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Research on Bohai Bay coal ports in coal transportation from North to South China

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Research on Bohai Bay Coal Ports in Coal Transportation from North to South China (CTNSC)

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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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ABSTRACT

Title of Integrative Paper: **Research on Bohai Bay Coal Ports in Coal Transportation from North to South China (CTNSC)**

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China is a big country in coal production and consumption, and coal consumption accounts for about 70% in China's energy consumption structure. At the same time, because of the imbalance in the distribution of coal resources in China, coal transportation from North to South China has been formed. In recent years, as the capacity of railway coal transportation is hardly to be increased, the market share of coal transportation by sea from North to South China is rapidly going up. And the coal loading ports are playing a much more important role in the coal transportation system and become the nodes which can help to realize the maximization of logistics and information flows. Among all the coal loading ports in North China, Bohai Bay coal ports' market share is the largest (above 80%).

Under the trend of centralization of coal loading ports (centralized in Bohai Bay 4 coal ports), carrying out the analysis and comparison research on the 4 Bohai Bay coal ports is quite necessary. This paper collects the recent data of Bohai Bay coal ports; statistics analysis and AHP modal are used in order to investigate the current situation and the important status of the 4 Bohai Bay coal ports in CTNSC.

Chapter 2, Chapter 3, Chapter 4 and 5 is the main content of this paper. Chapter 3 is the core part of this paper--the quantitative analyses of the 4 biggest Bohai Bay coal ports and comparison among them are elaborated. The statistic analysis is implemented and the AHP approach is used in this chapter. Chapter 4 is the analysis of emergency measures of these Bohai Bay coal ports. In Chapter 5, the developing trends of these Bohai Bay coal ports in China's coal transportation system are displayed.

KEY WORDS: Bohai Bay, Coal ports, Coal transportation from North to South China (CTNSC)

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CTNSC	Coal Transportation from North to South China
Three West	Shanxi Province, Shananxi Province, and west area of Inne Mongolia in China
GDP	Gross Domestic Product
TEDA	Tianjin Economic Development Area
DGPS	Differential Global Position System
AHP	Analytic Hierarchy Process Model

1 Introduction

1.1 Background

Coal, as the primary source of energy in China, constitutes nearly 70% of the total energy consumption. And it is estimated that coal is still going to be the mainstay of China's energy industry, and its fundamental position will not be changed in the future.

Coal transportation from north to south China is caused by the imbalance of coal resource distribution and economic development. The coal resources in China mostly repose in the under-developed areas where the transport facilities are not perfect. In contrast, the economic development in the south and coastal areas of China has been very fast in recent decades, and their demand for fuels and energy is quite strong. But the reserves of energy resources are quite scarce, and that is why coal has to be transported from the areas which are rich in energy resources to the south areas. Under this kind of condition, coal transportation from North to South China (CTNSC) has been formed and it is the main movement direction of coal resources in China.

North China (especially "Three West"--Shanxi Province, Shananxi Province, and west part of Inner Mongolia) is the main place of coal production, in which coal production is much more than consumption, and represents a coal output to the outside areas. In East and South China (including Shanghai, Jiangsu Proince, Zhejiang Province, Fujian Province, and Guangdong Province, etc.), coal consumption is much bigger than coal production, and they are areas which need the coal input. As the derived demand from trade, coal transportation from North to South China becomes the connection between the supply and demand sides. The main coal transportation lines are railway lines, coastal transportation line and a small number of inland water transportation lines (Yangtze River and Pearl River).

In China, light and heavy industries are all developing very fast; the demand of daily-use electricity is also rapidly increasing. Accordingly, the consumption demand for coal is still rapidly moving up. In January 2008, the snow damage in south China much more intensified the tense situation--the short supply of coal used for electric power production. And the four biggest Bohai Bay coal ports did play a crucial role in alleviating the coal shortage in South China. In this kind of situation, coastal coal transportation from north to south becomes a central issue again, and Bohai Bay coal ports in CTNSC really deserve our further more analysis on them.

1.2 Literature review

Coal transportation and logistics is not a new concept to scholars who are specialized in transportation and logistics research. Coal as a basic energy resource, is extremely needed by almost every single country around the world. Because of the unbalanced distribution of coal resources, the demand for coal transportation is derived from the coal trade. Sea transportation of coal is a basic mode of coal transportation, and the coal ports also play a very important role in it.

In China, the research and analysis on the coal transportation have never stopped. As the main distribution direction, the coal transportation from the north to south is always the most attractive part for scholars to analyze. Mr. Qi (2005) analyzed the market structure of China's coal transportation from north to South, and Mr. Zhao (2004) did the research on the changing tendency of China's coal transportation from north to south and provided countermeasures. There are also literatures which criticized the coal transportation from north to south China, and the problems were pointed out and methods of how to improve were also included. Wang Liqun (2007) presented the problems in the coal transportation from north to south China, and suggestions were provided. Li Wenge (2007) gave the idea of the integrated coal transportation system that is to make the coal products go smoothly through the supply chain. Sheng Jiaduo (1996) compared the three types of coal transportation (water, railway, and road) and showed the advantages and disadvantages of each type of coal transportation. At the same time, Ren Wuyuan (1996) and Luo Yang (2001) made their own efforts on how to choose and use the reasonable mode of transportation to move the coal from the north to south China.

As for railway transportation of coal from north to south, literatures in this area also exist. In China, railway transportation is always the backbone of coal transportation from the north to south. But in recent years, railway's expansion ability to transport dramatically increasing amount of coal is quite limited. Zheng Yong (2005) pointed out that the old railway management system hindered the coal transportation, and he also gave suggestions to reform the management regime to satisfy the demand of coal transportation. Wang Liqun (2006) analyzed the expansion of transportation ability of Datong—Qinghuangdao Railway, and found out its influence on the coal transportation from north to south China. Guo Xiaoyuan and Xing Xiujiang (2001) analyzed how to make the railway better serve the coal enterprises and achieve effective coal transportation service.

Nowadays, as the demand of coal in South China increases, water coal transportation is taking more and more responsibility on coal transportation from north to south. Ma Xiping and Pan Ping (2005) did research on how to improve water coal transportation capacity, and Mr. Yang (2004) pointed out that China's water-borne transportation of coal had to pass 4 tollgates. Qian Weizhong (2004) presented the coastal transportation of coal, and analyzed the demand and supply of the coastal coal transportation. Qinhuangdao Port, Tianjin Port, Tangshan Port, and Huanghua Port are the 4 main coal ports in Bohai Bay, where the coal resource in North China is dispatched from. Qinhuangdao, as one of the most important ports for water transportation of coal from the north to south, there are a lot of literatures providing us with the importance of the port for coal transportation, its running system, methods for its improvement, etc. Li Yan (2004) described the role of Qinhuangdao Port in the coal transportation from north to south, analyzed the port's advantages and disadvantages, and gave suggestions on how to survive in the fierce competition. Yang Yiping (2003), Li Zhipeng (2003), Zhang Weijian (2003), Zhu Chaoyang (2004), Li Xiaomin (2005), and Wang Liqun (2005) all made their efforts on the development research of Qinhuangdao Port. Zhang Lina (2006) did research on the strategic development of Tianjin Port, and the development research of Tangshan Port was carried out by Sun Wenzhong (2006). Mr. Dong (1999) pointed out the strategic position of Huanghua Port in China's coal transportation from north to south. At the same time, Li Nan (2002) wrote paper on the competition of the Bohai Bay coal ports.

As for America and other European countries, the concept of coal supply chain is quite popular in recent years. Shan Mao (2002) analyzed several terminals which specialize in coal business, such as the terminals in Port of Ayr, Port of Swansea, Port of south Wales, Port of Los Angeles, whose existing pattern and running system depending on the type of coal, usage, sales direction and quantity, and the specific requirement from the consumers. Shan Mao's contribution of his article is that he found out that different port has its own way of operation, but purpose of all these ports is to adjust themselves to make their coal handling business more effective.

Previous literatures, both foreign and local, have all made great efforts on the development of China's coal transportation from the north to south. And these literatures established a solid foundation for the further study on China's coal transportation and coal ports.

1.3 Structure and methodologies

This integrative paper includes 6 chapters. The first chapter is the introduction, background and literature review, and structure & research methodologies are all included. In Chapter 2, firstly, demand and supply of coal in China are briefly introduced, and then the transport modes of CTNSC are presented; and the description of China's Combined Land & Coastal CTNSC system is shown. Chapter 3 is the central part of this integrative paper, the quantitative analyses of the 4 biggest Bohai Bay coal ports and comparison among them are elaborated, including loading quantity & market share, handling capacity, transportation distance and cost, and a specific case on the selection of Bohai Bay coal ports. The statistic analysis is implemented and the AHP approach is used in Chapter 3. Chapter 4 is the analysis of emergency measures of these Bohai Bay coal ports in CTNSC. In Chapter 5, the developing trends of these Bohai Bay coal ports in CTNSC system are displayed. Finally, conclusion of this integrative paper is drawn in Chapter 6.

2 Situation of China's coal demand and supply and whole structure of CTNSC

2.1 Analysis on China's coal supply

2.1.1 Location and reserves of coal resources in China

At present, China's coal resource distribution is not consistent with the regional economic development and coal consumption level. According to the result of coal resource investigation in 1999, the total coal resources/reserves is 1006.25 billion tons; Shanxi Province, Shananxi Province and west part of Inner Mongolia (also called "Three West") are the regions which have the most abundant coal resources and the coal reserves of these three regions is 645.851 billion tons, taking 64.2% of the coal reserves in the whole country.(Chen, 2003, p.6) "Three West" have large amount and varieties of coal, and the resources are easy to be exploited. Especially Shananxi Province and west part of Inner Mongolia, they are the regions which have the great potential for the development of China's coal industry; they are rich in coal resources and have good geological condition which will be quite suitable for the large-scale modernized exploitation.(Mao, 1999) Generally speaking, China's coal resource distribution is scarce in the East and South; and rich in the West and North, so there comes the coal transportation from West to East and North to South China.

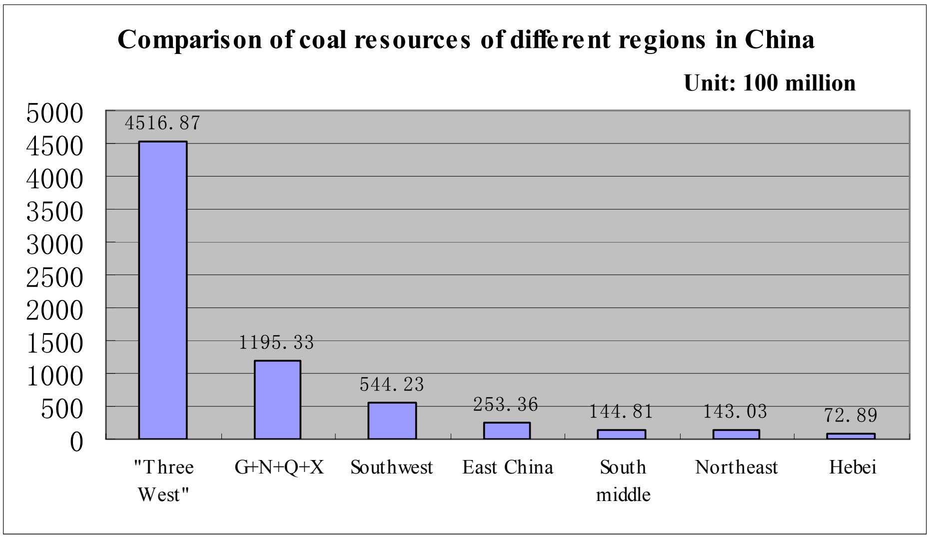
The result of coal resource investigation in 1999 is shown in Table 2-1. Figure 2-1 (derived from Table 2-1) directly shows the coal resources of different regions in China, and it is easy to see that "Three West" are the regions which have the most abundant coal resources and takes above 60% of the country's coal resources.

