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Peripheral Challenge in Container Port System: A Case Study of Pearl River Delta

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Abstract: The growth of peripheral ports to dominant hubs has been well documented in North America and Europe, and has led to the elaboration of several theoretical models. However, although changes in containerization growth have been taking place in the South and East Asia in recent years, particularly in China, only a few studies have focused on this region. The Pearl (Zhujiang) River Delta (PRD) has a typical port system with hub and peripheral ports, and provides an excellent case for studying the Peripheral Challenge. This paper introduces the theoretical evidence of the Hayuth model and analyzes the evolution of the container port system in the PRD with five phases: 1) phase I: preconditions for change and phase II: initial container port development in the 1970s and early 1980s; 2) phase III: diffusion, consolidation, and port concentration in the middle and late 1980s; 3) phase IV: the load center in the 1990s; and (4) phase V: the Peripheral Challenge since the late 1990s. The results illustrate that the Shenzhen port presents mounting challenges to the Hong Kong port, descending from a transshipment hub of China to a regional load center of Southeast China. Furthermore, this paper explores five points that have led to the evolution of the port system in the PRD: 1) competition in the regional port systems; 2) different interested parties; 3) shift of investment strategies of international terminal operators; 4) integration of shipping networks and reorganization of carriers; and 5) cost-based competition.

Keywords: Hayuth model; peripheral challenge; Pearl River Delta (PRD); container shipping

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1 Introduction

Port system and port competition are major research fields in port geography. Since the 1960s, a number of studies have focused on enriching the port system theory with new features and a special development mechanism. Many forces have shaped maritime shipping network and port development together over the last half-century. A number of theoretical models have been used to reveal the mechanism for the evolution of container port systems in terms of forelands, hinterlands, and technology. For example, the six-phase model presented by Taaffe and Morril (1963) was regarded as the most classic model in port geography, and established the theoretical frame for port geography. The Taaffe model describes the spatio-temporal evolution of the port system and emphasizes the linkages between the port and its hinterlands; however, the Taaffe model ignores the inter-ports linkages. In the 1970s, further researches revised the Taaffe model and put forward some new models, such as a four-phase model offered by Haggett (1966) which stresses not only the linkages between the port and its hinterlands but also the inter-port linkages. In a word, geographers have seldom

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examined the relationship between the hub and peripheral ports when discussing the development of hub ports. How are they related to each other? Do hub ports and peripheral ports cooperate or compete with each other in cargo handling, shipping routes, hinterlands, and division of terminal functions? Most researches do not provide a clear answer.

Containerization, which began in the late 1950s (Gilman, 1982), is a great improvement to ocean shipping compared with the traditional cargo-handling technique. In the mid-1960s, most ports in the world began to use this new technology. Containerization technology became a competitive impetus among ports for expanding their hinterlands, resulting in the restructure of port hierarchies. Many researches have focused on the container port system since the 1970s. Mayer (1978) and Slack (1990) analyzed the differentiation of hubs and feeder ports, as well as the causes of decentralization. Hayuth (1981; 1988) examined the development of the container port system in the United States and described its evolution process with a five-phase model. This model, which is well-liked for studying the port system and is an important research landmark in port geography, emphasizes the port-hinterland relationship, as well as the inter-port linkage. Ever since then most studies have focused on case studies (Airriess, 1989; Kuby and Reld, 1992) or have improved the model to reflect the characteristics and development mechanisms of the port system in special regions (Starr, 1994; Notteboom, 1997; James, 2000). In China, several scholars have studied the container port system since the late 1990s (Cao, 1999; Cao *et al.*, 2004; Wang, 2007; Wang, 2008), including the introduction of the Hayuth theory and related case studies. Some studies focused on the development mechanism of the Hayuth theory (Cao and Cao, 2003), where the fifth phase is explained as *the Peripheral Port Challenge.*

Since the 1990s, the Pearl (Zhujiang) River Delta (PRD) has become one of the most active areas in the East Asian port system, considering the competition between the Hong Kong and Shenzhen ports. Therefore, examining the validity of the Hayuth model in this region is meaningful, especially considering the policy of 'one country with two systems' in the PRD. In this respect, the following issues are worth researching. Has the PRD container port system become concentrated or de-concentrated in recent years, and to what extent? Do small ports disappear gradually or form challenges to the hub port, as described in the fifth phase of the Hayuth model? What factors have affected the evolution of the PRD port system?

2 Peripheral Challenge: Theoretical Evidence

The five-phase model of Hayuth was developed from empirical research in the United States container port system during 1956–1970. The evolution of the container port system is divided into five phases in the model, with each phase having its own characteristics and development mechanisms.

In Phase I, preconditions for change, each port's development level and uniqueness in pre-containerization are analyzed, and the whole port system stays in a balance status, with stable patterns, hierarchical structure and hinterland areas. In this phase, technological innovation is needed for traditional ports and it becomes the interior drive for a port to realize containerization.

In Phase II, initial container port development, containerization technology is applied in large ports and several small ports firstly, widening the difference of ports. However, in this phase, only a few container ports and container vessels exist, and container shipping is mainly concentrated at local market.

In Phase III, diffusion, consolidation, and port concentration, containerization technology has become prevalent in the port system. The port that adopts the containerization technology early attracts the most container traffic and becomes a dominant port. The feeder shipping of secondary ports to major ports also begin to develop. A new port system is shaped gradually.

In Phase IV, the load center, the hub port expands further and continues to hold the most traffic. Meanwhile, inland transport corridors are constructed, and gradually intensify the concentration of the port system and port competition. The hub ports compete with each other for the international shipping and the small ports compete for the feeder shipping. Then, the new port hierarchical structure is strengthened.

