From a feeder port to a hub port: the evolution pathways, dynamics and perspectives of Ningbo-Zhoushan port (China)

Abstract: This paper analyses the spatio-temporal evolution of Ningbo-Zhoushan port growing from a feeder port to a hub port finding the historical pathways followed by its expanding in terms of container throughput capacity and total traffic. The dynamic mechanism of evolution is the results of economic globalization, containerization and its natural endowments in channel and terminal depths. Analysis of the traffic evolution and its underlying dynamics suggest 3 periods in the development processes of container transport in Ningbo-Zhoushan: (1) adoption period (1986-2000) in which the main dynamics is the impact of the Chinese 'Open Door policy'; (2) acceleration period (2001-2008) in which the dynamics is related of the mainland China's entry into the WTO; (3) peak growth period (2009-now) in which the dynamics is impacted by the anti-crisis strategy against the financial and economic crisis in 2008. We analyse the perspectives of Ningbo-Zhoushan port. ARIMA model is employed to forecast the container traffic in the coming future; about after 2026, the throughput in Ningbo-Zhoushan port would reach about 49 million TEU which would be approximately equal to that of Shanghai port. The resultant port development would exemplify a model of spatial distribution such as a multi-layered gateway hub. In the respect of growth potential, Ningbo-Zhoushan port possesses excellent coastline resource suitable for deep-water berthing, bonded port policy and free trade zone policy. Geographical position, service level, hinterland economic level and government will support its perspectives.

Keywords: bonded port; free trade zone; economic policy; ARIMA; deep-water coastline; evolution cycle.

1. Background

Ningbo locates in the middle of China's 18,000km coastline, where the Yangtze River meets up with the Eastern China Sea (see **Figure 1**). The port of Ningbo can be traced to hundreds of years ago (**Wang, 2012**). In 1986, containerized transportation appeared in Ningbo, and the container throughput was 4.1×10^3 TEU, then grew quickly to nowadays. In 2000, Ningbo first ranked the top 100 of world port, and became the 67th largest container port with the throughput of 0.9×10^6 TEU. In 2008, Ningbo-Zhoushan (Ningbo port merged with Zhoushan port in 2006 and formed a new Ningbo-Zhoushan port) first listed in the world's top 10 container ports; its container throughput reached 11.23×10^6 TEU and Ningbo-Zhoushan port became the world's 7th largest container port. In 2015, as a milestone event, Ningbo-Zhoushan port overtook Hongkong and ranked the 4th largest container port in the world.

Geographically, Ningbo-Zhoushan port is just 150 nautical miles from Wusongkou (inner port of Shanghai) and about 50 nautical miles from Yangshan (offshore port of Shanghai). Economically, Ningbo-Zhoushan port overlaps the actual and potential hinterland of Shanghai port (Wang et al., 2017a; Zhuang and Yu, 2014). Therefore, it is impossible to evade Shanghai when we give attention to Ningbo-Zhoushan port. Since 1990, the annual growth rate of container throughput in Ningbo-Zhoushan port was 29.7%, about 12 percentages more than those of Shanghai (see **Figure 2**). The above phenomena attracted many scholars' attention. What happened between Ningbo-Zhoushan port and Shanghai port? And what's the relationship of the two ports?

The questions became a hot study topic and were answered by dozens of researchers (see reviews in **Table 1**). Ningbo-Zhoushan port and Shanghai port had entered into competition with each other (**Li and Oh, 2010; Pan et al., 2017; Shao, 2012**), and the competition was caused by the overlapping of hinterland **(Comtois and Dong, 2007; Shao, 2012)**. **Li and Lee (2010)** regarded the hinterland of Ningbo-Zhoushan was just limited within Ningbo, Taizhou and Zhoushan; however, **Cullinane et al. (2005)** stated Ningbo port would continue to gain larger market share for its advantages in natural endowments, price and improved services. In consequence, Ningbo-Zhoushan port was ever a feeder port of Shanghai, but had transformed to a large deep-sea direct-call and (or) a hub port **(Wang, 2012)**. **Wang (2007)** and **Jiang (2008)** suggested a bi-hub port formed in Yangtze River Delta region. In 2017, the container throughput of Ningbo-Zhoushan port recorded 24.61×10^6 TEU, which was 61.2% of Shanghai port. As the 4th largest container port in the world, Ningbo-Zhoushan port was undoubtedly a hub port and the relationship of the two ports became a competitive one.

But how did the above phenomena happen? What would happen in the coming future? Which port system evolutionary model responds to Ningbo-Zhoushan port? And what could we learn from the prompt development of Ningbo-Zhoushan port? Regardless of the evolution pathways, mechanism or perspectives, some issues and problems still need further researching. For these concerns, this contribution analyses the evolution pathways and mechanism of Ningbo-Zhoushan port growing from a feeder port to a hub port first. Since the financial and economic crisis in late 2008, China's economy entered the 'new normal' (a slowdown phase after the financial crisis); the continuous increase in shipping capacity and port infrastructure led overcapacity (Xiao et al., 2012). Therefore, the competition between Ningbo-Zhoushan and Shanghai port for market share was becoming increasingly fierce. In light of these potentially conflicting forces, the second objective of the article is to analyse the perspectives in container traffic of Ningbo-Zhoushan port in the coming years.

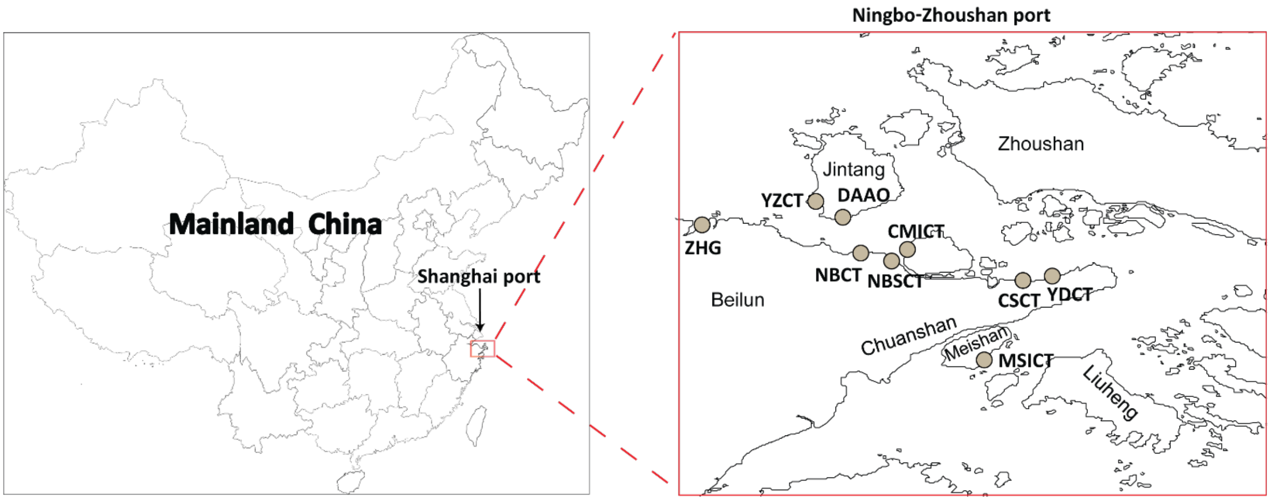


Figure 1 · Location of Ningbo-Zhoushan port (left) and container terminals in Ningbo-Zhoushan port (right).

Sources	Concerns	Brief descriptions of related research
Cullinane et al. (2005)	Competition	Ningbo will continue to gain greater market share as the result of advantages in its natural endowments (particularly water depth), price (especially in terms of recovering the cost of capacity expansions) and quality of service improvements.
Comtois and Dong (2007)	Competition	Competition between the ports of Ningbo and Shanghai are caused by the overlapping hinterland of container distribution for Zhejiang province.
Wang (2007)	Evolution	Ningbo port transformed from Shanghai's feeder port to a large deep-sea direct-call and would to hub port. Bi-hub port would be special relationship between Shanghai and Ningbo port.
Jiang (2008)	Evolution	Shanghai port and Ningbo port have experienced a transform from hub port – feed port to hub port – large deep-sea direct-call port, and it's possible to form a bi-hub port in future.
Li and Oh (2010)	Competition	Shanghai port and Ningbo port have entered into competition with each other.
Li and Lee (2010)	Competition	The YRD port cluster is undergoing a process of decentration since 1990s, and the hinterland of Ningbo port in Zhejiang province only includes: Ningbo, Taizhou and Zhoushan.
Wang (2012)	Evolution	In the period of 1864-1936, Shanghai became one of the most important hub ports in East Asia while Ningbo was the feed of Shanghai.
Shao (2012)	Competition	Shanghai port and Ningbo port have entered into competition with each other, and they should turn competition into cooperation along with competition.
Zhuang and Yu (2014)	Competition	Hinterland areas of Ningbo port was gradually expanding, while less hinterland cities were selecting Shanghai port from 1990.
Wang et al. (2017a)	Evolution	Shanghai and Ningbo are unique in that both ports are similarly focused on foreign trade because they both have deep-water harbours, excellent geographical location, export-oriented hinterland economy, and close foreign investment relationships.
Pan et al. (2017)	Evolution	The relationship between Shanghai port and Ningbo port has evolved from

Sources	Concerns	Brief descriptions of related research
		feeding relationship to competing relationship.

Table 1. An overview of the researches about the relationship of Ningbo-Zhoushan port and Shanghai port.

The paper is structured as follows. We first introduce the spatial location and temporal evolution pathways of the containerized transportation in Ningbo-Zhoushan port in the section 2. Then, in section 3, we analyse the dynamic mechanism of Ningbo-Zhoushan port growing from a feeder port to a hub port. In section 4, we discuss the perspectives of Ningbo-Zhoushan port in the coming future using a time-based prediction. Finally, we close with the final remarks.

The data used in this study stem from Ningbo Economic and Social Development Statistical Bulletin, Ningbo statistical yearbook and China Port Yearbook over the researching years.

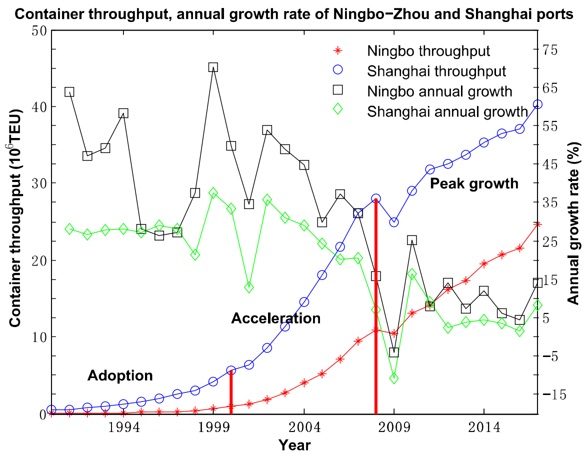


Figure 2. Container throughput, annual growth rate of Ningbo-Zhoushan and Shanghai port.

