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Study on the port classification of 21st century Maritime Silk Road west line

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STUDY ON THE PORT CLASSIFICATION OF 21st CENTURY MARITIME SILK ROAD WEST LINE

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Declaration

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

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(Date): 2019-06-25

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Abstract

The initiative ‘Silk Road Economic Belt’ and ‘21st century Maritime Silk Road’ in short ‘One Belt and One Road’ put forward in September 2013 by President Xi. ‘21st Century Maritime Silk Road’ has been divided into two lines, west and south.

This thesis first introduces and analyzes the current situation of the ports, then use Principal Components Analysis and Clustering method to classify the 19 ports of Quanzhou, Guangzhou, Port Kelang, Nhava Sheva, Singapore, Chattogram, Colombo, Jebel Ali, Gwadar, Mombasa Port, Djibouti, Port Sudan, Alexandria, Piraeus, Istanbul, Malta Freeport, Valencia, Antwerp, Rotterdam along the west line into Central port, Main hub port, Regional hub port and Basic port four types. Base on the result, propose suggestions on increasing ports’ competitiveness and determine ports’ functional position alone the 21th Century Maritime Silk Road for the purpose of cooperation and complementing each other.

Key words: Port classification, Principal Components Analysis, Clustering Analysis, Port competitiveness

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1 Introduction

1.1 Research background

The two strategic concepts ‘Silk Road Economic Belt’ and ‘21st century Maritime Silk Road’ in short ‘One Belt and One Road’ put forward in September 2013 by President Xi. The overall goal is to establish a path-connected, free trade, marine cooperating and peacefully- developing community of common destiny.

China has huge demand on energy import from the world, while countries along the 21st century Maritime Silk Road contain rich energy resources. Those countries as Saudi Arabia, Amen, Kuwait are top 10 sources of world oil import. The 21st century Maritime Silk Road has been divided into two lines, extending from the coastal ports of China, South Sea, Malacca Straits, India Ocean to Europe (west line). Another line extends along the South Sea from coastal ports to the South Pacific (South line). The south line mainly go through Australia and New Zealand, which are under stable condition in terms of politics, while the west line go through more complicated regions. The situation in Southeast Asia is much better and the ASEAN Community is steadily improving. However, due to the great differences on the economic level and territorial disputes among ASEAN members, the regional integration is still a hard rock.

Most countries alone the 21st century Maritime Silk Road are developing countries, which have strong needs to develop. The problem is they are under inadequate infrastructure and shortage of funds. The Middle East, North Africa and Australia are rich in energy resources, which China has huge demand for. Saudi Arabia, Oman,

Iraq, Iran, the United Arab Emirates and Kuwait rank the top ten sources of China's oil imports, while Australia is the largest source of China's iron ore imports.

With Sri Lanka, Maldives, Pakistan and other countries expressing their willingness to participate in the 21st century Maritime Silk Road, India believes that China is the new rival in the Indian Ocean and strengthens its military diplomacy as countermeasures.

1.2 Research objective and purpose

Port plays a decisive role for economic development, almost half of the world's wealth gathered in the coastal port cities. Nearly 90% of the world's thirty major international metropolises are port cities or driven by ports. In the coastal areas of China, the development of regional economy benefits from the ports of the cities and ports play a leading role in these areas. At the same time, ports provide opportunities for these regions to further participate into the international market and make full use of international resources to develop regional economy. The initiative of 21st Century Maritime Silk Road has connected the ASEAN[1], South Asia, West Asia, North Africa and even Europe.

Most of the existing studies have classified the main ports in China or specific areas, but not the ports along the Silk Road west line. This paper select 19 ports alone the 21st century Maritime Silk Road west line as samples to study, as showed in the map of Figure 1. (Quanzhou, Guangzhou, Port Kelang, Nhava Sheva, Singapore, Chattogram, Colombo, Jebel Ali, Gwadar, Mombasa Port, Djibouti, Port Sudan, Alexandria, Piraeus, Istanbul, Malta Freeport, Valencia, Antwerp, Rotterdam)

[1] ASEAN: the Association of Southeast Asian Nations

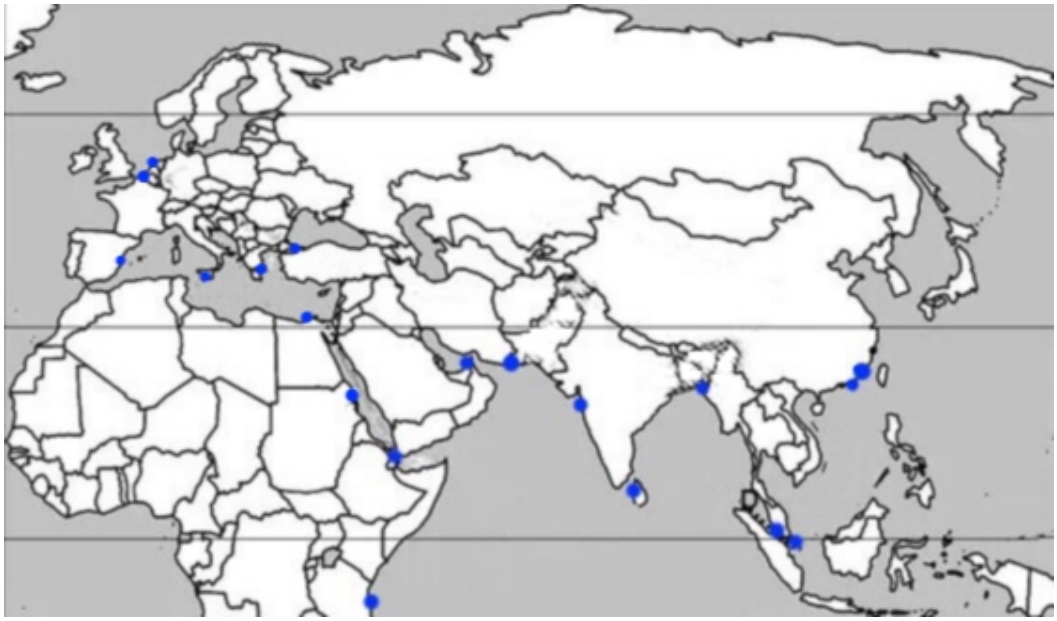


Figure 1 - Location of ports

First, by collecting the data of the Container throughput in 2018, Container throughput in 2017, Container throughput in 2016, Container throughput in 2015, Growth of Container throughput in 4 years, Berth number, Max draft, Length of port area, Max crane lifting capacity, GDP of the country in 2018, GDP growth from 2017, 2014 Merchandise trade, 2015 Merchandise trade, 2016 Merchandise trade, 2017 Merchandise trade, 2018 Merchandise trade and Liner shipping connectivity index to classify these nine port, the principal component analysis method will be used to evaluate the competitiveness of ports.

Secondly, use clustering analysis to classify these ports into Central port, Main hub port, Regional hub port, Basic port. To classify ports provide superior alternatives for selecting routes to transport.

1.3 Dissertation Structure

The structure of the dissertation is described as follows. Chapter 1 is the introduction of the dissertation where comprises the research background, research objective and purpose, dissertation structure, the schedule of dissertation and literature review, which reveals the current study condition on port classification and functional position of the main ports along west line. Chapter 2 first introduces the basic concept of Principal Component Analysis and Clustering Analysis. Secondly, list the data will be used. Chapter 3 divides ten ports into three parts by their location, demonstrates the overview and market condition of them. Chapter 4 concludes components selection for Principal Component Analysis. Chapter 5 uses Clustering Analysis for classifying the ports and result elaborating. Chapter 6 is the comprehensive conclusion, both positive and negative on the result.

1.4 Literature review

A new initiative called the "Silk Road Economic Belt and the 21st-Century Maritime Silk Road", in short "One Belt and One Road", was proposed in 2013 by China. This initiative aims to strengthen the economic and maritime connectivity among Asia, Europe, and Africa. Furthermore, China has been very active in developing the China-Africa-South America (CASA) routes in recent years (Chen et al., 2013; Lee, 2015).

The initiative of 21st century Maritime Silk Road is another approach for opening to the outside world. Unlike the opening to the east, the developed countries in 1987, this time is to those developing countries in the west, and the scope is designated in those developing countries as ASEAN countries, South Asian countries and Gulf countries. (Yi Quan, Jie Wang, Wanting Liu, 2014)

There are a lot of studies has introduced the current market and political situation of the countries alone 'The Road'. The developed countries such as the United States, Europe and Japan are China's traditional export markets, but their incremental space is not very large. While a huge number of developing countries along 21st century Maritime Silk Road have huge market potential which may help to digest the overcapacity in China. Various nations, culture, religions and conflicts occur along the west line, which may challenge the safety of the Maritime Silk Road. (Mengzi Fu, Chunhao Lou, 2015). The scholars analyze the transshipment flows that could be captured by potential hub ports in the SSA region due to the developments in sub-Saharan Africa (SSA). And also analyze the different vessel sizes, speeds, carbon taxes in association with the 21st Century Maritime Silk Road initiated by China. (H.J.Kim, J.S.L.Lam, P.T.W.Lee, 2018)

Stochastic Frontier Gravity Model is established to estimate the trade potential of 13 countries (Indonesia, Malaysia, Singapore, Philippines, Vietnam, Pakistan, India, Sir Lanka, Oman , The United Arab Emirates, Qatar) in Southeast Asia, South Asia, Central Asia and West Asia. (Xiujie Tan, Maorong Zhou, 2015). Wang studies the trade potential of the countries alone the Maritime Silk Road west line by Gravity Model and comes to the conclusion that Philippines and Indonesia in Southeast Asia, India in South Asia, Qatar, Iraq and Kuwait in West Asia are potential countries. Malaysia, Pakistan, Sri Lanka, Egypt, Kenya and other countries have responded positively to the 'One Belt and One Road' initiative. (Pengjie Wang, 2017)

Every container terminal is characterized by some physical values that represent relevant properties of the terminal. By employing DEA, can measure the efficiency of the port and set benchmark for those inefficiency terminals. It may give biases result because all terminals vary in capacity. (Mithun J. Sharma, Song Jin Yu, 2009)

In container liner shipping operation, shipping networks always play an important role. The 21st century Maritime Silk Road shipping network shows uneven distribution and obvious agglomeration. Those big ports as Shanghai, Singapore have significant influence, which should be connected with important hubs (Port Kelang) to strength the links between countries alone Maritime Silk Road. The development of Maritime Silk Road has also speed up the construction of these potential ports (Chattogram, Colombo, Piraeus) (Naixia Mou, Caixia Liu, 2018).