The last phase of the Hayuth model is the Peripheral Challenge, and focuses on the relationship between the hub and peripheral ports. This phase reflects the de-concentration trend of the container port system. The last phase is the research focus of this paper.

The phase of the Peripheral Challenge in Hayuth model has several characteristics. First, the hub port continues to attract most traffic but faces many limitations for further expansion, such as land shortage, cost increase, traffic congestion, the need for a deep-water port, the inhabitants′ protest to port expansion, and environmental protection. All these limitations lower the advantages of scale economies and weaken the competitiveness of the hub port (Baird, 1997). Currently, many hub ports in Europe, North America, and East Asia are confronting similar problems. Second, the conditions of peripheral ports are greatly improved by constructing transport routes to hinterlands and cargo-handling infrastructures, *etc*. Besides, peripheral port has deep-water berths for large vessels, abundant land resources and low-cost labors. These characteristics were put forward according to the development background before the 1980s. Currently, new characteristics have gradually formed: 1) the central or local government, either by promulgating port planning or by providing preferential policies for a port, has begun to play an important role for the development of a port system or a single port; and 2) carriers and terminal operators have significant influences on the development of the peripheral port through reorganizing the shipping route network and shifting investment in terminal construction. However, due to the socio-economical background then, Hayuth did not pay more attention to the characteristics mentioned above and add them into the theory. With the increase of competitiveness of peripheral ports, they gradually form peripheral challenges and become hub ports. The relative advantages of the hub port gradually weaken and may even disappear in the end. The container port system enters a transition and likely steps into an initial phase of a new port system. The conditions mentioned above are the foundation for the Peripheral Challenge. In recent years, some hub ports have begun to enter the Peripheral Challenge phase. Two classic examples are well known: 1) the Singapore port and Tanjung Pelepas port in Malaysia, and 2) the Hong Kong and Shenzhen ports.

3 Case Study in Pearl River Delta

3.1 Study area

The PRD has entered the fifth phase of the Hayuth model, *Peripheral Challenge,* which was also known as the decentralization stage. In this paper, 25 container ports in the PRD were selected: Hong Kong, Shenzhen, Guangzhou, Shantou, Shanwei, Huizhou, Zhongshan, Zhuhai, Zhanjiang, Maoming, Zhaoqing, Shatian, Mayong, Xintang, Jiangmen, Xinhui, Yangjiang, Sanbu, Gongyi, Xinshi, Rongqi, Xinan, Wuhe, Taiping, and Nanhai. All 1970–2007 data are obtained from the Year Book of China Transportation & Communication (Editorial Board of China Transportation & Communication, 1971–2008).

3.2 Evolution of container port system in Pearl River Delta

(1) Phases I and II: Preconditions for change and initial container port development in the 1970s and the early 1980s. In the 1970s and the early 1980s, the port system in the PRD was divided into two parts: the Hong Kong port and the other ports. The Hong Kong port began its containerization in the late 1960s, roughly at the same time as ports in Europe and the USA. In 1970, the container traffic of Hong Kong port reached 35 679 TEU (Twenty-feet Equivalent Unit). In 1972, the first container wharf in Hong Kong region was built by Modern Terminals Limited. In the mid-1970s, the other ports in the PRD also began their containerization process. In the preconditions for change phase, Guangzhou was the largest one with traffic of 1.0×10^8 t in 1976, followed by Zhanjiang and Shantou ports with throughputs of 9.47×10^6 t and 1.53×10^6 t, respectively. In 1977, Guangzhou port was furnished with the 25–36 t forklift, small matching forklifts, and trailers, equipped with the handling capacity for international containers. In 1980, Guangzhou port′s traffic reached 7300 TEU. In the late 1970s and the early 1980s, the ports in the PRD stepped into the second phase of the Hayuth model. Hong Kong port and the other ports were appropriate for different containerization paths, because the Hong Kong Region and the mainland of China were in different economic development levels and had different institutional settings.

(2) Phase III: Diffusion, consolidation, and port concentration in the middle and late 1980s. Since the late 1970s, international trade and marine shipping have emerged and propelled the development of China′s container ports. With the success of the Guangzhou port, the other ports followed and adopted containerization technology, including the Zhanjiang port in the early 1980s, and the ports of Zhuhai, Jiangmen, Shanwei, and

Zhongshan in 1986. Since then, the number of container ports has increased gradually (Fig. 1). In 1988, the ports of Shenzhen and Shantou owned the ability of container shipping, and then the development of Shenzhen port became outstanding in the PRD. In the same year, the Hong Kong port attained traffic of 1.46×10^6 TEU, accounting for 90.6% of the total in the PRD, much higher than that of others ports (e.g., 1.2×10^5 TEU in the Guangzhou port and 1.3×10^4 TEU in the Shenzhen port). During this phase, the Hong Kong port was the hub, whereas the other ports were feeders that had to connect to the international shipping network via Hong Kong port. The Gini coefficient is a widely used index to assess the concentration level of traffic in one port system, its value is high, the traffic distribution in the port system is more unequal and only several ports expand rapidly to become the hub. As shown in Fig. 2, the

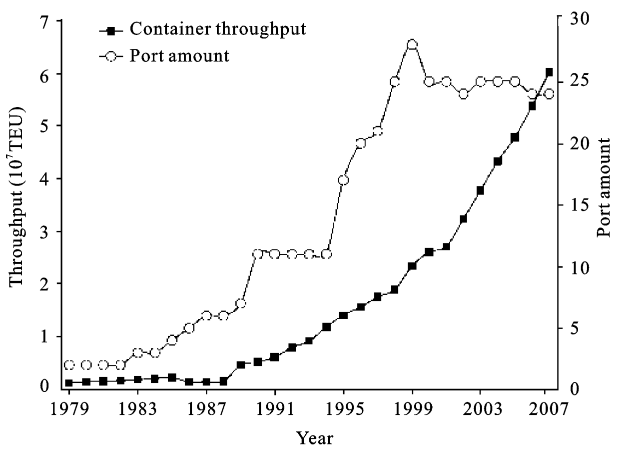

Fig. 1 Number of container ports and container throughput in Pearl River Delta (1979–2007)