2. Spatio-temporal pathways of Ningbo-Zhoushan port growing from a feeder port to a hub port

The Spatio-temporal pathways of Ningbo-Zhoushan port were plotted in **Figure 3. (a-i)**. In 1986, containerized transportation in Ningbo appeared at Zhenhai port area (ZHG) (see **Figure 3. (a)**). Because the terminal was not well specialized, its annual container throughput always maintained at hundreds to thousands TEU per year. In 1991, NBCT-the first specialized container terminal in Ningbo port put into service (**Figure 3. (b)**), which was a breakthrough and the annual growth rate of container throughput in Ningbo port recorded at 45.7% from 1991 to 2001 (see **Figure 2**). 2001 is a milestone year for Ningbo port; this year China entered WTO and the second specialized container terminal, NBSCT, opened (see **Figure 3. (c)**). Afterwards, container throughput in Ningbo entered a rapid growth period. Before 2008, CSCT, CMICT and YDCT were built and came into use with substantial container throughput (**Figure 3. (d)**-**Figure 3. (f)**). At the end of 2008, the container throughput of Ningbo-Zhoushan reached 11.23 $\times 10^6$ TEU and Ningbo-Zhoushan port became China's 4th and world's 7th largest container port. With this, Ningbo-Zhoushan port had grown from a feeder port to a hub port (**Jiang, 2008; Wang, 2007; Wang, 2012**). Although Ningbo port had merged with Zhoushan port in 2006, Zhoushan port area (YZCT) did not contribute substantially to Ningbo-Zhoushan port (see **Figure 4 (left)**. The main concern for Zhejiang provincial government to combine them would be explained in **Section 5.4.**).

After 2008, the world economic environment had changed greatly due to the financial and economic crisis. The economic change led to a slowdown in growth of port freight volumes **(Notteboom and Yang, 2017)**. From **Figure 2**, we can find that the annual growth rate of container throughput during 2009 - 2017 in Ningbo-Zhoushan port dropped off to 9.7%, about 27 percentages less than the average rates of 2001-2008 and 32 percentages of 1990-2000. It was a significant change, which indicated the container throughput in Ningbo-Zhoushan port had entered the stable period from the rapid growth period. In this period, YZCT (Zhoushan port area) and MSICT (Meishan port area) completed and put into operation (**Figure 3. (g)**- **Figure 3. (h)**). At the end of 2017, Ningbo-Zhoushan port became China's 3rd and world's 4th largest container port with the container throughput reaching 24.62×10^6 TEU; its position as a hub port had been further strengthened **(Pan et al., 2017)**.

To analyse the spatial-temporal evolution of Ningbo-Zhoushan port, we plot its barycentre trajectory of total container throughput and the standard deviational ellipses (see **Figure 3. (j)**). The first period is characterised by a static point exactly at ZHG. Then the barycentre moves near to NBCT terminal after 1991. In the third period, the entering into service of NBSCT, CSCT, CMICT and YDCT induces the continuous shifting of barycentre eastwards (2000-2011). The standard deviational ellipses during 1991, 2001 and 2007 shows a clear elongated pattern consistent with the locations of the terminals mentioned previously. The length of the ellipse axis oscillates in function of the entering in service of the terminals. For instance, the decrease of the length axis during 2001 in comparison 1991 is associated to the entering into service of NBSCT, which is located near the barycentre. Finally, south-eastward movements of barycentre are observed after 2012 due to the increasing traffic share of MSICT terminal. In this case the elongated shape of the standard deviational ellipse is reduced during 2017 due to the opening service of MSICT terminal. Overall, the development process of Ningbo-Zhoushan port is a gradual transformation from an estuary port to seaport, and from the shallow-water port to deep-water port.

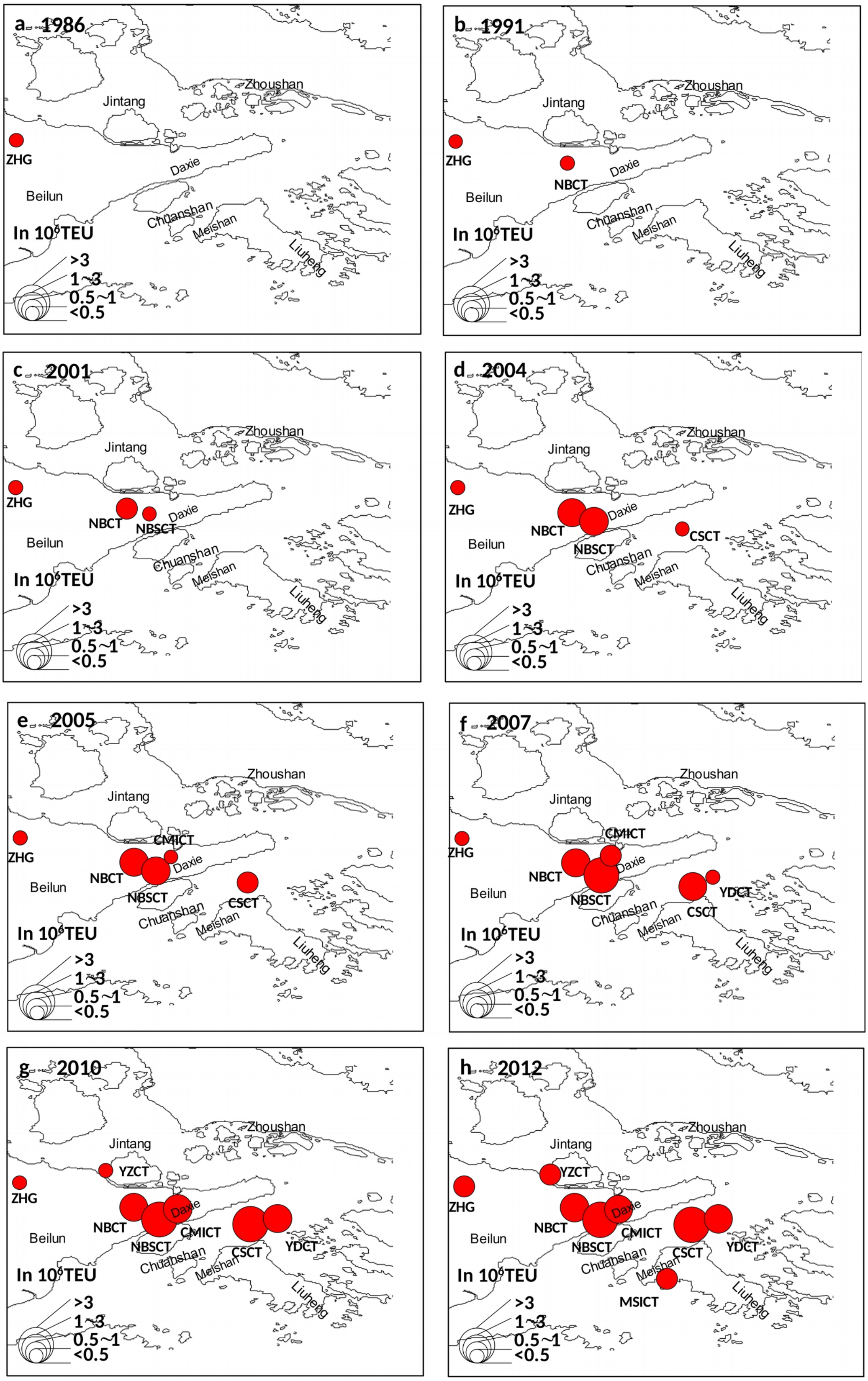
This traffic evolution also is observed with Herfindahl-Hirschman Index (HHI) (see **Figure 4 (left)**), which shows a deconcentration tendency due to opening of new container terminals (see **Figure 3. (a-i)**).

In conclusion, we can find that the spatio-temporal pathways of Ningbo-Zhoushan port growing from a feeder port to a hub port are achieved by expanding the port capacity and then expanding its port container throughput (see **Figure 4 (left)**). According to opinion of **Guerrero and Rodrigue (2014)**, and if we regard each container terminal in Ningbo-Zhoushan port as an individual port, then Ningbo-Zhoushan port has already realized its special and functional diffusion in geographical growth structure.

3. Dynamic mechanism of Ningbo-Zhoushan growing from a feeder port to a hub port

3.1. Impact of the global changes in a broader economic environment

Economic globalization is one of the most powerful forces to have shaped the post-war world (**Frankel, 2000**). With the global economic shift towards newly industrialized Asian regions since the 1980s, and in concurrence with the Chinese 'Open Door policy', China has experienced rapid and significant increase in GDP and trade, thus providing Chinese ports with unprecedented business (**Song, 2002**). According to **Review of Maritime Transport 2017 – UNCTAD**, 64% world container port volumes were distributed in Asia region, and 7 of the world's top 10 largest container ports were located in China in 2017.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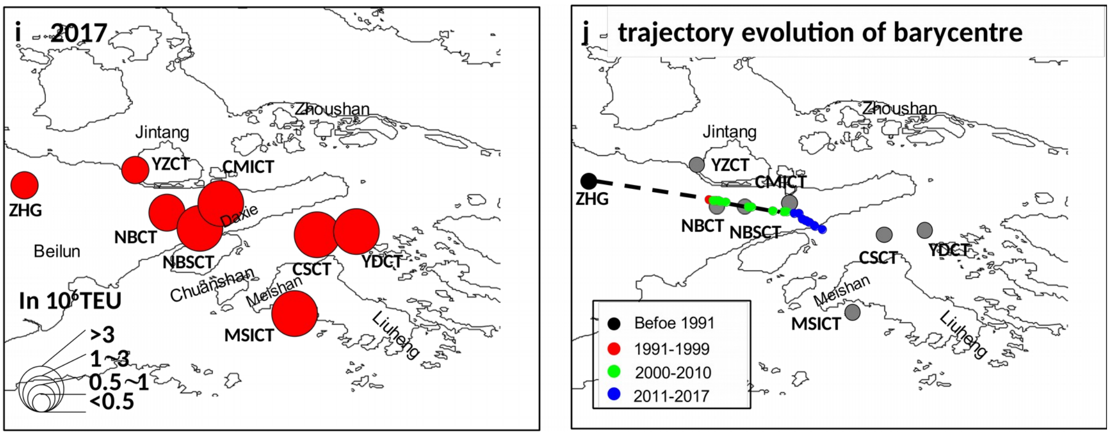


Figure 3. Spatial location and temporal evolution of Ningbo-Zhoushan port (a-i); barycentre trajectory of total container throughput in Ningbo-Zhoushan port (j).