Table 2-1 Summary of findings on reserves of coal resources (1999)

Regions Unit: 100 million tons	Basic reserves		Resources		Total	
	Quantity	%	Quantity	%	Quantity	%
Hebei Province	99.00	3.1	72.89	1.1	171.89	1.7
Shanxi, Shananxi Inner Mongolia	1941.64	60.8	4516.87	65.7	6458.51	64.2
Northeast China	171.31	5.4	143.03	2.1	314.34	3.1
East China	280.86	8.8	253.36	3.7	534.22	5.3
South middle China	149.39	4.7	144.81	2.1	294.20	2.9
Southwest China	346.10	10.8	544.23	7.9	890.33	8.9
Gansu, Ningxia, Qinghai, Xinjiang	203.68	6.4	1195.33	17.4	1399.01	13.9
Whole country	3191.98	100	6870.52	100	10062.50	100

Source: Chen, W., Tang, X., & Zhang, X. (2003). China's coal resources and analysis on its exploitation and utilization, *Coal Economic Research, 7,* 6-11

Figure 2-1 Comparison of coal resources of different regions in China



Explanation: "G+N+Q+X" means the 4 regions-Gansu, Ningxia, Qinghai, and Xinjiang.

2.1.2 Coal production

Coal remains China's main energy resource in the long term, because in China coal has absolute advantage than other energy resources. There are three reasons: firstly, coal is the most abundant local energy resource, and coal supply is reliable and safe; secondly, coal and its related industries could provide large amount of job opportunities; lastly, compared with other energy resources, coal has obvious price advantage in China. Table 2-2 shows China's coal production plan from 2001 to 2010. From the table we can see that "Three West" are the main coal production areas.

Table 2-2 China's coal-production plan from 2001 to 2010

Regions	Production capability (Unit: 10 thousand tons)			
	Year 1990	Year 2000	Year 2010	
			Year 2010	Compared with year 2000
Shanxi, Shananxi, Inner Mongolia	15434	28148	47510	+19632
Southwest China	5843	6595	10950	+4355
Gansu, Ningxia, Qinghai, Xinjiang	2148	4361	9280	+4919
Northeast China	12698	9836	19740	+9904
Hebei Province	5503	4876	4440	-436
South middle China	11188	8436	19320	+9884
East China	11515	14683	22000	+7317
Total	62329	76976	132240	+55264

Note: This table only includes statistics of state-owned coal mines.

Source: Qian, W. (2004). *Analysis on China's coastal coal transportation market.*

2.2 Analysis on China's coal demand

2.2.1 Coal consumption market

China's coal consumption is mainly caused by 3 areas--electricity generation, industrial production and daily-use consumption, which account for 75% of the total amount of the coal consumption. Among the above areas, electricity generation and industrial production are the greatest demand for coal. (Li, 2003, p.5)

Power industry is the first major coal consumer, and it contributes 60% of the total annual coal consumption of the country. Compared with other methods of electricity generation, electricity generated by coal represents low cost and short construction cycle and has a strong cost advantage. Additionally, as China is relatively rich in coal resources, electricity generated by coal is the main method of electricity production. It is reported that in 2007, China consumed 1280 million tons of coal to generate electricity. The future development of electric power will still rely on coal. In many power plants, the coal prepared to be used in peak summer periods was consumed ahead of schedule, and the coal inventory in some power plants can only satisfy 2-3 days' consumption which is far lower than the warning line of coal inventory. At the beginning of 2008, the snow damage in South China had also intensified the coal shortage and created a tremendous impact on the normal operation of the power plants. (Data got from Http://www.chinacoal.gov.cn)

Iron and steel industry is the main coal consumer in industrial production, and nowadays is ranked as the second largest coal consumer (industry) in China. As Qinghai-Tibet Railway and a series of "iron-cement" major infrastructure projects are carried out and real estate, automobile and other industries continue to develop rapidly, their demand for coal has also increased very fast.

2.2.2 Regional distribution of coal consumption

In China, the level of economic development is in great imbalance for different regions, so the demand for coal is also quite different. Coastal areas have more developed economy and are densely populated. They have a great demand for coal but coal resources in these areas are very scarce. On the contrary, the economy of the coal-abundant areas is relatively underdeveloped, and the demand for coal in these areas is quite low. So the trans-regional transportation of coal in large quantities is formed. Table2-3 is the data on coal production and marketing of different regions in China. From the table we know that East and South China are the regions which have a large demand for coal and need coal to be transported into these areas. Shanghai and Zhejiang Province in East China and Guangdong Province in South China are the areas which need coal to be delivered by coastal transportation. It can be said that the coal demand of power plants in south and east coastal areas dominates the demand of coal transportation from North to South China.

Table 2-3 Balance of coal production and marketing in China (2001)

Unit: 10 thousand tons

	Northeast China	North China	East China	South middle	Southwest China	Northwest China
Production quantity	12000	42400	21500	15000	13600	11700
Consumption quantity	18999	40498	41270	27823	15233	8823
+/-	-6999	+1902	-19770	-12823	-1633	+2877

Source: Li, Z. (2003). *Research on China's coal market and strategies of Qinhuangdao Port.*

2.3 Transportation modes of CTNSC

Coal transportation from North to South China is the basic pattern of China's coal transport. Large volume and long distance are the 2 typical characteristics of CTNSC.

The routes of CTNSC are as follows,

1> Direct transportation to the demand place in East and South China by railway

2> Transportation from the west hinterlands to the coastal loading ports in North China, and then shipment to the discharging ports in East and South China by sea.

3> Transportation by rail or road to the river ports, and then shipment along the inland river to the demand place.

At present, the second transportation route–the combined land & coastal coal transportation is taking the most important role in CTNSC.

The emphasis of this paper is the analysis of the 4 Bohai Bay coal ports in CTNSC system, so the combined land & coastal coal transportation system will be analyzed in detail. The direct railway coal transportation and inland-river coal transport will not be mentioned detailedly.

2.3.1 Railway coal transportation

The most important coal-production area in China is "Three West" and coal demand is mostly in southeast coastal areas. Coal has to be firstly transported from the hinterland to the ports in North China by railway, and then to the demand place by sea. So the combined land & coastal coal transportations need railway transport as an indispensable part. The coal railway corridors from west to east which connect the coal loading ports in North China are classified as north corridor, middle corridor and south corridor. These railway corridors include many coal transportation railway arteries. But the railway transport capacity (especially the coal corridors) has been deficient for many years and is hardly to expand. This problem becomes the crucial constraint for the coal supply to increase. (Yuan, 2005, p.46) China's Ministry of Railways makes great efforts to ensure the transportation of coal which is used in electricity generation in East and South China, and in fact the transportation of other key materials has already been affected. Nowadays, the government is still making efforts to increase the investment in the railway infrastructure construction to enhance the railway transport capacity and ease up the coal transport bottleneck.

2.3.2 Coastal coal transportation

Compared with other transport modes, water transportation has the features of less spatial occupation, lower cost, large transport capacity, less energy consuming, less investment in advance, better profitability, environment protection, and relative safety, etc. Water transportation has irreplaceable outstanding advantages in the comprehensive transport system. It is said that when per capita GDP reaches 1,000 USD, the development of water transportation should be paid more attention to in order to make full use of water transportation's advantages. (Yang, 2006, p.19) Additionally, coal demand of southeast coastal areas is dramatically increasing, and the capacity of direct railway coal transportation has reached the limitation in recent years, so water transportation (especially the coastal transportation) becomes an important transport method which helps to share the coal transport pressure. The market share of coastal coal transportation is going up year by year.

Coastal coal transportation has the advantages of large transport capacity and low transport cost. The direction of China's coastal coal flows is from the loading ports in North China to the discharging ports in coal demand areas (East and South China). At present, the loading ports in North China are Qinhuangdao Port, Tangshan Port, Tianjin Port, Huanghua Port, Rizhao Port, Qingdao Port, Lianyungang Port. The coal discharging ports are Shanghai, Ningbo, Guangzhou, Shenzhen, Shantou, Zhanjiang, etc. Among these coal discharging ports, Shanghai, Ningbo, and Guangzhou Port have the largest coal discharging capacity, and now these ports are making efforts on the construction of coal distribution center and improvement of coal transportation facilities.

2.3.3 Cooperation of different transport modes in CTNSC

To sum up, due to the features of China's coal transportation (large volume and long distance), our country's coal transport mainly relies on railway and water transportation. But because there is a relatively long distance from coal hinterlands to the coal loading ports, sea transportation of coal still depends on railway to collect and deliver the coal to the ports. Road coal transport has the characteristics of flexibility and mobility and is suitable for short distance of coal transport. So road transportation can be used as assistant transport method of port in assembling and distributing coal. Road transportation can be applied as the connection between ship and railway, and help the cargo owners to realize the "door to door" transport service. (Yang, 2003, p.9)

2.4 Whole structure of China's combined land & coastal CTNSC and the four biggest coal ports in Bohai Bay

Generally speaking, the combined land & coastal coal transportation system can be divided into 2 parts—land railway transport system and coastal transport system.

2.4.1 Land transportation system

"Three West" is the largest energy base in China, taking the responsibility of supplying coal to Beijing & Tianjin, East China and South China. There are 3 corridors—north, middle, and south corridors, and they connect "Three West" areas with the coastal coal loading ports. Through the corridors, coal resources in "Three West" are transported to the coastal loading ports and then shipped to the demand places in East and South China.

In order to satisfy the increasing demand of coal transportation, the improvement of coal transport capacity from "Three West" to the outside areas is still the emphasis of Ministry of Railways' construction plan in recent years. The improvement of coal transport railway corridors from west to east will provide a guarantee to coastal coal transportation to East and South China.

1> North Corridor

Daqin Railway is the most important railway line of North Corridor. Daqin Railway (from Datong in Shanxi Province to Qinhuangdao in Hebei Province) is the specialized railway for coal transport from North to South China. This railway contributes a lot to the development of the energy base in Shanxi Province and plays a very important role in easing the tense situation of coal supply. In the west, Daqin Railway is connected with the main coal production base in "Three West", and is linked to Qinhuangdao and Tianjin Port in the east coastal area of North China. After the capacity expansion, the transportation capacity of Daqin Railway will reach 20 million tons per year. (Dong, 2007, p.2) Especially after the completion of Qiancao

Railway (Qianan-Caofeidian) which is the extension railway line of Daqin Railway, the transportation capacity of Daqin Railway will be largely expanded. Qiancao Railway is connected with Caofeidian terminal of Tangshan Port which will have several professional deep-water coal berths.