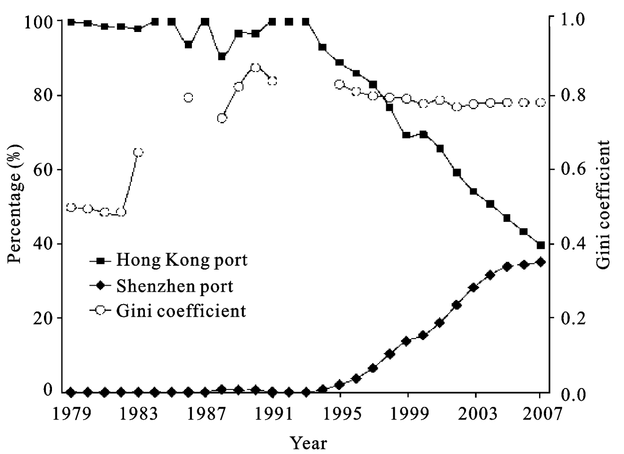

Fig. 2 Gini coefficient in Pearl River Delta and traffic proportion of Hong Kong and Shenzhen ports (1979–2007)

Gini coefficient has increased rapidly in the PRD and it reflects the concentrating trend of container traffic on Hong Kong port.

(3) Phase IV: Load center in 1990s. Since the 1990s, the export-oriented trade in the PRD has rapidly developed. With the mature operation of the front-shop-back-factory cooperation model, container cargo and international marine shipping lines have grown. The PRD port system stepped into the fourth phase, the load center, of the Hayuth model. Meanwhile, most ports have completed containerization (Fig. 3). The container port number increased from 11 in 1990 to 28 in 1999, and then remained stable (Fig. 1). With the further improvement of inland transportation, corridors from the hub port to the hinterlands emerged. In the early 1990s, several highways connected to the ports came into operation, such as the Guangzhou—Shenzhen, Shenzhen—Shantou, and Huizhou—Shenzhen highways. To the Guangzhou-Shenzhen railway, its third line was added in 1994, and its first line and second line were also electrified in 1997. These changes improved the accessibility of the PRD, especially the Hong Kong and Shenzhen ports. In 1990, the Hong Kong port handled 5.1×10^6 TEU, accounting for 96.7% of the total traffic. Although the throughput of the Hong Kong port continued to rise after 1990 and achieved 1.6×10^7 TEU in 1999, its ratio decreased to 69.4%. Accordingly, the Gini coefficient declined slowly and further demonstrates the developing trend of Hong Kong port (Fig. 2). Conversely, the peripheral ports developed rapidly, and their ratios of traffic increased gradually. For example, the Shenzhen port handled 3.23×10^6 TEU and accounted for 13.8% of the total traffic in 1999. In this phase, the feeder network of the Hong Kong port was stable with mature inland transport and water shipping networks through the Pearl River.

(4) Phase V: Peripheral challenge since the late 1990s. In the late 1990s, the container port system in the PRD stepped into the fifth phase of the Hayuth model, the Peripheral Challenge (Fig. 3). Since then, competition has existed between the Hong Kong and Shenzhen ports. The total number of container ports dropped to 24 during this phase. The Gini coefficient decreased slightly in the early years, but has again increased in recent years because of the rapid expansion of the Shenzhen port. Although the container traffic of the Hong Kong port is continuously and slowly increasing, its proportion has

declined persistently. In 2007, the Hong Kong port handled 2.4×10^7 TEU, and its proportion declined to 39.7%. With the expansion of Hong Kong port, diseconomies of scale emerged because of the lack of space and high labor and terminal operation cost. Meanwhile, the container facilities of the Shenzhen port were improved rapidly with the injection of foreign investments. Some carriers moved from the Hong Kong port to the Shenzhen port, resulting in a certain degree of de-concentration in the port system. Consequently, the traffic of the Shenzhen port rose, and its proportion increased to be the highest annual growth rate in the PRD. In 2007, the Shenzhen port handled 2.1×10^7 TEU (Fig. 3), accounting for 35.1% in the PRD, only 4.6% lower than that of the Hong Kong port (Fig. 2). The rapid development of the Shenzhen port has resulted in a small growth of the Gini coefficient in recent years. The Guangzhou port also developed quickly and achieved traffic of 9.3×10^6 TEU in 2007, accounting for 15.4% of the total in the PRD.

3.3 Methods for peripheral challenge

To obtain available and comparable data, 1970 is selected as the base year to analyze the Peripheral Challenge in the PRD port system. Assuming P represents the peripheral port; H represents the hub port; t is container traffic of port. Then the equation to calculate t_i is:

$$t_i = t_{io} + t_{ic} + t_{id} \tag{1}$$

where t_{io} is the international shipping volume of port i; t_{ic} is the coastal shipping volume of port i; t_{id} is the domestic shipping volume of port i.