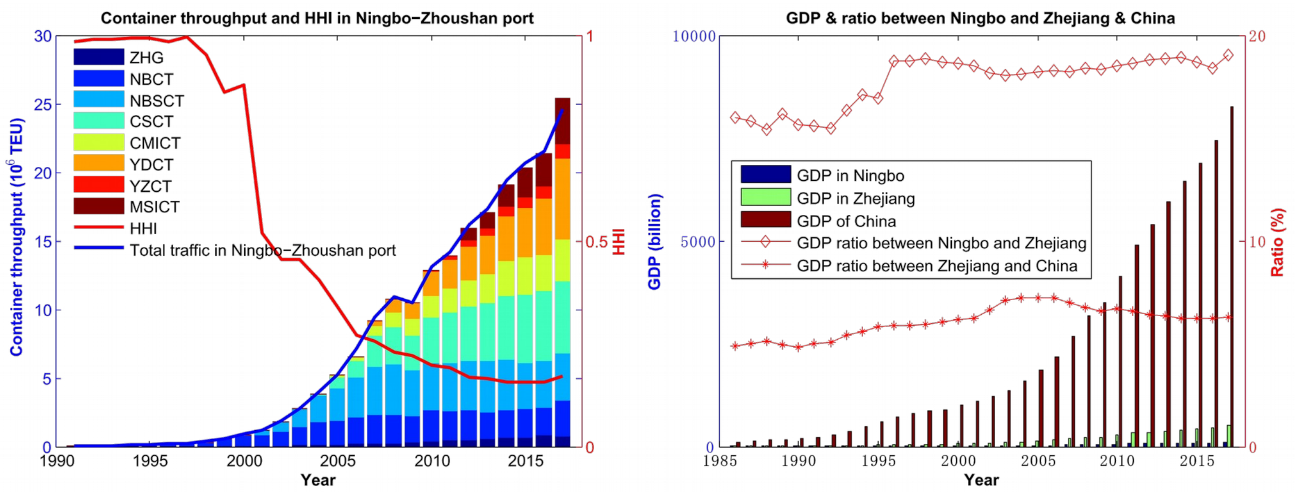


Figure 4. Container throughput of each terminal in Ningbo-Zhoushan port and HHI (left); Growth in GDP of Ningbo, Zhejiang and China in 1986-2017 (right).

Figure 4 (right) and **Figure 5(left)** shows China's progress in GDP and international trade. During 1986–2017, China's GDP and trade grew by 80.23 and 55.6 times respectly, and the annual growth rate was 14.7% and 13.4%. In the same period, Zhejiang province (which includes Ningbo) and Ningbo as the hinterland of Ningbo-Zhoushan port, their GDP grew by 103 and 122.8 times individually, and the annual growth rates are 15.6% and 16.2%; their international trade grew by 293.3 and 5414.3 times separately, and the annual growth rates are 19.4% and 30.8%, which are much higher than those of China, and show the more pronounced export-oriented economy in Zhejiang and Ningbo. Rapid and significant expansion in international trade provided a huge and stable goods for ports. As in **Figure 5(right)**, just from 1986 to 2008, container throughput in Chinese ports, Shanghai port and Ningbo-Zhoushan port added by 204.8, 137.4 and 2645.5 times separately, the annual growth rates were 18.1%, 16.6% and 27.9%. Data confirmed that with the development of economic globalization, Shanghai port fell behind relatively, while Ningbo-Zhoushan port grew faster and won a larger market share in the container throughput.

3.2. Impact of the containerization wave

Since Malcom McLean initiated container transportation in the middle of the 20th century, it had become popularized quickly and developed tremendously in the world for its virtues in multimodal transportation and efficiency (**Cudahy, 2006; Parker, 2013**). In 2016, container port traffic of all countries and economies in the world recorded 701.42×10^6 TEU (**World Bank, 2017**). According to **Marine Traffic (2017)**, the proportion of container ship in the world fleet structure was 26.4% and that in the total dead-weight tonnage was 39.7% in 2017, which showed global popularity and prosperity in container transportation.

The containerization in China began in 1973. At that time, the State Council of China took it as a political task and set up a specialized agency to push on containerization. Since then, more and more general cargoes were loaded into containers, more and more container terminals were built, and the containerization ratio (the ratio between containerized throughput of the port and the total general cargo volumes handled in the port) in China increased rapidly. Before the financial and economic crisis in 2008, China's port containerization ratio reached 75% (see **Figure 5(right)**), which was the average level in the Western developed countries according to **Rodrigue and Notteboom (2015)**. As showed in **Figure 5(right)**, port container traffic expanded quickly with the ascend of containerization ratio. From 1986 to 2008, China's containerization ratio rose from 17% to 75%, port container traffic of Ningbo-Zhoushan, Shanghai and total Chinese ports grew by 2645.5, 137.4 and 204.8 times separately, and the annual growth rates were 43.2%, 25.1% and 27.4%.

In the process of containerization, Shanghai port, as the largest port in China and one of the three ports that firstly engaged in container transportation at that time, performed a decline proportion in the total port container traffic of China from 55.6% to 21.8% due to the geographical containerization (or deconcentration in container port system). However, just in the 22 years of 1986-2008, the proportion of Ningbo-Zhoushan increased from 0 to 8.45%, and the ratio of port container traffic between Ningbo and Shanghai increased continuously from 0 to almost 38.7%. So, the wave of containerization is always accompanied by the deconcentration in container port system and port regionalization **(Guerrero and Rodrigue, 2014)**; obviously, Ningbo is a beneficiary from the containerization. In 2017, the ratio of port container throughput between Ningbo and Shanghai rose to 61.2% (Shanghai port 40.23×10^{6} TEU Vs Ningbo-Zhoushan port 24.61×10^{6} TEU).

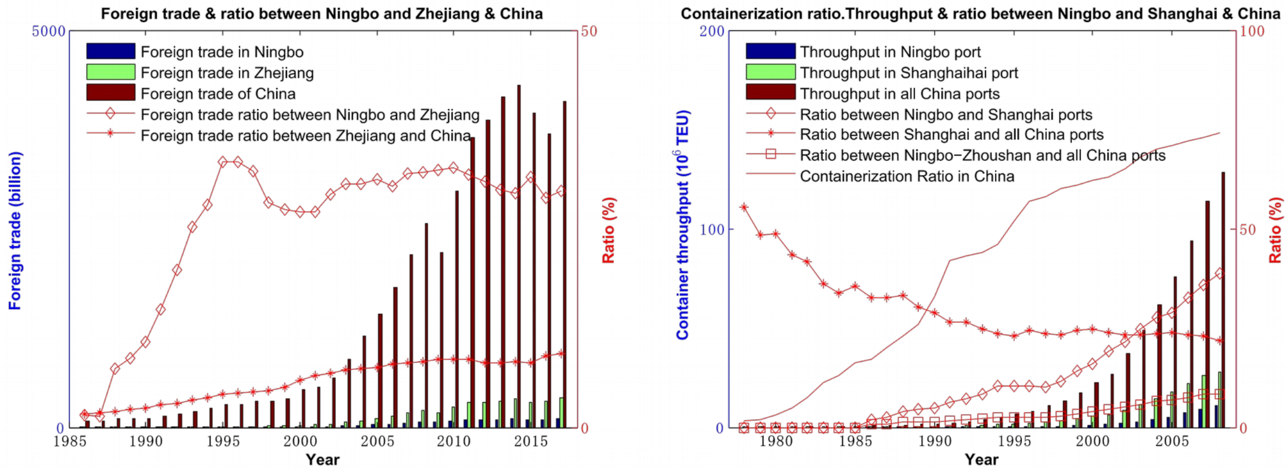


Figure 5. Growth in trade of Ningbo, Zhejiang and China in 1986-2017 (left); Growth in Container throughput of Ningbo-Zhoushan port, Shanghai port and Chinese ports in 1986-2008 (right).

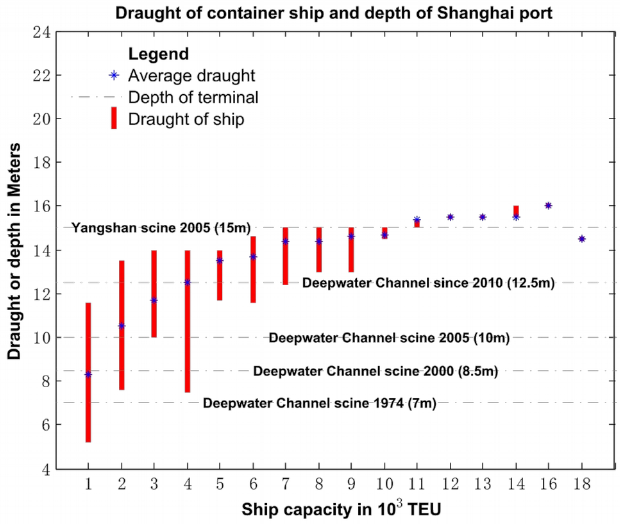
3.3. Impacts of natural endowments in depth

Continuous growth of global containerization and increasingly competitive circumstances led to the popular deployment of larger mega vessels, these massive container ships always serve only a limited number of hub ports due to efficiency and cost-saving (**Fremont, 2007; Imai et al., 2006; Ircha, 2001**). However, bigger ships bring bigger challenges as maritime access may be restricted by draught restrictions. Therefore, port choice and container terminal selection become an important question not only for deep-sea container carriers (**Wiegmans et al., 2008**) but also for port authorities **(Hacegaba, 2014)**. According to **Hacegaba (2014)**, in the list of physical infrastructure at a port, the depth of the access channel and berth has the most important impacts on the larger ships.

Ningbo-Zhoushan port is about 50 nautical miles away Yangshan port area of Shanghai port. Because of the geographical proximity, depth plays a crucial role in the competition between the two ports. **Figure 6 (left)** and **(right)** reveal the depth restrictions in Shanghai port and Ningbo-Zhoushan port during different periods respectly.

Prior to the opening of Yangshan port area, Changjiang Estuary Deepwater Channel is the only access channel into Shanghai port (mainly Waigaoqiao port area) for large ships. In 1974, the Deepwater Channel was dredged to 7 m. From **Figure 6 (left)** we can find that most 1000 TEU container ships are blocked out of Shanghai port due to the draught restrictions. In this context, Yangtze Estuary Deepwater Channel Rectification Engineering was carried out. In 2000, Phase I was finished and the Channel was dredged to 8.5 m; then the 1000 TEU container ship could call Shanghai and some 2000 TEU and 4000 TEU container ship could visit Shanghai port by tide. In 2005, Phase II was completed and depth of the Channel was maintained to 10 m; the tide window was further improved. With the dredging of Phase III in 2010, depth of the Channel added to 12.5 m; and the majority of 6000 TEU container ship were permitted to enter the inner Shanghai port by tide. Yangshan port area of Shanghai is an offshore terminal which came into use in

2005, and the depth of its channel is 15 m. From Figure 6 (left) we can see that the 10000 TEU container ships are able to call day and night; however, ships more than 10000 TEU have to use tide, which sometime is a quite big trouble for the tight schedule and sensitive efficiency of main global container carriers.