Beitongbao Railway—Jingyuan Railway—Jingshan Railway is another railway passage in north corridor. The beginning of this passage is the coal production area in the middle of Shanxi Province, and the end of the passage is connected with Tianjin Port and Tangshan Port. Because this railway line is used for both passengers and cargo, the coal transport capacity is limited. The bottleneck of this passage is Jingyuan Railway.

Shitai Railway—Jingguang Railway—Jingshan Railway is a railway passage which connects the middle and south area of Shanxi Province with Tianjin Port. But it is also a railway line both for passengers and cargoes.

It is estimated that the coal transport capacity of north railway corridor will reach 430 million tons (per year) in the year 2010. (Yuan, 2005, p.45)

2> Middle Corridor

Shenshuo Railway—Shuohuang Railway—Huanghua Port is the main railway line of middle corridor. Shenshuo—Shuohuang Railway is the second specialized railway for coal transport from North to South China. This railway line begins at Shenchi in Shanxi Province, ends at Huanghua Port in Hebei Province, and the overall length is 982 km. The designed transport capacity of this railway passage is 30 million tons per year. (Li, 2004, p.7) Coal produced by Shenfu-Dongsheng Coal Mine (Shenhua Group) and a small amount of coal produced in Shanxi Province and Shananxi

Province always go through this railway passage to Huanghua Port to be loaded and then go to Shanghai or Ningbo Port, etc.

Shuohuang Railway—Jingjiu Railway—Bajin Railway—Tianjin Port is another railway passage which serves both passengers and cargoes. Coal transport capacity of this railway line is above 6 million tons per year, (Qi, 2005, p.8) and the coal resources are loaded in Tianjin Port and then go to the coal demand areas in East and South China.

Shitai Railway—Shide Railway—Jinghu Railway—Jiaoji Railway—Qingdao Port is also a railway passage in middle corridor. This railway line takes Shijiazhuang as the railway hub, and connects Jiaoji Railway through Dezhou in Shandong Province. The final coal loading port of this railway line is Qingdao Port.

3> South Corridor

South corridor includes 3 railway passages: The first one is Yanshi Railway—Rizhao Port. The second passage is Houyue Railway—Rizhao Port. The third one is Longhai Railway—Lianyungang Port. The total coal transport capacity is 30 million tons per year. (Zhao, 2004, p.8)

2.4.2 Coastal transportation system

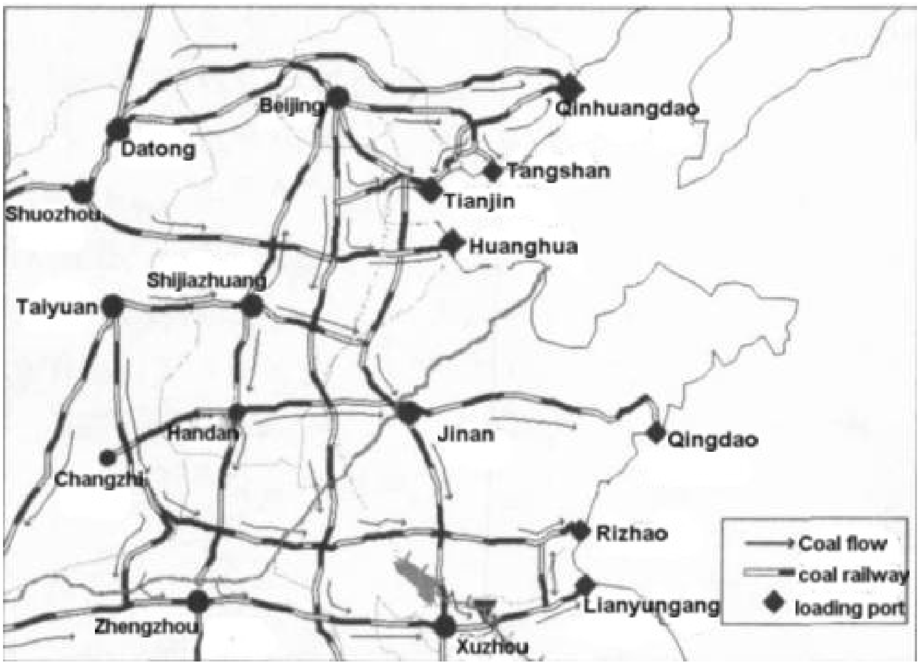
The main direction of China's coastal coal flows is from "Three West" to loading ports in North China, and through coastal transportation to discharging ports in southeast areas, such as Zhejiang, Shanghai, Fujian, and Guangdong Province.

At present, coal loading ports in North China are Qinhuangdao Port, Tianjin Port, Tangshan Port, Huanghua Port, Qingdao Port, Rizhao Port, and Lianyungnag Port. In 2007, total coal loading quantity of these seven ports takes 90% of the whole coal loading market. In East and South China, major coal discharging ports are Shanghai, Ningbo, and Guangzhou Port. The total coal discharging quantity of these 3 ports accounts for 60-70% of the whole country's discharging quantity.

2.4.3 Loading ports in North China

Figure 2-2 shows the geographical locations of the seven coal loading ports in North China. Ministry of Communications specially analyzed the layout and construction plan of the four Bohai Bay ports--Qinhuangdao Port, Tangshan Port, Tianjin Port, and Huanghua Port in order to enhance the coastal coal transport capacity and meet the growing demand of coastal coal transportation.

Figure 2-2 Geographical location of seven coal loading ports in North China



Source: Zhao, Y., & Y, P. (2007). The spatial pattern of coal flow and flowing channel in China. *Economic Geography, 27*(2), 198

1> Qinhuangdao Port

Qinhuangdao Port is located in Bohai Bay's west side and in the northeast of the North China Plain. It is one of the largest energy resource exporting ports in the world, and at present, it is also the biggest coal loading ports in CTNSC system and takes great responsibility for CTNSC. The coal loading quantity of Qinhuangdao Port takes 40% of the coal loading quantity of all the ports in China (per year). Qinhuangdao Port has perfect natural condition-wide water area, high depth of water, small waves, seldom frozen or silted. Daqin Railway, Jingqin Railway, and Jingshan Railway are all connected with the port, and land transportation is quite convenient. A large amount of 'Three West" coal are transported through Daqin Railway and loaded in Qinhuangdao Port, and then go to East and South China by sea. Coal transferred by Qinhuangdao Port goes to Shanghai, Zhejiang Province, Jiangsu Province, Fujian Province, Guangdong Province, etc.

Good berthing conditions, good land transportation to the port, good handling capacity are the 3 major advantages of Qinhuangdao Port. But limited capacity of coal stacking yard and longer land transportation distance are 2 major disadvantages of this port.

In order to satisfy the increasing coal demand caused by the rapid economic growth, a number of programs on capacity expansion of Qinhuangdao Port have been carried out. In the year 2007, after the fifth time of capacity expansion, the designed coal handling capacity of this port reached 180 million tons per year. And the stacking capacity has reached 10 million tons. (Sun, 2006, p.17)

2> Tianjin Port

Tianjin Port is the largest artificial port in China. It is located in Western Bohai Bay, at the estuary of Haihe River into the sea, and it is a very important coal loading port in China. The distance between Tianjin Port and “Three West” area is relatively short. Coal produced in “Three West” can be transported through Daqin Railway, Jingguang Railway, or Jingyuan Railway and finally be loaded onto the ship in Tianjin Port. Advantageous geographical position, good land transportation into the port, sufficient stacking capability are the 3 major advantages of Tianjin Port.

Coal is one of the major types of cargo of Tianjin Port, and from the end of 1980’s until now, coal handling business has taking one third of the port’s total handling capacity. Because coal handling operation area was originally in the north area of the port and had a very short distance to TEDA, it brought environmental pollution to the city and the surrounding areas. So from the mid 1990’s, the coal business began to move from the north part of Tianjin Port to the south part which has professional coal handling facilities there and is quite far away from the city .

From the beginning of 2007, all the coal operation had been moved from the north part to Nanjiang terminal area (the south part of Tianjin Port). The movement project with the investment of 10 billion RMB which took 10 years of time was finished. China Coal Hua’Neng Coal Terminal is located in Nanjiang terminal area, and at present the designed coal handling capacity is 43 million tons per year. In October of 2007, Shenhua Group Tianjin Coal Terminal was put into operation in Nanjiang area, and the coal handling capacity of this terminal is 45 Million tons per year.
(Information obtained from http://www.ptacn.com/meimatou/web/index.htm)

3> Huanghua Port

Huanghua Port is 100 km south of Tianjin Port, and is connected with the second largest professional coal railway-Shuohuang Railway. Huanghua Port has the shortest land distance from the coal hinterland of “Three West”. It is a big energy exporting port which is growing up in recent years. It is mainly invested by Shenhua Group, and is the access to the sea for the coal produced in Shenfu-Dongsheng Coal Mine.

At the end of 2006, the second time of coal terminal construction was finished, and the designed coal handling capacity reached 65 million tons per year. This port’s coal loading quantity in 2006 has reached 80 million tons and became the second largest coal loading port in China. (Zhang, 2006, p. 21) Huanghua Port is playing an important role in breaking through the constraints of China’s coal transportation.

The construction area of Huanghua Port is a large area of mudflat, and this port has a very long and narrow artificial fairway. The problem on how to keep the fairway unobstructed is the bottleneck restricting the port’s development. Shenhua Group has carried out the project to carry the silts out of the fairway to ensure the port’s normal operation.

4> Tangshan Port

Tangshan Port is another important coal loading port in Bohai Bay. Tangshan Port is consisted of Jingtang terminal area and Caofeidian Terminal area, and it is another coal access into the sea in the system of CTNSC.

Jingtang Terminal area is located to the southeast of Tangshan City, 64 nautical miles away from Qinhuangdao Port, and 70 nautical miles away from Tianjin Port. The coast line suitable for port construction is 12 km. There are 3 typical features of Jingtang Terminal: the first is deep water and steep shore, the -10 m isobaths is only 4.8 km away from the shore; the second is that the port is seldom frozen or silted, the silt quantity of the 70,000-ton fairway is less than 300,000 cubic meters per year; the third is broad land area and stacking yard, the planned port area is 35 square meters which are all salinas and wasteland available for development, and there is also more than 100 square meters' salina in the backside of the port waiting for further exploitation. (Information got from http://www.jtport.com.cn)

Tangshan Port Railway is the main transport method for Jingtang terminal, and the railway is 77 kilometers' long with the transport capacity of 12 million tons per year. This railway in connected with Daqin Railway, Jingshan Railway, and Jingqin Railway, and at present this railway's capacity expansion project is ongoing.

Coal is the main type of cargo of Jingtang terminal. Coal has always been ranked as the top quantity of cargo in Jingtang terminal. At present, Jingtang terminal becomes one of the seven coal loading ports in CTNSC. Although the cargo types have become diversified in recent years, the fundamental position of coal in Jingtang terminal has never been shocked. Coal will still be treated as the leading type of cargo in Jingtang terminal in the long run.