Alternative approaches have been used to measure the port competitiveness. Scholars investigated both the factors and their relative importance weights in determining a port's competitiveness via the AHP. (Chi-lok Andrew Yuen, Anming Zhang, Waiman Cheung, 2012). Huang and Qu select 11 major function indexes from 24 seaports in China to establish factor analysis model. They cluster 24 ports into 7

catagories. (Huang shunquan, Qu linchi, 2011) Bruce A. Blonigen and Wesley W. Wilson measure the ocean port efficiencies through the basic statistical tools using data of U.S. import flow. (Bruce A. Blonigen and Wesley W. Wilson, 2006)

Scholars designed a model called CCPE, which integrates Condition, Capacity, Potential and Efficiency of the ports to estimate their competitiveness. Port's status in the global maritime transport network was the most influential of all competitiveness indices. (Peng Peng, Yu Yang, 2018) Competitive ports were mainly concentrated in the Mediterranean, the Suez Canal, and the Hormuz Strait, with Singapore, Marsaxlokk, and Algeciras ranking as the top three. The least competitive ports were mainly concentrated in East Africa, with Songkhla, Mtwara, and Sittwe ranking lowest. Third, port competitiveness was clearly polarized in that the most competitive ports stood far above all others due to significant gaps in their network status index. (Yuen Chi-lok Andrew, Anming Zhang, Waiman Cheung, 2012)

After the evaluation port competitiveness by principal component analysis and clustering analysis, 14 coastal ports in China have been classified into four categories: Central port, Main hub port, Regional hub port and Basic port. (Yunmei Zhan, Jun Chen, 2018)And therefore the role orientation and content division of these four categories of ports on the 21st century Maritime Silk Road are planned. (Wang Pengwei, 2017). From 1992 to 2002, 17 ports were selected from the top 20 ports in China ranked in terms of throughput for clustering analysis. They are divided into ordinary growth ports, accelerated growth ports and fluctuating growth ports. (Lina Liu, Zijian Guo, Xiangqun Song, 2006).

Scholars combine clustering, stochastic frontier analysis and self-organized maps to set improvement targets for ports as a function of their specific cluster.(Beatriz T ,Héctor R.D, 2015) These studies analysis the port competitiveness alone the 21st

century Maritime Silk Road only in China, there is almost no information about the port competitiveness focusing on the 21st century Maritime Silk Road. Another study uses container throughput in 5 years as variable for clustering analysis to classify the coastal container ports in China. (Yuwen Zhong, 2006)

Port efficiency and port clustering are two aspects that have received different degrees of attention in the existing literature. While the actual estimation of port efficiency has been extensively studied, the existing studies have paid little attention to developing methodologies for port classification. Some studied the port classification, but focusing on a specific region or among a country. Others make commentary towards port and analyze the advantages and disadvantages of which. There is barely study had classified the main ports along the Maritime Silk Road west line.

2 Research method design

2.1 Principal Component Analysis

Principal Component Analysis is a method to recombine original indicators of which have certain correlation into a new set of independent comprehensive indicators and to reveal the internal structure of multiple variables through a few principal components. This is to say that a few principal components are derived from the original variables in order to retain as much information about the original variables as possible.

First, assume there are **P** evaluation indexes as $\mathbf{X_j}$ (j =1，2，...，p), which are composed by **Q** principal Components, $\mathbf{f_k}$ (k = 1，2，...，q) , the number of the components is the number of the variables. $\mathbf{a_{pq}}$ is the load matrix of the principal components. The formula shows as

$$\begin{cases} \mathrm{X}_1 = a_{11}\mathrm{f}_1 + a_{12}\mathrm{f}_2 + \ldots + a_{1q}\mathrm{f}_q \\ \mathrm{X}_2 = a_{21}\mathrm{f}_1 + a_{22}\mathrm{f}_2 + \ldots + a_{2q}\mathrm{f}_q \\ \mathrm{X}_3 = a_{31}\mathrm{f}_1 + a_{32}\mathrm{f}_2 + \cdots + a_{3q}\mathrm{f}_q \\ \qquad\qquad \ldots \\ \mathrm{X}_p = a_{p1}\mathrm{f}_1 + a_{p2}\mathrm{f}_2 + \ldots + a_{pq}\mathrm{f}_q \end{cases} \tag{1}$$

The score of principal component $\mathbf{f_k}$ is

$$f_{ki} = \omega_{k1}X_{i1} + \omega_{k2}X_{i2} + \cdots + \omega_{kp}X_{ip} \qquad (2)$$

In this formula $\boldsymbol{\omega_{kp}}$ is the coefficient of the principal component $\mathbf{f_k}$ corresponding evaluation index, $\mathbf{X_{ip}}$ is the the evaluation indexes of sample **i**. The score of the principal component $\mathbf{f_k}$ is the weighted sum of the principal components' weight. The weight for principal component $\mathbf{f_k}$ is

$$\omega'_k = \frac{\lambda\kappa}{\lambda 1+\lambda 2+\cdots+\lambda q} \qquad (3)$$

$\boldsymbol{\lambda\kappa}$ is the characteristic value of $\mathbf{f_k}$. So, the final score of the principal component is

$$F_i = \omega'_1 F_{1i} + \omega'_2 F_{2i} + \cdots + \omega'_q F_{qi} \qquad (4)$$

The principal components are Container throughput in 2018 (X_1), Container throughput in 2017 (X_2), Container throughput in 2016 (X_3), Container throughput in 2015 (X_4), Growth of Container throughput in 4 years(X_5), Berth number(X_6), Max draft(X_7), Length of port area(X_8), Max crane lifting capacity(X_9), GDP of the country in 2018(X_{10}), GDP growth from 2017(X_{11}), 2014 Merchandise trade(X_{12}), 2015 Merchandise trade(X_{13}), 2016 Merchandise trade(X_{14}), 2017 Merchandise trade(X_{15}), 2018 Merchandise trade(X_{16}), Liner shipping connectivity index (X_{17}).

2.2 Clustering Analysis

Clustering analysis is based on the similarity or friendliness relationship of variables' characteristics. It mathematically divides the variables step by step according to certain rules, forms a classification system diagram in the end. Firstly, the data will be converted because they are measured by different units of which may lead to magnitude differences. Secondly, the clustering statistics will be calculated. After that a clustering method will be used to cluster the closely related units into one group.

The article will use hierarchical Clustering method, combine the two categories with the smallest Sum of Squares of Deviations in each step, until all cases are classified into one category. And calculate the distance between categories by Square Euclidean distance. The formula is

$$d_{il} = \sqrt{\sum_{j=0}^{p} (X_{ij} - X_{lj})^2} \qquad (5)$$

of which p means p variables per sample, X_{ij} is the value of the i-th sample on the j-th variable, X_{lj} is the value of the l-th sample on the j-th variable.

A dendrogram will be generated from the clustering process to classify the ports into Central port, Main hub port, Regional hub port and Basic port, four types. Both of the models will be processed be SPSS and sharing the same original data. The analysis will base on the score of each port from Principal component analysis and the classification result from clustering analysis.

2.2 Data Collection

The components will be used for the models are shown in Table 1

Table 1 - Components for model

X_1	Container throughput in 2018
X_2	Container throughput in 2017
X_3	Container throughput in 2016
X_4	Container throughput in 2015
X_5	Growth of Container throughput in 4 years
X_6	Berth number
X_7	Max draft
X_8	Length of port area
X_9	Max crane lifting capacity
X_{10}	GDP of the country in 2018
X_{11}	GDP growth from 2017
X_{12}	2014 Merchandise trade
X_{13}	2015 Merchandise trade
X_{14}	2016 Merchandise trade
X_{15}	2017 Merchandise trade
X_{16}	2018 Merchandise trade
X_{17}	Liner shipping connectivity index

3 Overview of main ports on 21st-Century Maritime Silk Road

3.1 Overview and functional positioning of main ports in Asia

QuanZhou

QuanZhou, developed from Song Dynasty, was the starting point of the ancient Maritime Silk Road. The special geographic location determined the vital position of QuanZhou. The development of the port QuanZhou had played an significant role in promoting ancient China from economy, society and culture aspect.

Port QuanZhou locates in the south-east of Quanzhou city, for both political and military reason, port QuanZhou was closed in 1957 and started to rebuilt in 1978. The current equipment shown in Table 2

Table 2 - Current equipment in port Quanzhou

Dockland	4
Operating section	16
Berth	54
Berth for over 10,000 dwt vessel	19

There are still 7 berths, capacity of 3 millions ton under construction. A 100,000-ton oil-specific terminal is under construction to adapting to the oil transshipment business. Port QuanZhou is also the first port in China that broadened the harbor for improving port capacity and accepting over 10,000 dwt vessels.

GuangZhou

Port GuangZhou locates in the century of the Pearl River Delta region, which is also the entrance of Pearl River. It is a combination of inland river and seaport, undertake a large number of transshipment business relying on its rich hinterland resources. The transshipment amount of GuangZhou Port is about 60% to 70% of its total throughput. The seaport has 4 docklands (Neigang, Huangpu, Xinsha, Nansha) and running through Guangzhou, Dongguan, Shenzhen, Zhongshan and Zhuhai.

Nansha is the main dockland of Guangzhou seaport, operating by 27 port companies with 92 berths, in which sixteen of them have the capacity over 10,000 tons, two over 100,000 tons and one over 120,000 tons. Until 2016, Nansha had operated 65 international routes, increased liner density.

Xinsha is the largest inland port in south China, with an over 3.6 million tons annual throughput, Xinsha is the also the largest and highly modernized dockland in Guangzhou port.

As a transportation hub in South China, Guangzhou has developed a transportation network to cover south-east Asia and connect the whole world by water channels, railways, highways and air system. Relying on the network of Pearl River, Guangzhouport trades with more than sixty countries all over the world. The convenient railway, road network makes Guangzhou port the most important terminal for domestic trade. While the biggest problem is the foreign trade takes less than 40% of the total throughput in Guangzhou, too few major international routes will restrict its development. It is necessary to strengthen both hardware and software in port area for the purpose of attracting regular liner shipping routes.

Port Kelang

Port Kelang is the biggest port in Malaysia, locates in the north-east of Strait of Malacca, 40 kilometers away from the city Kuala Lumpur. Most route transported from the far east to Europe will go through Port Kelang, it is the port that Maritime Silk Road must go through. With its adjacent to the free trade zone and vast hinterland, Port Kelang has a strong competitive edge in the shipping market. Being the largest port in Malaysia, Port Kelang owns three terminals, south, north and west terminals. The south terminal mainly loads and unloads bulk cargo and liquid cargo. The north terminal is container terminal, in the mean time, it also has dry bulk and liquid bulk cargo handling areas. The north terminal owns 18 berths (12 for container, 2 for ordinary cargo, 2 for dry bulk cargo and 2 tanker mooring berths), with a total length of 3939 meters and the container storage capacity of 19212 TEU. Except for the basic port area, the west terminal also provides ferries for passengers. There is an energy jetty in Port Kelang, dedicated offering oil and coal for Kapar power station.