Assuming T_o is the total international container traffic in the PRD and consists of the international traffic of hub ports t_{ho} and peripheral ports t_{po}. The equation is as follows:

$$T_o = t_{ho} + t_{po} \tag{2}$$

In 1996, the Shenzhen port became the calling port of Global Alliance, Grand Alliance, and Maersk/Sealand, and thus joined the global container shipping network. The container traffic of the Shenzhen port began to increase, chasing that of the Hong Kong port. Thus, 1997 is selected as the base year for the forecast. The Guangzhou port, another important port in the PRD, can not be ignored because it has been shipping international containers since the 1980s. In this paper, a time series model is adopted to forecast the international container traffic of the port system in the PRD and the Guangzhou port. The equation is expressed as follows:

$$t_{io}' = ax^2 + bx + c \tag{3}$$

where a and b are parameters, and c is a constant; t_{io}' is the international container traffic of port i, including the hub port H and the peripheral ports P; x is the time length from the base year to the forecast year.

Then, assuming t_{go} is the international container traffic of the Guangzhou port. According to the total international container traffic T_o in the PRD from 1979 to 1997, the forecast model of the international traffic in the PRD and of Guangzhou port during 1998–2007 are simulated as follows:

$$T_o' = 7.234x^2 - 64.453x + 260.01 \tag{4}$$

$$t_{go}' = 0.237x^2 - 2.274x + 7.277 \tag{5}$$

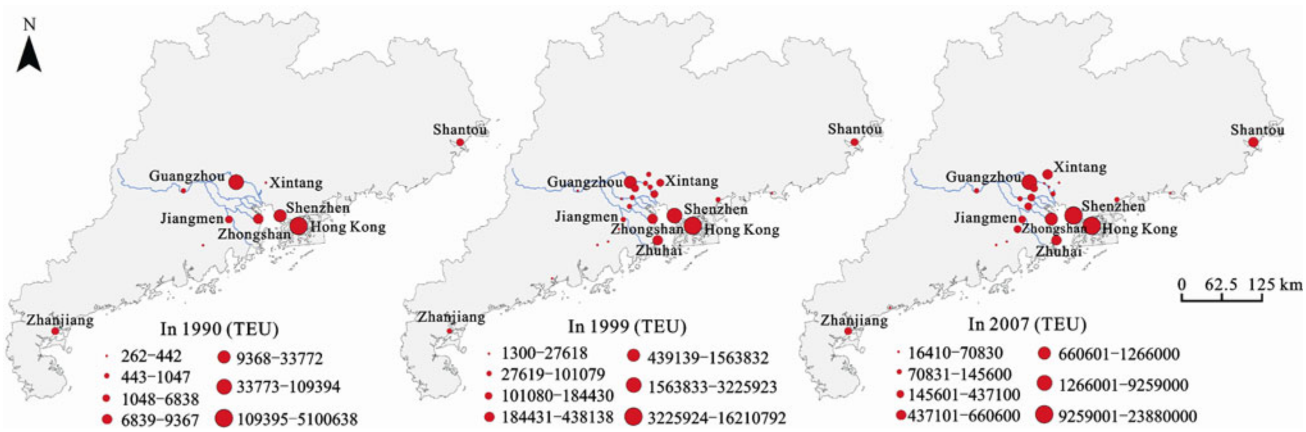

Fig. 3 Spatial pattern of container port system in Pearl River Delta in 1990, 1999 and 2007

where T_o' is the forecast value of T_o; t_{go}' is the forecast value of t_{go}.

The forecast international container traffic of the hub port t_{ho}' (i.e., Hong Kong port) from 1998 to 2007 is transferred as:

$$t_{ho}' = T_o' - t_{go}' \quad (6)$$

The forecast traffic data is compared with the actual traffic data with the error ratio δ. The formula is given as follows:

$$\delta = (T_o' - t_{ho} - t_{po}) / (t_{ho} + t_{po}) \times 100\% \quad (7)$$

Measuring the challenges of the peripheral port P_i (i.e., Shenzhen port) to the hub port H is the point of the research. And the challenge here is expressed by the diversion index. Generally, the indices t_{ic} and t_{id} are determined by the peripheral port P_i itself; however, the international cargoes t_{io} need to be transferred via the hub port H. Therefore, the Peripheral Challenges of the Shenzhen port to the Hong Kong port can be measured by the traffic of the international shipping routes. The diversion index is written as follows:

$$\sigma = (t_{so} / t_{ho}') \times 100\% \quad (8)$$

where σ is the diversion, t_{so} is the international container traffic of Shenzhen port.

3.4 Results

The major forecast results are shown in Table 1.

Comparing the forecast traffic with the actual traffic of the Hong Kong and Shenzhen ports, four points are evident:

Table 1 Forecast traffic result of Hong Kong and Shenzhen ports

Year	T_o' (10^4 TEU)	t_{go}' (10^4 TEU)	t_{ho}' (10^4 TEU)	δ (%)	σ (%)
1996	1444	43.08	1400.64	0.66	2.52
1997	1647	49.57	1597.36	4.05	4.00
1998	1734	56.54	1677.46	3.33	8.92
1999	2000	63.97	1936.03	1.28	14.18
2000	2300	71.88	2228.12	1.17	16.67
2001	2440	80.27	2359.73	3.92	19.71
2002	2780	89.12	2690.88	2.19	25.85
2003	3170	98.45	3071.55	0.21	32.42
2004	3550	108.26	3441.74	–2.26	37.52
2005	3850	118.54	3731.46	–2.64	41.20
2006	4200	129.29	4070.71	–2.72	43.10
2007	4550	140.51	4409.49	–2.91	45.36

(1) As shown in Table 1, the data are valid and the methods are effective. The error ratio of δ in each year is small and lower than 5%. All of the results are within the accepted error range. It shows the forecasting data are applicable to analyze the Peripheral Challenge from the Shenzhen port to the Hong Kong port.

