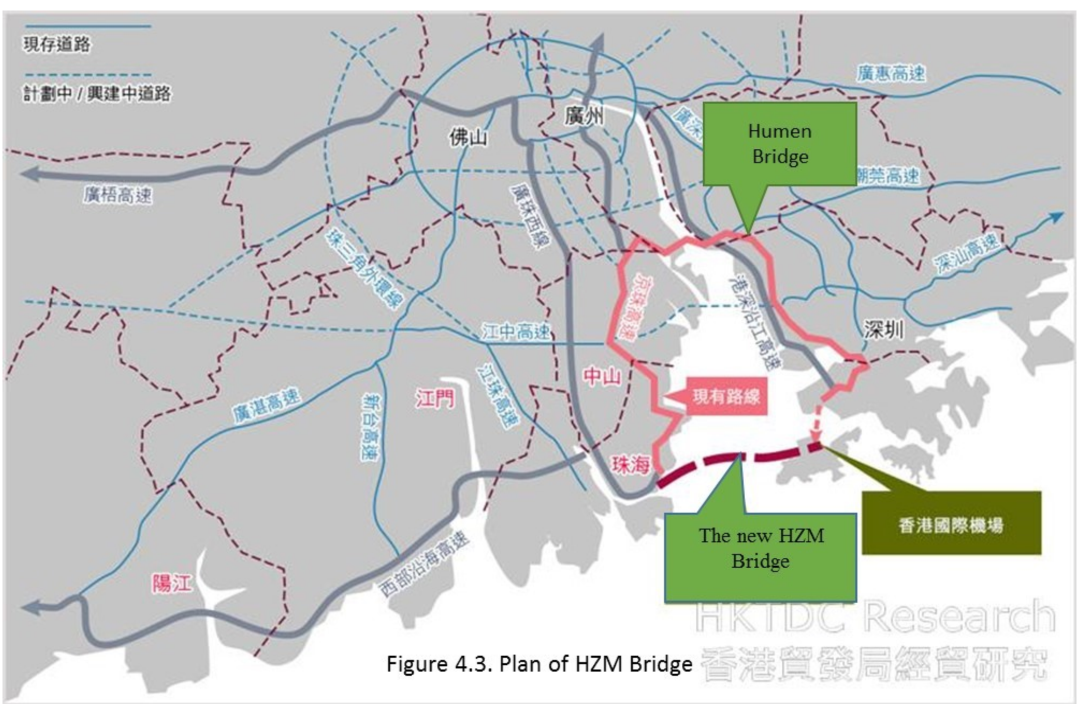


Figure 4.3. Plan of HZM Bridge

(Source: HZMB Management website, 2015)

Besides the new HZM Bridge, terminal constructions and land usage for Hong Kong are also new infrastructures. As discussed above, the terminal in Hong Kong has the problem of the relatively high cost of handling, limited yard sides for stacks, and congestion of barge terminals. The cost issue is a long-run problem, and the gap will be narrowed as the labor cost of Shenzhen is increased to a comparable level of Hong Kong. The yard size affects transshipment ability largely. According to one study of Transport and Housing Bureau, total areas of the Kwai Tsing Container Terminals are hard to expand, due to the limited land size and high real estate price. The Government and the general public have discussed the development of new Container Terminal Ten several times, but environment concerns from the public hamper the project to be executed. The Port authority needs a solution for effective and efficient usage of the limited yards. For this problem, the Transport and Housing Bureau has proposed new rental plans for the land.

On the other hand, effective usage of river terminals and mid-stream operation will largely improve the transshipment efficiency. In 2011, the usage rate of Hong Kong River Trade Terminal is only 49% (BMT 2014). The river terminals will improve to attract ships for international trade with an international transshipment (ITIT). In the next section, I will discuss the possibility of expanding part of the river terminals to sea vessel container terminals.

4.3.2. Transshipment gateway port

Researchers, policy makers, and industry participates are concerning about the future of Hong Kong port for a long time. One major question is whether Hong Kong port will continue to be a gateway for the Pearl River Delta. Before answering this question, I discuss the definition of "gateway."