In the year of 1994, the government of Tangshan brought forward the plan to construct the deep-water terminal in Caofeidian area. At the end of 2004, the construction of Caofeidian terminal was placed on the "port construction plan in Bohai Bay area" issued by the central government. Caofeidian terminal area is adjacent to Beijing, Tianjin and the land distance is 220km from Beijing, 120 km from Tianjin, 170 km from Qinhuangdao. Caofeidian terminal is an island in band shape, and it is the deepest point of Baohai sea. In the long run, Caofeidian terminal will become another big energy exporting port in Bohai Bay. There are iron ore terminals, crude oil terminals and coal terminals, etc. in Caofeidian terminal area. (Zhang, 2006, p.20) In the long term construction plan, there will be 16 professional coal berths (50, 000-100,000 tons per berth), and the designed coal handling capacity is 100 million tons per year. The capacity expansion project of Daqin Railway—Qiancao Railway line (which is mentioned above), will finally lead to Caofeidian terminal area. According to the layout plan of China's Ministry of Railways, Qiancao Railway line can distribute 130 million tons of coal from Daqin Railway, and 30 million tons will go through Jingtang terminal area, and the other 100 million tons of coal will go through Caofeidian terminal area and finally be shipped to the coal demand place. (Information got from http://news.xinhuanet.com)

Mr. Yuan (2005) mentioned in his article that when the coal berths are put into production, Caofeidian terminal will obtain strong competitive advantage depending on the good geographical location and marine environment. Then the coastal coal transportation pattern in CTNSC will be formed, and Qinhuangdao Port, Tangshan Port, Tianjin Port, and Huanghua Port will inevitably divide the coastal coal transportation market into four parts.

5> Qingdao Port

Qingdao Port was founded in 1892, and has a long history of more than 100 years. It is an important pivot port of sea transportation on Pacific west coast. Coal, oil and gas, iron ore, and containers are the major 4 types of cargo which Qingdao Port is dealing with. There are 3 coal handling berths, and designed coal loading capacity is 16 million tons per year. Among the 3 berths, two berths are professional coal handling berths, the length of the berth is 566 m, the depth of the forefront water is 14.1 m, can berth a 35 thousand-ton ship and a 50 thousand-ton ship at the same time, the maximum berthing capacity is 10,000 tons. Part of the coal produced in Shanxi Province is loaded in Qingdao Port and then to the coal demand place by sea. But because Qingdao Port is engaged in the development of container business, the coal loading business represents a shrinking trend. (Information got from http://www.qdport.com)

6> Rizhao Port

Rizhao Port is located at the end of Yanshi Railway, and it is also an coal loading port in CTNSC. At present, this port has 3 professional coal berths, including two 125,000-ton coal berths, and a 50,000-ton coal berth. The designed coal loading capacity is 35 million tons per year. The port has 10 professional coal stacking yards, and the total capacity is 35 million tons. (Qian, 2004, p.12)

Yanzhou Coalfield is the main coal hinterland of Rizhao port. Although there is still potential in coal production of this coal hinterland, the coal demand of the local and surrounding areas is also increasing very fast. So it becomes difficult for the coal resources to go out and meet the demand of the outside areas in East and South China. Because of the dual-limitation: limited coal resources and railway transport capacity, the development of Rizhao Port's coal business has become slower in recent years. (Li, 2004, p. 9)

7> Lianyungang Port

Lianyungang Port is situated at the end of Longhai Railway, and it is also the loading port of coal produced in Anhui Province. There are 2 professional coal berths, one is 16,000-ton coal berth, and the other is 35,000-ton coal berth. The designed coal loading capacity is 15-20 million tons per year. (Zhao, 2004, p. 9) Huaibei area and Yanzhou in Anhui Province are coal hinterlands of Lianyungang Port. Same as Rizhao Port, Lianyungang is also confronted with the dual-limitation—limited coal resources and railway transport capacity. Also, the direct railway transport and inland river transport is more convenient and profitable for Huaibei coal to go to the South area. So the coastal coal transport is less competitive for Huaibei coal.

3 Analysis and comparison of the four biggest Bohai Bay coal ports

3.1 Analysis of the four ports' coal loading quantity and market share

In recent years, the centralization trend of the coal loading ports in North China is becoming obvious. Coal loading capacity of the 4 Bohai Bay coal ports and their growth rate are significantly higher than the average level in China. Table 3-1 gives the coal loading quantity of the four ports in Bohai Bay and the total coal loading quantity of China's ports in the year 2006 and 2007.

Table 3-1 Coal loading quantity of four Bohai Bay coal ports (2006-2007)

Unit: 10 thousand tons

Ports	Year 2006		Year 2007		Loading quantity increased
	Loading Quantity	Market share	Loading Quantity	Market share	
Qinhuangdao Port	17651	43.9%	21400	46.2%	21.24%
Tangshan Port	1437	3.6%	1561	3.4%	8.6%
Tianjin Port	5232	13%	7485	15.3%	35.5%
Huanghua Port	8018	19.9%	8169	17.6%	1.9%
Total (Bohai Bay Four ports)	32338	80.4%	38615	83.4%	18%
Qingdao Port + Rizhao Port + Lianyungang Port	4023	10%	3907	8.4%	-2.9%
Other ports	3860	9.6%	3813	8.2%	-1.2%
Total (all ports)	40221	100%	46335	100%	15.2%

Source: website of Water Transportation Department of Ministry of Communications

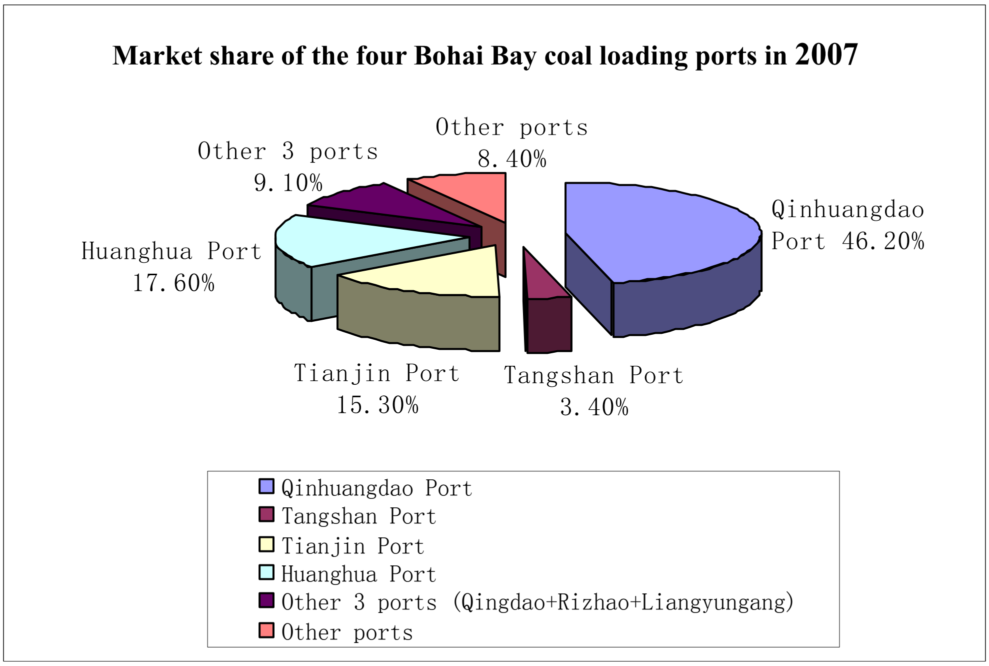
http://www.moc.gov.cn/zizhan/siju/shuiyunsi

From the table we can see that Qinhuangdao Port is still ranked as the first position of coal loading quantity. 21.4 million tons of coal was loaded in Qinhuangdao Port in 2007, the loading quantity is much bigger than those of other coal loading ports.

Compared with 2006, the coal loading quantity of the 4 Bohai Bay coal ports all increased. It is remarkable that the loading quantity of Qinhuangdao Port and Tianjin Port in 2007 increased by 21.24% and 35.5% than that in 2006. It is believable that this is directly related to the transport capacity expansion of Daqin Railway, and handling capacity expansion of Qinhuangdao Port and Tianjin Port. The total coal loading quantity of the 4 Bohai Bay ports in 2007 is 38.615 million tons, increased by 18% than in 2006. On the contrary, other loading ports all showed the negative growth of coal loading quantity in 2007.

In 2007, the total market share of the 4 Bohai Bay coal ports in the coastal coal loading market increased by 3 % than that in 2006 (80.4% in 2006, and 83.4% in 2007). Oppositely, the market share of other coal loading ports fell down in 2007. Figure 3-1 shows the market share of the coal loading ports, and Qinhuangdao Port nearly occupies half of the country's coastal coal loading quantity. Qinhuangdao Port is followed by Huanghua Port with the market share of 17.6%. Tianjin Port is ranked as the third one, and its market share is 15.3%. Besides these 4 Bohai Bay coal ports, the total market share of other coal loading ports is only 17.5%. The centralization trend of coal loading ports is quite obvious, and the market share is more and more concentrated in Bohai Bay region.

Figure 3-1 Market share of the four Bohai Bay coal loading ports in 2007



Source: derived from Table 3-1

3.2 Analysis and comparison of the four ports' coal loading capacity

Through investigation and calculation, Table 3-2 is drawn. This table includes 4 aspects: number of coal berths; designed loading capacity (per year); maximum anchoring capacity; utilization ratio of handling capacity. These 4 aspects of the four Bohai Bay coal ports from 2006 to 2008 are described in this table. The following is the detailed analysis on the loading capacity and developing trends of the four Bohai Bay coal ports.

Table 3-2 Comparison of loading capacities of four Bohai bay coal ports

Unit: 10 thousand tons

	Year	Qinhuangdao	Tangshan	Tianjin	Huanghua
Number of coal berths	2006	17	5	10	4
	2007	21	5	7	7
	2008	21	11	7	7
Designed loading capacity (per year)	2006	13700	1225	5000	3500
	2007	18700	1225	8800	6500
	2008	18700	9000	8800	6500
maximum anchoring capacity	2006	10	3.5	20	5
	2007	15	3.5	20	10
	2008	15	10	20	10
utilization ratio of handling capacity	2006	128.8%	117.3%	104.6%	229.1%
	2007	114.4%	127.4%	85.1%	125.7%

3.2.1 Loading capacity and developing trend of Qinhuangdao Port

Until the end of 2008, Qinhuangdao Port totally has 21 coal handling berths; the maximum berthing capacity is 150,000 tons; the designed coal handling capacity is 187 million tons per year. The area of coal stacking yard is 2.498 million square meters, and the maximum stacking capacity is 6.03 million tons. There are 22 coal loading operation lines, and the maximum efficiency is 6,000 tons / hour (per operation line).

There are two fairways for ships to enter or leave the port, and the maximum capacity of the fairway which is mainly used for coal ships is 150,000 tons. “DGPS” navigation system of the port provides services all day long for the entering or leaving ships. The current handling capacity of Qinhuangdao Port was formed after the completion of the fifth-time capacity expansion project (May of the year 2005).