(2) As shown in Table 1, the total international container traffic of port system in the PRD should reach 1.647×10^7 TEU in 1997 theoretically, and continuous to keep the fast growth in the next few years. According to the forecasting data, it should reach 4.55×10^7 TEU in 2007, and increase by 2.90×10^7 TEU. This shows that there is a rapid growing trend of the international container trade. Guangzhou port has been always the one gateway of west region of the PRD since the 1980s, and should achieve the international container traffic of 4.957×10^5 TEU in 1997 which accounts for 3% of total international traffic in the PRD. This port also should keep a rapid growth and achieve 1.405×10^6 TEU in 2007, and hold on the share of 3.1% or so.

(3) As the major gateway port of the PRD, the container traffic of the Hong Kong port has grown at a high rate since the 1990s. In 1996 its actual container traffic reached 1.4×10^7 TEU and accounts for 97% of the total container traffic in the PRD. According to the developing trend before 1996, it should continue to keep a high growth ratio and hold on the most shares. As shown in Table 1, it should achieve the throughput of 4.4×10^7 TEU in 2007 and account for 96.9% of the total international container traffic in the PRD, and increase by 3.0×10^7 TEU than that in 1996. However, its actual growth rate began dropping after the late 1990s. For instance, the Hong Kong port only had an increase of 1.5×10^4 TEU in 1998 with a growth rate of 0.1%, much lower than its theoretical growing rate of 5%, and its container traffic accounts for 86.5% of the international container traffic in the PRD, but its theoretical traffic should reach 1.68×10^7 TEU in this year accounting for the 96.7% which is higher than its actual proportion. In 2007, the Hong Kong port handled 2.39×10^7 TEU and only accounts for 54.2% of the theoretical throughput which is 4.4×10^7 TEU in this year, with an increase of 9.90×10^6 TEU than in 1996 and is lower 2.01×10^7 TEU than the theoretical growth of 3.01×10^7 TEU. For the Hong Kong port, its Kuiqing Terminal covered 1.43×10^7 TEU, with a 6.4% increase in 2005, whereas other terminals handled 8.1×10^6 TEU, with a 4.9% decline.

Meanwhile, Hutchison port and Modern Container had a negative growth of traffic in the Kwai Chung Terminal of Hong Kong port, where the traffic declined for successive four months beginning in June 2006. From 1999 to 2004, the Hong Kong port was the largest container port in the world; however, because of the continuous competition from Shenzhen port and decrease of container traffic, it was surpassed by the Singapore port in 2005 and then the Shanghai port in 2007, and has now become the third largest port. Whereas, as shown in Table 1, if Hong Kong port could keep its theoretical growth, its traffic would continue to top the world′s first and is higher than the traffic of Singapore and Shanghai ports. The transshipment traffic of Hong Kong port increased slowly, and part traffic was transferred to the Shenzhen port. Consequently, the Hong Kong port has fallen from a hub port for Asia and China into a load center for South China.

(4) The Shenzhen port, which began operations in 1981, had the largest growth rate over the past few years before 2007. In 1996, its traffic was only 3.5×10^5 TEU, accounting for 2.5% in the PRD. In 2005, the Shenzhen′s international container traffic surpassed 1.537×10^7 TEU, achieving 38.9% in this region and becoming the world′s fourth largest container port. However, in this year Hong Kong port only completed the traffic of 2.24×10^7 TEU, and it is lower 1.49×10^7 TEU than its theoretical traffic which is almost equivalent to the traffic of Shenzhen port. In 2007, the Shenzhen port handled the international container traffic of 2.0×10^7 TEU, and is also almost equivalent to the decrease of Hong Kong port which reaches 2.01×10^7 TEU. Furthermore, Fig. 4 shows the close relationship of the international container traffic between the Hong Kong and Shenzhen ports. The international traffic data of the Hong Kong and Shenzhen ports couple well with the actual data of Hong Kong port from 1970 to 1997, as well as with the theoretical traffic of Hong Kong port after 1997. In 2007, the sum of actual international container traffic of Hong Kong and Shenzhen ports reaches 4.388×10^7 TEU and is only lower 2.1×10^5 TEU than the theoretical throughput of Hong Kong port. Therefore, the increase of international traffic in the Shenzhen port has been proven to be derived from the Hong Kong port. Since the late 1990s, the difference between the Hong Kong and Shenzhen ports has begun to reduce gradually (Fig. 5). Gap values were 1.41×10^7 TEU in 2000, but only 2.8×10^6 TEU in 2007. The index σ in Table 1 can provide the forceful explanation for the diversion of Shenzhen port to Hong Kong port. It was only 2.52% in 1996, but continuous to expand in the next few years and increased to 45.36% in 2007. The change of diver-