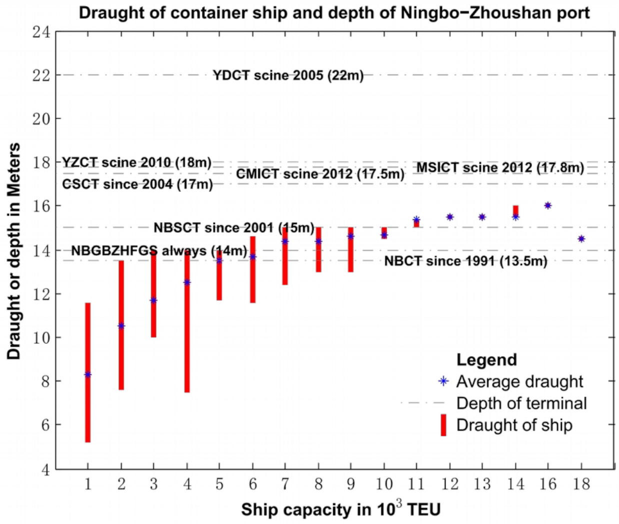


Figure 6. Draught of container ship [1] and depth of Shanghai port (left); Draught of container ship [1] and depth of Ningbo-Zhoushan port (right).

Next, let's put our eyes on the depth conditions in Ningbo-Zhoushan port. The channel depth in Ningbo-Zhoushan port is more than 25.3 m, which never is a restriction on any container ships in the world. Then how about the depth in terminal? Figure 6 (right) shows the depth restrictions of berth in Ningbo-Zhoushan port during different periods. ZHG is the first terminal that called container ship in Ningbo, and its depth is 14 m at most, which is enough for any coastal or feeder container ship. In 1991, the first specialized container terminal in Ningbo port, NBCT, put into operation; its depth is 13.5 m, by which even the largest container ship at that time was allowed to visit. In 2001, NBSCT with 15 m in depth was completed to accommodate world's largest container ship. After 2004, the depths of all newly-built terminals are more than 17 m, by which even the largest container ship in the world is permitted to call freely with enough under keel clearance. Obviously, Ningbo-Zhoushan port has an incomparable advantage prior to Shanghai port in calling dominant mega container ships (Li and Oh, 2010; Shao, 2012; Slack and Wang, 2002; Wang, 2007).

4. Evolution cycle and the dynamics of Ningbo-Zhoushan growing from a feeder port to a hub port

Containerization waves are indicative of global changes in a broader economic environment (Guerrero and Rodrigue, 2014). According to circular relationship of maritime transport and economic development, we divide the evolution cycle of container transport in Ningbo-Zhoushan port into 3 distinct phases with the growth rate in GDP, trade and container traffic.

4.1. Adoption and the impact of the Chinese 'Open Door policy': 1978-2000

In 1978, the central government of China issued the reform and opening-up policy. To speed up the opening-up, 14 coastal port cities opened to the outside world in 1984 and Ningbo was listed of them. To develop an export-oriented economy, Ningbo established Ningbo Economic & Technical Development Zone in 1985, which was one of the top 5 national economic and technical development zones in China at that time. In 1988, Ningbo obtained the right of self-managed import and export and the right to sign foreign economic and technological cooperation from the central government. As a result, a large of overseas investors were attracted. Up to 1990, more than 250 foreign-funded enterprises settled in Ningbo, which promoted the international trade increasing rapidly. In this period, the total import and export volume of Ningbo port exceeded 5.26 billion USD, and the annual growth rate reached 32.5%. In 1986, Ningbo port just began to promote the containerized transportation and merely 4.1 $\times 10^3$ TEU was transported in that year; however, its container throughput promptly increased to 22.1 $\times 10^3$ TEU in 1990, almost 5.4 times that of 1986, and annual growth rate recorded 52.3%. The rapid growth era of container throughput in Ningbo port was coming.

After 1992, China's reform and opening-up further accelerated. In 1992, Ningbo Bonded Area was established. In 1993, Ningbo Daxie Development Zone was set up. In 1999, Ningbo National New & Hi-tech Industrial Development Zone was founded. In 2000, the total import and export volume of Ningbo reached 161.3 billion USD, which was 10.9 times that of 1990, and the annual growth rate was 29.5%. The rapid growth of foreign trade brought about the rapid growth

1 [1] Draught by containership capacity is cited from https://transportgeography.org/?page_id=2237

of container throughput. In the same period, although impacted by the financial crisis in 1998, the container throughput in Ningbo port rose from 36 $\times 10^3$ TEU to 0.9 $\times 10^6$ TEU, the annual growth rate reached 45.7% (see Figure 7 **(left)**). Ningbo first ranked in the top 100 of world port and became the 67th largest container port. The period is the introduction and adoption period of container transportation in Ningbo port.

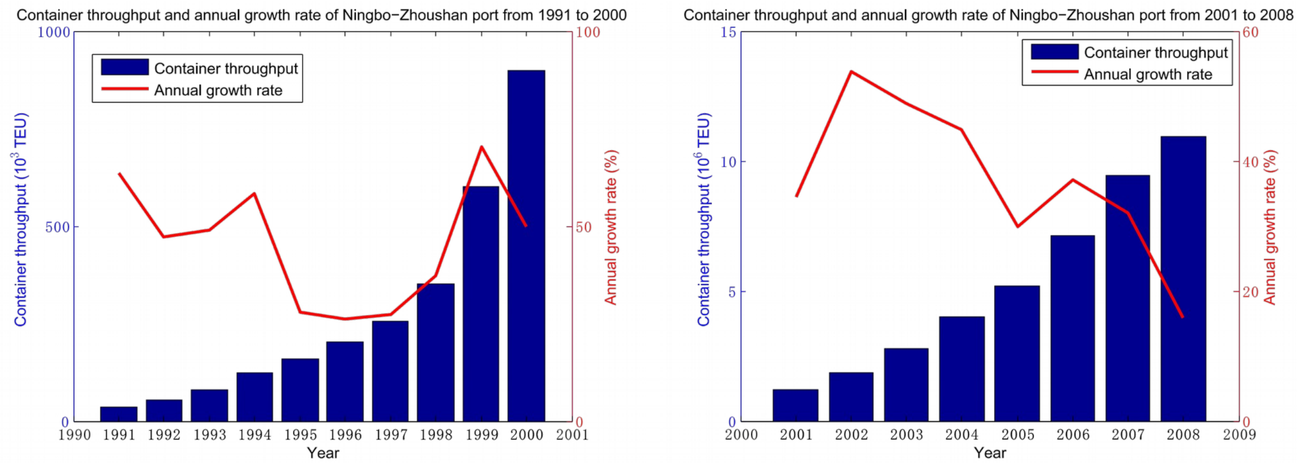


Figure 7. Container throughput and annual growth rate of Ningbo-Zhoushan port from 1991 to 2000 (left); Container throughput and annual growth rate of Ningbo-Zhoushan port from 2001 to 2008 (right).

4.2. Acceleration and the impact of the mainland China's entry into the WTO: 2001-late 2008

In 2001, mainland China entered the WTO; since then, the foreign trade atmosphere was further improved. From 2001 to 2008, more than 7400 foreign-funded enterprises settled in Ningbo, and 15.7 billion USD overseas funds were invested. The value of import and export of Ningbo in 2008 reached 140.2 billion USD, which was approximately 9 times that in 2001, and annual growth rate was 34.3%.

The rapid growth of import and export greatly increased the seaborne transport demand and encouraged the development of port infrastructure. In 2001, the rights of port construction and management were decentralized to the local governments (mainly port city government) and the policy of separating port enterprises from administration was implemented to give local governments incentives to develop port infrastructures (**Yang et al., 2018**). In this period, NBCT and Hutchison Whampoa jointly form the new NBCT in 2001, which was the first joint venture container of Ningbo port, and introduced advanced port management concepts from Hongkong port. In 2001, 2004, 2005 and 2007, another 4 large-scale container terminals, NBSCT, CSCT, CMICT and YDCT were completed and put into use one after another. In 2008, Meishan Bonded Port Area was set up, which was the 5th bonded port area in China. This year, the container throughput in Ningbo-Zhoushan port rose to 10.93 $\times 10^6$ TEU, the annual growth rate was 22.6% (see Figure 7 **(right)**). For the first time, Ningbo-Zhoushan port listed in the world's top 10 container ports and became the world's 7th largest container port. The period is the acceleration period of container transportation in Ningbo-Zhoushan port.

4.3. Peak growth and the impact of the financial and economic crisis in 2008: late 2008-now

The economic crisis of 2008-2009 induced by the huge toxic debts of financial institutions is indicative of a correction that is having fundamental consequences on international trade, and the emergence of acute imbalances has been an enduring characteristic of global trade patterns for at least a decade (**De Monie et al., 2009**). The crisis resulted in a generalized recession in all OECD countries and in most emerging economies, which had serious impacts on the future indexes, shipping and trade (**De Monie et al., 2009**). For instance, the BDI collapsed by 94% between July and December 2008; the total container traffic in Chinese ports shrank by 4.95% and the international trade of China decreased by 14%. In the context of anti-crisis strategy, the Chinese government introduced a package of economic stimulus measures, which promoted the rapid recovery of economy. In 2017, GDP, trade and port container traffic of China were 2.37, 1.86 and 1.95 times those of 2009, the annual growth rates were 11.4%, 8.06% and 8.71%, which were 4.9, 17.9 and 16.5 percentages less than those of 2001-2008. The economic environment has changed greatly with the economic slowdown and economic structural changes which led to a slowdown in growth of port freight volumes (**Notteboom and Yang, 2017**). There is no doubt that the period of high growth in GDP, trade and port container traffic is over. In this circumstance, Ningbo municipal government introduced a series of measures to improve shipping atmosphere and expand its hinterland to maintain the business.

Firstly, to develop dry port and exploit the rail-sea transhipment. From 2009 to 2017, Ningbo-Zhoushan port exploited more than 6 rail-sea container transportation lines by which its hinterland extended to the middle and upper reaches of the Yangtze River Basin, even to Xinjiang province (the westernmost province in China). In 2017, the transhipment of rail-sea recorded 0.25 $\times 10^6$ TEU, more than 150 times that of 2009, the annual growth rate was 87.1%. what's more, Ningbo municipal government also carries out policy to provide extra subsidies to encourage the rail-sea transhipment.