There are two terminal areas of Qinhuangdao Port—east and west terminal area, and the coal handling business is mostly operated in the east terminal area. Qinhuandao Port is the supporting coal exporting port for the professional coal transport railway line-Daqin Railway. This port has the most advanced automated coal handling equipments; unloading coal from trains and loading coal onto the ship are all managed by automation system. The dumper techniques are all used in the unloading process in east terminal area, and the dumper machines which were procured in the third and forth time of capacity expansion projects can all successfully unload the coal from the 10,000-ton coal transport trains or even the 20,000-ton super-length coal transport train. Coal trains can directly go into the dumpers and be unloaded in the condition without removing the hooks. At present, Qinhuangdao Port has a total of 10 dumper machines; the single machine's utmost working efficiency is 5,400 tons / hour.

Through the analysis of the capacity utilization in Table 3-1, we can see that the coal loading quantity of Qihuangdao Port always goes beyond the designed coal handling capacity, although the capacity expansion projects have never been stopped. As the high utilization of coal berths of this port has never fallen down, ships have to wait for long time to be berthed and this situation is becoming more serious. In order to better satisfy the demand of coastal coal transportation, the continuation of the fifth-time capacity expansion project will be carried out. At the same time, in order to be able to berth larger coal ships and improve the economic efficiency of the port, building the 200,000-ton fairway becomes an urgent need of Qinhuangdao Port.

But compared with other Bohai Bay coal ports, there are still comparative disadvantages of this port, such as limited coal stacking capacity, longer railway distance from the coal hinterland, etc. (Statistics got from http://www.portqhd.com)

3.2.2 Loading capacity and developing trend of Tangshan Port

Until the end of 2008, there are totally 8 coal handling berths in Tangshan Port and the maximum berthing capacity is 100,000 tons. The designed coal handling capacity is 42.25 million tons per year. And the current coal handling capacity of this port is formed in 2007 after the construction of the 30 million tons of coal terminal was finished in Jingtang terminal area. And in July of 2008, the first-time construction of coal berths in Caofeidian terminal area will be completed, and this project will add 5 professional coal handling berths to Tangshan Port and then the coal handling capacity of Tangshan Port will reach 90 million tons per year.

In fact, either the coal handling capacity expansion of Jingtang terminal area, or the forthcoming professional coal berths in Caofeidian terminal area are all coordinated with Daqin Railway's coal transport capacity expansion project—Qiancao Railway line. At present, the south part of Qiancao Railway has already been put into operation, and the Railway's south part construction is ongoing. It is estimated that after the completion of the professional coal berths' construction in Caofeidian terminal area, Qiancao Railway's south part will also be open to coal transportation soon.

At present, the area of stacking yard in Jingtang terminal area is above 2 million square meters. The stacking yard is only one kilometer away from the terminal's forefront. And there are a number of special railway lines running through the area and directly reaching the forefront of berths. So it is very convenient for cargoes to be transferred from the stacking yard to the handling berths. The stacking yard is fully equipped with professional coal handling facilities. Jingtang terminal area currently has 4 coal loading machines (three of them work for the speed of 1,200 tons / hour, and the other one works for 1,600 tons / hour), and five 10-ton gantry cranes. The handling speed for the coal ships below 10,000 tons is at least 8,160 tons / 24-hour, and 14,300 tons /24-hour for the coal ships above 10,000 tons. As for the fairway of Jingtang terminal area, it is 12 meters' deep and 6,820 meters' long. The width of the bottom is 160 meters, and the capacity is 35,000-ton. 70,000-ton ship can go through this fairway by the tides.

The coal handling berths of Caofeidian terminal area are still in the process of construction, and In the long term construction plan, there will be 16 professional coal berths (50, 000-100,000 tons per berth), and the designed coal handling capacity is 100 million tons per year. Caofeidian terminal is an island in band shape, and it is the deepest point of Baohai sea. From Caofeidian terminal area, there is a natural (27 meters' deep) water channel extending into Bohai Straits, and then leading to Yellow sea through the straits. The combination of fairway and deep channel is the particularly favored advantage given by nature for the large-scale deep-water terminal to be constructed in Caofeidian area. The coast line in 30 meters' depth is longer than 6 kilometers, and does not freeze or silt. This natural terminal location is the single one which can be constructed into 300,000-ton large-scale berths without excavating the fairway and basin. (Zhang, 2006, p.21)

Railway transportation was always the main constraint for the development of Tangshan Port. But the construction of Qiancao Railway will effectively improve the situation and ease the railway bottleneck for Tangshan Port. When Qiancao Railway is thoroughly open into operation, good railway transport condition will become the competitive advantage of Tangshan Port, and lays a good foundation for the further development of Tangshan Port. (Statistics got from the inside material of Tangshan Port)

3.2.3 Loading capacity and developing trend of Tianjin Port

In Tianjin Port, from the beginning of 2007, all the coal operation had been moved from the north part to the south-Nanjiang terminal area, and the professional coal terminal operation was basically realized. At present, the coal handling facilities are divided into two parts. One part is China Coal Hua'Neng Coal Terminal, and the other part is Shenhua Group Tianjin Coal Terminal which was put into operation in October, 2007.

China Coal Hua'Neng Coal Terminal was founded in November, 2000. And it is located in Nanjiang terminal area of Tianjin Port, and this terminal company is specialized in a professional coal handling operation with the designed coal handling capacity of 43 million tons per year.

China Coal Hua'Neng Coal Terminal has 4 large-scale coal berths; the coastline is 1110 m in length; and the deepest water of the forefront is -19.6 m; it can berth the ship of 150,000-200,000 tons. The area of stacking yard is 300,000 square meters with the stacking capacity of 1.76 million tons. The belt corridor, train or truck can directly deliver the coal into the stacking yard. Through the conveyor belt in 9.3 kilometers' long, coal can be directly carried to the forefront of the terminal. This kind of coal logistics both improves the efficiency of the operation and reduces the operation cost. This terminal company has a variety of modern coal handling facilities such as dumpers, loading machines, coal stackers and feeders, large-scale gantry cranes. The facilities are stable in performance with high operating efficiency. The operation efficiency of a single loader is 6700 tons / hour; the dumper's operation rate is 4300 tons / hour. The company realized the modern automated control of discharging coal from trains, loading coal onto the ships, static & dynamic dust suppression, etc. Coal handling, storage, and related supporting services are all in the business scope of China Coal Hua'Neng Coal Terminal. (data got from website of China Coal Hua'Neng Coal Terminal Co., Ltd. http://61.181.250.157/)

In 2007, the new fairway with the capacity of 250,000 tons was built up, and this provides a great convenience to the ships entering or leaving the port. But as Tianjin Port is an artificial port, the fairway needs continuous dredging work which will increase the port's operating cost.

In October 2007, Shenhua Group Tianjin Coal Terminal was put into use. This professional coal handling terminal consists of 3 deep-water berths, one is 150,000-ton berth, and the berthing capacity of the other two is 70,000 tons. This terminal is located in the east part of Nanjiang terminal area, south to the main fairway of Tianjin Port, and the coast line is 890 meters' length. There are 3 coal dumpers, 4 stacking lines, 3 feeding lines, and 6 stacking yards with the total area of 248,300 square meters. The designed coal loading capacity of this terminal is 45 million tons per year. (Statistics got from http://www.ce.cn)

Until now, the total designed coal loading capacity of Nanjing terminal area is 88 million tons per year. In addition, Shenhua Group will continue to carry out the second phase of coal berth construction, and the designed coal handling capacity of the second phase is 35 million tons.

The professional coal handling berths in Nanjiang terminal area obviously enhance the advantage of Tianjin Port in coal handling business. And the advantage in good hardware facilities and efficient loading operation is no longer distinctively belonged to Qinhuangdao Port. Especially, there is hinterland overlap of Tianjin Port and

Qinhuangdao Port, and the land transport distance to Tianjin Port is slightly shorter than that to Qinhuangdao Port. So as the coal handling capacity of Tianjin Port increases, the competition between Tianjin Port and Qinhuangdao Port will be intensified.

3.2.4 Loading capacity and developing trend of Huanghua Port

Huanghua Port is the second largest energy exporting port which is ranked after Qinhuangdao Port, and it is the access to the sea for coal which is delivered through the second largest professional coal transportation railway—Shuohuang Railway. At present, Huanghua Port has 7 professional coal handling berths, 6 dumpers and 14 automated loading machines. The railway inside the port is 46.83 kilometers' long; the area of stacking yard is 713,000 square meters. The maximum berthing capacity is 100,000 tons and the designed coal handling capacity is 65 million tons. The current coal handling capacity of Huanghua Port was formed when the second phase of construction was finished in 2006. World's advanced technologies are applied into the port's coal handling system; automated control and the performance of each type of equipments are all at the leading level in China. Each dumper can discharge 4000 tons of coal from the train per hour. Coal can be carried on 20 lines of underground belt conveyors, and finally reach to the forefront of the berth. The whole procedure is monitored and directed by the central control system, and the average rate of coal handling flow is 3,000 tons / hour. (statistics got from http://www.he.xinhuanet.com)

As for the fairway of Huanghua Port, the length of the inner fairway is 3.48 kilometers, and the outer fairway is 35 kilometers' long. In January 2007, the construction project on widening and deepening the fairway was completed, and the bottom width of the fairway became 170 meters (from original 140 m); the fairway depth became -13 m; water depth of berths increased to -14.7 m from original -13.7 m. (statistics got from http://www.hebjtinfo.com)

Now the third-phase construction project of Huanghua Port is in the stage of reconnaissance, so the coal handling capacity will be further improved in the future. From Table 3-1, we can see that although the handling capacity of Huanghua Port is continuously increasing in these years, the utilization ratio of the coal handling capacity is still above 100%. That is to say, the coal handling capacity of this port is always in the saturated situation.

Compared with other Bohai Bay coal ports, the disadvantages of Huanghua Port are the inadequate depth of the fairway and berths and big quantity of silt. So it will be difficult for ships with big tonnage to enter or leave the port.

3.3 Transportation distance and cost of coal transferred through the four ports

3.3.1 Transportation distance of coal transferred through the four ports

In the combined land & coastal CTNSC system, the total transportation cost consists of railway transport cost, port charges, and coastal transport cost. We can say that the most influential factor for the coal transport cost is the transport distance, that is to say, the transport distance is the main determinant of the coal transport price. Table3-4 gives the freight distance from Bohai Bay coal ports to the main coal discharging ports in East and South China.

Table 3-3 Freight distances from Bohai Bay coal ports to the main coal-discharging ports in East and South China

Unit: Nautical mile

	Shanghai	Ningbo	Guangzhou
Qinhuangdao	688	800	1453
Tangshan	700	812	1456
Tianjin	721	833	1504
Huanghua	621	733	1404
Qingdao	404	516	1205
Rizhao	385	497	1205
Lianyungang	383	495	1195

Source: Ministry of Communications. (1983). *Cargo Freight Distance List for Shipping Enterprises Directly Affiliated to Ministry of Communications.*

From the above table, we can see that Qinhuangdao port and Huanghua port have the advantages in sea transportation distance. But as the land transport distance from coal hinterlands to Qinhuangdao port is longer than that from the hinterlands to other ports, Qinhuangdao's advantage in sea transportation distance is counteracted.

Table 3-4 Railway freight distances from "Three West" to Bohai Bay coal ports

Unit: km.