Tongzon and Oum (2007) presented a definition for a gateway:

"*In international trade a gateway can be defined as a node in a globalized supply chain that serves as a critical link between geographical areas or regions by providing a system of road, rail, marine and air transportation infrastructure of national significance for international trade*".

The definition is designated for a particular city, but similar ideas can also be applied to a gateway port. A simplified definition for "gateway" is stated as:

A gateway port is a node on international or inter-regional trade routes and serves as a critical link between its regional hinterland and global destinations.

This definition has three indispensable factors, namely "international or inter-regional trade routes", "critical link" and "regional area and global destinations". First, a gateway exists only in international trade or inter-regional trade. For the local trade or intra-regional exchange, gateway does not necessarily exist. The term "critical links" describes the importance of the node. The "critical links" should be the only limited nodes for international trade between this hinterland region and global destinations. The gateway port exists if cargoes are necessarily transported via it from "non-gateway" ports (feeder ports) and then to global destinations. Finally, the term "gateway" also emphasizes the interaction between "regional areas" and "global destinations". This interaction requires a gateway to contribute enough for regional logistics services. For example, if a port serves only international destinations as an international transshipment hub, then the port is not a gateway, because a gateway port should serve both local transportation and international carriage. One example of this port kind is Port Salalah. The core business of Port Salalah is international transshipment, and the transshipment container throughput was 96.5% of total throughput (3.34 million TEU) in 2013 (Port Salalah, 2014). The economic contribution of Port Salalah on regional economy is limited. Therefore, Port Salalah is generally defined as “an international transshipment hub” rather than a gateway.

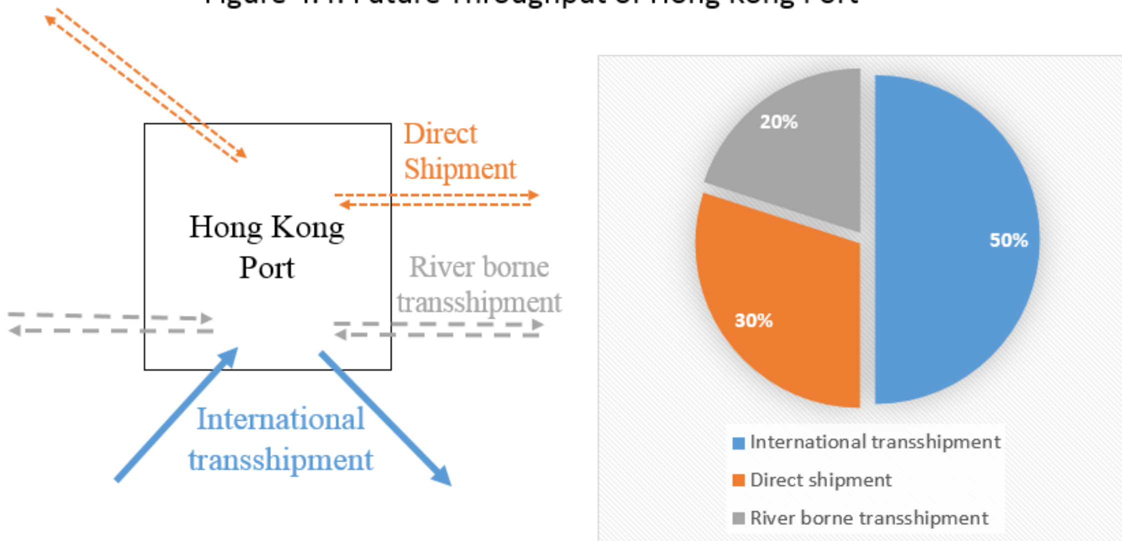
Table 4.4. Comparison of Shenzhen, Hong Kong and Salalah

Port	Direct Shipment	Transshipment	Gateway
Shenzhen	√	×	√
Hong Kong	√	√	√
Salalah	×	√	×

Measured by above three activities as shown in Table 4.4, both Hong Kong and Shenzhen are able to be categorized as gateway ports. First, both ports provide network services between Pearl River Delta and global destinations. Besides, for containerized cargo exchange between PRD region and global destinations, Hong Kong and Shenzhen are almost the only two links. Guangzhou port, in the future, has the potential to be a new gateway for PRD region. Finally, both Hong Kong and Shenzhen contribute intensively for regional economy growth.