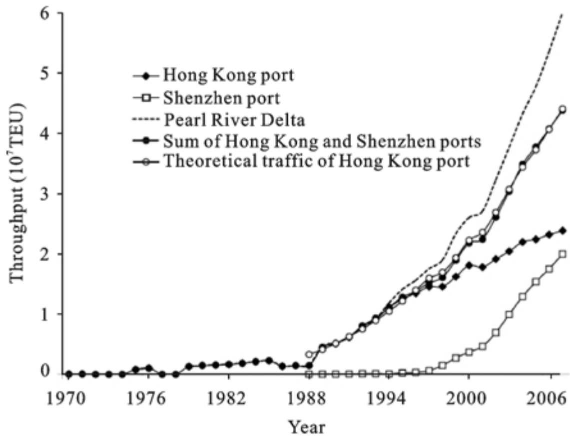

Fig. 4 Evolution of container traffic in Pearl River Delta

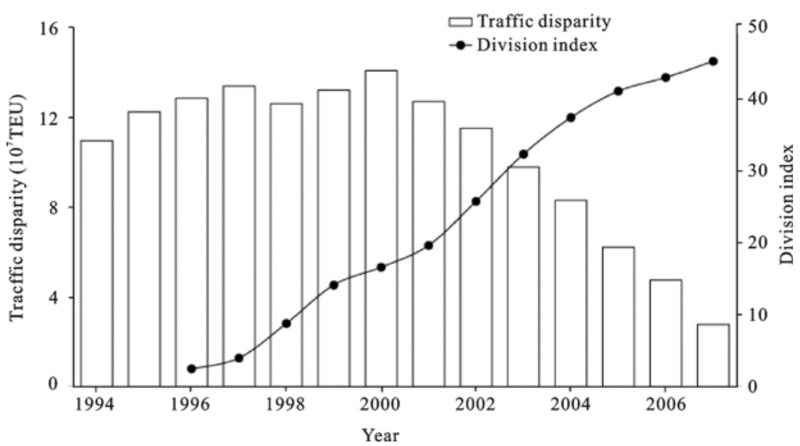

Fig. 5 Evolution of diversion index and disparity between Hong Kong port and Shenzhen port

sion index σ indicates that the transfer of international containers from the Hong Kong port to the Shenzhen port intensified.

4 Mechanisms of Peripheral Challenge in Pearl River Delta

The significant changes in the PRD over the past few decades are twofold: 1) the era of Hong Kong port as the monopolistic gateway for the mainland of China was over; and 2) the Shenzhen port began to compete with the Hong Kong port by offering direct international shipping. To explore the mechanisms behind these challenges, five points are considered.

4.1 Competition in regional port systems

Interior competition is the primal impetus to the Peripheral Challenge due to several reasons. First, the extent of Chinese international containers transferred by Hong Kong port has gradually fallen since the 1990s. In 1997, Chinese container traffic was less than 1.0×10^7 TEU, and only the Shanghai port handled over 1.0×10^6 TEU. In 2005, the total traffic reached 7.58×10^7 TEU, with ten ports each handling over 1.0×10^6 TEU, and some being trunk ports. Chinese ports lessened their dependence on Hong Kong port for transferring international traffic, its transferring ratio reducing from 10% in 1997 to 2.4% in 2005. In terms of the *National Coastal Port Planning of China in 2006*, the Shenzhen port will be constructed as the hub port of South China, further shrinking other ports′ dependence on the Hong Kong port.

Second, ports close to one another share almost the same navigation channels, hinterlands, and offer similar shipping services and port facilities. This is why intra-industry competition exists. The main behavior for interior is bidding (i.e., price competition). To attract container cargoes and carriers, many ports go toe-to-toe to reduce their service fares, even at no profit. With the government′s implicit subsidies, the situation becomes worse. Because of its closeness to the hinterlands and its low-cost labor, transport fares, and port services, the Shenzhen port became the main competitor of the Hong Kong port. Most international cargoes in Western Guangdong are mainly exported through the Shenzhen port (Table 2).

Third, the significant change of industrial structure in the PRD since the 1990s was also a major reason for the transformation of cargo transport. Traditional processing and manufacturing industries of Hong Kong Region were gradually reduced, and finance and business led the economic development. Accordingly, the processing and manufacturing industries of Hong Kong Region transferred to the other regions in the PRD, specifically Shenzhen and Dongguan. The PRD has become a world processing trade base with ′both material supply and market overseas′, which drives the changes in major commodity and logistics structure in this region, as well as the transfer of the cargo transport business from the Hong Kong port to the Shenzhen port.

Table 2 Feeding proportion of the feeder ports in Pearl River Delta to Hong Kong and Shenzhen ports

Port region	Feeder port	Hong Kong port (%)	Shenzhen port (%)
West region	Jiangmen	80–90	10–20
	Zhongshan	80–90	10–20
	Zhuhai	95	5
Middle region	Guangzhou	93	3
	Foshan	100	
East region	Dongguan	30	65
	Huizhou	40	40

Source: http://info.hktdc.com/shippers/vol29_6/vol29_6_chi_logistic. htm

4.2 Different interested parties

Although Hayuth proposed the Peripheral Challenge as the fifth phase in his model, he neither pointed out its applicable range nor considered the political or administrative impacts. According to the areas where the Peripheral Challenge occurs, the hub and peripheral ports generally belong to different interested parties, and even to different countries. The side with the hub port attempts to control the international transshipment of the adjacent countries and to hold their gateway role in that region. In contrast, the other side with feeder ports attempts to construct deep-water wharfs near the hub port to maintain the independent role in the international shipping network and to reduce transshipment.

Before the 1980s, the ports in the mainland of China had not yet adopted the containerization technology, and their international cargoes were mainly transferred via the Hong Kong port. Hong Kong port was the international gateway of the mainland of China until 1995. In 1997, Hong Kong Region returned to China, and the competition between the Hong Kong and Shenzhen ports changed from being ports owned by two different countries to ports managed and operated by two different sectors. Due to the 'one country, two systems' principles, Hong Kong Region has thus far managed to keep its international identity. Therefore, the trade between Hong Kong Region and the mainland of China is still regarded as 'international', and the Hong Kong port retains its free port status. Thus, a container from a mainland port to Hong Kong Region must clear customs at the latter. However, the same rule does not apply to the case of sending and receiving containers between two mainland ports. The above difference in transshipments between the Hong Kong port and a mainland port and between two mainland ports has various implications to carriers. Moreover, exporting directly from the local jurisdiction might result in greater economic and political benefits. Therefore, the local government plays an important role in making port policies. As a special economic zone in the mainland of China, the Shenzhen is given many privileges and preferential policies in terms of tax, land, and so on in order to attract foreign investments and international terminal operators and carriers. These also strengthen the Peripheral Challenge from the Shenzhen port to the Hong Kong port.