Secondly, to perfect the transportation network. In 2008, a critical infrastructure project, Hangzhou Bay Bridge, was in service, which had a direct impact on the competitive arena between Shanghai and Ningbo-Zhoushan. This bridge shortens the distance from the north and western provinces to Ningbo, which leads to a modelled average reduction in road haul costs of 600 RMB per TEU moved from Suzhou, Wuxi, Changzhou and Nanjing to Ningbo, and 700 RMB per TEU from Shanghai to Ningbo. The bridge averages out to almost a 30% cut in road haul costs and has a significant effect on the port choice (**Wang and Ducruet, 2012**). In 2013, another Hangzhou Bay Bridge, Jiashao Bridge put into operation, which further strengthened the connection between Ningbo-Zhoushan port and the northern hinterland. During this period, Ningbo promoted the renovation and upgrading of Hangzhou-Ningbo canal, which was conducive to strengthening ties with the economic hinterland such as Shaoxing, Hangzhou, Huzhou and Jinhua. It's worth to emphasize that the Chinese central government has decided to build the Zhoushan River - Sea Combined Transportation Service Centre in 2016, which means that the construction of transportation network in Ningbo-Zhoushan port had risen to the national strategy.

Thirdly, to speed up port integration. Ningbo-Zhoushan Port Administration Committee was established in 2007 with the name of Ningbo-Zhoushan Port; however, Ningbo port and Zhoushan port operated independently in fact. In 2015, ZPSIOG merged Zhoushan Port Group Co., Ltd. and Ningbo Port Group Co., Ltd. and formed the largest port group in the world. The headquarter of ZPSIOG was located in Zhoushan and the target was to integrating all seaports and the main inland ports and dry ports in Zhejiang. In 2016, Zhejiang Seaport Development Committee (ZSDC) was established as a new provincial organisation. ZSDC oversees ZPSIOG. The objective of ZSDC is to form the regional port structure of the 'one body two wings and interactive development'. It is interpreted as the main body of Ningbo-Zhoushan Port, two wings of the south-eastern seaports (Taizhou port and Wenzhou port) and northern ports of Zhejiang province (Jiaxing port) respectively and the interactive development with Yiwu International Dry Port and other inland ports (Huzhou port, Hangzhou port and Shaoxing port).

Fourthly, to improve shipping atmosphere. In 2009, Ningbo municipal government proposed the construction of the Ningbo International Shipping Service Centre, and in 2013 the Ningbo Container Export Index (NCFI) - the Sea Silk Road Index was introduced, which improved the shipping environment and promoted the attraction of Ningbo-Zhoushan port. For instance, impacted by the recession of shipping in 2009, many global container carriers closed or reduced their lines; however, the largest container carrier in the world, Maersk, relocated its transhipment centre in northeast Asia to Ningbo-Zhoushan port, which improved the container business of the latter.

In 2017, Ningbo-Zhoushan port became the largest container port in Zhejiang province, the 2nd largest in the YRD region, the 3rd largest in China and the 4th largest in the world with container throughput of 24.61×10^6 TEU. From 2009 to 2017, its annual growth rate was 11.23% (see Figure 8) and the growth is still strong, but how about its perspective in the coming future?

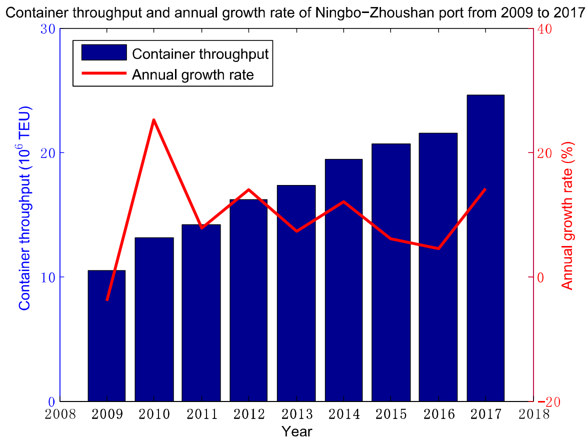


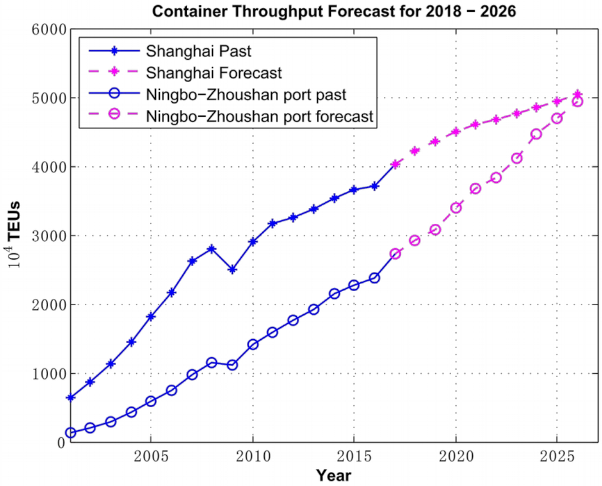
Figure 8. Container throughput and annual growth rate of Ningbo-Zhoushan port from 2009 to 2017.

5. Perspectives in the coming future

5.1. Container throughput forecasting

In order to check the perspectives in the coming future, we use ARIMA model to predict the container traffic of Ningbo-Zhoushan port and Shanghai port. ARIMA model is generally denoted as ARIMA (p, d, q), where p, d and q are non-negative integers which define the order of the autoregressive model, the degree of the differencing and the order of the moving-average model respectively. The formulation of ARIMA and its identification of procedure and parameters are found in **Box et al. (1994)**. As the analysis in **Section 4.3** and considering Ningbo-Zhoushan port still in its peak growth period, we use the container traffic of 2000-2015 as prediction sample, and those of 2016-2017 as test set. The model has been verified in **Table A 1**, **Figure A 1** , **Figure A 2** and **Table A 2**. As calculated in **Table A 3**, MAPEs of Shanghai port and Ningbo-Zhoushan port are 2.36% and 2.41% respectly, which shows a good agreement between the prediction and the real data.

The forecasting results (see **Figure 9 (left)**) show that if there is no turning point (serious events leading a sudden decline in China's economy such as the financial crisis in 2008) in the forecasting period, Ningbo-Zhoushan port would maintain its stable and moderate growth; about after 2026, its container traffic would reach about 49×10^6 TEU which is approximately approaching to that in Shanghai port. The annual growth rate would be 5.98%, and that in Shanghai port would be 2%. Would this be possible? June 2018, Shanghai International Shipping Institute (SISI) had analysed the world top 100 container ports using the indexes including growth rate in container throughput, GDP growth rate in hinterland, investment, number of newly-open lines, natural conditions of port and government behaviour; Ningbo-Zhoushan ranked second just falling behind Singapore. During January to September 2018, the actual growth rate in Ningbo-Zhoushan port is 7.8%, which seems a good start for our prediction target.



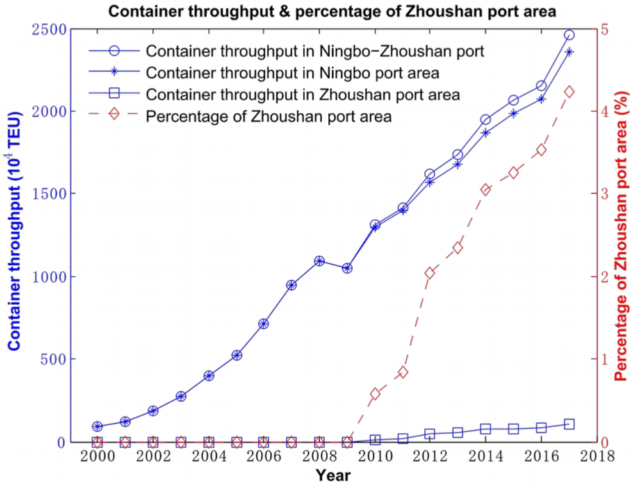


Figure 9. Container throughput forecasting for Ningbo-Zhoushan port and Shanghai port from 2018 to 2026 (left); Container throughput of Ningbo port area, Zhoushan port area and Ningbo-Zhoushan port & percentage of Zhoushan port area (right).

5.2. Competitiveness

Before 2017, port charges in mainland China are based very closely on a standard rate specified by the central government. It mainly includes charges for stevedoring and piloting (another important cost is tug charges, however considering that the tug charges are fixed by the central government since 2017, the price gap between different ports is not significant, so we will not discuss it here). Shanghai port and Ningbo-Zhoushan port both adopt a flexible pricing policy for stevedoring. Their approach is characterized by a differentiation between large and small customers, especially with respect to the stevedoring charge (Cullinane et al., 2005). Table. 2 reflects that Ningbo was more competitive than Shanghai according to the stevedoring charges.

After 2017, Chinese government lifted the control over the stevedoring charges, and the price of stevedoring is mainly determined by the market and port authorities themselves. In 2018, stevedoring charges for 20/40 ft full in Shanghai and Ningbo-Zhoushan are 930/1390 RMB and 490/751 RMB separately. Obviously, Ningbo-Zhoushan's advantage in price is still more prominent.

Port	20 ft full	20 ft empty	40 ft full	40 ft empty	Compared with MOT
MOT rate	425.5	294.1	683.3	441.1	
Shanghai	504.9	353.5	757.4	530.2	About 120%
Ningbo	383	264.7	547.5	397	About 90%

Table 2. Stevedoring charges in Shanghai and Ningbo container terminals in RMB (June 2005) (Cullinane et al., 2005).

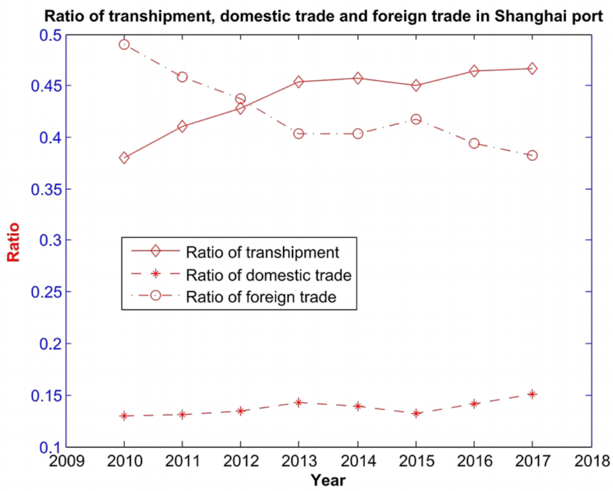
Piloting tariffs are all set by China's Ministry of Transport. For distances less than 10 nautical miles, the rate is 0.50 RMB per net ton; and for distances above 10 nautical miles, the rate for the rest of the voyage is 0.005 RMB per net ton per nautical mile. Since the piloting distance for Ningbo-Zhoushan is relatively shorter than those of Shanghai, so piloting charges in Ningbo-Zhoushan port are cheaper generally.