	Qinhuangdao	Tangshan	Tianjin	Huanghua
Shanxi	783	745	641	
Shananxi	1113	1020	960	
Inner Mongolia	933	895	824	
Shenfu-Dongsheng Coalfield	1264	1175	1098	860

Source: China Railway Publishing House. (1985). *Ministry of Railways-Cargo Freight Distance List*.

Explanation of Table 3-4:

1> Shenfu-Dongsheng Coalfield lies in Yulin area in Shananxi Province and Yikezhao League in Inner Mongolia. It is one of the eight major coal fields in the world. Its proven coalfield area is 31,200 square kilometers, with the geological coal reserves of 223.6 billion tons. At present, the construction area of this coal field is 3,481 square meters, with the geological coal reserves of 35.4 billion tons. Coal produced in this coal field is excellent in quality and environmental protection, and can be used in power-generation, metallurgy, and chemical industry.

2> Shenhua Group is a large state-owned coal company which is in charge of the exploitation and administration of Shenfu-Dongsheng Coal field and the related coal transport railways, coal loading ports and shipping fleets, etc. The professional coal transport railway—Shuohuang Railway and the supporting coal loading port-Huanghua Port are all affiliated to Shenhua Group.

3> Huanghua Port is the major coal loading port for Shenhua Group and most coal loaded in Huanghua Port is from Shenfu-Dongsheng Coalfield. In 2006, Shenhua Group loaded 80,000 million tons's coal in Huanghua Port, 14 million tons in Qinhuangdao Port, and 23.5 million tons in Tianjin Port. (Hu, 2007, p. 5)

4> Because Huanghua Port's coal loading capacity is nearly fully employed by Shenfu-Dongsheng Coalfield, coal produced in other area is seldom transferred in Huanghua Port. So the distances from other coal hinterlands to Huanghua Port are not listed in Table 3-4.

3.3.2 Analysis on transportation cost of coal transferred from the four ports

In the following analysis, Ningbo Port will be taken as the coal discharging port, and the comparison among the transport costs of "Three West" coal (per ton) transferred in the 4 Bohai Bay coal ports will be calculated.

The calculation procedure of railway transport cost is as follows,

1> Identify the railway distance from the coal hinterland to the coal loading port.

2> Find the freight No. of the cargo type in the table of railway cargo freight numbers (Table 3-5)

3> Find basic price 1 and basic price 2 which are applicable to the freight No., and then use the following method to calculate the railway transport freight.

Railway freight = (basic price 1 + basic price 2 * freight distance) * cargo freight

Table 3-5 Railway cargo freight numbers

Freight No.	Applicable types of cargo
1	Phosphorus minerals
2	Non-metal minerals, plaster, sand, stone material, farm chemical, salt, printed matter, etc
3	Specified cargo
4	**Coal**, metal materials, grain, cotton, live animals, agricultural and sideline products, agricultural machinery, etc
5	Coke, steel products, cement, cement products, glass, timber, chemical products, metal products, fresh fruit and vegetables, drink and food, textiles, paper and educational products, medical products
6	Petroleum, industrial machinery, electronic machinery, daily-use eletronical appliance, etc

Source: website of China's railway cargo transportation http://www.zgtlhy.cn

Table 3-6 Railway (state-owned) cargo freight-rate

	Freight No.	Basic price 1		Basic price 2	
		Unit	Price	Unit	Price
Full-load cargo	1	Yuan/ton	5.6	Yuan/ ton km.	0.0288
	2	Yuan/ton	6.3	Yuan/ton km.	0.0329
	3	Yuan/ton	7.4	Yuan/ton km.	0.0385
	4	Yuan/ton	9.3	Yuan/ton km.	0.0434
	5	Yuan/ton	10.2	Yuan/ton km.	0.0491
	6	Yuan/ton	14.6	Yuan/ton km.	0.0704

Source: China Railway Publishing House. (1993). *Freight Rate Rules for Railway Cargo Transportation*.

The coastal coal transport price (freight) is quoted from the freight rate list for shipping enterprises directly affiliated to Ministry of Communications (Ministry of Communications, 1985)

Because the cargoes transported by ship are charged by different freight rates, we have to firstly find the grade of coal, and identify the freight rate according to the grade. In shipping freight classification table (Ministry of Communications, 1985), coal is classified into the fifth grade, so the freight should be the 5^{th}-grade freight rate.

Table 3-7 Integrative transport costs from “Three West” to Ningbo through Bohai Bay Coal Ports

Unit: Yuan/ton

Regions	Bohai-Bay coal ports	Railway transport			Port charges	Sea transport			Integrative transport cost
		Distance	Freight	Freight/ Distance		Distance	Freight	Freight/ Distance	
Shanxi	Qinhuangdao	783	43.28	0.0553	18.5	800	22.91	0.0286	84.70
	Tangshan	745	41.63	0.0559	19	812	23.07	0.0284	83.71
	Tianjin	641	37.12	0.0579	24	833	23.54	0.0283	84.66
Shananxi	Qinhuangdao	1113	57.60	0.0518	18.5	800	22.91	0.0286	99.02
	Tangshan	1020	53.57	0.0525	19	812	23.07	0.0284	95.64
	Tianjin	960	50.96	0.0531	24	833	23.54	0.0283	98.51
Inner Mongolia	Qinhuangdao	933	49.79	0.0534	18.5	800	22.91	0.0286	91.21
	Tangshan	895	48.14	0.0538	19	812	23.07	0.0284	90.22
	Tianjin	824	45.06	0.0547	24	833	23.54	0.0283	92.61
Shenfu-dongsheng coal mine	Qinhuangdao	1264	64.16	0.0508	18.5	800	22.91	0.0286	105.57
	Tangshan	1175	60.30	0.0513	19	812	23.07	0.0284	102.37
	Tianjin	1098	56.95	0.0519	24	833	23.54	0.0283	104.50
	Huanghua	860	46.62	0.0542	21.5	733	22.02	0.0300	90.14

Table 3-7 is the calculation result of the railway and coastal transport costs. And the integrative transport costs are achieved by adding the railway transport cost, port charges (port charges can be got from websites of the port enterprises), and sea transport cost together. By comparing the integrative transport costs of coal transferred from different Bohai Bay coal ports, we can see the four Bohai Bay coal ports’ competitive ability which is influenced by the integrative transport distance, as shown in Table 3-8.

Table 3-8 Integrative transport costs of coal transferred from Bohai Bay coal ports and rankings

Coal hinterland	Loading ports	Integrative transport cost	Rankings
Shanxi	Qinhuangdao	84.70	3
	Tangshan	83.71	1
	Tianjin	84.66	2
Shananxi	Qinhuangdao	99.02	3
	Tangshan	95.64	1
	Tianjin	98.51	2
Inner Mongolia	Qinhuangdao	91.21	2
	Tangshan	90.22	1
	Tianjin	92.61	3
Shenfu-Dongsheng Coalfield	Qinhuangdao	105.57	4
	Tangshan	102.37	2
	Tianjin	104.50	3
	Huanghua	90.14	1

From the above table, we can see that for a coal hinterland, the integrative transport costs for coal transferred in different Boahai Bay coal ports are different. This is the reason why different coal hinterland will choose the most effective and economic coal loading port to ship their coal to the demand place.

From the above analysis, we can get the following information:

Firstly, for coal from Shanxi Province, the integrative transport cost is the lowest if the coal is transferred from Tangshan Port. The cost is a little bit lower if transferred from Tianjin Port than the cost if transferred from Qinhuangdao Port.

Secondly, for the coal resources in Shananxi Province, Tangshan Port can also help to realize the lowest integrative transport cost, and the highest cost happens when the coal is transferred from Qinhuangdao Port.

Thirdly, Inner Mongolia's coal transferred from Tianjin Port presents the highest integrative transport cost, and the lowest cost is realized by being transferred from Tangshan Port, too.

Fourthly, coal from Shenfu-Dongsheng Coalfield can reach the lowest integrative transport cost by being transferred from Huanghua Port. If the coal transferred from the other three Bohai Bay coal ports, the costs are at least 12 Yuan/ ton higher than transferred from Huanghua Port.

From the above analysis, the conclusion can be drawn:

Firstly, coal from "Three West" can get the lowest integrative transport cost by being transferred from Tangshan Port. So it is quite necessary for Tangshan Port to enhance the coal handling capacity in order to attract more coal being loaded in this port and realize the lowest integrative transport cost.

Secondly, Tianjin Port is also attractive for the coal from Shanxi Province, Shananxi Province, and Shenfu-Dongsheng Coalfield, but the integrative transport cost for coal transferred in Tianjin Port is a little bit higher than transferred in Tangshan Port.

Thirdly, Qinhuangdao Port lies in the north of Bohai Bay, and the land transport distance is the longest than the other three Bohai Bay coal ports. So there is no distinctive advantage in the integrative transport cost for coal transferred from Qinhuangdao Port. The only exception is the coal from Inner Mongolia, if the coal transferred from Qinhuangdao Port, the cost is relatively lower than if transferred from Tianjin Port.

Fourthly, for coal produced in Shenfu-Dongsheng Coalfield, the lowest integrative transport cost can be realized if transferred from Huanghua Port. That is why the major coal hinterland of Huanghua Port is Shenfu-Dongsheng Coalfield.

In fact, the construction of 30 million-ton coal terminal and the upcoming Caofeidian coal terminal are all the actions taken by Tangshan Port to make full use of the advantage in integrative transport cost and attract more coal from “Three West”. Shenhua Group Tianjin Coal Terminal which was put into production in 2007 also shows that Tianjin Port is trying to attract coal produced in Shenfu-Dongsheng Coalfield to be transferred from this port. This also indicates Tianjin Port’s advantage in the integrative transport cost of coal. Huanghua Port’s obvious advantage in the integrative transport cost for coal from Shenfu-Dongsheng Coalfield makes this port become the access to the sea especially for the coal produced in Shenfu-Dongsheng area. Qinhuangdao, as the largest coal loading port at present, nearly has no advantage in the integrative transport cost for coal. But the operation hardware and services for coal are all excellent in Qinhuangdao Port. We cannot neglect the crucial position of Qinhuangdao Port in the CTNSC system.

3.4 J Company’s selection of Bohai Bay coal ports—AHP model

3.4.1 Introduction of Company J

J Company is located in Shanxi Province, and it is a coal production enterprise which is invested by the state. This company is an important part of the coal base which is located in the east of Shanxi Province, and it is the important production base of the high-quality anthracite, and ranked as the 7^{th} among the 100 biggest coal enterprises in China.

The major business of Company J is coal mining and processing. At present, this company has 8 teams of productive coal mines, 38 holding subsidiaries, and 11 branches. Until the end of 2007, this company realized the profit of 1.877 billion Yuan, and 32.21 million tons of coal output.
(information got from J Company's website: http://www.jccoal.com)

At present, 70 percent of the coal produced by Company J is transferred by Bohai Bay coal ports and then delivered to the demand place in East or South China by sea. During the last 10 years of the 20th century, the major access to the sea for J Company's coal is Qinhuangdao Port. Later on, Tianjin Port diverted a portion of J Company's coal which is delivered to the south area in China. But now the handling capacity of Qinhuangdao Port has been nearly fully used, and the new professional coal berths of Tianjin Port and Tangshan Port are all constructed. With the increasing capacity of the supporting coal transport railway, Tianjin Port and Tangshan Port are attracting more coal resources to be transferred through these 2 Bohai Bay ports. Therefore, it is quite necessary for Company J re-rank the Bohai Bay coal ports, in order to realize better economic benefit. It should be mentioned that, although the land transport distance from J Company's coal mine to Huanghua Port is the shortest, it is still not quite possible for the coal produced by Company J to be transpferred from Huanghua Port. This is because Huanghua Port's coal handling capacity is still limited and almost the port's entire coal handling capacity is employed by Shenhua Group. So Huanghua Port is not included in the following analysis.