Nheva Sheva

Nheva Sheva, the unloading and transshipment port for inland cities, which also can be called Mumbai new port, is the biggest container port in India. Nheva Sheva port is very closed to the Mumbai, the reason of building it is that Mumbai port is less than 10 meters deep, which is incapable for the large vessel to berth. Nheva Sheva port handling half of the maritime transportation in India, while is only available for container ship. It owns four terminals, as Figure 2

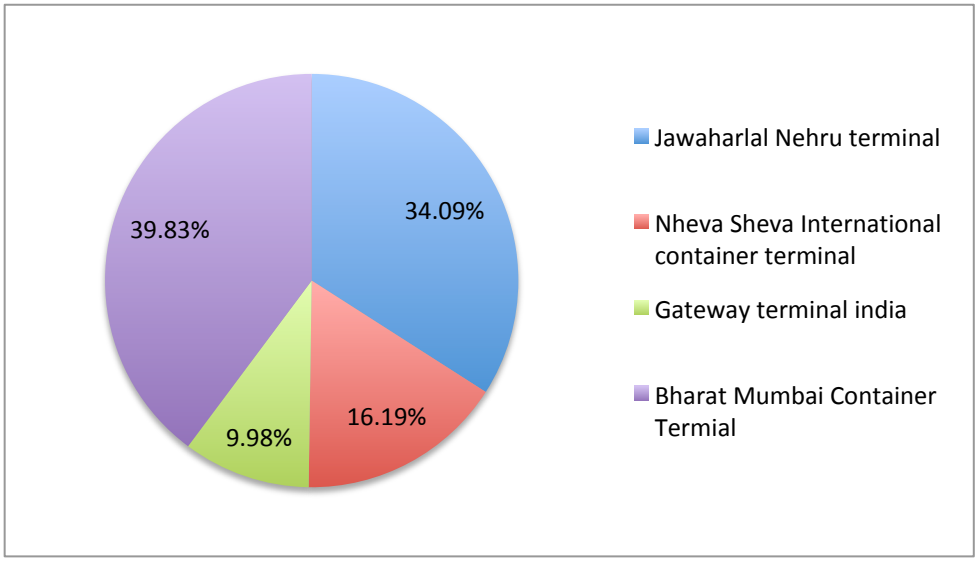


Figure 2 - Composition of Nheva Sheva

Out of the total traffic of 4.50 million TEUs in 2017, the share of the JNT was 34.09%(1.53 million TEU), for NSICT was 16.19% (0.73 million TEU), for GTI was 9.89% (0.45 million TEU) and the remaining 1.79 million TEU (39.83%) were contributed by Bharat Mumbai Container Termial.

It mainly imports The main imported products are chemicals, industrial equipments, construction materials, vegetable oils, mainly exports cotton, textiles, wheat, leather.

JNT is the biggest terminal of port Nheva Sheva, handling over 50%, container cargo of India. The facilities of JNT are user-friendly, also economical and convenient to transport to the hinterland by rail or road, which meet all international standards.

Singapore

Singapore Port is located in the southern part of Singapore Island, southeast of the Strait of Malacca, and artery between the Indian Ocean and the Pacific Ocean, which makes Singapore the largest transshipment port in the Asia-Pacific region. Singapore is also the busiest transshipment port in the world, with an average of 12 minutes for

a ship to enter and leave. The main imported products of Singapore include a large number of foods, as a result of its shortage of natural resources. At the same time, Singapore exports oil, machinery equipment, industrial material and chemical products, etc.

The port of Singapore has connection with over 600 ports from 123 countries or regions. Due to the excellent transshipment service it offered, containers' dwell time in Singapore is very short, approximately 3 to 5 days, 20% of them have the dwell time for only 1 day, by which increase the international transporting efficient in a great deal.

Except for its transshipment business, it offers comprehensive services, as air freight, oil refining and vessel repairing. Singapore, the largest ship-repairing yard in Asia, owns a huge 400,000 tons-dry dock and two 300,000 tons-dry dock, which can fix vessels of two million tons at the same time. These comphrensive services allow shipowners to berth fully-loaded ships in Singapore, transiting to another ship for the following voyage and maintaining the original vessel in Singapore.

The annual crude oil traffic amount in Singapore Port reaches 50% of the world total crude oil traffic. The product oil price is also very low, because many large oil companies refines oil there. With the business amount, price and special location of Singapore, it is now an international fuel-supplying center for ship.

Chattogram

Chattogram, name changed in 2018 to suit local language. The Port of Chittagong is the largest seaport in Bangladesh, located by the estuary of the Karnaphuli River in Patenga, near the city of Chittagong. Chattogram, with 11 berths, handled over 92% of maritime trade of Bangladesh.

Export products include jute, cotton, eggs, paper, bean cakes and livestock Foods and importing grain, coal, cement, fertilizer, wood, sugar, vehicles and machinery.

Chattogram port is also well-knowned for its congestion. The maximum handling capacity is 1.7 million TEU, while it handled 2.9 million TEU in 2018. Second, the severe shortage of barges aggravated the congestion in the port. The port demand at least 500 barges to meet its operation, but owning only 150 in reality. Third, the strike in Chattogram is also very unpredictable and they don't work during the ramadan. Last but not least, the water depth is insufficient. A port with an annual throughput of more than 2 million TEUs like Chattogram only has a berth depth of 6.4 - 8.5 meters, which means these large container ships can not berth.

Colombo

Port of Colombo is one of the biggest artificial port in the world, which is also a important port for the routes going through Eurasia, Pacific and Indian Ocean area. With an area of 24,000 square meters and a total length of 1,200 meters, the port is suitable for large vessels and handling over 90% commodity of Sri Lanka. Major importing and exporting commodites include tea, coffee, cocoa, rubber, coconut oil, coal, ironware,etc.

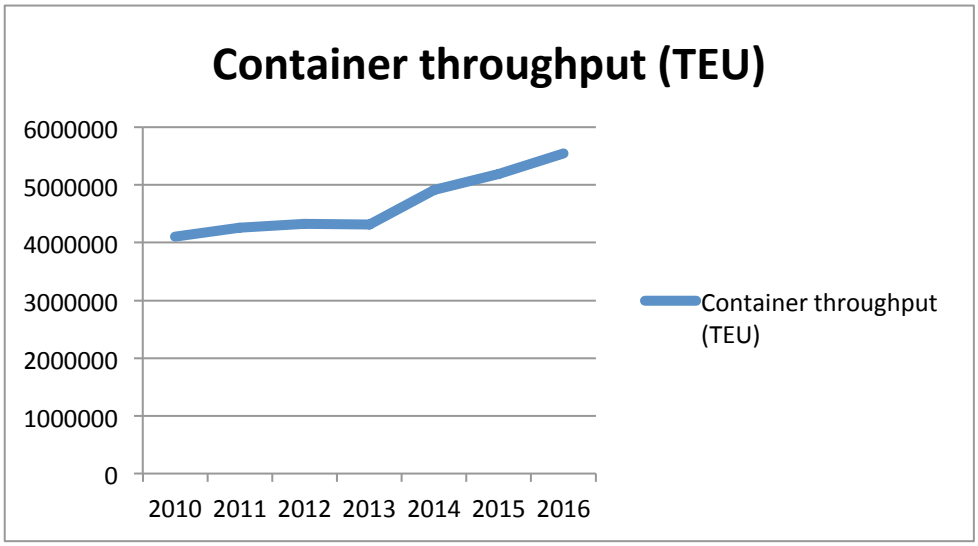


Figure 3 - Container throughput of port Colombo from 2010 to 2016

As Figure 3 shows, there is a substantial growth in container throughput in port Colombo of 2014. China Merchant Group had invested $500 million in Colombo South container for the operation of 35 years, according to the agreement signed with Sri Lanka government in 2011. And the south terminal accomplished a 680,000 TEU in 2014, which increase 14% compares to 2013. The container throughput grew from While under the pressure from India, Sri Lanka government changed the agreement from ‘permanent use of 20 hectares of land’ to ‘99 years leasing’ in 2016.

Jebel Ali

Port of Jebel Ali, located in 35 km south-west of Dubai, United Arabic Emirates, is the largest human-made port and the busiest port in middle east. The government built a Jebel Ali village for the purpose of performing excellency, which covers 134 square kilometers, with more than 300 people from 120 countries. Jebel Ali has a 1.4 million sqm yard, serving not only the loading and unloading of goods, but also the storage of goods in the medium and long term. This includes 928,499 sqm of open

storage and 71,501 sqm of covered storage area. Jebel Ali Port combines unparalleled access by sea, air and land with a multitude of modern facilities, a wide choice of logistics service providers and excellent connections with the hinterland, which makes it irreplaceable for serving the gulf and African markets. DP World's flagship Jebel Ali Port is ranked amongst the most sophisticated and best-performing container ports in the world. The three existing container terminals (Container Terminal 1, Container Terminal 2, Terminal 3) at Jebel Ali Port in total have the capacity of 19.3 million TEU.

Gwadar

Gwadar deepwater Port is Pakistan's third largest port, which is Central Asian inland countries' estuary. In 2002, under the request of Pakistan President, Chinese Government invested and provided technical assistance for the construction. In 2012, the Pakistan government handed over Gwadar's controlling rights to three Chinese enterprises (China Overseas Port Holding Campany, China Merchants Holdings and COSCO Shipping).

China is expected to create a channel for energy transportation to western regions such as Xinjiang, since port of Gwadar is 400km away from Strait of Hormuz, which is the main route for oil transportation. 60% of the energy supply comes from the Middle East, while 80% of it transported through the Strait of Malacca. By creating such route will reduce China's dependence on Malacca area for a great deal. These ports in Asia mainly import and export food commodity and consumer good.

According to the liner shipping connectivity index[2] from UNCTAD, showed in the Figure 4

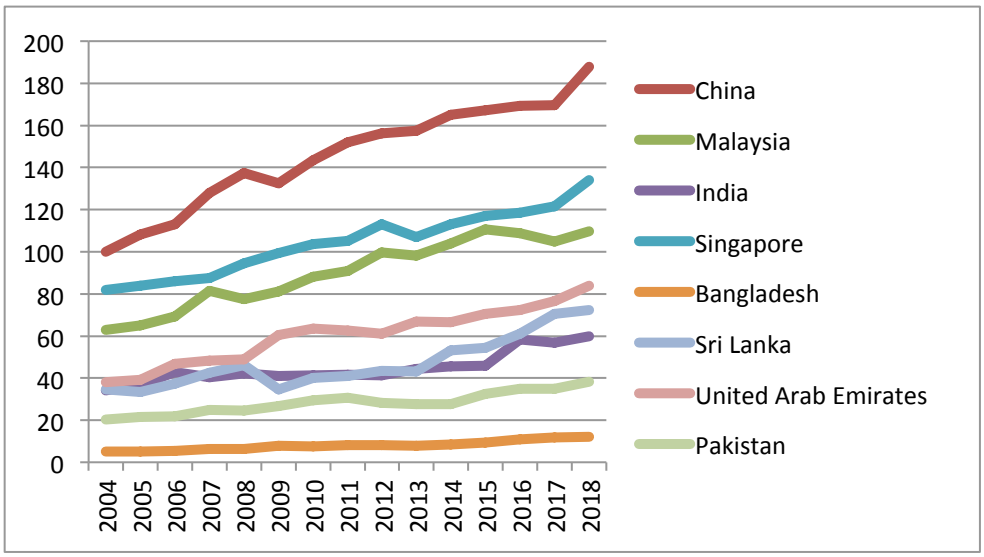


Figure 4 - Liner Ship Connectivity index of Asia ports

The ports in Asia varies a lot in LSCI, LSCI reveal the degree of connectivity and the transporting capability of a port in the scale of destination range. Due to the economy unit of the index is country, some ports might have a better connectivity than those with larger container throughput. Those with lower connectivity means it has fewer connection with foreign countries. The port Quanzhou is concluded into China, which have a better connectivity than Singapore, while shows the otherwise in reality. For Guangzhou and Jebel Ali, both of ports rank in top for container throughput, but perform otherwise in connectivity, because both of them operate only 50 and 45 main routes weekly. By expanding the number of service in Guangzhou and Jebel Ali can increase the competitiveness.