Stevedoring and piloting charges are the principal port costs when calling a Chinese port. By the cost comparison in calling a similar ship, it is no doubt that Ningbo-Zhoushan port possesses a definite price advantage. With respect to Ningbo's price advantage, this is likely to persist not only because of its preferential geographic location with respect to navigable routes into and out of the two competitor ports, but also because of the very high development costs associated with Yangshan, at USD 150 million per berth, compared to a unit cost for a new berth in Ningbo of just USD 100 million **(Chambers, 2004)**. Additionally, we should remember that developments in Shanghai will be restricted by the maximum draught of 15 metres for ships calling, while in Ningbo-Zhoushan maximum draught is more than 17 metres. As ships get bigger (and, if historical precedent is anything to go by, they inevitably will) the competitive advantage that Ningbo exerts over Shanghai will also inevitably become ever larger, particularly when it comes to attracting transhipment business (**Cullinane et al., 2005)**. After all, port infrastructure improvement and reductions in port charges is critical to attract businesses within the same geographical proximity **(Wang et al., 2017b)**.

5.3. Direction of effort

In 2010, Shanghai Port surpassed Singapore and became the world's largest container port. In 2017, container traffic of Shanghai port reached 40.23×10^6 TEU, which was almost 7×10^6 TEU more than those of Singapore (it was still the 2nd largest container port in the world). Then, what can Ningbo-Zhoushan port learn from Shanghai port? From **Figure 10,** we can find that the ratios of domestic trade in Shanghai port and Ningbo-Zhoushan port were all about 10% in 2017; however, the ratio of transhipment in Shanghai port recorded 46.7% contrasting that of Ningbo-Zhoushan port was 26.8%. In 2017, the ratio of foreign trade in Ningbo-Zhoushan port still retained 61%, but that in Shanghai port had fallen to 38.2%. Obviously in terms of container throughput, Shanghai port had transformed into a transhipment centre; however, Ningbo-Zhoushan port was still a deep-sea direct-call port.

Then let's put our eyes on **Figure 11**. From **Figure 11,** the foreign trade of Ningbo-Zhoushan port was 15.01×10^6 TEU vs. 15.37×10^6 TEU of Shanghai port in 2017. Therefore, in terms of container throughput in foreign trade, Ningbo-Zhoushan port had caught up Shanghai almost; however, in respect of transhipment and domestic trade, Ningbo-Zhoushan was still only 35.1% and 49.4% of Shanghai. Considering its GDP was only about 1/3 of Shanghai's, it seemed impossible to overtake Shanghai in domestic trade for Ningbo-Zhoushan. So, direction of effort for Ningbo-Zhoushan lies in transhipment.



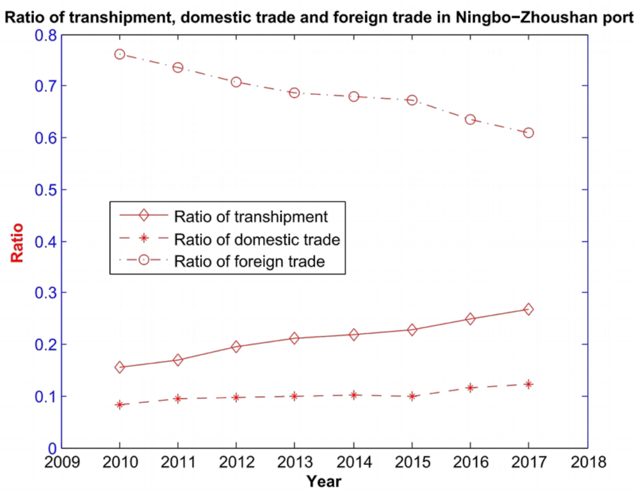


Figure 10. Ratio of transhipment, domestic trade and foreign trade in Shanghai port (left); Ratio of transhipment, domestic trade and foreign trade in Ningbo-Zhoushan port (right).

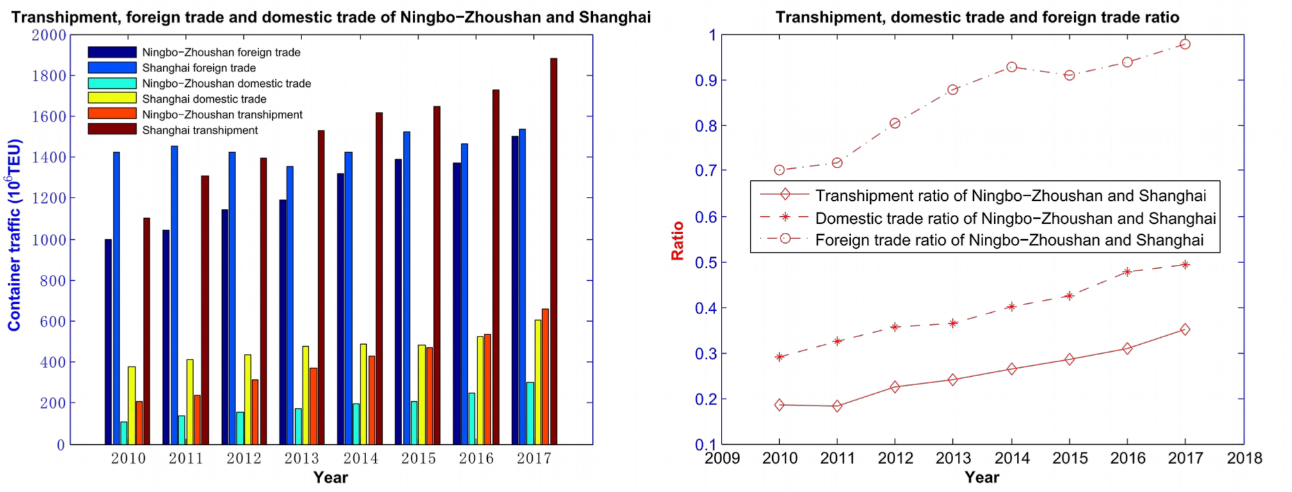


Figure 11. Transhipment, foreign trade and domestic trade of Ningbo-Zhoushan and Shanghai (left); Transhipment, domestic trade and foreign trade ratio of Ningbo-Zhoushan and Shanghai (right).

5.4. Potential in growth

In 2006, Zhoushan port was merged into Ningbo port and a new Ningbo-Zhoushan port was formed. **Figure 9 (right)** showed the container traffic in Ningbo-Zhoushan port, Ningbo port area and Zhoushan port area. In addition, **Figure 12 (right)** shows that YZCT (Zhoushan port area) just contributed a very small share in the total traffic of Ningbo-Zhoushan port. There are 3 main reasons. Firstly, the small economic hinterland of Zhoushan restricted its growth in container throughput. In 2017, its GDP is just 121.9 billion RMB, only 12.4% of Ningbo's. Secondly, Zhoushan is an offshore port, and connected to the mainland China only by Jintang bridge. Due to the investment return, the bridge toll is very expensive, which restricts the expansion of economic hinterland seriously. The poor collection & distribution conditions leaded to a small container traffic in Zhoushan port. Thirdly, during this period, the priority of transhipment in Ningbo-Zhoushan port was still in Meishan Port Area. Even in 2017, container traffic of Zhoushan port area was only 1.04×10^6 TEU, which was just 4.23% of total traffic in Ningbo-Zhoushan port. So why did the Zhejiang provincial government fully put forward the merger of the two ports? Table 3 gives the answer.

Port	Terminal	Throughput (10^4 TEU)	Throughput capacity (10^4 TEU)	Capacity utilization ratio (%)
Shanghai	SHSICT	890	430	207
	SGICT	760	500	152
	SMCT	650	280	232
	SECT	400	180	222
	SIPGZCT	660	250	264
	Total	3360	1640	215
Ningbo port area	NBCT	268	1197	197.8
	NBSCT	341		
	CSCT	528		
	YDCT	592		
	CMICT	301		
	MSICT	337		
Zhoushan port area	YZCT	104	100	104

Table 3. Capacity utilization of Ningbo-Zhoushan port and Shanghai port.

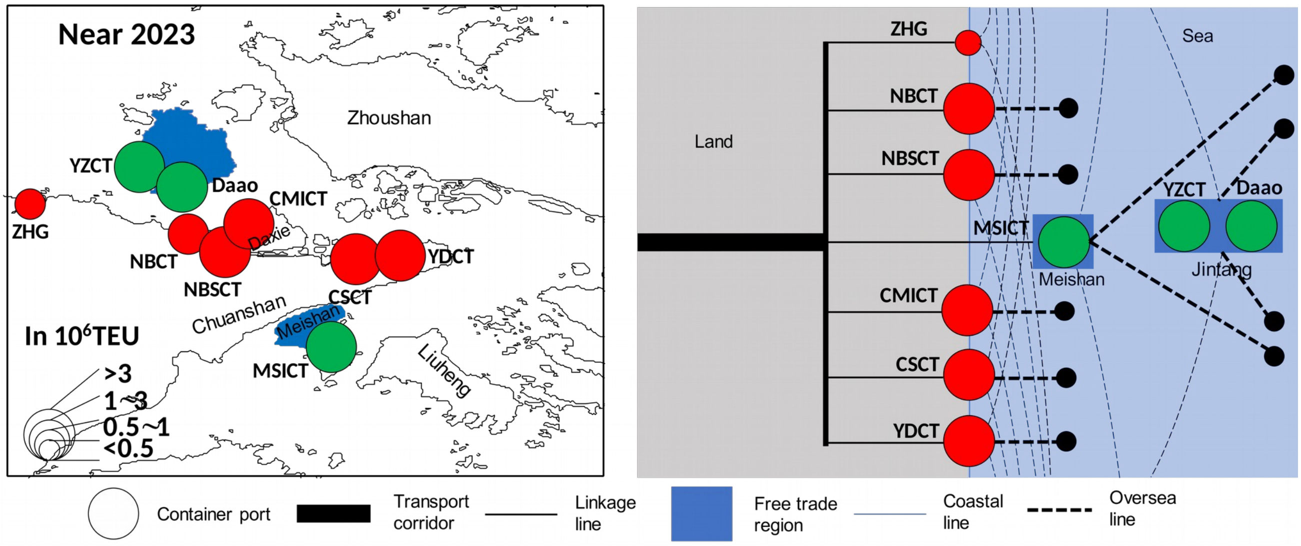


Figure 12. Spatial location in near 2023 (left) and spatial evolution model of Ningbo-Zhoushan port (right) (modify from Notteboom and Rodrigue (2005) and Wang and Ducruet (2012)). Green dots represent new container terminals or those in undergoing expansion.

Table 3, shows the average capacity utilization ratio of 5 international container terminals in Shanghai port which locate in Waigaoqiao and Yangshan port area is 215%; obviously, Shanghai port is quite congested. Just in 2017, 2 blockage cases had occurred in Yangshan port area (actually in Yangshan Phase III of which capacity utilization ratio was 152%) due to the congestion, which had caused schedule delayed, lines adjusted and logistics confusion in Shanghai port (Xu, 2017). The consequence of congestion affects costs, inter-port competition and other logistics functions (Fan et al., 2012). Then how about Ningbo-Zhoushan port? From Table 3, we can also see that the average capacity utilization ratio of Ningbo port area is 197.8% in 2017, almost as same as Shanghai port. In the context of congestion, the previous integration of Ningbo port and Zhoushan port seems quite necessary and reasonable. The strategic value of scarce coastline resource suitable for deep-water berthing continues to increase, thus placing greater emphasis on the rational use of these coastlines and their demands within the port integration paradigm (Wang et al., 2015). Just along Jintang Island in Zhoushan port area, the length of coastline suitable for mega container ship exceeds 7km, which overtakes those of Yangshan port area in Shanghai. With the increase of capacity utilization ratio in Meishan port area, the transhipment role of Zhoushan port area will gradually emerge. Only then, the direct and positive effect of port merger between Ningbo and Zhoushan would really stand out.