3.4.2 The index system of this AHP model

It is the first step to set up a index system in order to evaluate the 3 Bohai Bay coal ports. The feasibility and rationality will be affected by the way of setting up this system. Here, the AHP model is applied and an evaluation index hierarchy is made.

The index system mainly includes two aspects—hard environment and soft environment of the coal loading port.

There are three elements in the aspect of the hard environment of the coal port: land transportation to the port, expenses on port and sea transport, and port technical conditions. The land transport condition includes 2 sub-elements: the port location and the transport routes. Port location determines the land distance from the coal production base to the coal loading port, and in turn affects the land transport cost; land transport routes, especially the number and coal transport capacity of railway lines directly influences the port's coal handling quantity. The element of expenses can be divided into 2 sub-elements: port charges and sea transport cost. The sea transport distance is the major determinant of sea transport cost. Port technical conditions include 5 sub-elements: depth of the fairway, condition of being silted up, berth designed loading capacity, capacity of stacking yard, and production facilities.

The soft environment could be divided into 2 parts: macro-environment and micro-environment. The detailed sub-elements are shown in the following table (Table 3-9).

Table 3-9 Evaluation Index System

Target layer	Sub-target layer	Criteria layer		Sub-Criteria layer	
Bohai Bay coal ports' ranking for J Company's selection (T)	Hard environment (Ta)	Level of land transportation to the port	（T1）	Geographical location	(T11)
				Land transport routes	(T12)
		Expenses	(T2)	Port charges	(T21)
				Freight charges (Sea transport)	(T22)
		Technical condition of the port	(T3)	Fairway depth	(T31)
				Condition of Being silted up	(T32)
				Berth designed loading capacity	(T33)
				Capacity of stacking ground	（T34）
				Level of production facility	（T35）
	Soft environment (Tb)	Macro-environment	（T4）	Priorities given by the government	（T4）
		Micro-environment	（T5）	Human resource	（T51）
				IT level	(T52)

The weight of each criterion is set up by referring to several experts. And the procedure on how to get the weight is as follows,

1> Fix the scale for judgment: In this AHP model, the elements and sub-elements have to be compared in pairs in order to determine the priorities at each level. So the ratio scale measurement method is applied here. The preferences given by the experts are classified into 9 scales, as shown in Table 3-10.

Table 3-10 Scale of preference between two elements

Weights of preference	**Definition**
1	Equally preferred
3	Moderately preferred
5	Strongly preferred
7	Very strongly preferred
9	Extremely preferred
2, 4, 6, 8	Intermediates values
Reciprocals	Reciprocals for inverse comparison

2> Establish the comparison matrix: The comparison matrix shows how much one element is more important than another element in the same hierarchy. Suppose that element T1 includes several sub-elements as T11, T12… T1n, the comparison matrix should be established as follows,

Table 3-11 Sample of comparison matrix

T_1	T_{11}	T_{12}	…	T_{1n}
T_{11}	a_{11}	a_{12}	…	a_{1n}
T_{12}	a_{21}	a_{22}	…	a_{2n}
…	…	…		…
T_{1n}	a_{n1}	a_{n2}	…	a_{nn}

In the above matrix, a_{ij} (i=1, 2,…, n; j=1, 2,…,n) means the relative importance of T_{1i} compared with T_{1j}.

Normally, the experts who are professional and familiar with the issue can determine the value of a_{ij}. In this AHP model, the value of a_{ij} is obtained by several exports and personnel who are engaged in the coastal coal transportation.

3> Check the consistency of each matrix: There is a crucial validating parameter which is used to check the consistency of the matrix and it is λ_{max}. λ_{max} is the biggest latent root of the comparison matrix, make the corresponding eigenvector unitized, then we get the relative weights of the elements.

If “n” of the matrix is quite large, the calculation will be much complicated. So usually, λ_{max} and the corresponding unitized eigenvector are always drawn by using the software-MATLAB.

When establishing the matrix, because of the complexity of the objects and the ambiguity of people’s judgment, it is impossible for people to give the exact value of the relative importance between the two elements, although experts are engaged in the determination process. So the value of a_{ij} is not always consistent with the actual value. So the concept of “consistency” is applied in AHP model in order to see how much the a_{ij} value is consistent with the actual value.

The steps to check the consistency of the matrix are shown as follows,

Firstly, calculate the Consistency Index (CI):

$$\mathbf{CI} = \frac{\lambda_{max} - n}{n - 1}$$

If the comparison matrix is a completely consistent matrix, λ_{max} is equal to "n", and all the other latent roots are 0. But usually, if the matrix has satisfactory consistency, λ_{max} will be a little bit bigger than "n", and other latent roots are close to 0. (Hu, 2007, 28)

Secondly, refer to the Random Coherence Index and get the corresponding RI (Random Index).

Table 3.12 Random Coherence Index

n	3	4	5	6	7	8	9	10	11	12	13
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.54	1.56

Thirdly, the Consistency Ration is calculated as:

$$\mathbf{CR} = \frac{\mathbf{CI}}{\mathbf{RI}}$$

Lastly, make the judgment. If CR< 0.1, the consistency of the matrix is perfect; if not, the matrix should be corrected.

The following tables (from Table 3-13 to Table 3-19) show the calculation of the comparison matrixes and the CR of each matrix.

Table 3-13 Comparison matrix between T11 and T12

Criteria T1	T11	T12	W
T11	1	5	0.833
T12	1/5	1	0.167

λ_{max}=2; CI=0; CR=0<0.1

Table 3-14 Comparison matrix between T21 and T22

Criteria T2	T21	T22	W
T21	1	1/6	0.143
T22	6	1	0.857

λmax=2; CI=0; CR=0<0.1

Table 3-15 Comparison matrix among T31, T32, T33, T34 and T35

Criteria T3	T31	T32	T33	T34	T35	W
T31	1	4	3	1/3	2	0.2417
T32	1/4	1	1/3	1/5	1/4	0.0527
T33	1/3	3	1	1/4	1/3	0.0960
T34	3	5	4	1	2	0.4149
T35	1/2	4	3	1/2	1	0.1947

λmax=5.2473; CI=0.061825; CR=0.0552<0.1

Table 3-16 Comparison matrix between T51 and T52

Criteria T5	T51	T52	W
T51	1	1/3	0.25
T52	3	1	0.75

λmax=2 ; CI=0; CR=0<0.1

Table 3-17 Comparison matrix between T4 and T5

Criteria Tb	T4	T5	W
T4	1	2	0.667
T5	1/2	1	0.333

λmax=2 ; CI=0; CR=0<0.1

Table 3-18 Comparison matrix among T1, T2 and T3

Sub-target layer Ta	T1	T2	T3	W
T1	1	1/2	1/4	0.1365
T2	2	1	1/3	0.2835
T3	4	3	1	0.6250

λmax=3.0184; CI=0.0092; CR=0.0159 <0.1

Table 3-19 Comparison matrix between Ta and Tb

Target layer	Ta	Tb	W
Ta	1	7.5	0.882
Tb	1/7.5	1	0.118

λmax=2; CI=0; CR=0<0.1

Finally, the global weights for each factor can be reached. See Table A-7

Table 3-20 Global weights for the factors

Target	Sub-target layer		Criteria layer		Sub-criteria layer		
		Relative weights		Relative weights		Relative weights	Global weights
T	(Ta)	0.882	（T1）	0.1365	(T11)	0.833	0.1003
					(T12)	0.167	0.0201
			(T2)	0.2835	(T21)	0.143	0.0358
					(T22)	0.857	0.2143
			(T3)	0.6250	(T31)	0.2417	0.1332
					(T32)	0.0527	0.0291
					(T33)	0.0960	0.0529
					(T34)	0.4149	0.2287
					(T35)	0.1947	0.1073
	(Tb)	0.118	(T4)	0.667	(T4)	0.667	0.0787
			(T5)	0.333	(T51)	0.250	0.0098
					(T52)	0.750	0.0295

3.4.3 Evaluation of Bohai Bay coal ports for Company J

By referring to several specialists, the elements are scored with the use of the different degrees—excellent, good, normal, bad, or too bad. And accordingly, the scores are 9, 7, 5, 3, 1.

Eight specialists or people related to this field provide their scores to each element. And then the average score of each element is achieved.

Table A-11 is the evaluation for Qinhuangdao Port; Table A-12 is the evaluation for Tangshan Port; Table A-13 is the evaluation for Tianjin Port.

Table 3-21 Evaluation for Qinhuangdao Port

Target	Element	Global weights	9	7	5	3	1	Average score
T	(T11)	0.1003		4	4			6.00
	(T12)	0.0201	5	3				8.25
	(T21)	0.0358	1	6	1			7.00
	(T22)	0.2143		5	3			6.25
	(T31)	0.1332	2	6				7.50
	(T32)	0.0291	5	3				8.25
	(T33)	0.0529	4	4				8.00
	(T34)	0.2287	3	5				7.75
	(T35)	0.1073	2	5	1			7.25
	(T4)	0.0787	5	3				8.25
	(T51)	0.0098	3	5				7.75
	(T52)	0.0295	4	4				8.00

Table 3-22 Evaluation for Tangshan Port

Target	Factor	Global weights	9	7	5	3	1	Average score
T	(T11)	0.1003		6	2			6.50
	(T12)	0.0201	1	6	1			7.00
	(T21)	0.0358		7	1			6.75
	(T22)	0.2143		4	4			6.00
	(T31)	0.1332		5	3			6.25
	(T32)	0.0291	6	2				8.50
	(T33)	0.0529	1	7				7.25
	(T34)	0.2287	5	3				8.25
	(T35)	0.1073		3	5			5.75
	(T4)	0.0787	4	4				8.00
	(T51)	0.0098	3	5				7.75
	(T52)	0.0295	4	4				8.00

Table 3-23 Evaluation for Tianjin Port

Target	Factor	Global weights	9	7	5	3	1	Average score
T	(T11)	0.1003	1	6	1			7.00
	(T12)	0.0201	3	3	2			7.25
	(T21)	0.0358		3	5			5.75
	(T22)	0.2143		3	4	1		5.50
	(T31)	0.1332	5	3				8.25
	(T32)	0.0291		3	4	1		5.50
	(T33)	0.0529		7	1			6.75
	(T34)	0.2287			5	3		4.25
	(T35)	0.1073		6	2			6.50
	(T4)	0.0787	5	3				8.25
	(T51)	0.0098	2	6				7.50
	(T52)	0.0295	5	3				8.25

The score for each element can be drawn by multiplying the global weight with the average score. And then the final evaluation score can be achieved by calculating the sum of the scores for the elements. So the evaluation score for Qinhuangdao Port is 7.531.In the same way, the evaluation score for Tangshan Port is 7.229; and the evaluation score for Tianjin Port is 6.484.