[2] LSCI is generated from five components: (a) the number of ships, (b) the total container-carrying capacity of those ships, (c) the maximum vessel size, (d) the number of services, (e) the number of companies

3.2 Overview and functional positioning of main ports in Africa

Mombasa Port

Mombasa port, located on the Mombasa island on the south-east coast of Kenya, is the largest port of Kenya. There is no port can exceed it from Red Sea in North to South Africa in South, as a result, it is also the largest port in East Africa. The port is equipped to handle various cargoes of dry bulks, liquid bulks, bagged products, break-bulk and containerlized cargos. The port has a total of 16 deepwater berths, six for container ships, others for tankers, dry bulk.

The Port of Mombasa is served by road and rail to inland destinations including the capital Nairobi, and the neighbouring states of Uganda, Rwanda, Burundi and South Sudan. Mombasa port authority has equipped CFS container yard in Nairobi, Kesumu and Canberra, which has created favorable condition for intermodal transportation. But most of containers from port Mombasa still transfer to inland area by road due to the failure corporation between port authority and railway company.

They mainly exports leather, fiber, cotton, tea, coconut dried, coffee, wood, syrup, meat and dairy products and imports machinery, vehicles, textiles, grain, building materials, food, sugar. The annual importing and exporting volume of containers in Mombasa Port is about 3 to 4 times that of the adjacent ports.

Djibouti

There are three terminals in Djibouti, Djibouti Old Port, Djibouti Doha Lei Container Terminal (DCT) and Djibouti Multifunctional Port (DMP). Djibouti Old port designed annual capacity of 6.2 milllion tons, 55% of it will transfer to Ethiopia. It

currently owns 15 berths, two for contianers, others accept grain, fertilizer, steel, livestocks, etc. DCT operates 3-100,000-ton-professionlized container berths, with total length of 1050 m and a 50,000-ton-oil wharf for product oil, liquefied petroleum gas and liquid chemicals. DMP is still under construction, designed capacity of 7.08 million tons and 200,000 TEU.

China Merchants International Company has acquired 23.5% share of Djibouti port from Djibouti Ports and Free Zones Authority in 2013, with the acquisition price of $185 million.

Port Sudan

Port Sudan is the only seaport in Sudan, located in the west coast of Red Sea, with 14 berths, length of 2381m. Port Sudan has an oil refinery and a pipeline to carry oil to the capital Khartoum, a rail terminal that serves a rich, cotton-growing area of the Nile Valley. The neighbouring area is teemed with salt, which meets demand for the whole country. The major exporting goods are cotton, acacia, deep-fried dough cakes, melon seeds, cottonseed and petroleum products. Importing goods mainly include grain, crude oil, grocery.

North quays of Port Sudan are dedicated for handling general cargo, dry bulk, liquid bulk, molasses, edible oil. It receives 19% of total throughput and 36.2% of total ship calling in Port Sudan.

On the east side of Port Sudan main quays, locates a green harbor, which offers a special entrance for accommodating ships. It also serves dry bulk and containers handling. It release more area for multi-operation and increase port capacity.

Alexandria

Alexandria, Egypt's first port in Mediterranean Sea, is a hub between Europe and Eastern countries in ancient time for culture exchanging and trading. Alexandria is divided into two parts, east and west, most of commodity are traded in the west. The west area is deep-sea port, owning 60 berths with the length of 10143m and specialized docks or coal, grain, timber and oil. Every year, approximately 80% to 90% of Egypt's foreign trade is transferred through Alexandria.

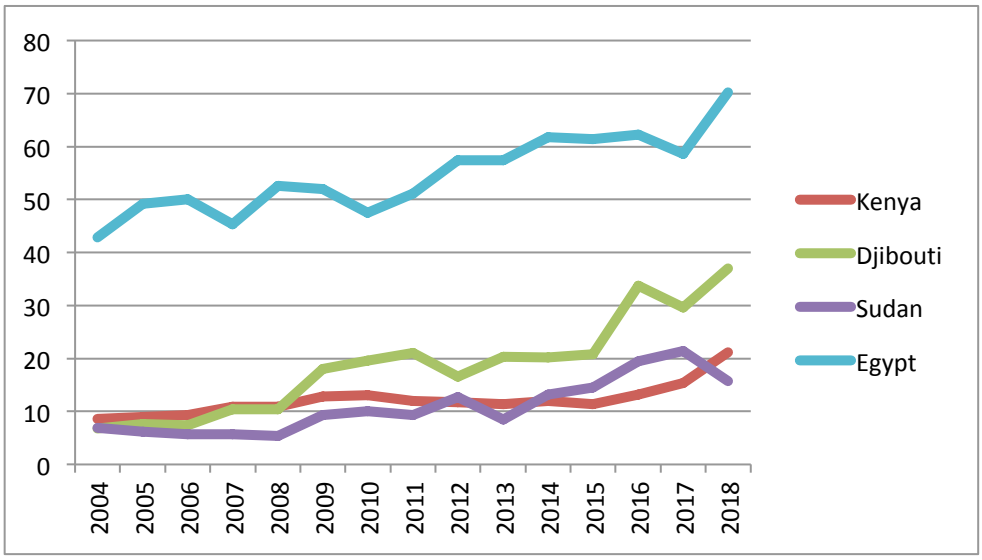


Figure 5 - Liner Ship Connectivity index of Africa ports

The connectivity shows in Figure 5, African ports are much weaker than those in Asia. Except Alexandria, the rest of the ports in Africa are at a low level in connectivity.

For historical reasons, the economic development in most of African countries is behind steps. Countries from Europe and America dump their surplus products into Africa, which leads to the exporting imbalance and numerous containers return in empty. With rich hinterland resource and infrastructure, the ports in Africa still

operate in lower level. If the government department and port authority communicate and cooperate more frequently, the ports might handle more cargos.

3.3 Overview and functional positioning of main ports in Europe

Piraeus

Located about eight kilometers from Athens' city center and some 528 nautical miles northwest of the Port of Alexandria in Egypt, the Port of Piraeus surrounds Phaleron Bay. It is the busiest passenger terminal in Europe, with more than 20 million passengers each year. The port uses an Information Display system for passenger, providing the exact vessel arriving and leaving time. The Port of Piraeus is a hub for the transshipment of automobiles in the eastern Mediterranean. It contains three car terminals with a total of 1400 meters of docks that can accommodate five ships at once.

The terminal has three piers today and the facilities will be upgraded for larger capacity. The Port of Piraeus Container Terminal offers tide-free deep-water facilities that can accommodate the largest container vessels and new super-post-Panamax ship-to-shore cranes will be added in Pier 1. Also a railway has been constructed in Pier 1 for moving cargos. Both in Pier 2 and Pier 3, a high-density stacking system will be equipped which will increase the capacity by one million TEU.

COSCO Shipping took over the Pier 2 and Pier 3 in 2010 and purchased 67% equity in 2016. Piraeus is a significant point for transporting to Europe on Maritime Silk

Road. By railway transportation from Piraeus to the east Europe countries will spend 5-10 days less than transship from the traditional route.

In 2018, the Port of Piraeus handled more than 4.91million TEUs of containerized cargo. The car terminals handled 619.4 thousand vehicles. In 2017, almost 20 million passengers moved through the Port of Piraeus, including 8.4 million ferry passengers and 1.6 million cruise passengers.

Istanbul

Istanbul is the only city that strides over the Eurasian continent, as the port of Istanbul is composed of two ports, Ambarli in the Europe and Haydarpasa in Asia.

The port of Haydarpasa is owned and operated by the government, which leads to the difficulty for customs clearance. They mainly imports coal, metal like lead, copper, timber, butter, industrial products and exports commodities as wool, cotton, dry wood, tobacco leaves, silk and leather.

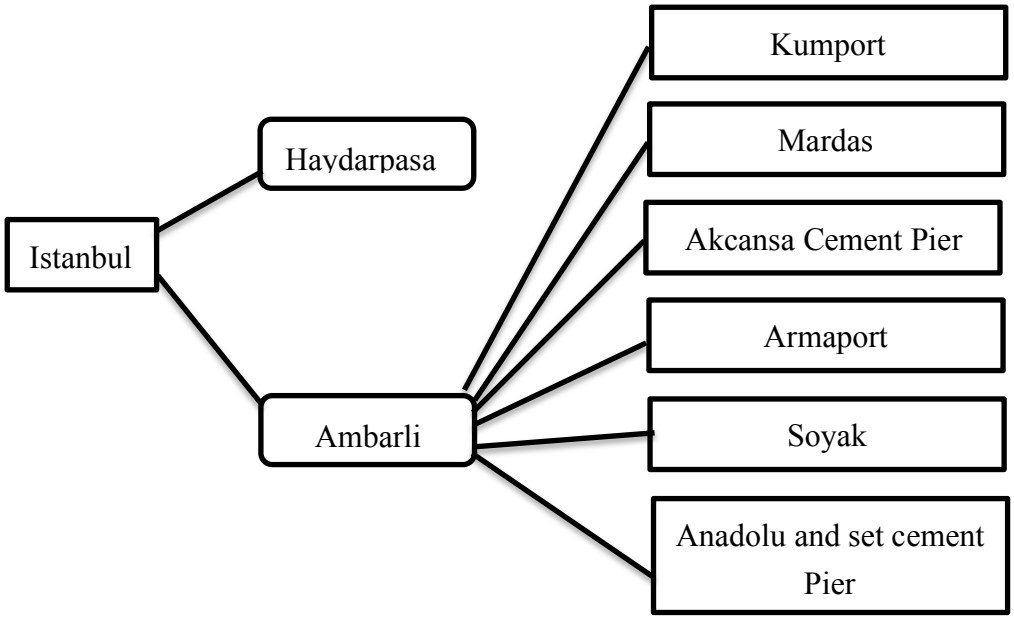


Figure 6 - Composition of port Istanbul

The port of Ambarli is on the Europe side, Kumport was purchased by China Merchants Group in 2015. It is more convenient and efficient to unload commodity that will be sent to Europe in Ambarli than Haydarpasa, when companies go through the port of Istanbul. The container throughput of Istanbul has reached 3.17 million TEU in 2018.