In 2016, Phase II of YZCT had started to construct; finally, YZCT would form the throughput capacity of 4 $\times 10^6$ TEU. In 2019, Daao container terminal, another container terminal which is adjacent to YZCT (see Figure 12 (left)) will begin construction and will form the throughput capacity of 3.5×10^6 TEU in 2023. Therefore, in the next 5 years, Ningbo-Zhoushan port will have an additional throughput capacity of 6.5×10^6 TEU in Zhoushan port area. If suppose their capacity utilization ratios are similar to those of Ningbo port area or Shanghai port, and take 200%, then the container throughput of Ningbo-Zhoushan port will increase by 13 $\times10^6$ TEU in Zhoushan port area (including YZCT and Daao container terminal).

Additionally, Phase II of MSICT with the throughput capacity of 4×10^6 TEU had started to build in December 2015 and will come into operation soon. According to the above hypothesis of capacity utilization ratios equal to 200%, MSICT would add 11×10^6 TEU to Ningbo-Zhoushan port (its traffic was 3.37×10^6 TEU in 2017 with the capacity utilization ratio was 112% because it was a new terminal just putting into use in the end of 2012).

As a conclusion, the new terminals in building would bring about 24×10^6 TEU (13×10^6 TEU from Zhoushan port area and 11×10^6 TEU from MSICT); therefore, 49×10^6 TEU in 2026 which we forecast in Section 5.1 would seem possible to come true.

5.5. Challenges and opportunities in policies

1) Challenges in politics. To promote the construction of Shanghai International Shipping Center, Chinese central government had ever explicitly declared Yangshan port as its symbolic project and, in order to ensure its success, had stipulated that Ningbo cannot expand too far or too fast at the expense of container throughput in Yangshan, which was ever the obstacle and ceiling for the development of Ningbo-Zhoushan port. Therefore, Wang and Ducruet (2012) believed that strong support from the central government to Shanghai's globalization favoured Yangshan new port rather than existing neighbouring ports (i.e. Ningbo) for infrastructure expansion and offshore hub development. However, nobody could underestimate the combined impact of the market forces. What's more, in much more pragmatic terms, it is how far Zhejiang provincial government can circumvent such edicts and support the further development of its regional port at Ningbo that will probably emerge as the true determinant of the relative competitive success between Shanghai and Ningbo-Zhoushan (**Cullinane et al., 2005**).

From a political perspective, the relative competitive fortunes of the ports of Shanghai and Ningbo are likely to depend, to some considerable extent, upon central government approval and the practical implications of its approach to, and policies on, the decentralization of port governance (**Cullinane et al., 2005**). After all, the development of ports always involves every aspect of local interests, and a hint should be dropped that the Chinese President was ever the governor of Zhejiang province. From this point of view, perhaps we may understand why the preferential policies and ambitious infrastructure expansion in Ningbo-Zhoushan could be approved by the central government.

2) Challenges in shipping atmosphere. Shanghai is the international shipping center of China and Ningbo-Zhoushan port is close to Shanghai geographically. Due to the effect of siphon from Shanghai, Ningbo-Zhoushan port always faces fierce competition from Shanghai in terms of shipping finance, insurance and services, resources, policies and professionals, etc. In any cases, Meishan Bonded Port Area was set up in 2008, which was the 5th bonded port area in China. To improve shipping atmosphere, Ningbo municipal government proposed the construction of the Ningbo International Shipping Service Centre in 2009, and in 2013 the Ningbo Container Export Index (NCFI) - the Sea Silk Road Index was introduced, which improved the shipping environment and promoted the attraction of Ningbo-Zhoushan port. In 2017, China (Zhejiang) Pilot Free Trade Zone was established in Zhoushan. The bonded port policy and free trade port policy will bring a quite positive impact on Ningbo-Zhoushan port. Preferential policies on added taxes, consumption taxes, export tariffs and tax refurbishment would encourage international trade and promote transport demand (**Yang et al., 2018**), which would help to weaken the siphon effect from the Shanghai Free Trade Area and strengthen the position of Ningbo-Zhoushan port as a gateway and hub port.

3) Challenges in administrative division. Ningbo port and Zhoushan port belong to two different administrative regions. After the nominal merger of the two ports in 2006, they were actually operated independently. Until 2015, Zhejiang provincial government took over the management of the two ports. However, port infrastructure construction always needs to be promoted by local governments, after all, their respective local interests are not the same. For example, the Ningbo municipal government has long focused on the development and construction of Meishan port area, while the Jintang port area in Zhoushan, despite its excellent port conditions, has made slow and little progress due to financial lack. With the growth of container traffic and the drying-up of deep-water coastline in Ningbo port area, the development of a so-called offshore hub in Meishan Island (MSICT) and Jintang Island (Zhoushan port area including YZCT and Daao container terminal) (see **Figure 12 (right)**) would help to maintain the significant role of Ningbo-Zhoushan port and meet the needs the main global carriers. The resultant port development exemplifies a new model of spatial distribution such as a multi-layered gateway hub **(Notteboom and Rodrigue (2005); Wang and Ducruet, 2012)** where the offshore hub (for instance Zhoushan port area and MSICT) would act as an offshore container terminal oriented to transhipment activities and develop valued-added activities in relation to a local cargo. The main gateway (such as NBCT, NBSCT, CMICT, CSCT and YDCT) would compensate the shifts of container services to the offshore hub by expanding its involvement in the logistics integration of the hinterland and also via increased activity at dry port **(Wang and Ducruet, 2012**). Finally, ZHG will continue to mainly engage in coastal transportation.

6. Final remarks

Containerized transport appeared at Ningbo-Zhoushan in 1986. During the past 30 years, Ningbo-Zhoushan port has grown from a feeder port to a hub port. In 2017, Ningbo-Zhoushan was the largest port in Zhejiang province with and its spatio-temporal pathways are achieved by expanding its throughput capacity and then expanding its container traffic. Dynamic mechanism is the result of economic globalization, containerization and its natural endowments in depth of channel and terminal.

The development of container transport in Ningbo-Zhoushan port has experienced 3 periods: (1) adoption period in which the main dynamics is the impact of the Chinese 'Open Door policy' (1986-2000); (2) acceleration period in which the dynamics is impact of the mainland China's entry into the WTO (2001-2008); (3) peak growth period in which the dynamics is impact of the anti-crisis strategy again the financial and economic crisis in 2008 (2009-now). In the near future, the evolution of Ningbo-Zhoushan port would be consistent with the multi-layered gateway hub in which different port area will undertake their distinct functions. In this sense, this port system evolutionary model is similar to that observed in other regions (e.g. **Notteboom and Rodrigue (2005)** and **Wang and Ducruet (2012)**). The multi-layered hub will be achieved by the construction of MSICT and Meishan Bonded Port Area and consolidated by the YZCT and Daao terminal with their adjacent free trade region. In this case the offshore hub (for instance Zhoushan port area and MSICT) would act as an offshore container terminal oriented to transhipment activities and develop valued-added activities in relation to a local cargo; the main gateway (such as NBCT, NBSCT, CMICT, CSCT and YDCT) would compensate the shifts of container services to the offshore hub by expanding its involvement in the logistics integration of the hinterland and also via increased activity at dry port; ZHG will continue to mainly engage in coastal transportation. Finally, particularities or divergences from the generic model Notteboom and Rodrigue (2005) in the case of Ningbo-Zhoushan are, in one side, the multiple offshore nodes in comparison to a unique sole transhipment node and, secondly, the spatial development influenced by the port integration as a results of an administrative merging to unify strategies.

According to the prediction model based on time-series (i.e. ARIMA), after 2026 (see Appendix), container traffic in Ningbo-Zhoushan port would reach about 49×10^6 TEU which would approximately approach that in Shanghai port if there is no turning point (serious events leading a sudden decline in China's economy such as the financial crisis in 2008) in the forecasting period. With the rapid increase of container traffic, port capacity utilization ratios in Shanghai and Ningbo reach about 200%, which means a serious congestion in port. Therefore, in future, coastline resource suitable for deep-water berthing will manifest its strategic values. In this respect, Zhoushan port area possesses excellent natural endowments in depth of channel and terminal, and also shows the growth potential of Ningbo-Zhoushan port. In the past servals years, Ningbo-Zhoushan port had obtained the bonded port policy in Meishan Island and the free trade zone policy in Zhoushan Island from the central government. Geographical position, service level, hinterland economic level and government will support its perspectives.

The evolution of the relationship between Ningbo-Zhoushan port and Shanghai port can be regarded as the formation process of a dual hub port development model. The retrograde attack to Shanghai of Ningbo-Zhoushan port is the result of making full use of its superior geographical position and excellent natural endowment under the background of global, China and regional economic prosperity. In this process, the comprehensive market force and the development impulse of local government played a key role. From these three aspects, the growth process of Ningbo-Zhoushan port is very similar to that of Shenzhen port. From the successful experience of Ningbo Port, we learn that the success of the port is the result of political and economic development, and depends on its own endowment and efforts.

As our prediction in **Section 5.1**, perhaps the container throughput of Ningbo-Zhoushan port would surpass that of Shanghai someday. However, Ningbo-Zhoushan must remain 'subservient to its larger neighbour in the north' **(Chambers, 2005)**. In the future, no matter how Ningbo-Zhoushan develops, in our opinion, Shanghai is China's International Shipping Center indeed, and Ningbo-Zhoushan is an important part of Shanghai United Ports. The relationship between Shanghai and Ningbo-Zhoushan is similar to that between Hong Kong and Shenzhen; although container throughput of Shenzhen port has surpassed that of Hong Kong, no one asserts that Shenzhen is more important than Hong Kong in shipping function.

Appendix. Correlograms, Estimation and Verification of ARIMA Model

Introduction about ARIMA prediction.