The ranking of the three Bohai Bay coal ports to J Company should be as follows,

Table 3-24 Ranking of the Three Ports to J Company

Ranking	1	2	3
Evaluation score	7.531	7.229	6.484
Ports	Qinhuangdao Port	Tangshan Port	Tianjin Port

The current Bohai Bay coal ports' ranking for Company J is as the above. And the evaluation scores of Qinhuangdao Port and Tangshan Port are quite close to each other, although Qinhuangdao Port is still ranked as the first choice for J Company. But as mentioned in the previous analysis, after the completion of Qiancao Railway and the new professional coal handling berths in Tangshan Port and Tianjin Port, the comprehensive coal handling capacity of Tangshan Port and Tianjin Port will be greatly enhanced, and then the ranking will be changed again.

4 Analysis of emergency measures of Bohai Bay coal ports in CTNSC

In recent years, because of the seasonal changes of demand for coal and the occurrence of the natural damages, coal loading ports' capability of responding to emergencies becomes another focus for researchers to analyze. Especially at the beginning of 2008, the massive snow damage in south China aggravated the coal demand in south China. But at that time, railway and road coal transportation were all blocked by the snow weather. Then coal could only rely on coastal transportation to be delivered to the demand place in south China. This kind of situation really intensified the pressure of Bohai Bay coal loading ports. So the improvement on the emergency measures of Bohai Bay coal loading ports is quite helpful for them to effectively respond to the sharply increasing coal demand and ease the pressure of coastal coal transportation.

It is reported that at the beginning of 2008, when the snow damage in south China happened, the four Bohai Bay coal ports took various measures to ensure the smooth coal loading procedure and shipment. During the period of snow damage, four Bohai Bay coal ports closely cooperated with shipping companies, scientifically arranged the coal handling operation, kept the handling facilities in good working condition. The working efficiency of the coal berths, stacking yard all increased under the emergency.

4.1 On how to ensure the service quality of coal ports under emergency

During the snow damage at the beginning of 2008, the four Bohai Bay coal ports made their great efforts on loading the coal which is used in electricity generation, and “five priorities” were carried out to the ships delivering power-generation coal: priority in arranging the time table, priority in pilotage, priority in entering and leaving, priority in berthing, priority in coal handling. All the priorities were set to ensure the smooth coastal transportation for coal used for electricity generation.

Take Jingtang terminal area of Tangshan Port as an example, in order to support the disaster areas and effectively rush to load the coal used to generate electricity, the port put forward 4 guidelines. Firstly, try best to increase the quantity of coal deployment into the port. Assign personnel to go to the coal hinterlands and communicate with large coal production enterprises, such as Shenhua Group, China Coal Group, etc., in order to consolidate the coal supply and ensure coal deployment into the port. Secondly, improve the coordination with the coal consumers, try to get the dynamic state of the ship and ensure the accuracy of ships’ arrival. Thirdly, enhance the working efficiency. During the period of snow damage, there were 21 coal trains which arrived at Tangshan Port (nearly 30,000 tons per day). For the frozen coal, the port arranged 11 grab cranes to discharge the coal from the train, and workers even had to sweep out the ice by hand. The port ensured discharging the coal from a train within 2 hours. Fourthly, try to exploit the potential capacity of the stacking yard, and enlarge the stacking area. During the period of snow damage, the coal stacking capacity of Jingtang terminal area reached 4.8 million tons.

In order to ensure the coastal transportation of coal used in electricity generation, Huanghua Port also took positive actions. They intensified the coordination with the related department of Shenhua Group to ensure the coal supply, and carry out the "Five Priorities" to realize high operation efficiency. The object was set as the best loading plan for the ship, the shortest loading time, and the highest coal turnover rate. (Information got from China Communication News Net http://www.zgjtb.com)

4.2 On how to ensure safe and effective operation of the coal ports under emergency

In order to ensure the coal ship in the safe and efficient operation, the maintenance of the port fairway was strengthened by Bohai Bay coal ports; the site patrol is also intensified, the coal ships were monitored in all directions in order to be safely operated in the port; the convoy service was also provided to the coal ship.

Qinhuangdao Port is the largest the energy exporting port in China. During the period of snow damage in Qinhuangdao Port, coal ships had the right of priority to use the fairway to enter and leave the port and they were monitored and provided with the convoy service to ensure the safe navigation. When the weather condition permitted, the coal ships were allowed to discharge the ballast water in advance in order to improve the ship turnover rate. In the marine forefront, 24-hour duty was implemented, the priority to get the entering and leaving visa was also provided to coal ships. The port's tugboats were inspected in advance before they carry out tasks in order to ensure the service efficiency.

"Plan on emergency measures to ensure the safe operation of coal ships during the Spring Festival" was carried out by Huanghua Port, and this plan covered all the emergency measures to react to the foreseeable urgent situation. Keeping the rescue forces in the "stand-to" condition and ensuring the quick and smooth flow of information were all included in the plan. In addition, examine and repair of the facilities were also strengthened in order to remove the potential problems in time and ensure safe operation. The 24-hour port pilotage was also carried out, and the pilots were on duty in shifts.

Tianjin Port also positively took measures to ensure the coal loading operation. The measures include scientifically deploying the berths for coal ships to be loaded; scientifically arranging the coal stacking capacity to full use of potential capacity; making plans for coal ships to enter and leave the port in priority; increasing pilotage and monitoring to ensure the coal ships' safe sailing; sweeping the fairway for coal ships with large tonnage when necessary; etc. (Information got from China Water Transportation News Net http://www.zgsyb.com)

5 Developing trends of Bohai Bay coal ports in CTNSC

5.1 Unchanged important position in China's coal transportation system

The position of Bohai Bay coal ports in CTNSC becomes more and more prominent and they are treated as the nodes which can help to realize the maximization of logistics and information flow. Through the analysis in Chapter 3, the centralization trend of coal loading ports is not difficult to be seen. In other words, China's coal loading ports are more and more concentrated in Bohai Bay region. The total coal loading quantity of four Bohai Bay coal ports and their growth rate are all significantly higher than the average level in China, and the importance of these four coal loading ports in CTNSC is also gradually strengthened. This kind of centralization trend exactly comforts the main direction between the coal supply and demand in China. So the role of Bohai Bay coal ports in CTNSC will not be changed, but can only be strengthened.

5.2 Much fiercer competition among Bohai Bay coal ports

In recent years, accompanied by the increasing coal demand in China's east and south area, the handling capacity of Bohai Bay coal ports is continuously expanding. But the fact which cannot be ignored is that the coal hinterlands of the 4 Bohai Bay coal ports are more or less the same, and the coal resources mostly come from "three West". So the competition on the overlap of coal hinterlands will be unavoidable. Increasing coal handling capacity and the phenomenon of coal hinterland overlap will make the competition among the Bohai Bay coal ports much fiercer.(Huang, 2006, 29) The professional coal handling berths in Huanghua and Tianjin Port have already diverted a portion of coal which was originally loaded in Qinhangdao Port. And as the coal handling berths of Tangshan Port are going to be put into production, the coal which is loaded in Qinhuangdao and Tianjin Port will be diverted for another time. With the disadvantage of longer land distance from the coal hinterland, to keep the existing market share is no longer a easy task for Qinhuangdao Port. And for Tianjin Port, because it is an artificial port, the disadvantage in water conditions (especially the water depth), will hinder its further increase of market share.

Generally speaking, with the fast development of Bohai Bay coal ports, competition among them is inevitable. But overmuch competition will weaken the overall competitiveness of Bohai Bay coal ports, and coal will flow away to other transportation modes. So it is necessary to form the association to a certain extent, and change the isolated situation at present, in order to set up the coordinated coal loading port system and achieve the persistent healthy development of Bohai Bay coal ports.

5.3 Coordination among Bohai Bay coal ports waiting to be improved

At present, reasonable planning the development of the coal ports in Bohai Bay in order to promote the cooperation among Bohai Bay coal ports has become an important topic for discussion in order to promote the cooperation among Bohai Bay coal ports. Bohai Bay coal port cluster has been basically formed, but the cooperation development has never been achieved in reality. If the homogenous competition among the coal ports in Bohai Bay continues, the port cluster's overall benefit will be reduced.

In fact, in the market economy, it is inevitable for the influence and competition among the adjacent port. As the competition and check among the ports develops, a higher level of “port cluster” will be formed. The overall benefit is not the simple sum of every single port’s benefit, but it is greater than the simple sum of individual benefits. The cooperation system of the highly developed port cluster will avoid the vicious hinterland resource division, and enhance the acceptance and radiation functions of the port cluster. (Chen, 2005, p.71) Bohai Bay coal port cluster must scientifically control the construction scale of the coal handling berths according to the hinterland’s requirements on the port, the port’s natural condition and land transportation ability. Only in this way, the repetitious construction and resource waste will be avoided.

6 Conclusion

Coal resources' dominant position in China's energy structure will not be changed for a long time in the future. The lack of coal resources and the continued growth of energy demand will certainly make the coal transport pattern of CTNSC exist in long-term. Because of the difficulties in the capacity expansion of the coal transport railways, the coastal coal transport system will fully play an important role in the CTNSC system. Four Bohai Bay coal loading ports-Qinhuangdao Port, Tangshan Port, Tianjin Port, and Huanghua Port, as the access to the sea for the coal resources from "Tree West", are becoming more and more important for CTNSC.

Through the analysis and comparative studies in the above chapters, it is not difficult to see the centralization trend of coal loading port (centralized in Bohai Bay area); the coal loading quantity of Bohai Bay coal ports and the market share are continuously increasing; the supporting professional coal transport railways are continuously enlarged in capacity; the infrastructure of the coal ports is continuously improved; and the level of specialization of coal operation facilities is far beyond that of the ports in other area.

In order to carry out the in-depth comparative analysis on the four Bohai Bay coal ports, statistical calculation and AHP model are applied in this paper. Through the statistical calculation, the integrative transport distance and transport cost for the coal which are transferred from different Bohai Bay coal ports are gained; through the

AHP model, taking Company J as an example, the detailed analysis on the selection among the Bohai Bay coal loading ports is carried out and in this way the comparison among the four coal ports is carried on into the specific case.

On the future developing trend, Bohai Bay coal ports' important position will not change in China's Coal Transportation System. But as the coal handling capability of each port increases, the competition on the coal hinterland will become furious. Competition is unavoidable, but if without reasonable planning and coordination, all the coal ports in Bohai Bay will suffer from the vicious competition. So the scientific coordination and cooperation among the Bohai Bay coal ports will be aspect which needs to be improved in the future.

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China's Railway Cargo Transportation Net. (http://www.zgtlhy.cn)

China Water Transportation News Net. (http://www.zgsyb.com)

Hebei Traffic Technology Information Net. (http://www.hebjtinfo.com)

Jingtang Terminal Area of Tangshan Port. (http://www.jtport.com.cn)

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Qinhuangdao Port. (http://www.portqhd.com)

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Tianjin Port Coal Terminal. (http://www.ptacn.com/meimatou/web/index.htm)

Xinhua Net. (http://news.xinhuanet.com)