Malta Freeport

Malta Freeport locates on the Vallentta island, east from The Republic of Malta, south of Malta Strait and the middle of Mediterranean Sea. It connects the transportation of Asia, Europe and Africa. The major industry in Malta is ship repairing and shipbuilding, others includes manufacturing and textile. The ship repairing yard contains seven docks, can contain the maximum of 300,000 ton vessel. The Freeport also offers fix on ship.

Malta Freeport Terminals has two Container Terminals, named as Terminal One and Terminal Two. Mainly exporting cotton, potatoes, wine, scrap metal, gloves, pigment, plastics, rubber and importing fuel, fruit, vegetable, transportation equipment and daily necessities. A 100,000 tons tanker can be berthed at the oil terminal with pipes connected to the oil depot. Malta Freeport is currently the key port for transshipment within Mediterranean area. The high volume of containers being handled is a result of the Freeport's track record and the positive international reputation of which companies and shipowners recoginize Malta Freeport as a reliable port with good credit. The container throughput of Malta Freeport has reached 3.31 million TEU in 2018.

Valencia

Port of Valencia is one of the three major container ports in the Mediterranean Sea and the most commonly used port for importing and exporting on the western route. It also have the longest working time in east Spain, mostly 7-24. The container throughput is ranked as the third after Algesiras and Barcelona. Port of Valencia is operated by Spanish port management company, Noatum Port Holding until COSCO shipping took over with 203 million euro for 51% of its equity.

The Port of Valencia also has regular passenger traffic to and from the Balearic Islands and Italy. In recent years the Port of Valencia has experienced a continued and solid growth in Mediterranean cruise traffic.

In 2001, the Spanish Mediterranean port of Valencia overtook main rival Barcelona to become Spain's leading import-export gateway. Ever since then, Valencia has remained in pole position. It ended last year with container throughput up to 5.18 million TEU, while traffic at Barcelona at 4.3 million TEU. The reason for this inversion simple to explain: Valencia is closer to Madrid than Barcelona, with 350 km and 621 km. Terminal operators thinks the extra 271km doesn't have an advantage in transporting, although it is possible to send container cargo to the Spanish capital, Madrid, overnight from Barcelona.

Valencia port authority has invested heavily in line with traffic growth, but the port authority has singularly failed to adequately address the shortage of sufficiently trained stevedores. As in all Spanish ports, terminals only have some of their own employees, which is not sufficient for daily operation, the additional human resource have to be hired from a pool company, of which the members are highly unionized workers. Incumbents guard their jobs jealously and nepotism determines who gains the employment in port or not. There are not too much new employees can break into

this lucrative field, in order to making sure of having high wages. This phenomenon will become a problem in the upcoming days.

While the entire port community agrees something must be done to address the labour problems, senior terminal managers stress the need for evolution rather than revolution. After all, no port wants to get a reputation for industrial disharmony. Recent agreements have nevertheless resulted in more stevedores being taken on and somewhat better working practices adopted. The situation is not ideal, but is much improved, say all involved.

Antwerp

Port of Antwerp is the second biggest port in Europe in terms of freight volumes and biggest port in Belgium, locates in the north of Antwerp. It is owned and operated by the Antwerp Port Authority. 70% of Belgium seaborne trade goes through Antwerp, which makes it an important transshipment port of Europe. The port connects other major European ports since it is strategically situated in the center of the north-west Europe. Antwerp has a rich hinterland resource supported by a fully-developed internal transport network, with 270 km road, 1000 km railway and 300 km pipeline. The network directly links to several major highways in Europe and also connects to the main inland waterway in Nordic Europe. The port is accessible for Capesize vessels.

What's special about port of Antwerp is its 6 sea locks. Port of Antwerp is mainly located on the right bank of the Skelt River, and most of the berths are constructed in the excavated-in harbor basin. They are separated from the Escow River by lock to prevent the effects of the North Sea tides. The sea locks are used to separate Skelt

River and the terminals, protecting the terminals from the effects of North Sea tides, as a result, insuring the daily operation.

The Port of Antwerp has the facilities to handle and store all types of products. The main functions of the port include loading and unloading, the storage of goods, and the repacking and distribution of freight. It also offers the service of logistics, pilotage and the value-added service of repackaging and quality control.

The Port of Antwerp offers 1,474 tanks with a capacity to store 3.6 million cubic meters of liquid bulk cargo. The container traffic is handled at dedicated container terminals. Bulk cargoes handled include coal, iron ore, non-ferrous concentrates, cement, minerals, fertilizer and China clay. The port has extensive terminals for the loading and unloading of cars and trucks.

Rotterdam

Port of Rotterdam is the biggest port in Europe and one of the most important logistics center all over the world, located at the confluence of River Rhine and River Mas. You can Rotterdam city is rely on the port, since the port is the main part of the city. Port of Rotterdam has business with over one thousand ports from the world, volume of commodity transported is 78% of total volume in the Netherlands. It operates the most advanced ETC container terminal, no ice in the winter, no locks in the channel, wind and waves won't affect its operation. General cargo, petroleum, coal, ore sand, grain, chemicals, bulk, container, all of them can be loaded and unloaded in Rotterdam. It has

also developed a consummate transporting network in Euorpe and connected with the world, with railway, highway, river and pipeline. The major importing and exporting counties are from EU as Germany, France, Spain, etc.

It is owned and operated by the Rotterdam Port Authority. Rotterdam stores, transports and reprocesses commodity through bonded warehouses and cargo distribution centers to increase the added value of product, after that, transports to other countries in Europe by river, road, railway, o destinations in the Netherlands and Europe through road, railway, river, air freight and ocean freight. Thanks to the evolved - railway system in Europe, it is much quicker and convenient to transport by railway and road. The Netherlands has a strong competitive edge in road transportation, the transported volume by which accounts for 30% of the whole EU.

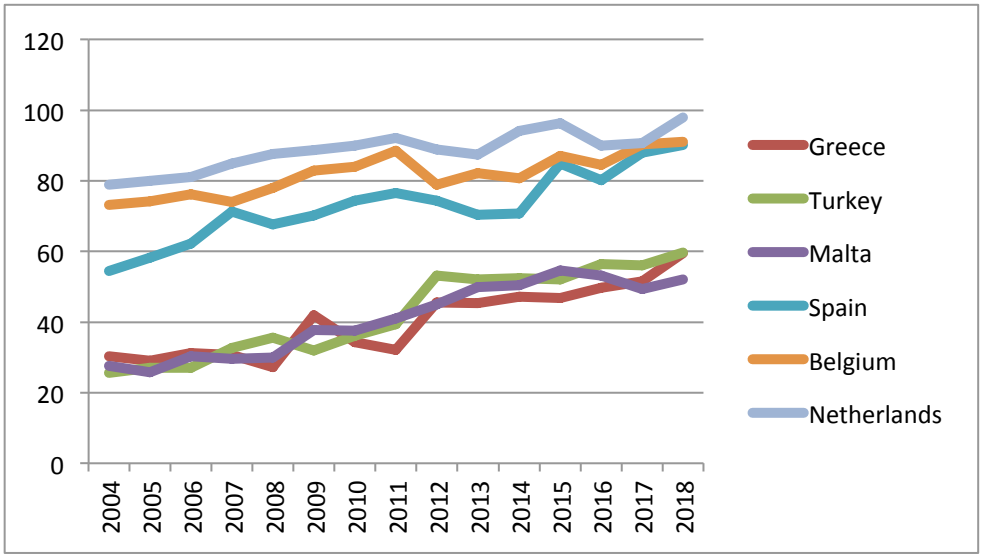


Figure 7 - Liner Ship Connectivity index of Europe ports

As the connectivity index for Europe ports in Figure 7, the overall level is lower than Asia ports. A big port might have the same level connectivity as a small port with similar transporting range. On the other hand, the ports along the west coast of Europe continent have an higher level connectivity than those in Mediterranean area. The economic development of the Netherlands, Belgium and Spain is superior to

Greece, Turkey and Malta. This has also led to a higher level of infrastructure in Western European countries, coupled with the cooperation of EU countries and a developed railway network, the range of radiation in the hinterland of Western European ports is also larger.

4 Methodology formulation

4.1 Principal Component Analysis on Chosen Ports

4.1.1 Components Selection

This article selects Container throughput in 2018/ TEU (X_1), Container throughput in 2017/ TEU (X_2), Container throughput in 2016 / TEU (X_3), Container throughput in 2015/ TEU (X_4), Growth of Container throughput in 4 years/% (X_5), Berth number (X_6), Max draft/m (X_7), Length of port area/m (X_8), Max crane lifting capacity/ton (X_9), GDP of the country in 2018/million$ (X_{10}), GDP growth from 2017/% (X_{11}), 2014 Merchandise trade/million$ (X_{12}), 2015 Merchandise trade/million$ (X_{13}), 2016 Merchandise trade/million$ (X_{14}), 2017 Merchandise trade/million$ (X_{15}), 2018 Merchandise trade/million$ (X_{16}), Liner shipping connectivity index (maximum 2004 = 100 for China) (X_{17}) as principle components. $X_{1\text{-}4}$ illustrates port scale, $X_{6\text{-}9}$ for port infrastructure and $X_{10,12\text{-}17}$ explain the hinterland condition for the port. The classification and evaluation of those ports along 21th –Century Maritime Silk Road west line use Quanzhou, Guangzhou, Port Kelang, Nhava Sheva, Singapore, Chattogram, Colombo, Jebel Ali, Gwadar, Mombasa port, Djibouti, Port Sudan, Alexandria, Piraeus, Istanbul, Malta Freeport, Valencia, Antwerp and Rotterdam as samples.