In recent decades, predictions of port container throughput have also received increasing attention. Forecasting methods are usually classified as qualitative or quantitative, where the latter can be divided further into causal methods and time-series methods **(Abraham and Ledolter, 2009)**. Causal methods **(Chou et al., 2008; Langen et al., 2012; Patil and Sahu, 2016)** examine the correlation between the container throughput and a series of economic indicators of port hinterland, and built a forecasting model according to the relevant economic indicators **(Xiao et al., 2014)**. In contrast, time-series prediction methods are based on the historical throughput and extrapolate the behaviour in the future. A third approach of forecasting is artificial intelligent (AI) methods, such as genetic programming (GP) **(Chen and Chen, 2010)**, artificial neutral network (ANN) **(Gökkuş et al., 2017; Tsai and Huang, 2017)**, System Dynamics **(Yeo, 2017)**, TEI@I methodology **(Tian et al., 2013)**. However, AI methods have their own disadvantage, c. g., GP is sensitive to parameter selection, while ANN often suffers from local minima and over-fitting **(Yu et al., 2008)**. Additionally, some hybrid techniques have been developed, including qualitative and analytical analyses with a good level of prediction accuracy **(Huang et al., 2015; Intihar et al., 2017; Mo et al., 2018; Niu et al., 2018; Pang and Gebka (2017); Zhou and Tao, 2015)**. However, as noted by Peng and Chu (2009) or Twrdy and Batista (2016), there is not a clear best method for realistic predictions in container throughput. What's more, as suggested by Peng and Chu (2009) and Makridakis and Hibon (2004), a simple method seems to perform extremely well and sophisticated or complex methods do not necessarily provide more accurate forecasts then simpler ones. Considering historical container throughput data is easy to obtain, we intent to use the quantitative time-series method for forecasting in the article.

Feng: you should include a little bit more of information in the Appendix:

- ***What is show in Tables and Figures in the Appendix?: "Tablñe A1 show the stationary***

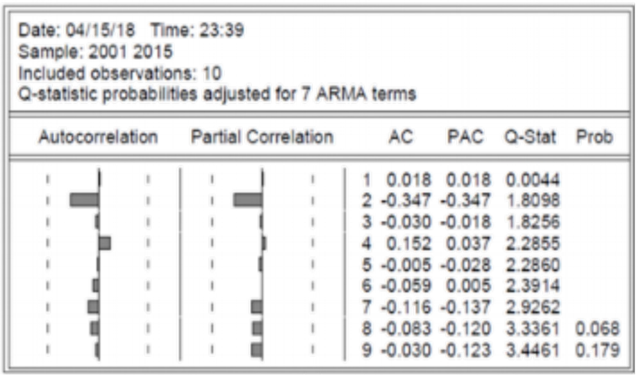
test in order to establish the differentiation order…. Figure A1 shows the correlograms... … "

- ***To talk about the confidence of the predictions and the tendence at short term:***

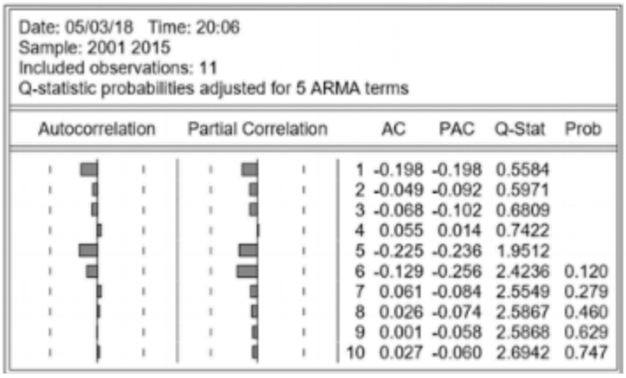
"The accuracy of the ARIMA method decrease as the prediction horizon increase. However, the time-series prediction at short-term show an undeniable decrease of the container throughput difference between Ningbo-Zhoushan and Shanghai ports.

			First difference		Second difference	
			t-Statistic	Prob.	t-Statistic	Prob.
Shanghai port	ADF test statistic		-1.99096	0.2864	-3.98444	0.014
	Test critical values:	1% level	-4.05791		-4.20006	
		5% level	-3.11991		-3.17535	
		10% level	-2.7011		-2.72899	
Ningbo-Zhoushan port	ADF test statistic		-1.75444	0.3839	-4.043519	0.0128
	Test critical values:	1% level	-4.05791		-4.200056	
		5% level	-3.11991		-3.175352	
		10% level	-2.7011		-2.728985	

Table A 1. Stationary tests of first difference and second difference.

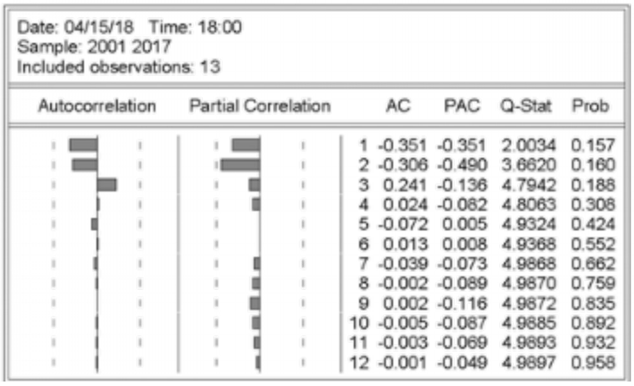

Date: 04/15/18 Time: 23:39
Sample: 2001 2015
Included observations: 10
Q-statistic probabilities adjusted for 7 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.018	0.018	0.0044	
		2	-0.347	-0.347	1.8098	
		3	-0.030	-0.018	1.8256	
		4	0.152	0.037	2.2855	
		5	-0.005	-0.028	2.2860	
		6	-0.059	0.005	2.3914	
		7	-0.116	-0.137	2.9262	
		8	-0.083	-0.120	3.3361	0.068
		9	-0.030	-0.123	3.4461	0.179

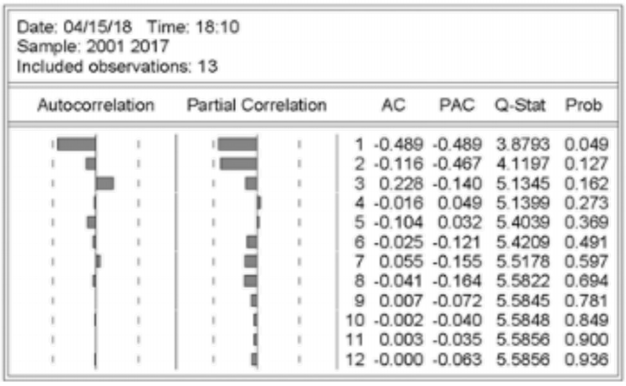

Date: 05/03/18 Time: 20:06
Sample: 2001 2015
Included observations: 11
Q-statistic probabilities adjusted for 5 ARMA terms

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.198	-0.198	0.5584	
		2	-0.049	-0.092	0.5971	
		3	-0.068	-0.102	0.6809	
		4	0.055	0.014	0.7422	
		5	-0.225	-0.236	1.9512	
		6	-0.129	-0.256	2.4236	0.120
		7	0.061	-0.084	2.5549	0.279
		8	0.026	-0.074	2.5867	0.460
		9	0.001	-0.058	2.5868	0.629
		10	0.027	-0.060	2.6942	0.747

Figure A 1. Correlograms of second difference for Shanghai port (left), Ningbo-Zhoushan port (right).


Date: 04/15/18 Time: 18:00
Sample: 2001 2017
Included observations: 13

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.351	-0.351	2.0034	0.157
		2	-0.306	-0.490	3.6620	0.160
		3	0.241	-0.136	4.7942	0.188
		4	0.024	-0.082	4.8063	0.308
		5	-0.072	0.005	4.9324	0.424
		6	0.013	0.008	4.9368	0.552
		7	-0.039	-0.073	4.9868	0.662
		8	-0.002	-0.089	4.9870	0.759
		9	0.002	-0.116	4.9872	0.835
		10	-0.005	-0.087	4.9885	0.892
		11	-0.003	-0.069	4.9893	0.932
		12	-0.001	-0.049	4.9897	0.958


Date: 04/15/18 Time: 18:10
Sample: 2001 2017
Included observations: 13

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.489	-0.489	3.8793	0.049
		2	-0.116	-0.467	4.1197	0.127
		3	0.228	-0.140	5.1345	0.162
		4	-0.016	0.049	5.1399	0.273
		5	-0.104	0.032	5.4039	0.369
		6	-0.025	-0.121	5.4209	0.491
		7	0.055	-0.155	5.5178	0.597
		8	-0.041	-0.164	5.5822	0.694
		9	0.007	-0.072	5.5845	0.781
		10	-0.002	-0.040	5.5848	0.849
		11	0.003	-0.035	5.5856	0.900
		12	-0.000	-0.063	5.5856	0.936

Figure A 2. Correlograms of Residuals for Shanghai port (left), Ningbo-Zhoushan (right).

Dependent Variable: D (Shanghai port, 2)

Variable	Coef.	Std. Error	t-Statistic	Prob.				
					R-squared	0.996	Mean dependent var	-0.008
C	-0.013	0.027	-0.508	0.662	Adjusted R-squared	0.984	S.D. dependent var	0.051
AR (1)	-0.971	1.619	-0.600	0.610	S.E. of regression	0.006	Akaike info criterion	-7.272
AR (2)	-0.563	2.563	-0.220	0.847	Sum squared resid	0.000	Schwarz criterion	-7.030

AR (3)	1.681	2.437	0.690	0.562	Log likelihood	44.361	Hannan-Quinn criter.	-7.538
MA (1)	-1.342	14.931	-0.090	0.937	F-statistic	80.283	Durbin-Watson stat	1.677
MA (2)	-4.289	17.529	-0.245	0.830				
MA (3)	-17.443	48.688	-0.358	0.754	Prob(F-statistic)		0.012	
MA (4)	30.957	44.257	0.699	0.557				
Dependent Variable: D (Ningbo-Zhoushan port, 2)								
Variable	Coef.	Std. Error	t-Statistic	Prob.	R-squared	0.970	Mean dependent var	-0.012
C	-0.017	0.002	-9.992	0.000	Adjusted R-squared	0.941	S.D. dependent var	0.049
AR (1)	-0.938	0.988	-0.949	0.386	S.E. of regression	0.012	Akaike info criterion	-5.698
AR (2)	-0.350	0.786	-0.445	0.675	Sum squared resid	0.001	Schwarz criterion	-5.481
MA (1)	-2.256	1.692	-1.334	0.240	Log likelihood	37.337	Hannan-Quinn criter.	-5.834
MA (2)	-4.513	2.755	-1.638	0.162	F-statistic	32.764	Durbin-Watson stat	2.137
MA (3)	0.565	4.951	0.114	0.914	Prob(F-statistic)		0.001	

Table A 2. Estimation of ARIMA model for Shanghai port and Ningbo-Zhoushan port.

Year	Port	Total container traffic (in TEU)	Total container traffic predicted (in TEU)	Standard deviation predicted (in TEU)	APE (in %)
2016	Shanghai	3713	3813.5	312.8	2.64
	Ningbo-Zhoushan	2384.7	2458.5	124.2	3.0
2017	Shanghai	4023	3940.6	398.3	2.09
	Ningbo-Zhoushan	2727.1	2678.5	178.4	1.82

Table A 3. Verification test results: real and prediction of the container traffic. MAPE is the Mean…

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