Hong Kong is also a special case. Hong Kong port serves both regional and international transshipments.

Figure 4.4. Future Throughput of Hong Kong Port



By this definition, even if Hong Kong Port does not serve direct shipment of PRD any more, it is still one gateway of PRD, given that the port maintains considerable percentage of river borne transshipment for the hinterland.

For the entire PRD, in the short run, a duo port system of Shenzhen and Hong Kong will serve the region. The throughput of Hong Kong is dependent of that of Shenzhen port. Direct shipment of Hong Kong will continue to drop as Shenzhen's expansion and Guangzhou's emerging. However, the Hong Kong-Zhuhai-Macau Bridge slows the process when the project is complete. In the long run, a triple port system of Shenzhen-Hong Kong-Guangzhou will come into being. Each port performs its special functions. Shenzhen mainly serves direct shipment of containers. Hong Kong focuses on container transshipment and international transshipment. Guangzhou serves general cargoes.

In summary, this thesis has tested the correlation between the direct shipment and transshipment of Hong Kong and external effects of Shenzhen. The results release that transshipment of Hong Kong has both short term and long term correlation with total throughput of Shenzhen. While direct shipment of Hong Kong is not significantly affected by Shenzhen, local export or re-export in long term are factors influencing direct shipment.

Current port transshipment throughput increase for Hong Kong is a result of multiple factors, location, barge connectivity, Shenzhen ports handling capacity, and the terminal cost. Direct shipment is affected by the land connectivity and terminal cost. In the future, Hong Kong and Shenzhen constitute a regional port system to serve Pearl River Delta.

5. Conclusions

This thesis has studied the port throughput, which has been divided into transshipment and direct shipment. Transshipment has become a dominant part of the throughput with rapid growth in the past 15 years in Hong Kong. On the other hand, direct shipment of Hong Kong has been experiencing a slow decay.

The major factors lead to the change of Hong Kong is from multiple aspects. From internal factors, Hong Kong is a small economic entity, the demand for foreign goods and services are limited. The limited land connectivity between Hong Kong and Pearl River Delta has also reduced the traffic volume. The overall cost of direct shipping goods from Hong Kong is generally higher than Shenzhen Port and Shanghai Port, which is an accumulated result of developed economy and over-heated real estate market. The land usage highly limited the development potential of Hong Kong's shipping industry. Compared with the land transportation cost, river transportation of Hong Kong still enjoys the advantage of international trade with an international transshipment, which results in simplified checking and documentary procedure. As a result, increasing numbers of containers are transported by river to Hong Kong for transshipment.

Externally, before the raise of Shenzhen Port, Hong Kong serves as the only gateway of Pearl River Delta. However, Shenzhen has the cost advantage and well-constructed connections with cities in Pearl River Delta. As an external competitor, Shenzhen has been absorbing the direct shipment amount of PRD largely, which in return, causes the drop in Hong Kong's direct shipment. On the other hand, Shenzhen acts as a stimulus for Hong Kong's transshipment growth. The growth in Shenzhen's throughput will predict a growth in Hong Kong's transshipment volume, and the effect happens at the same period of calculation. External factors, such as global economic change and the geographical location also contribute to transshipment growth.

In the future, Hong Kong will still be a gateway connecting PRD and global destinations. To compete with Shenzhen and enhance the position in world port ranking, Hong Kong needs a series of port policies. First, a new land rental and usage plan for Kwai Tsing terminal, and additional yard area should be provided for increasing demand on transshipment services. Some new barge terminals may be constructed for increasing river transport. Some river terminals may be reconstructed to ocean terminals to solve the problem of congestion. The connection between Hong Kong and PRD region could be enhanced by the new Hong Kong-Zhuhai-Macau Bridge, but the future cost of crossing will affect the usage. Creating connection with other provinces such as Guangxi and Hainan, or foreign countries such as Vietnam may create demand for Hong Kong Port.

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