Major indicator of nineteen ports are shown in Table 3 and Table 4

Table 3 - Data of major indicator of 19 ports alone Maritime Silk Road Part 1

Port	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
QuanZhou	2400000	2220000	2060000	2000000	20.00	54	10	15971
GuangZhou	21870000	20370000	18850000	17620000	24.12	112	12.5	50654
Port Kelang	12320000	12060000	13170000	11890000	3.62	25	13.4	4934
Nhava Sheva	5050000	4500000	4490000	4480000	12.72	12	16.5	3912
Singapore	36600000	33670000	30900000	30920000	18.37	52	16	15500
Chattogram	2900000	2570000	2350000	2020000	43.56	11	8.5	15000
Colombo	7050000	6210000	5740000	5190000	35.84	8	18	1200
Jebel Ali	14950000	15370000	14470000	15590000	-4.11	67	13.5	1200
Gwadar	2985600	2755600	2755600	2534600	17.79	3	11.5	602
Mombasa Port	1200100	1076100	1076100	1012000	18.59	16	13.4	2343
Djibouti	987000	987000	910000	736000	34.10	19	20	4250
Port Sudan	551900	538000	538000	538000	2.58	14	12	2381
Alexandria	1610000	1610000	1670000	1690000	-4.73	67	10.6	10143
Piraeus	4910000	4060000	3680000	3330000	47.45	29	11.5	5649
Istanbul	3170000	3120000	2780000	3220000	-1.55	66	16.5	34000
Malta Freeport	3310000	3203000	3170000	3023900	9.46	12	12	2685
Valencia	5180000	4830000	4730000	4620000	12.12	25	14	5914
Antwerp	11100000	10450000	10040000	9650000	15.03	124	15.8	31034
Rotterdam	14510000	13730000	12390000	12240000	18.55	656	22	89000

Table 4 - Data of major indicator of 19 ports alone Maritime Silk Road Part 2

Port	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
QuanZhou	40	882055	9.92	28616	25780	23709	24123	28518	100
GuangZhou	250	2784678	8.34	130589	133867	129308	143249	138461	100
Port Kelang	50	314707	5.9	442778	375169	358089	412472	464836	104.8
Nhava Sheva	100	2757667	6.68	785604	660310	625352	747698	836227	56.9
Singapore	203	323901	3.62	775551	643383	629990	700926	783264	121.63
Chattogram	125	245633	7.28	71524	74426	79726	88687	100752	11.87
Colombo	35	87357	3.31	30715	29440	29493	32340	34435	70.62
Jebel Ali	120	382575	0.79	619061	563500	566000	582000	598500	76.49
Gwadar	30	302139	5.68	72321	65884	67222	79315	83957	34.86
Mombasa Port	40	74938	4.89	24511	21999	19802	22434	23346	15.33
Djibouti	50	1845	4.09	932	1005	844	910	972	29.68
Port Sudan	54	120266	3.2	13561	12678	11405	13234	11335	21.46
Alexandria	200	195136	4.18	93637	84923	81257	87231	99624	58.56
Piraeus	100	203086	1.51	100200	77020	77067	89410	104615	51.56
Istanbul	250	851542	7.44	399787	351073	341148	390793	391013	56.13
Malta Freeport	75	12553	6.68	9726	8643	9559	8325	9335	49.4
Valencia	80	1314314	2.98	683393	594125	600902	671512	733210	88.01
Antwerp	800	494764	1.69	925892	772371	777595	839469	916840	90.24
Rotterdam	700	830573	3.16	1261980	1082547	1071403	1226711	1368697	90.63

Data resource: UNCTAD maritime profile, UNCTAD 10-17 container port throughput, Port authority website of each port

4.1.2 Analysis of the Components

The Total Variance contribution is showed in Table 5 by analyzing the data of nineteen ports using Principal Component Analysis.

Table 5 - Variance contribution

Component	Initial Eigenvalue			Extraction Sums of Squared Loading			Rotation Sums of Squared Loading		
	Total	% of Variance	Cumulative%	Total	% of Variance	Cumulative%	Total	% of Variance	Cumulative%
1	9.096	53.507	53.507	9.096	53.507	53.507	6.218	36.579	36.579
2	2.782	16.367	69.874	2.782	16.367	69.874	5.147	30.278	66.858
3	1.58	9.296	79.17	1.58	9.296	79.17	1.829	10.756	77.614
4	1.313	7.726	86.896	1.313	7.726	86.896	1.578	9.282	86.896
5	0.815	4.792	91.688						
6	0.52	3.059	94.747						
7	0.334	1.964	96.711						
8	0.294	1.728	98.439						
9	0.235	1.385	99.824						
10	0.024	0.138	99.962						
11	0.004	0.021	99.983						
12	0.002	0.013	99.997						
13	0	0.003	99.999						
14	6.11E-0	0	100						
15	3.41E-0	0	100						
16	1.06E-0	6.23E-05	100						
17	1.28E-0	7.53E-06	100						

Extraction Method: Principal Component Analysis

The rule of extracting the principle component is to select the components that the initial eigenvalue exceeds one, the number of it depends on how many component have an initial eigenvalue over one. In this case, as shown in Table 4, four principle components are extracted. Berth number, Max draft/m , Length of port area/m , Max crane lifting capacity/ton, 2014 Merchandise trade/million$, 2015 Merchandise trade/million$, 2016 Merchandise trade/million$, 2017 Merchandise trade/million$ and 2018 Merchandise trade/million$ have a higher loading on the first component, which can be seen in Table 5. These results means the first principal component mainly reflects the information of these indicators and the variance contribution rate for the first component is 36.579%. The second principle component can reflect the indicators of Container throughput in 2018/ TEU, Container throughput in 2017/ TEU, Container throughput in 2016/ TEU, Container throughput in 2015/ TEU and Liner shipping connectivity index, the variance contribution rate is 30.278%. The indicator of Growth of Container throughput in 4 years/% has a higher loading on the third component and the variance contribution rate is 10.756%. For the fourth principle component, GDP of the country in 2018/million$ and GDP growth from 2017/% have a higher loading value, as the component can mirror the information of these two indicators. And the variance contribution rate is 9.282%. The cumulative variance contribution rate is 86.896% for these four component. It shows that the information of all indicators can be extracted into these the four principal components, as a result, four new variables will be used to replace the original seventeen indicators.

Table 6 - Component Matrix

	Component			
	1	2	3	4
Container throughput(TEU) in 2018	0.194	0.976	-0.004	0.002
Container throughput(TEU) in 2017	0.197	0.975	0.019	-0.003
Container throughput(TEU) in 2016	0.184	0.977	0.045	-0.003
Container throughput(TEU) in 2015	0.188	0.972	0.072	-0.025
Growth of Container throughput in 4 years	0.008	-0.008	-0.796	-0.072
Berth number	0.889	0.081	-0.15	0.098
Max draft（m）	0.715	0.052	-0.078	-0.191
Length of port area (m)	0.812	0.159	-0.249	0.393
Max crane lifting capacity（ton）	0.841	0.166	-0.007	-0.006
GDP of the country in 2018(m $)	0.212	0.193	0.242	0.758
GDP growth from 2017 (%)	-0.284	-0.113	-0.129	0.858
2014 Merchandise trade (m $)	0.795	0.377	0.445	-0.061
2015 Merchandise trade (m $)	0.796	0.376	0.448	-0.053
2016 Merchandise trade (m $)	0.799	0.374	0.443	-0.065
2017 Merchandise trade (m $)	0.807	0.36	0.438	-0.041
2018 Merchandise trade (m $)	0.81	0.358	0.428	-0.042
Liner shipping connectivity index(maximum 2004 = 100 for China)	0.264	0.744	0.227	0.215

Extraction Method: Principal Component Analysis

a. 4 components extracted

Each load in Component matrix reveals the correlation coefficient between principal component and corresponding variables. Then calculate and rank the score for each

principle component and ports, according to formula (4) in chapter 2.1, the final result is shown in Table 6.

Table 7 – Variable score for each port

	1th component F_1	2nd component F_2	3rd component F_3	4th component F_4	Score F	Rank
QuanZhou	-0.6912	-0.29688	-0.22247	1.73076	-0.35158	10
GuangZhou	-0.26242	1.56495	-1.24386	2.50537	1.4710	3
Port Kelang	-0.52548	0.75896	0.87889	0.0575	-0.0815	9
Nhava Sheva	0.42438	-0.48584	1.75088	1.28158	0.2228	7
Singapore	-0.33148	3.16767	1.01809	-0.8306	2.9135	2
Chittagong	-0.28814	-0.56742	-1.24711	0.28116	-0.4058	14
Colombo	-0.32824	0.04083	-1.23193	-0.89569	-0.3790	12
Jebel Ali	-0.22185	0.86929	1.41778	-1.24244	0.0683	8
Gwadar	-0.66725	-0.49919	-0.04405	-0.05003	-0.5882	19
Mombasa Port	-0.49161	-0.801	-0.35213	-0.43886	-0.5303	17
Djibouti	-0.01756	-0.79082	-1.31814	-0.8804	-0.3733	11
Port Sudan	-0.65843	-0.87202	0.34951	-0.62877	-0.5141	16
Alexandria	-0.50107	-0.66759	0.64286	-0.08785	-0.4277	15
Piraeus	-0.26823	-0.17606	-1.27275	-1.04906	-0.3927	13
Istanbul	0.39981	-0.72549	0.59283	0.89607	0.2526	5
Malta Freeport	-0.7612	-0.42637	-0.0201	0.11875	-0.5406	18
Valencia	0.21923	-0.23774	1.52824	-0.11058	0.2439	6
Antwerp	1.46998	0.13908	1.49915	-0.80179	1.3206	4
Rotterdam	4.50076	0.00564	-0.72568	1.14487	3.0921	1

As Table 7 presents, for the port of Rotterdam, the score of first principle component is 4.5007, the comprehensive score is 3.0921. From the result, we can see that, after Principle Component Analysis, the comprehensive ranking order of ports is as follows: Rotterdam (1), Singapore (2), Guangzhou (3), Antwerp (4), Istanbul (5), Valencia (6), Nhava Sheva (7), Jebel Ali (8), Poet Kelang (9), Quanzhou (10),

Djibouti (11), Colombo (12), Piraeus (13), Chittagong (14), Alexandria (14), Port Sudan (16), Mombasa Port (17), Malta Freeport (18), Gwadar (19).

4.2 Clustering Analysis

4.2.1 Data processing

The data for Clustering Analysis will be the same in the Principle Component Analysis. First, the data will be standardized by SPSS, because the quantity unit for each indicator varies. Without standardization, in order to achieve convergence effect, the number for iterations will increase and the clustering effect will not be obvious. The standardization result is shown in Table 8 and Table 9.

Table 8 - Standardization result Part 1

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
QuanZhou	-0.62	-0.63	-0.65	-0.64	0.20	-0.12	-1.24	0.03
GuangZhou	1.53	1.52	1.49	1.37	0.47	0.28	-0.49	1.58
Port Kelang	0.47	0.53	0.77	0.63	-0.89	-0.32	-0.21	-0.47
Nhava Sheva	-0.33	-0.36	-0.34	-0.32	-0.29	-0.41	0.72	-0.51
Singapore	3.15	3.09	3.03	3.08	0.09	-0.24	0.27	-0.22
Chittagong	-0.57	-0.59	-0.61	-0.64	1.76	-0.41	-1.24	-0.01
Colombo	-0.11	-0.16	-0.18	-0.23	1.25	-0.44	1.17	-0.63
Jebel Ali	0.76	0.92	0.93	1.11	-1.40	-0.03	-0.18	-0.63
Gwadar	-0.56	-0.57	-0.56	-0.57	0.05	-0.47	-0.79	-0.66
Mombasa Port	-0.75	-0.76	-0.77	-0.76	0.10	-0.38	-0.21	-0.58
Djibouti	-0.78	-0.77	-0.80	-0.80	1.13	-0.36	1.77	-0.50
Port Sudan	-0.83	-0.83	-0.84	-0.83	-0.96	-0.39	-0.64	-0.58
Alexandria	-0.71	-0.70	-0.70	-0.68	-1.44	-0.03	-1.06	-0.23