4.3 Shift of investment strategies of international terminal operators

In recent years, the investment behavior of terminal operators has impelled the Peripheral Challenge. The Chinese government promulgated *Provisions on Guiding Foreign Investment Direction* in 2002, allowing foreign enterprises in Sino-foreign joint ventures to buy shares and even hold the majority in Chinese companies, thereby attracting foreign investments for the development of the Shenzhen port.

First, most port facilities in Hong Kong Region are financed, owned, and operated by the private sector. However, local government of Hong Kong Region is unable to provide sufficient public subsidies or other support, and is restricted to undertaking long-term planning for port development, such as building roads and dredging access channels to the terminals. Since 1993, capital shortcoming in the Hong Kong port has hindered the construction of port infrastructure and the enhancement of its handling capacity. In contrast, the Shenzhen port is owned and operated by the government, and thus receives economic and political support from the government, such as preferential policies, public subsidies, and others, to enhance their handling capacity.

Second, many terminal operators have shifted their investment focus from the Hong Kong port to the mainland ports. Some have even withdrawn their investments or dropped their investment plans in the Hong Kong port. These terminal operators can offset their loss through high return on investments in the mainland ports. Since the early 1990s, the terminal operators of Hong Kong Region have strengthened their investments in the mainland ports, particularly the Shenzhen port. For example, the Hutchison Port concentrates its investment in the Yantian Terminal of Shenzhen port; Modern Terminals Limited focuses its investment chiefly in the Chiwan and Dachanwan Terminals of Shenzhen port; and Chinese Merchant mainly invests in the Shekou, Nanjibu, and Chiwan Terminals of Shenzhen port. Other famous terminal operators have also enhanced their investment in the Shenzhen port, such as P&O Nedlloyd. By the end of 2005, the Shenzhen port had attracted the investment of 3.0×10^{10} yuan (RMB) and constructed a 24.5 km terminal shoreline and 23 container terminals, achieving a handling capacity higher than the capacity planned by the National Transport Ministry in 1998. For example, the container handling capacity increased from 1.0×10^7 TEU to 1.5×10^7 TEU in the Yantian Terminal, from 5.0×10^6 TEU to 1.0×10^7 TEU in the Shekou Terminal, and from 5.0×10^6 TEU to 7.0×10^6 TEU in the Dachanwan Terminal. The infrastructure and facilities, technology, the handling efficiency, and service level in the Shenzhen port greatly improved and reached an international level.

In addition, to minimize the cost, the carriers became the stockholders of new terminals, and moved the call of container vessels from the hub port to the peripheral port, accelerating the traffic diversion from the hub port to the peripheral port.

4.4 Integration of shipping networks and reorganization of carriers

Shipping enterprises are also the operating carriers. Therefore, they not only dominate the organization of the global container shipping network, but also control the global shipping resources and profoundly affect the rise and development of hub port. Two aspects reflect the significance of the carriers.

First, with the adjustment of the international carrier shipping networks, Global Alliance officially added Yantian into the calling ports in its Europe, Asia, and North America service in 1995, beginning the international shipping service in the Shenzhen port. Later, the Shenzhen port became a regular calling port of Grand Alliance, Maersk, Hyundai Merchant Marine, and K-Line. The Shenzhen port joined into the global shipping network, allowing its international cargoes into the international market directly instead of transshipping via the Hong Kong port. In 2006, the Shenzhen port was used by 660 container ships monthly, and the number of its international shipping routes rose to 131. These routes are operated by 50 international line carriers, and include 51 lines to North America, 3 lines to South America, 38 lines to Asia, 33 lines to Europe, 5 lines to Oceania, and 1 lines to Africa (Table 3). Therefore, the Shenzhen port has become one of the busiest ports in South China, and a hub port of the global shipping network.

Second, international carriers have further integrated the resources of terminals and other logistics, and the merger of terminal operators and carriers became a development trend in the global shipping market (Notteboom, 1997). For many ports in the PRD, attracting the carriers and supplying the preferential policies and effective services are important strategies for the government. Many famous carriers in the world, such as Maersk/Sealand and Orient Overseas Container Line, have invested in the construction and operation of the Shenzhen port. In 1994, Maersk purchased 10% of Yantian Terminal′s stock of Shenzhen port. When one carrier chooses a port as its hub, the carrier focuses its investment on the port′s construction and adjusts its shipping network to support the port′s development. These behaviors change the direction of container cargoes and shift them to the new hub for transshipment. Therefore, the new hub port rises significantly in traffic volume, and becomes promoted to a hub port in a short time.

4.5 Cost-based competition

According to the Hayuth model, a hub port will face many limitations if it continues to expand over the economies of scale because of land resources shortage, high labor and terminal handling cost, and transport congestion. These limitations increase operation cost and weaken the port′s competitiveness. For the Hong Kong port, some limitations continue to emerge, particularly the high cost of land transportation and port operation (Table 4 and Table 5). In contrast, the terminal handling charge in the Shenzhen port is much lower, and

Table 3 International shipping routes of Shenzhen port and major wharf region

Port and wharf region	North America	South America	Europe	Oceania	Africa	Asia	Total
Shenzhen	51	3	33	5	1	38	131
Yantian	36	—	18	1	—	5	60
Chiwan	7	2	16	3	1	13	42
Shekou	10	1	3	1	—	21	36

Source: http://www.szport.net

Table 4 Comparison of labor costs of Hong Kong and Shenzhen ports

Profession		Monthly salary		Shenzhen port/ Hong Kong port (%)
		Hong Kong port (Hong Kong Dollar)	Shenzhen port (yuan)	
Carrier	Shipping director	17290	4000–5000	23–29
	Shipping staff	11417	2500–3000	22–26
	Accountant director	18679	3500–4500	19–24
	Administrative director	17462	3500–4500	20–26
Container shipping	Control man	14480	2500–3000	17–21
	Driver	10861	5000–6000	46–55
	Deliveryman	8742	1000–1500	11–17
	Accountant	10312	1500–2500	15–24
	Secretary	8987	2000–2500	22–28