Piraeus	-0.35	-0.41	-0.44	-0.47	2.02	-0.29	-0.79	-0.43
Istanbul	-0.54	-0.52	-0.56	-0.48	-1.23	-0.04	0.72	0.84
Malta Freeport	-0.52	-0.51	-0.51	-0.51	-0.50	-0.41	-0.64	-0.57
Valencia	-0.32	-0.32	-0.31	-0.30	-0.33	-0.32	-0.03	-0.42
Antwarp	0.34	0.34	0.37	0.35	-0.13	0.36	0.51	0.70
Rotterdam	0.72	0.73	0.67	0.68	0.10	4.01	2.37	3.30

Table 9 - Standardization result Part 2

X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
-0.62	0.29	2.06	-0.80	-0.81	-0.81	-0.82	-0.80	1.08
0.35	2.59	1.43	-0.54	-0.48	-0.49	-0.49	-0.53	1.08
-0.57	-0.39	0.44	0.26	0.25	0.21	0.24	0.27	1.23
-0.34	2.56	0.76	1.14	1.11	1.03	1.15	1.19	-0.24
0.14	-0.38	-0.48	1.12	1.06	1.04	1.03	1.06	1.75
-0.23	-0.48	1.00	-0.69	-0.66	-0.64	-0.64	-0.62	-1.62
-0.64	-0.67	-0.60	-0.80	-0.80	-0.80	-0.79	-0.79	0.18
-0.25	-0.31	-1.62	0.72	0.82	0.85	0.70	0.60	0.36
-0.67	-0.41	0.35	-0.69	-0.69	-0.68	-0.67	-0.67	-0.91
-0.62	-0.68	0.03	-0.81	-0.82	-0.83	-0.82	-0.81	-1.51
-0.57	-0.77	-0.29	-0.87	-0.89	-0.88	-0.88	-0.87	-1.07
-0.56	-0.63	-0.65	-0.84	-0.85	-0.85	-0.85	-0.84	-1.32
0.12	-0.54	-0.25	-0.64	-0.63	-0.64	-0.65	-0.63	-0.19
-0.34	-0.53	-1.33	-0.62	-0.66	-0.65	-0.64	-0.61	-0.40
0.35	0.25	1.06	0.15	0.17	0.16	0.18	0.09	-0.26
-0.46	-0.76	0.76	-0.85	-0.86	-0.86	-0.86	-0.85	-0.47

-0.43	0.81	-0.74	0.88	0.91	0.95	0.95	0.93	0.72
2.90	-0.18	-1.26	1.51	1.45	1.50	1.40	1.39	0.78
2.44	0.23	-0.66	2.37	2.39	2.40	2.46	2.50	0.80

Then use the data in Table 8&9 for Clustering Analysis, the Figure 8 intuitively reflects the gradually process of samples merging into the same category.

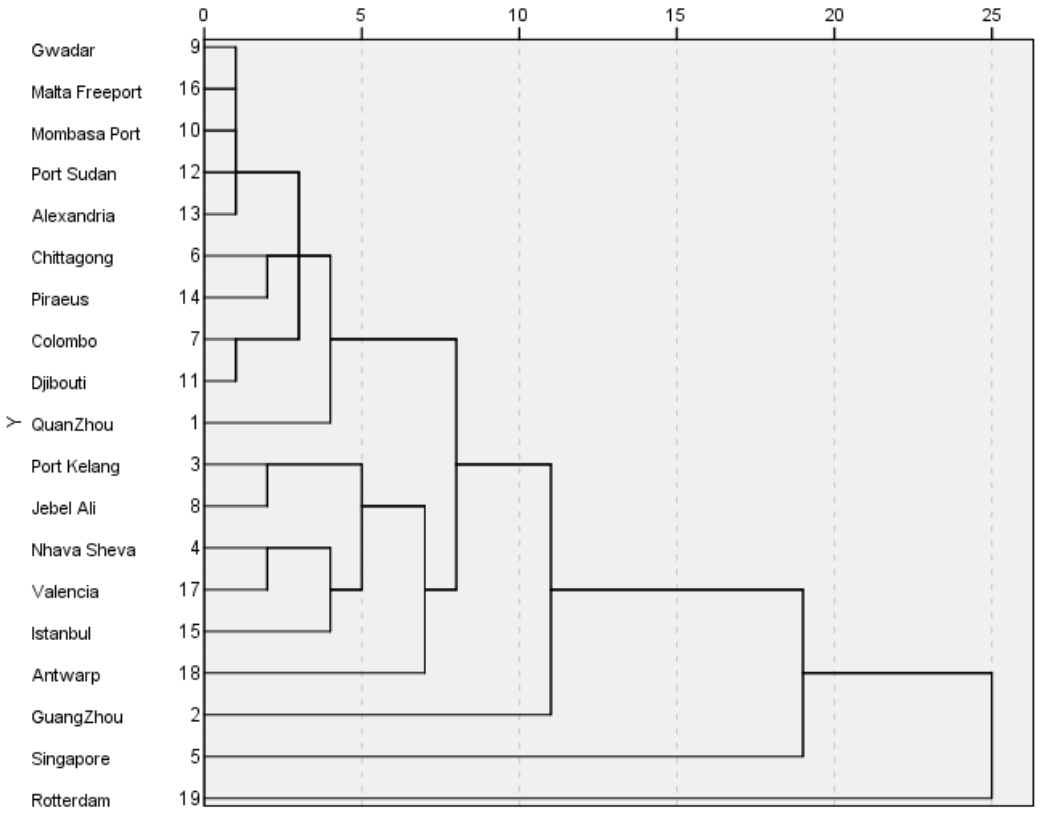


Figure 8 - Dendrogram of clustering result

4.2.2 Clustering Result

Table 10 – Port Classification

Category	**Port**
Central port	Rotterdam
Main hub port	Singapore, Guangzhou, Antwerp
Regional hub port	Istanbul, Valencia, Nhava Sheva, Jebel Ali, Port Kelang, Quanzhou
Basic port	Djibouti, Colombo, Piraeus, Chattogram, Alexandria, Port Sudan, Mombasa Port, Malta Freeport, Gwadar

According to the Figure 8 from clustering result and analysis, the ports can be classified into four categories.

Combining the source and destination of the container cargo, port infrastructure, hinterland condition, the Port of Rotterdam got the highest score in principal component analysis. The liner ship connectivity index and container throughput for Rotterdam also rank at top and it is a single category, combined at last in clustering analysis. The port Rotterdam is classified as Central port for container transportation.

For the second category, main hub port, which handles container throughput over 10 million TEUs, has a certain scale of ocean transportation and the ship call is frequent and scheduled. Therefore, Singapore, Guangzhou, Antwerp are classified into this category. Although port Kelang and Jebel Ali have an overall container throughput of more than 10 million TEUs, connectivity is not so high, the score from model also fall behind, as a result, they will be classified into next category.

Compared with main hub port, regional hub port attracts less international main route and ship call. Its ocean transportation has not formed a scale yet. Container cargos

mainly comes from the hinterland and transship less than the previous category. Alone with the result from the model, Istanbul, Valencia, Nhava Sheva, Jebel Ali, Port Kelang, Quanzhou are classified as regional hub port.

The rest of them, Djibouti, Colombo, Piraeus, Chattogram, Alexandria, Port Sudan, Mombasa Port, Malta Freeport, Gwadar ,will be classified into basic port, the result is presented in Table 10.

5 Conclusion and Suggestion

5.1 Research Results and shortcomings

First, the ports in this article are from 21th-Century Maritime Silk Road west line, which means most of them are from different countries. As a result, the data resource are also different, except the data from UNCTAD, others are collected from Port Authority of different countries. From which the indicators varies a lot, some port authorities provide detailed information as ships' calling, the number of ships leaving and entering country, some ports only provide the basic data of berth number and length, there is no excessive redundancy of other content. Data missing from individual ports will make the whole variable infeasible，such a distinction lead to the difficulty in collecting data and the diversity is somehow inadequate. The aspect for analyzing is not the most comprehensive.

Second, about the port selection, it is unavoidable to pick some small-scale ports on 21th-Century Maritime Silk Road west line, the data volume have a huge difference. For example, in 2018, the port of Rotterdam has a container throughput of 14.51 million TEUs, while it's only 551.9 thousand TEUs in Port Sudan. Those small ports are not as good as large ports in reflecting regular pattern because of the data magnitude, which will also have an impact on the results of the model.

Third, as a result of data-collect difficulty and some ports only handling container cargos, the article only discuss the container section, while there are also dry-bulk, general cargo, even cruises. The ranking and scoring result is suitable for container section, but may have some difference when it comes to the other sections.

On the other hand, comparing the results of Principal Component Analysis and Clustering Analysis, we can see that each port is adjacent to similar ports in the

comprehensive ranking, and the rationality and objectivity of the model can be verified.

5.2 Suggestions for increasing port's competitiveness

It is inevitable that there will be overlap between the hinterland of the port. On the basis of cooperation, competition is also occurred, under such condition, the port should strengthen the competitiveness for further development.

Improve basic infrastructure

As discussed in the overview chapter, he port of Singapore and Alexandria have a developed port infrastructure, while Gwadar is short of it. The infrastructure difference between Karachi Port and Gwadar Port is huge, Pakistan may pay more attention on the weaker side, especially when it has an advantage for its geographic location. Those ports locate in the Mediterranean area are superior than those alone Indian Ocean, but the ports with different infrastructure levels are evenly distributed.

Port condition include infrastructure, infrastructure condition and port service, in which port basic infrastructure is the fundament of port operating, perfect infrastructure will provide better service level. Port basic infrastructure can be divide into three parts: land-based infrastructure, port infrastructure and marine infrastructure. Port infrastructure means the equipment in port, includes berth, crane, etc. Most operating ports have all theses equipment, only varies from the scale. Speaking of marine infrastructure, mainly means draft of the berth. The draft will have a significant impact on ports' efficiency. India government built port Nhava Sheva to fix the shallow draft of Mumbai port, in order to berthing the large ships. On the contrary, Chattogram only has the draft 6.4m-8.5m, which is barely enough

for a port with annul container throughput of 2 million TEUs. The port of Chattogram is not capable of containing large containership, it relies on barges to connect the large vessel for handling the container. At the same time, port of Chattogram lacks barges, which leads to the port congestion. In this case, the suitable draft for a port will affect port's competitiveness a lot. Land-based infrastructure is the equipment for distributing cargos to destination and the connectivity from port to hinterland. High-speed cargo handling and distributing to hinterland also is a reflection of port service management level, which means the port has a high-level production efficiency and reasonable port resource allocation. The improvement from all three aspect is very important for port operation.

Develop hinterland condition

Hinterland condition include not only the hinterland economic condition, but also the hinterland network and the transport network within the port.

Since ports are built alone main-land, the economic conditions and development potential of hinterland will affect the operation of ports. Hinterland condition in different continent varies a lot, for example, the economic conditions of African countries are relatively backward and started late. In the process of development, shipping has not been given enough attention. By improving the railway and road network in Africa, can improve the commodity turnover in ports, as port Mombasa and Alexandria. While for the countries along the Mediterranean coast of Europe and Dubai in the Middle East have developed relatively well, which has also brought a lot of help to the operation of their ports.

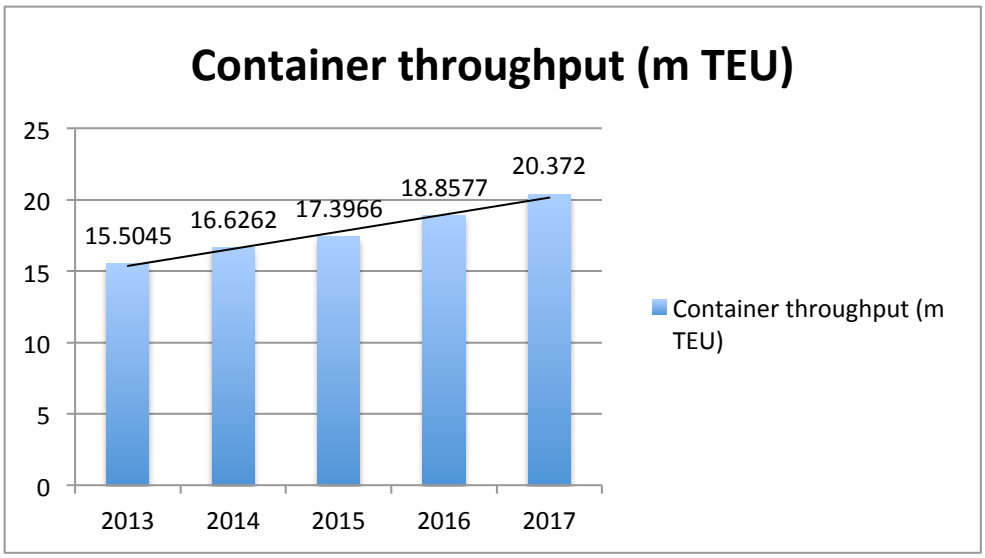
Rotterdam, as a central port, handled eighty percent of goods, which has a detination to the other countries in Europe. A complete collecting and diapatching system can

gather and distribute commodity more quickly, and win a competitive edge in the hinterland business. With its excellent inland transport network, railway, river, pipeline, road and air freight , port Rotterdam is connected to almost all Europe countries and transfer the commodity to destination. A large number of shipping companies and manufacturers are willing to transport through Rotterdam, even entering Rotterdam, set their own office for the reason of Rotterdam's unique geographical location, advanced equipment, convenient links with the mainland of Europe, high-quality value-added service, qualified workers and quick customs clearance. This kind of hinterland condition can promote port's business and increase its competitiveness, which also set an example for the others.

Minimize policy influence

There is no doubt that policy plays a key role in economic development. Firstly, as Malaysia and China, they set free trade zones aside the port to open more markets. Port Kelang of Malaysia and Port of Guangzhou have established their free trade zones[3].

[3] Free trade zone: refers to the complete elimination of tariffs and quantitative restriction in commodity trade among the member countries who signed the agreements, so that the commodities can be transported among the member countries without any restrictions. However, member countries still maintain their own restrictive policies on imports from non-member countries.



Data resource: Guangzhou statistics bureau

Figure 9 - Container throughput in Guangzhou 2013-2017

As shown in Figure 9, after setting the Free Trade Zone in port Guangzhou, the container throughput has steadily increased, from 15.5 million TEU in 2013 to 20.37 million TEU in 2017, which increased from 7.2% in 2014 to 8% in 2017 (compared to the previous year).

Just as the establishment of Port Kelang Free Trade Zone, Malaysia's government has created a large international free trade economic zone with its own characteristics, focusing on the development and expansion of the global Muslim market. With the existing facilities within Port Kelang Free Zone and the advantages of Port Kelang in port logistics, the Malaysia government has hosted many comprehensive commodity exhibition to expand its influence in Southeast Asian markets, Muslim countries and Commonwealth countries, totally 117 countries. Relying on the same religion, Port Kelang has built a modern food production center with Muslim characteristics,

making this Muslim products center a product distribution center for Muslim countries in the whole world.

Second, as port of Rotterdam, Singapore, Malta, etc, the government can build a free port. The majority of goods entering and leaving the port area are exempted from customs duties and a series of business activities are permitted in the free port. In port Rotterdam, there is a bonded warehouse in the port area, which is specially used for the storage of transshipment goods on board ships. All commodity are exempted from the customs duty and only need to pay for the warehouse using. Customs also provides shippers the most convenient approach. When the commodity meet the safety requirements, almost all of them can enter and exit without restrictions on types and quantities. It is for this reason that Rotterdam has attracted a large number of foreign vessels and cargo transit.

Third, the government should set up reasonable financial targets so as not to bring negative impacts on port operation. The overcapacity, as port Chattogram[4], will lead to unbalanced operation of the whole port, and the accumulated container volume will trigger the internal operation disorder, which will form a vicious circle.

Although as a regional hub port, the customs clearance is difficult in Haydarpasa, the Asian side of port Istanbul. Under such difficulty, ships are willing to berth in the European side or detour to other ports, which only brings negative effect to Istanbul and lower its competitiveness.

It is very important for the government to implement preferential policies and their continuity in port management or investment in port and related infrastructure when it comes to port competitiveness.

[4] The congestion situation of port Chattogram has been referred in previous chapter.

Expand port business

First, to expand the business. It is possible to expand business from ‘one belt, one road’, alone which are numerous ports. What makes Singapore stands out as a main hub port not only is its geographic location, but also it excellent value-added service. The short dwell time for transshipment, large ship yard and its bunker supply service, all relies on the modern technology and skilled operation. As a result, intelligent operation is also crucial to the port, modern logistics technology can be used to create time value for products, reduce overstock, lower storage cost. Most ports are the hub for domestic container trading. With the advantage of internal trade routes and the western route of 21th-Century Maritime Silk Road, they can carry out more business within their own country and also explore new routes alone the Maritime Silk Road, which can be benefited from the ‘one belt, one road’ initiative. The government can also build an information network by welcoming foreign enterprises to enter. The port of Singapore has attracted foreign shipping companies to set up headquarters in Singapore, and cultivate those with international vision and flexibility talent human resource. These approaches have consolidated Singapore's port as international shipping center.

Second, separate the operation and management of ports, just as port Singapore, the Maritime and Port Authority of Singapore Port (MPA) is responsible for the management of ports, and the Port of Singapore Authority(PSA) is responsible for the operation of ports. The government also give PSA the right to invest and operate overseas, cooperating with national policies to expand container business over the world.

Third, exploiting Inland Business with the geographical advantage and offering personalized service. Many ports are built relying on its hinterland, transporting cargoes by railway, road, pipeline, air to the inland cities. Ports can provide

transsshipment services or intermodal transporting services for customers, through which can not only enhance the port value, but also attract more customers to berth. The port should improve capacity and efficiency, port operation level, actively respond to customer needs to improve its competitiveness.

Fix human resource problems

Right now, lack of human resource is also an inevitable problem. Lack of human resources can also be divided into simple lack of human resources and lack of skilled labor. As we discussed in the previous chapter, in port Chattogram, there is a huge demand in stevedore to connect the barge with large vessel. The number of stevedores under the actual demand may lead to the logistics process delayed or congestion in port. With the development of automatic port, those skilled-labor are under highly-demand, this kind of shortage leads to the reduction of work efficiency and affects the development of ports to a large extent.

In Muslim countries of Bangeladesh, Sir Lanka, Egypt, there is still the problem of not working during Ramadan. Compared with overnight work in some ports, not working during the whole month of Ramadan can also result in operators choosing to berth at other ports. While on the other hand, the port of Valencia, the regional hub port, also has a demand on human resource for its 7*24 working hours.

In some areas, stevedores went on strike because their needs can not be satisfied, such uncertainty increase the risk of berthing at the port.

5.3 Ports' Functional position in 21th Century Maritime Silk Road

The port Rotterdam, with its complete hinterland network and advanced infrastructure, is an important entry connecting Europe, even the Nordic region alone the Maritime Silk road. Although Rotterdam is surpassed by some emerging ports in terms of container throughput, it is still irreplaceable.

Singapore has a pivotal position on the Maritime Silk Road. It is an important global main hub port located in the Straits of Malacca. It also provides value-added services such as ship repair and refueling. The efficient transship business also makes Singapore unique.

From the results of the model, although Port Guangzhou Port is in the same classification as Singapore Port, there is still a certain gap with Singapore. Port Guangzhou has potential becoming an international hub port by the geographic advantage. Its container throughput and hinterland condition are also competitive, comparing to others. The problem is its main business focusing in mainland, by adding more international routes and strengthening infrastructure level can increase the connectivity, which will benefit China along the Maritime Silk road. The port of Antwerp and Port Kelang, as main hub port and regional hub port, located quite close to Singapore and Rotterdam. Compared to these two ports, they are lack in the economic scale, as a result, port of Antwerp and Port Kelang are complementing to the superior ports nearby.

For those regional hub ports, Colombo is located in South Asia and is an important node of the Maritime Silk Road in the Indian Ocean. Recent years, China has continued to increase its investment in Colombo Port. The modern facility and logistic services allow Jebel Ali to cover the Central Asia. The railway that China helped to build in Turkey not only greatly shortens the transportation time in Europe,

but also provides new approach from port Istanbul to Europe. Valencia is the largest port in terms of container throughput in the Mediterranean, a transshipment hub in west Mediterranean. The port of Nheva Sheva and Quanzhou also undertake the important hub for their country.

The basic port is part of the transportation system, which has a positive effects for the economic development in its region. After China had fully acquired port Gwadar, it helped to build the railway and pipeline system, expecting which can release the pressure on Strait of Malacca. Port Piraeus is an important node for transporting automobile to Europe and Malta Freeport is a connection between south Europe and north Africa.

In Africa, port Alexandria and port Mombasa are hubs for distribution of goods to African landlocked countries, where are in highly demand of crop and infrastructure. The dwell time in port Mombasa are shorter than in other port of east Africa. The crude oil pipeline in Sudan and product oil pipeline in Kenya offer advantage to transport oil from port Mombasa and port Sudan alone the Maritime Silk road. Port Djibouti locates in the estuary between the Red Sea and the Indian Ocean which had established the free trade zone and can handle product oil, liquefied petroleum gas and liquid chemicals.

Table 11 - The port China participated along Maritime Silk Road

Year	Participation area	Participation profile
2010	Chattogram	Construction of a $14 billion port project
2011	Colombo	South Container terminal with a total investment of $550 million begin its construction
2011	Container port of Sir Lanka	Sign the contract of building and operating South Containe r terminal for 35 years
2013	Djibouti	Acquisition 23.5% stake of p ort Djibouti foe $185 million
2013	Gwadar	Take over port Gwadar

Obviously, these basic ports have difference with the previous types of ports in terms of scale and facilities, and the hinterland economic condition are also inferior to the previous countries. But as Table 11 shows, these basic ports still have vital position in Maritime Silk Road. Such ports can accept a certain degree of investment according to their own characteristics，so as to achieve the purpose of common development and complement each other.

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