Source: Zhang *et al*. (2005)

Table 5 Comparison of operation costs of Hong Kong and Shenzhen ports

Profession	Handle cost			
	Office rent (yuan/(m^2 · month))	Container freight station handling expenses (yuan/m^3)	Container storage (yuan/(m^2 · month))	Transport costs (cargo vehicle)
Hong Kong port (Hong Kong Dollar)	300–650	50–100	30–50	50–60
Shenzhen port (yuan)	55–100	16–30	8–10	18–20
Shenzhen port/Hong Kong port	1/6	1/3	1/4	1/3

Source: Zhang *et al.* (2005)

accounts for merely 25%–75% of the charges in the Hong Kong port. For example, the terminal handling cost in Hong Kong port is 97 US Dollar higher than that of the Shenzhen port. Low handling cost is one of the competitive advantages of the Shenzhen port over the Hong Kong port, and has become a primary factor to attract carriers and cargo owners. Moreover, land resources are very scarce in Hong Kong region, blocking its further expansion.

Most cargoes of the Hong Kong port come from the PRD hinterlands. Generally, the container cargoes arrive in the Hong Kong port by inland transport and pass through customs before being exported to other countries. Here, inland transport is the main approach to obtain cargoes; thus, transport cost is a key factor to determine the competitiveness of the Hong Kong port. According to the *Hong Kong Port Master Plan 2020*, the high cost of inland transport and clearing customs from the mainland of China to Hong Kong Region is the dominant element in weakening its competitiveness. The transport costs from Shenzhen, Huizhou, Dongguan, Guangzhou, and Shantou to Hong Kong port are 2500, 3400, 3600, 5100, and 7300 yuan (RMB) per TEU respectively. For international transportation, one needs to pay double insurance premiums, vehicle check fees, and various administrative costs for cargoes from the mainland of China to Hong Kong Region, further raising transport cost. For example, the international shipping cost from Hong Kong port to Europe and North America is only USD 50 per TEU lower than from Shenzhen; however, the inland transport cost from Southern China to Hong Kong Region is USD 313 per TEU higher than that of Shenzhen, accounting for two-thirds of the port cost (Table 6). Moreover, all vehicles traveling between the mainland of China and Hong Kong Region must pay for the high cross-boundary-vehicles-use-fee of 1×10^5 yuan every three years to the Guangdong government. There are also some problems involving bilateral vessel inspection, license fees, insurance premiums, and so on.

5 Conclusions

Since the 1950s, the containerization technology has provided a new impetus for port competition. The last phase, *Peripheral Challenge*, in the five-phase model presented by Hayuth, describes the competition relationship between the hub port and its peripheral ports. However, the Hayuth model does not provide a detailed explanation for the development mechanism. Today, the PRD has become the focus of the Asian port system. This paper shows that, since 1997, the development of the container port system in the PRD has stepped into the phase of the Peripheral Challenge, and the challenge is mainly between the Hong Kong and Shenzhen ports. As the analysis of Hayuth, competition becomes an important mechanism behind the challenges from the peripheral port to the hub port, i.e. Shenzhen to Hong

Table 6 Transport cost of Hong Kong port and Shenzhen port

Content (USD)	Via Hong Kong port		Via Yantian, Shenzhen port		Via Shekou/Chiwan, Shenzhen port	
	20-feet Container	40-feet Container	20-feet Container	40-feet Container	20-feet Container	40-feet Container
Shipping cost	2000	2700	2000	2700	2000	2700
Incidental cost	599	1014	579		579	994
Trunk cost	308	333	128	154	141	167
Terminal handling cost	274	366	141	269	141	269
Total	3181	4413	2848	4117	2861	4130

Source: Economic Development and Labour Bureau (2004)

Kong Region, and the peripheral port has lower operational costs than the hub port. In this paper, we have explored some special reasons for the formation of the Peripheral Challenge due to the policy of 'one country, two systems'. In other words, when the hub and peripheral ports belong to different interested parties, such as two countries or two administrative regions, competition between them is easily directed. In recent years, the carriers and terminal operators have played important roles in strengthening the Peripheral Challenge. International terminal operators have shifted their investment focus from the hub to peripheral ports, resulting in the improvement of the handling technology and enhancement of container-handling capacity of the latter. The super-carriers have also integrated the logistics resources and have reorganized their shipping networks to call at the peripheral ports directly. Furthermore, some super-carriers have become stockholders in the terminals of peripheral ports, attracting cargoes and heightening the port's infrastructure-utilizing efficiency. The case study in this paper examines the validity of the Peripheral Challenge in the Chinese context, specifically under the special background of the policy of 'one country, two system' to help enrich the Hayuth theory.

With the rapid construction of many small ports, the terminal capacity in the PRD will be surplus in the future; thus, the PRD needs to strengthen the government restrictions of port construction. The port competition among the large ports, including the Hong Kong, Shenzhen, and Guangzhou ports, will also be intensified, and the division relationships of port function in the PRD, especially among large ports, need to be regulated and clarified. Furthermore, the competition focus should be shifted from the interior of the PRD's port system to Northeastern Asia and Southeastern Asia, with all the ports in the PRD acting as a unified system. The Hong Kong port should consider to reduce its terminal charge, and to mainly concentrate on the provision of overseas shipping and high-value-added logistics services to develop into a third-generation shipping center and compete with the Singapore and Pusan ports.

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